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ESTELA LEAL CHAGAS DO NASCIMENTO
Orientador: Prof. Dr. José Affonso Brod

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Honoré de Balzac

Real science can be far stranger than science fiction and much more satisfying.
Stephen Hawking

RESUMO

A Província Alcalina de Goiás (GAP) é uma das maiores províncias kamafugíticas no mundo. A porção sul da GAP é composta em sua maioria por depósitos piroclásticos e lavas utrapotássicas, ocorrendo carbonatitos localmente, e a porção central consiste principalmente de diatremas kamafugíticos. A porção norte da GAP possui predominantemente complexos intrusivos alcalinos ultramáficos a máfico-intermediários, com mineralização de níquel laterítico associada.

O Complexo alcalino carbonatítico Morro Preto, localizado na porção norte da GAP, é uma exceção na região, devido à associação carbonatito-kamafugito e devido à mineralização de fosfato associada. O complexo se caracteriza por duas intrusões subcirculares (Morro Preto Norte e Morro Preto Sul) de magnetita apatita magnesiocarbonatitos evoluindo para ankerita ferrocarbonatitos ricos em bário, e ferrocabonatitos tardios contendo siderita. A série carbonatítica fenitiza as rochas hospedeiras do Pré-cambriano, atingindo um halo metassomático de aproximadamente 800m em superfície.

A mineralização de fosfato hospeda-se nas rochas magnetita apatita magnesiocarbonatitos. Essas rochas variam em textura e composição modal: se apresentando desde cumulados ricos em apatita e magnetita, a até rochas com textura de fluxo magmático e com proporções menores de magnetita e apatita. A apatita é rara a ausente nos ferrocarbonatitos, sendo Fe-dolomita e ankerita os principais carbonatos. Siderita pode estar presente nas feições mais tardias, além de traço de monazita e carbonatos da série Magnesita-siderita.

Dados geológicos, geoquímicos e de química mineral são consistentes com a evolução dos magnesiocarbonatitos para ferrocarbonatitos, evidenciando processos de evolução por cristalização fracionada, imiscibilidade de líquidos, metassomatismo e eventos hidrotermais tardios.

As rochas silicáticas do complexo são diques de kamafugito e raras ocorrências de diques alcalinos félsicos e basalto alcalino, sendo que esse último litotipo não apresenta uma relação clara com a série carbonatítica do complexo. Os diques alcalinos de composição félsica possuem microcristais de K-feldspato em uma matriz afanítica, dominado por carbonato e argilominerais. Apesar de feições magmáticas reliquiares, essas rochas estão intensamente fenitizadas, e parte da fábrica mineral encontrada pode ser um produto de metassomatismo potássico.

Os kamafugitos representam as rochas mais primitivas do Complexo Morro Preto. Abrangem um intervalo composicional típico dos mafuritos descritos na GAP, indicando a natureza relativamente diferenciada desses diques em comparação com katungitos e com os picritos alcalinos que representam o magma parental da maioria dos complexos alcalinos ultramáficos do norte da GAP. Os kamafugitos de Morro Preto contêm glóbulos de carbonato, corroborando a hipótese de imiscibilidade entre líquido silicático e carbonatítico durante a formação do complexo, e indicando que representam o magma parental tanto das rochas silicáticas mais diferenciadas quanto das rochas da série carbonatítica.

O clinopiroxênio dos kamafugitos do Complexo Morro Preto tem composição química comparável à do piroxênio de bebedouritos de complexos alcalinos (e.g. Salitre) da Província do Alto Paranaíba (APIP) e do piroxênio em xenólitos de bebedourito em kamafugitos, tanto em Morro Preto quanto na Mata da Corda, na Província do Alto Paranaíba (APIP). Esta similaridade fornece evidências adicionais da associação kamafugito-carbonatito na GAP, e reforça as semelhanças petrogenéticas entre as duas províncias alcalinas.

Considerando que a APIP hospeda um número considerável de complexos intrusivos, alcalinos carbonatíticos, contendo mineralização de P-Nb-REE(-Ti-Ba-Fe-U), recomenda-se trabalhos exploratórios na GAP com o foco na identificação de complexos alcalinos carbonatíticos não aflorantes, utilizando a afinidade metalogenética do Complexo Morro Preto e a mineralização de fosfato associada como um guia exploratório.

ABSTRACT

The Late-Cretaceous Goiás Alkaline Province (GAP) is one of the largest kamafugite provinces in the world. It is dominated in its southern portion by ultrapotassic lavas and pyroclastic deposits, locally containing carbonatites, and in the central portion by kamafugitic diatremes. The northern portion of GAP consists of ultramafic to mafic/intermediate, plagioclase-bearing alkaline rocks and host mostly Ni laterite mineralization.

The Morro Preto Alkaline-Carbonatite Complex in northern GAP is an exception, in that it is characterized by an intrusive carbonatite-kamafugite association and contains significant phosphate mineralization. It comprises two circular intrusions (Morro Preto North and Morro Preto South) of magnetite apatite magnesiocarbonatites, which host phosphate mineralization, and gradually differentiate to barium-rich ferrocarbonatites, some containing carbonates of the magnesite-siderite series. Both carbonatite intrusions fenitized the Precambrian host rocks, the metasomatic halo reaching up to 800m.

The phosphate-mineralized magnetite apatite magnesiocarbonatites vary in texture and modal composition from magnetite-apatite cumulates (pseudophoscorites) to magnesiocarbonatites with only small amounts of magnetite and apatite. In the Ba-rich ferrocarbonatites, apatite is rare or absent, and the dominant carbonate varies from Fe-dolomite to ankerite and siderite. Carbonates of the magnesite-siderite series and traces of monazite and REE-carbonates are also present in the most evolved rocks.

Geological, geochemical and mineral chemistry data are consistent with the evolution of the Morro Preto Complex from the magnesiocarbonatites to ferrocarbonatites by crystal fractionation, liquid immiscibility, metasomatic overprinting and late hydrothermal events.

The silicate rocks in the complex are kamafugite dykes, felsic dykes and rare alkaline basalts. Due to their minor expression in the complex, the relation of alkaline basalts to the carbonatites remains unclear. The felsic dykes have K-feldspar microphenocrysts in an aphanitic groundmass dominated by carbonate and secondary clay minerals. Despite the remnants of magmatic textures, these rocks are strongly fenitized and might be the product of the potassic fenitization overprinting the complex.

Kamafugites represent the most primitive rock type in the Morro Preto complex. They have a compositional range similar to the GAP mafurites, indicating their relatively evolved position in the kamafugitic series, and distinguishing them from the regional MgO-rich alkaline picrites that are the parental magmas to most northern GAP alkaline complexes. Carbonate globules in the Morro Preto kamafugites are consistent with silicate-carbonate liquid immiscibility, suggesting that the kamafugites are the parental magmas both to the more evolved silicate rocks and to the Morro Preto carbonatite series.

The chemical composition of clinopyroxene in the Morro Preto kamafugites is comparable with (i) bebedourite xenoliths from the Morro Preto kamafugites, (ii) bebedourite xenoliths from the Alto Paranaíba Province (APIP) kamafugites (Mata da Corda), and (iii) bebedourites occurring in alkaline-carbonatite complexes (Salitre) from the APIP. This provides an additional evidence for the carbonatite-kamafugite association in the GAP, and an indicative of petrogenetic similarities between both alkaline provinces.

Considering that the APIP contains a number of carbonatite-bearing plutonic complexes hosting large P-Nb-REE(-Ti-Ba-Fe-U) deposits, additional exploration work directed toward the identification of yet undiscovered carbonatite complexes in the GAP should take into account the characteristics of the Morro Preto phosphate mineralization and, consequently, abroader metallogenetic affinity.

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CAPÍTULO 1: INTRODUÇÃO

1.1. APRESENTAÇÃO E OBJETIVOS

O estudo de carbonatitos e rochas alcalinas associadas sempre despertou o interesse acadêmico e industrial, devido tanto à singularidade da gênese e dos processos petrológicos, como ao interesse econômico atrelado aos tipos de mineralização encontrados nesses tipos de rochas.

A Província alcalina de Goiás (GAP) é uma das províncias alcalinas situadas na margem norte da Bacia do Paraná. Essas províncias alcalinas surgiram no Cretáceo Superior, geradas por intenso magmatismo ultrapotássico cujos produtos incluem diversos corpos intrusivos (complexos carbonatíticos, ultramáficos silicáticos e diques) e extrusivos (lavas e rochas piroclásticas).

Assim como a Província Ígnea do Alto Paranaíba (APIP), a GAP destaca-se pela presença de rochas de afinidade kamafugitica, mas ao contrário da APIP, não apresentava até agora, exemplos expressivos de depósitos minerais similares aos da associação carbonatito-kamafugito.

O complexo carbonatítico Morro Preto, localizado na margem noroeste da GAP, é o tema desta tese de doutorado, que tem como base o estudo da geologia, petrologia, geoquímica e química mineral dos carbonatitos do complexo e dos diques de kamafugito associados.

Esta tese divide-se em seis capítulos. O primeiro capítulo tem como objetivo apresentar a localização, o histórico e o contexto geológico regional do Complexo Morro Preto.

O segundo capítulo objetiva realizar um estudo do estado da arte sobre a petrologia e metalogenia dos carbonatitos e, mais especificamente, dos complexos alcalinos carbonatíticos das Províncias brasileiras para subsidiar o entendimento petrológico do complexo Morro Preto. O terceiro capítulo descreve os principais métodos utilizados para o processamento e interpretação dos dados coletados durante a tese de doutorado.

Os capítulos seguintes (4 e 5) estão estruturados em formato de artigo para publicação. O capítulo 4 detalha os controles geológicos e petrogenéticos que contribuíram para a formação do Complexo Carbonatítico Morro Preto. Como objetivos específicos desse capítulo podemos enumerar:

a) apresentação do contexto geológico do complexo carbonatítico Morro Preto;

b) Indicadores texturais e mineralógicos de cristalização fracionada, imiscibilidade de líquidos, mistura de magmas, desgaseificação do magma carbonatítico, e suas implicações para a formação do complexo e a gênese do minério;

c) Determinação da composição química de elementos maiores e traços em rocha total, para obtenção de indicadores químicos que auxiliem na caracterização petrológica e no entendimento de processos associados à gênese de carbonatitos;

d) Caracterização química dos carbonatos e apatita das rochas estudadas;

e) a partir da integração dos dados acima, determinação de uma sequência evolutiva preliminar destas rochas e proposta de um modelo petrológico do complexo.

O capítulo 5 aprofunda o contexto petrográfico e composicional dos diques de kamafugitos associados à série carbonatítica do Morro Preto, e as possíveis similaridades entre a associação kamafugito-carbonatito na GAP e na APIP. Dentre os principais temas abordados, temos:

a) Petrografia e composição química dos fenocristais e minerais presentes da matriz, e comparação das associações e texturas encontradas com outras ocorrências de kamafugitos na GAP e na APIP;

b) Relação dos kamafugitos na gênese dos carbonatitos por meio de imscibilidade de líquidos, interpretando os glóbulos de carbonatos presente nos kamafugitos como líquidos carbonatíticos imiscíveis.

c) Associação entre os xenólitos de clinopiroxenito encontrados nos kamafugitos da GAP e os bebedouritos encontrados na APIP, sua significância para o potencial metalogenético do Complexo Morro Preto, e por consequência, de outras possíveis intrusões carbonatíticas não encontradas ou não aflorantes na região.

A integração dos dois artigos está resumida no sexto e último capítulo do trabalho, sintetizando as conclusões finais sobre a pesquisa.

1.2 LOCALIZAÇÃO DA ÁREA DE ESTUDO E VIAS DE ACESSO

O complexo Morro Preto localiza-se a aproximadamente 40 km a norte da cidade de Piranhas, e a 43km a norte da cidade de Arenópolis, em Goiás. O complexo é formado por duas intrusões carbonatíticas, Morro Preto Norte e Morro Preto Sul, distantes 5km uma da outra. O Morro Preto Sul localiza-se na confluência entre o rio Caiapó e o rio Piranhas, e o Morro Preto Norte localiza-se a norte das margens do rio Caiapó.

O acesso à intrusão do Morro Preto Sul se dá pela GO-060 até a cidade de Arenópolis, seguindo a partir da entrada da cidade pelas estradas vicinais GO-445 que segue até as fazendas da região, seguida da GO-188, até o vilarejo de Campos Verdes. De lá, segue-se a oeste para a confluência entre o Rio Piranhas e o Rio Caiapó, local da intrusão de Morro Preto Sul. Devido à proximidade com as margens dos rios, o acesso à área da intrusão do Morro Preto Norte é feito pela porção norte da GO-188. A GO-060 permite a conexão às principais cidades do entorno, como Piranhas, São Luiz dos Montes Belos e Goiânia (Figura 1.01).

Os corpos intrusivos Norte e Sul possuem, cada um, cerca de 3km de diâmetro por 100m de diferença de cota aflorante. Ambos estão encaixados em gnaisses e granitos pertencentes ao Arco

Magmático de Goiás. O intemperismo gerou uma cobertura de solo e saprolito com média de 10 metros de espessura, caracterizado por vezes por uma banda espessa de silexito.

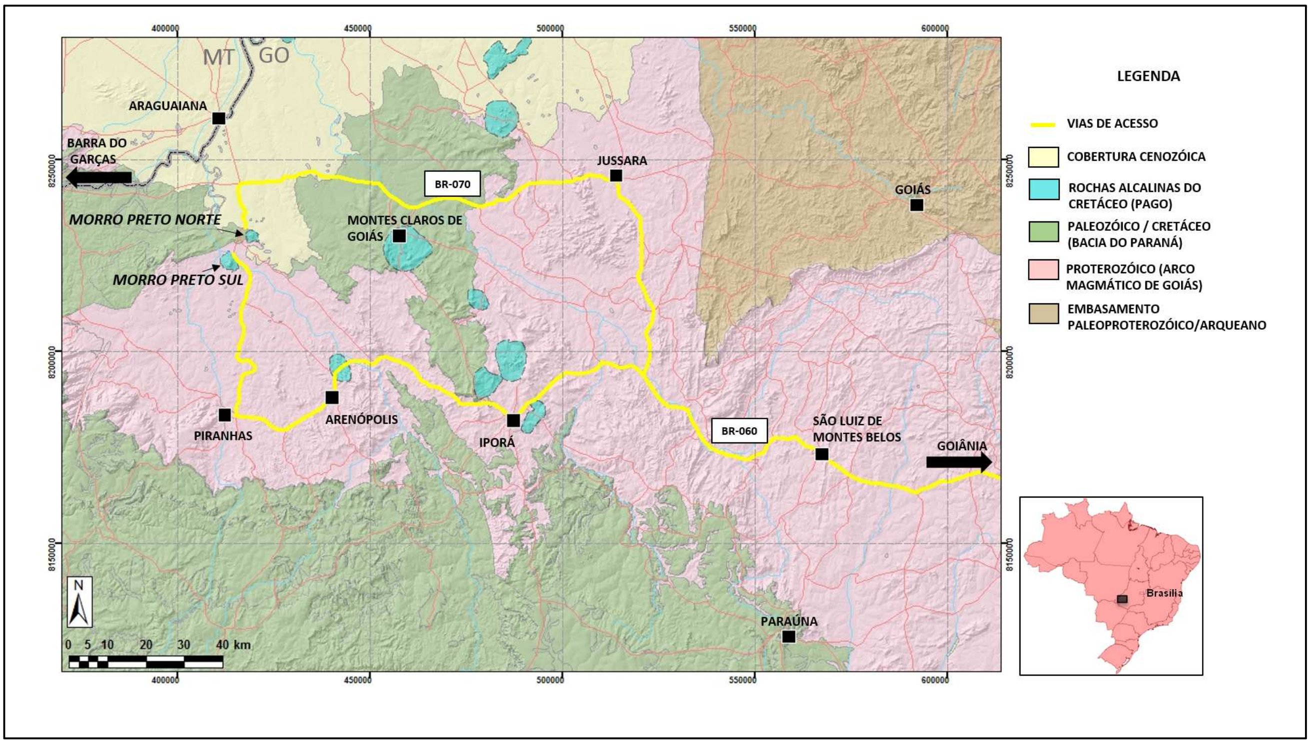

Figura 1.01. Principais unidades geológicas (adaptado de Lacerda Filho et al., 1999) e vias de acesso ao Complexo Morro Preto.

1.3. CONTEXTO GEOLÓGICO REGIONAL

As províncias alcalinas brasileiras localizadas às margens da Bacia do Paraná são o resultado de extenso magmatismo alcalino ocorrido principalmente durante o Cretáceo. Essas rochas são condicionadas a lineamentos com direção NW e NE, e subordinadamente N-S e E-W. As estruturas regionais NW, de subsidência tectônica, são também conhecidas como “Azimute 125°”, e são consideradas as principais responsáveis pelo estabelecimento das províncias alcalinas brasileiras (Almeida, 1983, 1986).

Além do controle estrutural, as Províncias às margens da Bacia do Paraná são distribuídas de forma geral tanto cronologicamente (Figura 1.02) como em termos de afiliação magmática e potencial metalogenético (Riccomini et al., 2005; Ribeiro et al, 2014).

- Permo-Triássico: idade do estabelecimento dos complexos alcalinos e carbonatíticos da Província Alto Paraguai (Riccomini et al., 2005). Ocorrem depósitos modestos de fluorita, ETR e mineralizações associadas a sienitos e nefelina sienitos.

- Cretáceo Inferior: foi o período de instalação de rochas alcalinas contemporâneas com os basaltos da Formação Serra Geral, como as da Província Arco de Ponta Grossa e da Província Paraguai Oriental. Grande parte das rochas alcalinas deste evento é de afiliação sódica. Também ocorrem misturas de rochas do Cretáceo Superior e Cretáceo Inferior (Província Santa Catarina), indicando recorrência do magmatismo alcalino em determinadas regiões ao longo do tempo. Essas províncias consistem de jazidas de médio a pequeno porte de fosfato, em estágio inicial de exploração mineral ou de produção.
- Cretáceo Superior: neste período surgiram as províncias alcalinas localizadas na borda norte da Bacia do Paraná, como as de Poxoréu, Goiás (GAP) e Alto Paranaíba (APIP). Estas províncias estão fortemente alinhadas segundo a direção NW e seu magmatismo alcalino está restrito ao Cretáceo Superior, entre 80 e 90 Ma. A composição desse grupo é tipicamente ultrapotássica, dominada por kamafugitos. Na província do Alto Parnaíba (APIP) ocorrem mineralizações multi-commodities e em maior volume. Na Província de Goiás (GAP) predominam atualmente os depósitos ricos em Ni laterítico (Ribeiro et al., 2014).
- Cretáceo Superior / Paleógeno: a Província Serra do Mar (Thompson et al., 1998) e o Lineamento Magmático Cabo Frio (Riccomini et al., 2005) são desse período, compostas por séries de composição sódica, predominando nefelina sienitos com raras ocorrências de carbonatitos e lamprófiros.

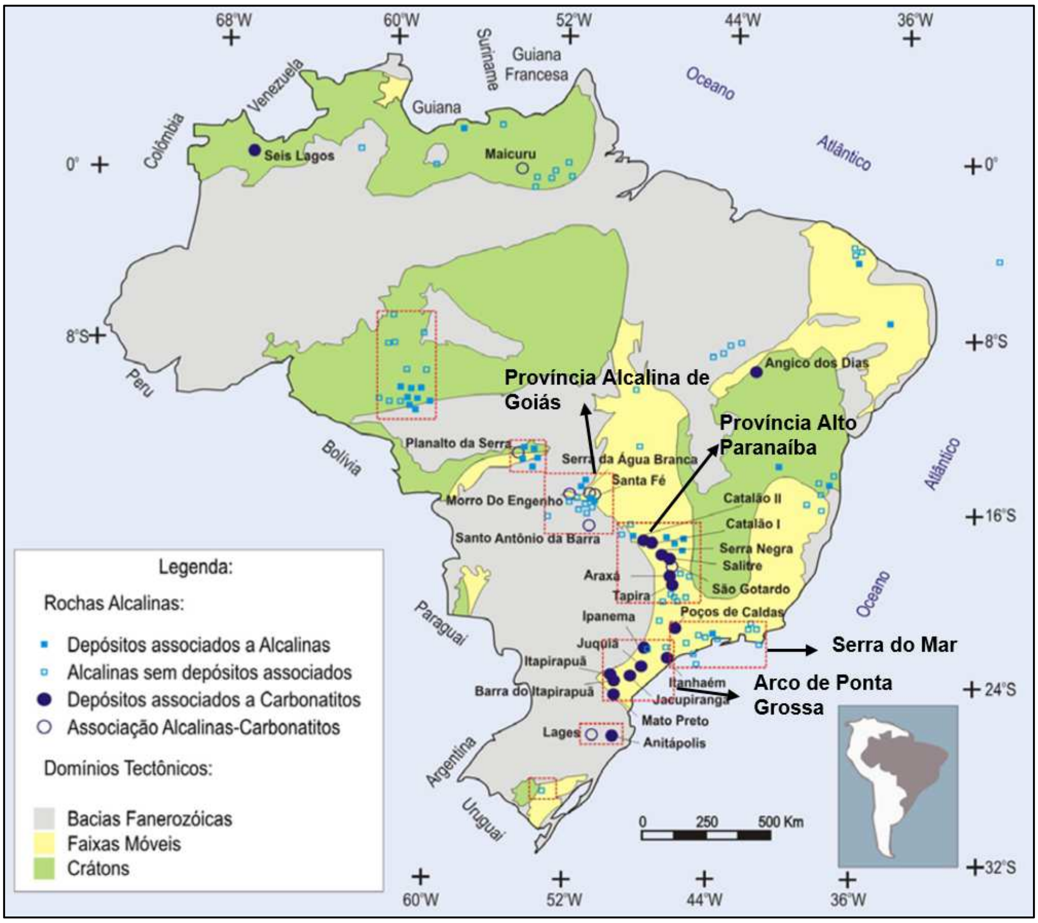

Figura 1.02. Localização das principais ocorrências de rochas alcalinas no Brasil (Berbert 1984, Gomes et al. 1990, Biondi 2005), com indicação das Províncias e complexos alcalino-carbonatíticos e a presença ou não de depósitos minerais associados (Adaptado de Ribeiro et al. 2014).

A sequência de províncias alinhadas de noroeste para sudeste, na borda NE da Bacia do Paraná: Poxoréu, Goiás, Alto Paranaíba e Serra do Mar ou Lineamento Magmático Cabo Frio, indica que o adelgaçamento da litosfera e a fusão parcial do manto promoveu essa série de províncias alcalinas, e que a pluma de Trindade influenciou na sua formação (Gibson et al. 1995, 1997; Thompson et al., 1998; Van Decar et al., 1995). Bizzi e Araújo (2005), por meio de estudos de assinatura isotópica, propõem uma contribuição de material proveniente da pluma mantélica de Tristão da Cunha, durante a ascensão da pluma de Trindade, na formação das rochas alcalinas.

As províncias alcalinas brasileiras apresentam importantes diferenças nas associações litológicas e nas afinidades geoquímicas, dentre as quais podem ser destacadas a diferença entre as províncias na borda norte da Bacia do Paraná (GAP e APIP), tipicamente potássicas e dominadas por kamagufitos, e as províncias alcalinas na margem sudeste do Brasil (Ponta Grossa, Serra do Mar, Linemanto Magmático Cabo Frio), de afinidade sódica, predominando nefelinitos, basanitos e ijolitos.

Até mesmo províncias com afinidade similar, como a GAP e a APIP mostram diferenças petrogenéticas que afetam seu potencial metalogenético, conforme descrito em Gaspar et al. (2003) e Ribeiro et al. (2014), respectivamente. Na APIP os depósitos são multi-commodities e de grande extensão e volume, predominando depósitos de Nb, P, ETR, Ti, Ba e vermiculita presentes em complexos alcalino-carbonatíticos intrusivos, como Tapira, Araxá, Salitre, Serra Negra e Catalão I e II. Já na GAP, são conhecidos depósitos de Ni laterítico, associados às intrusões ultramáficas silicáticas da porção norte da província.

A Província Alcalina de Goiás (GAP), originalmente designada como Grupo Iporá (Guimarães et al., 1968), estende-se desde as cidades de Araguaiana e Santa Fé, a norte, até a cidade de Rio Verde, a sul, em uma área de aproximadamente 17000 km^2 e de direção preferencial N30ºW (Brod et al., 2005). Contudo, toda a região da província foi afetada também por lineamentos estruturais de direção NE. Shobbenhaus Filho et al. (1975) associam esses últimos à reativação do lineamento Transbrasiliano durante o Cretáceo. A Figura 1.03 ilustra os principais controles estruturais regionais que afetaram os complexos alcalinos da GAP e da APIP.

Segundo Junqueira-Brod et al. (2005) a GAP é subdividida em extrusões kamafugíticas extensas na porção sul (Santo Antônio da Barra), corpos sub-vulcânicos e diatremas na zona central (Amorinópolis e Águas Emendadas), e intrusões ultramáficas alcalinas no norte (Santa Fé, Morro dos Macacos, Montes Claros, Morro do Engenho, Córrego dos Bois e Fazenda Buriti). É uma das maiores províncias kamafugíticas em volume do planeta (Junqueira-Brod et al., 2002, 2005; Brod et al., 2000), contudo carente de pesquisas, considerando o conjunto ainda limitado de estudos petrogenéticos relacionando as séries de rochas alcalinas (Brod et al., 2005).

A porção sul da GAP é definida pela área de Santo Antônio da Barra, região com derrames extensos de lavas e depósitos piroclásticos seguindo o lineamento tectônico Iporá-Santo Antônio da Barra (N40-50W). O derrame de lava nessa região possui um volume calculado de 23km^3 (Junqueira-Brod et al., 2002).

A zona central da GAP é caracterizada por intrusões sub-vulcânicas de kamafugitos, leucititos e basanitos / trefitos na forma de diques, plugs e sills intrudidos na Bacia do Paraná, juntamente com sequências sub-vulcânicas ultrapotássicas da região de Amorinópolis e de Águas Emendadas (Junqueira-Brod et al, 2002, 2005).

A porção norte da Província é dominada por complexo ultramáficos alcalinos, sendo o complexo Morro do Engenho o limite norte da GAP. Os complexos máfico-ultramáficos alcalinos dessa região consistem principalmente dunitos, peridotitos, clinopiroxenitos, gabros alcalinos, sendo comum halos de sienito, além de diques de fonolitos e lamprófiros, além de sequências de diques e plugs de picritos alcalinos (Danni, 1994, Brod et al., 2005).

O Complexo Morro Preto localiza-se na margem noroeste da GAP (Figura 1.01). Ao contrário do restante da região, caracterizada por grandes intrusões alcalinas, com a predominância de rochas silicáticas ultramáficas e carbonatitos subordinados ou ausentes, Morro Preto se caracteriza por ser de menor volume e composição essencialmente carbonatítica.

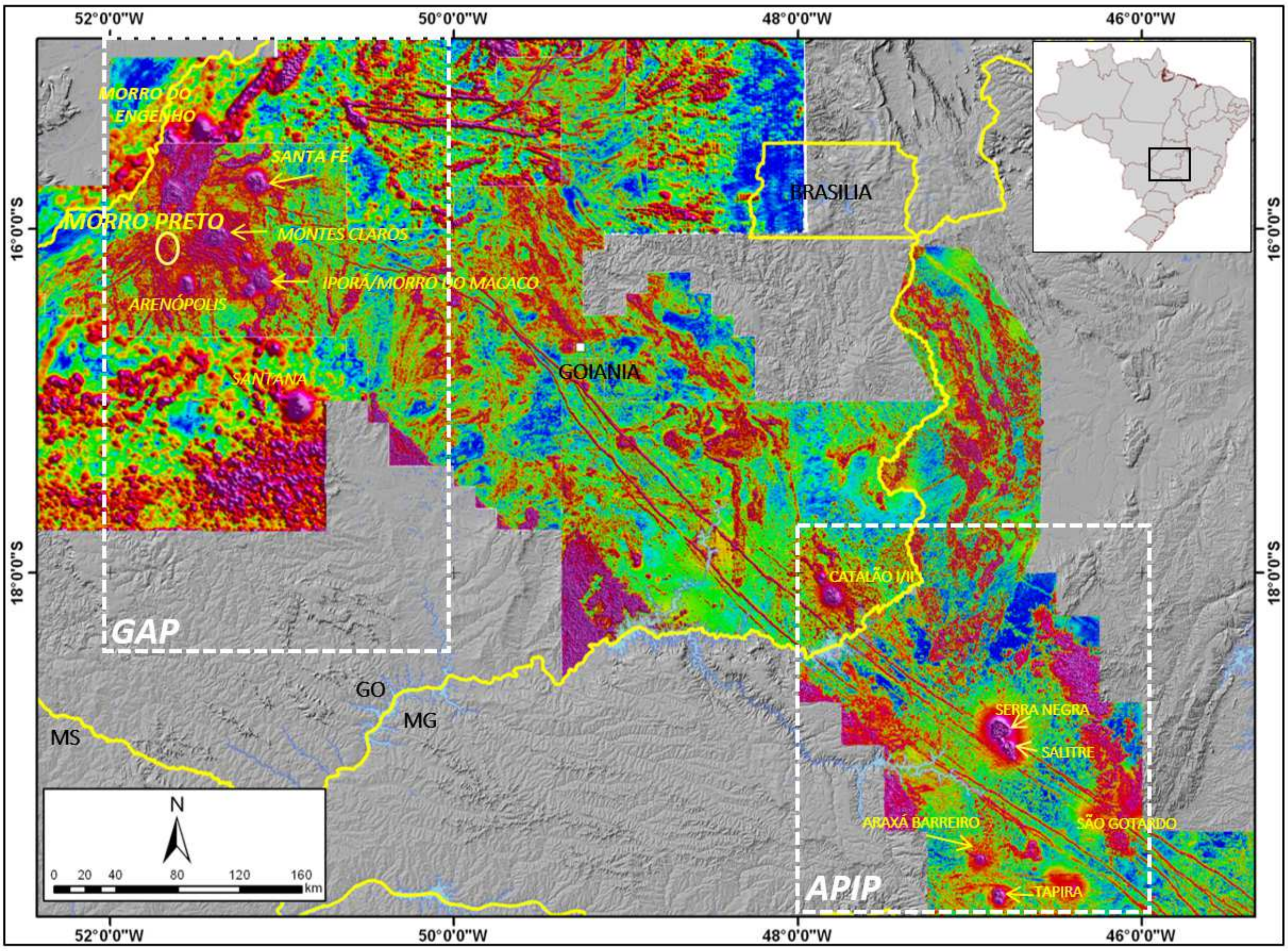

Figura 1.03. Localização das Províncias Alcalina de Goiás (GAP) e do Alto Paranaíba (APIP), com destaque para os principais complexos alcalino-carbonatíticos, inclusive o Complexo Morro Preto, e para os lineamentos regionais estruturais delineados pela magnetometria aéra (sinal analítico). Fonte do mosaico de imagens de magnetometria aérea: CPRM e Anglo American Brasil Ltda.

1.4. COMPLEXO MORRO PRETO: HISTÓRICO E CONTEXTO GEOLÓGICO LOCAL

Estudos iniciais nesse complexo incluiram trabalhos da CPRM de 1980, tendo a mesma Companhia continuado o trabalho através de um levantamento de sedimento de corrente nas drenagens no entorno da intrusão carbonatítica.

Resultados preliminares na intrusão sul indicaram anomalias substanciais para fósforo e bário. O levantamento aerogeofísico executado pelo projeto Iporá – CPRM, apresenta uma anomalia aeromagnética bem característica e valores radiométricos compatíveis com rochas alcalinas e carbonatitos (Pereira et al., 1980).

Em adição aos estudos da CPRM, Navarro et al. (2014) fizeram um estudo de caracterização litogeoquímica de elementos maiores, traços e terras raras com 21 amostras de superfície de rochas alcalinas e silexitosdo Complexo Morro Preto, concentrando os trabalhos na intrusão sul. De acordo com Navarro et al., a distribuição de elementos menores, traços e terras raras mostra que as amostras analisadas são produtos de alteração de rochas ígneas alcalinas como carbonatitos, lamprófiros e basaltos alcalinos, rochas já enriquecidas em elementos como Th, U, ETR (principalmente em ETRL), Nb e Ta, e cuja alteração supergênica produziu enriquecimento adicional em P_2O_5 e enriquecimento acentuado em terras raras, sugerindo a possibilidade de mineralizações destes componentes, similar às observadas em outros complexos alcalinos de Goiás e de Minas Gerais, como Catalão e Araxá.

Cada uma das intrusões do complexo Morro Preto possui aproximadamente 3km de diâmetro por 100m de altura aflorante, e está encaixada em gnaisses e em intrusões graníticas anorogênicas no domínio de Arco Magmático de Goiás. O alto grau de intemperismo gerou uma cobertura de solo e saprolito com média de 10 metros de espessura, caracterizado por vezes por uma banda espessa de silexito.

Os resultados do trabalho de prospecção, realizado pela empresa Anglo American entre 2011 e 2014, destacam rochas carbonatíticas com alto potencial para mineralização de fosfato. Os teores anômalos em amostras de solo e rocha em ambas as intrusões (Figuras 1.04 e 1.05) foram significativos: valores máximos de 1860 ppm Nb, 22,4% P_2O_5 e 1,19% ETR_T em amostras de solo coletadas no Morro Preto Sul, e valores máximos de 2000 ppm Nb, 5,93% P_2O_5% e 1,19% ETR_T no Morro Preto Norte.

A distribuição em solo das anomalias de Nb-P_2O_5-ETR_T-Ba-Al_2O_3-Fe_2O_3 se encontram associadas a anomalias circulares de alto magnético e de alto tório e urânio, ambas detectadas durante o levantamento geofísico aéreo (magnetometria e gamespectrometria) realizado no ano de 2012 sobre o complexo. Os resultados gamaespectrométricos também auxiliaram a delinear os limites (não aflorantes) das duas intrusões alcalinas (Figuras 1.04 e 1.05).

Para a intrusão Morro Preto Norte, os levantamentos de geoquímica de solo e de geofísica aérea caracterizam a intrusão como um corpo concêntrico. A parte central do corpo é dominada por carbonatitos (Figura 1.04), contudo a auréola externa é constituída por rochas fenitizadas, de composição máfica a ultramáfica, de acordo com a associação geoquímica observada no levantamento geoquímico de solo. Rochas ultramáficas fenitizadas não afloram e não foram interceptadas nos furos de sonda amostrados para este trabalho.

Os dados gamaespectrométricos da intrusão sul (Figura 1.05) também exibem o padrão de halos carbonatíticos concêntricos de alto tório e urânio, ambos associados às anomalias em superfície de P_2O_5 e ETR_T, contudo a resposta superficial à espessura maior de saprolito nessa intrusão, e a consequente cobertura de silexito, se sobrepõe às anomalias positivas de tório e urânio.

A geologia local interceptada nos furos de sonda confirmou a hipótese inicial de que o complexo seria dominantemente carbonatítico, intercalado com porções das rochas hospedeiras fenitizadas.

As rochas interceptadas nos testemunhos de sonda estudados permitiram a subdivisão das rochas carbonatíticas em três tipos principais: (i) magnetita apatita magnesiocarbonatitos, que contém mineralização de fosfato associada, (ii) ferrocarbonatitos ricos em bário, e (iii) ferrocarbonatitos tardios, com o enriquecimento em carbonatos ricos em ferro e manganês, como siderita e magnesita. Os furos de sonda também interceptaram diques de kamafugitos, que serão detalhados no capítulo 5 deste trabalho, e ocorrências menores de diques félsicos e basalto alcalino.

Os furos de sonda realizados sobre o complexo demonstraram a continuidade e a variabilidade dos teores anômalos em fosfato em associação com os tipos de rocha, fatores importantes a serem detalhados para um melhor entendimento da geologia do Complexo e da distribuição da mineralização. Uma seção representativa N-S de parte dos furos estudados, localizados na intrusão Morro Preto Sul, e com as interseções mineralizadas interceptadas, encontra-se detalhada na Figura 4.02, no capítulo 4, assim como o detalhamento das litologias encontradas em ambos os corpos intrusivos.

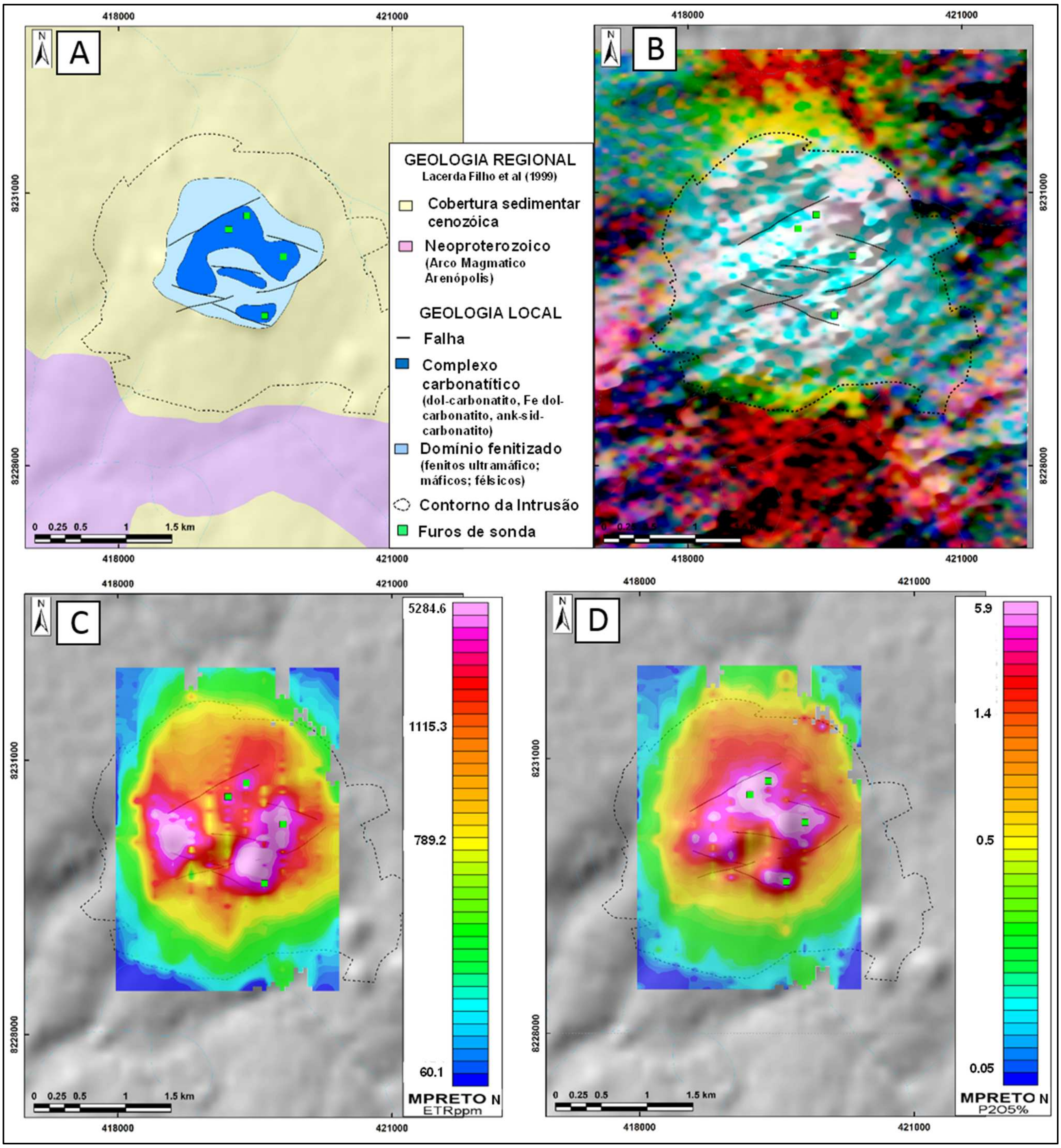

Figura 1.04. Morro Preto Norte: (A) geologia local, (B) imagem ternária da gamaespectrometria (vermelho=potássio / verde=tório / azul=urânio), (C) geoquímica de solo com – resultados de ETR_T (ppm), e (D) resultados de P_2O_5 wt.%.

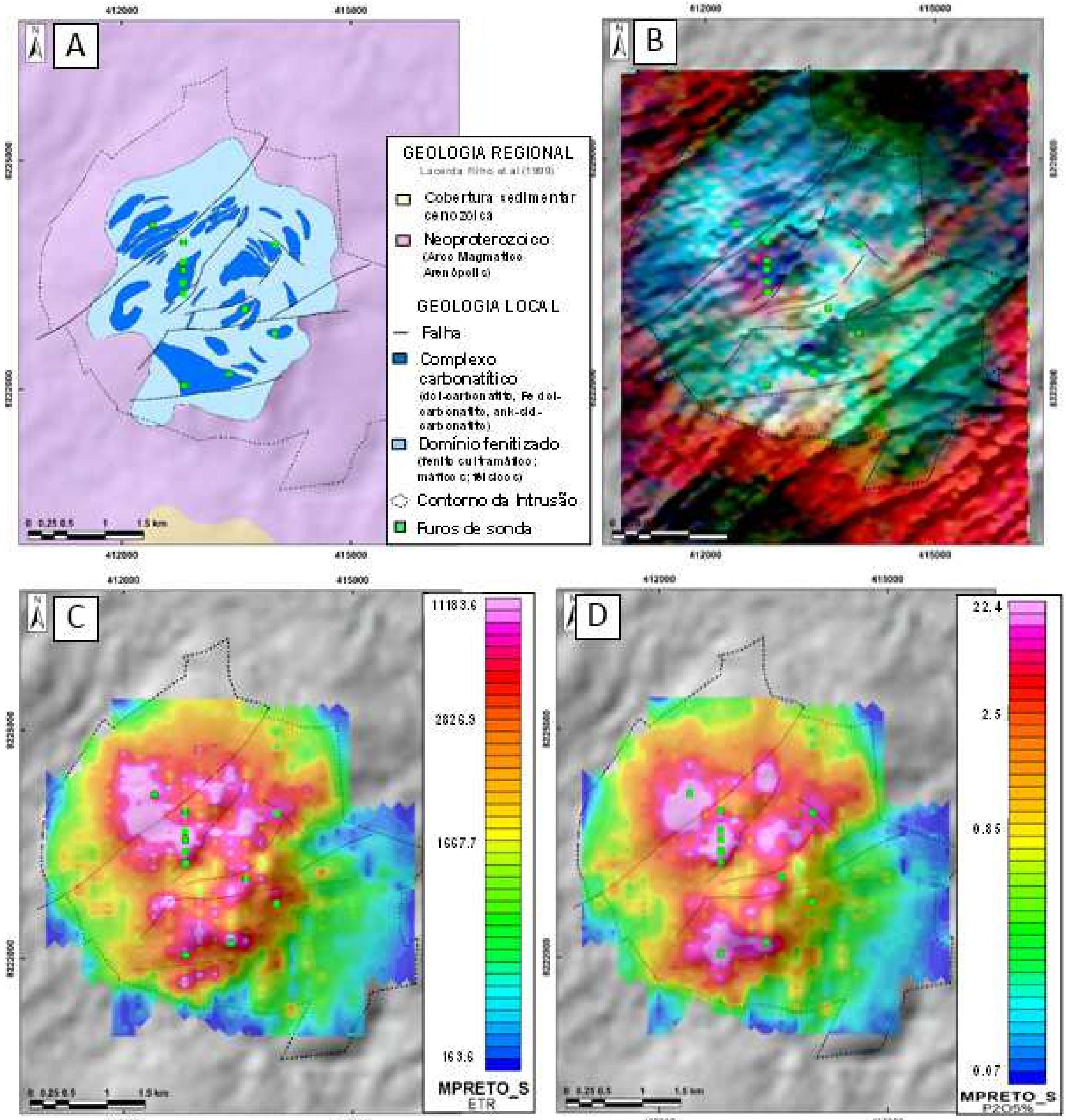

Figura 1.05. Morro Preto Sul: (A) geologia local, (B) imagem ternária da gamaespectrometria (vermelho=potássio / verde=tório / azul=urânio), (C) geoquímica de solo com – resultados de ETR_T (ppm), e (D) resultados de P_2O_5 wt.%.

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CAPÍTULO 2: COMPLEXOS ALCALINOS CARBONATÍTICOS

2.1. INTRODUÇÃO

Carbonatitos são definidos como rochas ígneas compostas por mais 50% de carbonato primário (magmático), e contendo menos de 20% de SiO_2 (Woolley & Kempe, 1989). Apesar dos carbonatitos conterem mais de 300 espécies minerais descritas, o que predomina na sua classificação é a concentração e o tipo de carbonato presente. Essas rochas podem ser intrusivas, extrusivas e hidrotermais, ou ainda ocorrer como corpos brechados.

O número de carbonatitos plutônicos conhecidos é muito maior do que o de seus equivalentes vulcânicos (cerca de 10 % do total - Woolley & Kjarsgaard, 2008), e virtualmente todos os depósitos minerais associados a carbonatito ocorrem em (ou diretamente associados a) complexos plutônicos (Ribeiro et al., 2014).

Os carbonatitos podem ser classificados mineralogicamente e quimicamente de acordo com a descrição da Tabela 2.01 e com o gráfico da Figura 2.01.

Classe	Sub-divisão mineralógica	Característica Química
Calciocarbonatito*	calcita carbonatito	$CaO/(CaO+FeO+MgO) > 0.8$
Magnesiocarbonatito*	dolomita carbonatito	$MgO > (FeO_T+MnO)$
Ferrocarbonatito*	ankerita carbonatito	$(FeO_T+MnO) > MgO$
Carbonatito rico em ETR		$RE_2O_5 > 1\%$ w.t.
Natrocarbonatito		$(Na_2O+K_2O) > (CaO+MgO+FeO)$

Tabela 2.01. Nomenclatura de tipos de carbonatito simplificada, adaptada de Woolley & Kempe (1989). (*) Denominação a partir da característica química da rocha.

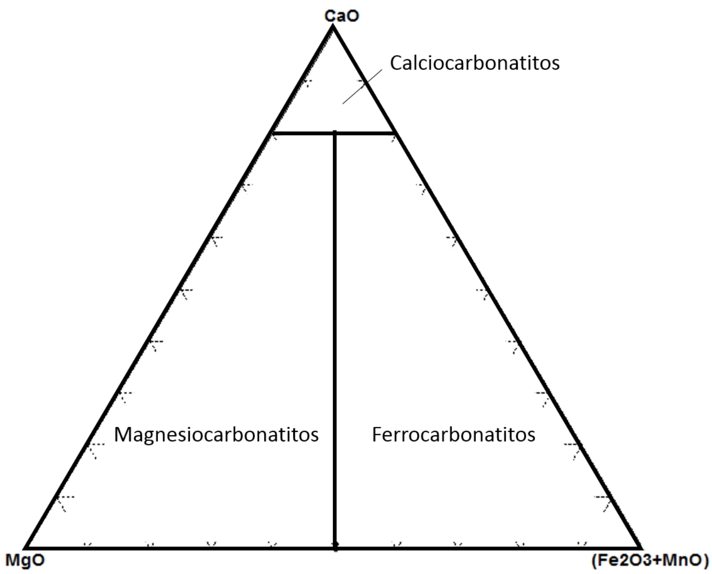

Figura 2.01. Classificação química dos carbonatitos de acordo com o teor de CaO-MgO-$(FeO+Fe_2O_3+MnO)$ (wt. %) (Woolley & Kempe, 1989).

Os carbonatitos mais primários são os mais ricos em alkalis, termos composicionais como magnesiocarbonatito e calciocarbonatito provavelmente resultam, em sua maioria, de diferenciação magmática por cristalização fracionada, imiscibilidade de líquidos e desgaseificação. Os natrocarbonatitos são encontrados unicamente em extrusão moderna de lava carbonatítica, no vulcão Oldoinyo Lengai, Tanzânia.

Os ferrocarbonatitos são tardios e mais raros nos complexos carbonatíticos, ocorrendo comumente como diques cortando as sequências de calciocarbonatitos e magnesiocarbonatitos. As texturas desse tipo de carbonatito são por vezes caracterizadas por fraturas com oxidação, "manchando" os grãos de calcita e dolomita originais, ou fluido rico em ferro interpenetrando a clivagem dos carbonatos originais, formando ankerita e outros carbonatos ricos em ferro na borda e por vezes formando massas enriquecidas em hematita (Le Bas, 1989).

2.2. OCORRÊNCIA

Primariamente, os carbonatitos ocorrem em áreas geologicamente estáveis, em contexto tectônico de intraplaca, normalmente associados a movimentação de plumas mantélicas. Ocasionalmente, também ocorrem marginais a cinturões orogenéticos ou zonas de rift. Contudo, a sua origem mantélica profunda desfavorece a ocorrência desses tipos de rochas em outros contextos geológicos, como arcos de ilha e zonas de subducção.

Os carbonatitos podem ocorrer isolados ou como uma parte, ou uma suíte, de um complexo intrusivo alcalino, onde estão associados com sequências de rochas alcalinas silicáticas, incluindo aí uma variedade expressiva de rochas ultramáficas a félsicas. A instalação (*emplacement*) dos carbonatitos pode ocorrer na forma de *plugs*, normalmente centrais, de complexos alcalinos intrusivos, ou na forma de diques, sills, brechas ou veios. A ocorrência em escala global dos carbonatitos compilada pelo Serviço Geológico do Canadá (Wooley & Kjarsgaard, 2008), encontra-se na Figura 2.02.

As idades de carbonatitos variam do Arqueano ao presente. Ao dividir as ocorrências carbonatíticas em diferentes intervalos geológicos, observa-se a distribuição de grupos e províncias correspondentes com os eventos geológicos geradores do magmatismo alcalino-carbonatítico (Figura 2.03).

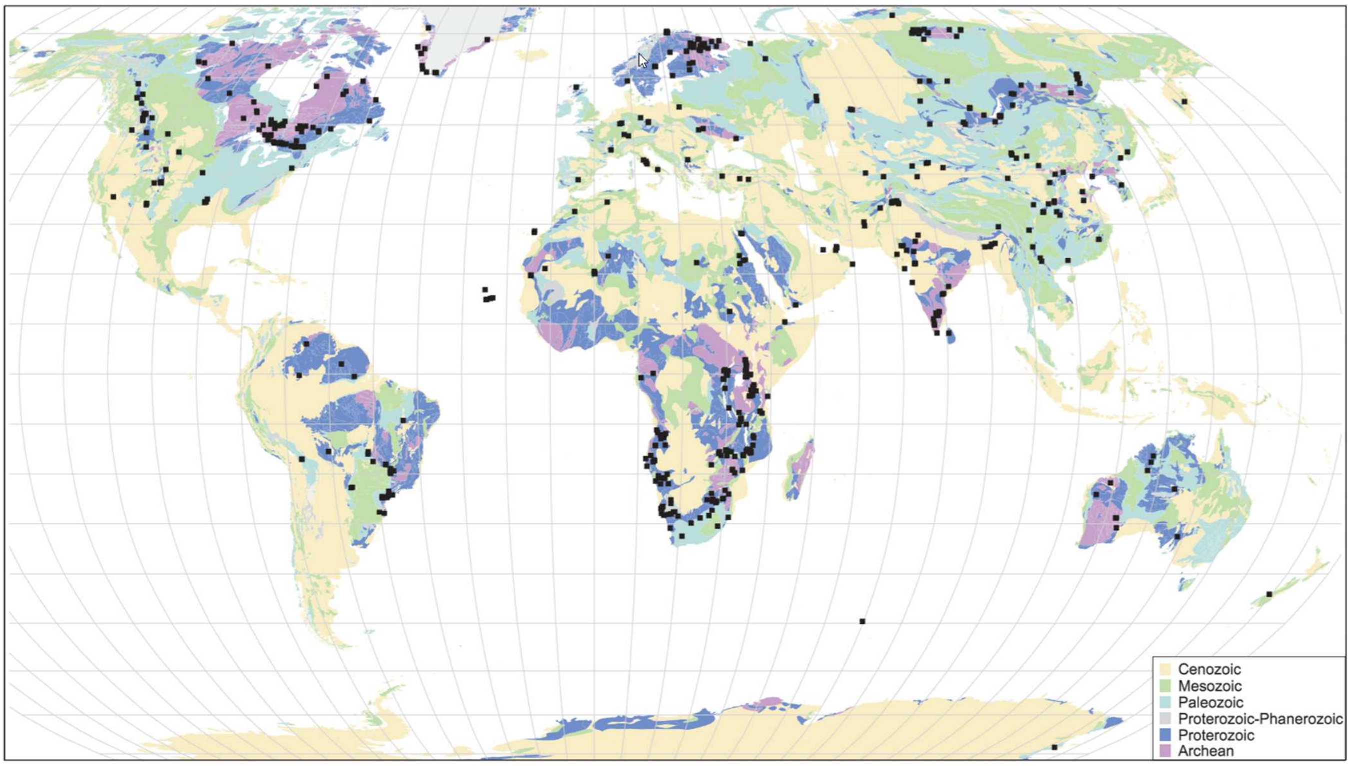

Figura 2.02. Mapa mundial com as principais localidades de ocorrências de carbonatito (Wooley & Kjarsgaard, 2008).

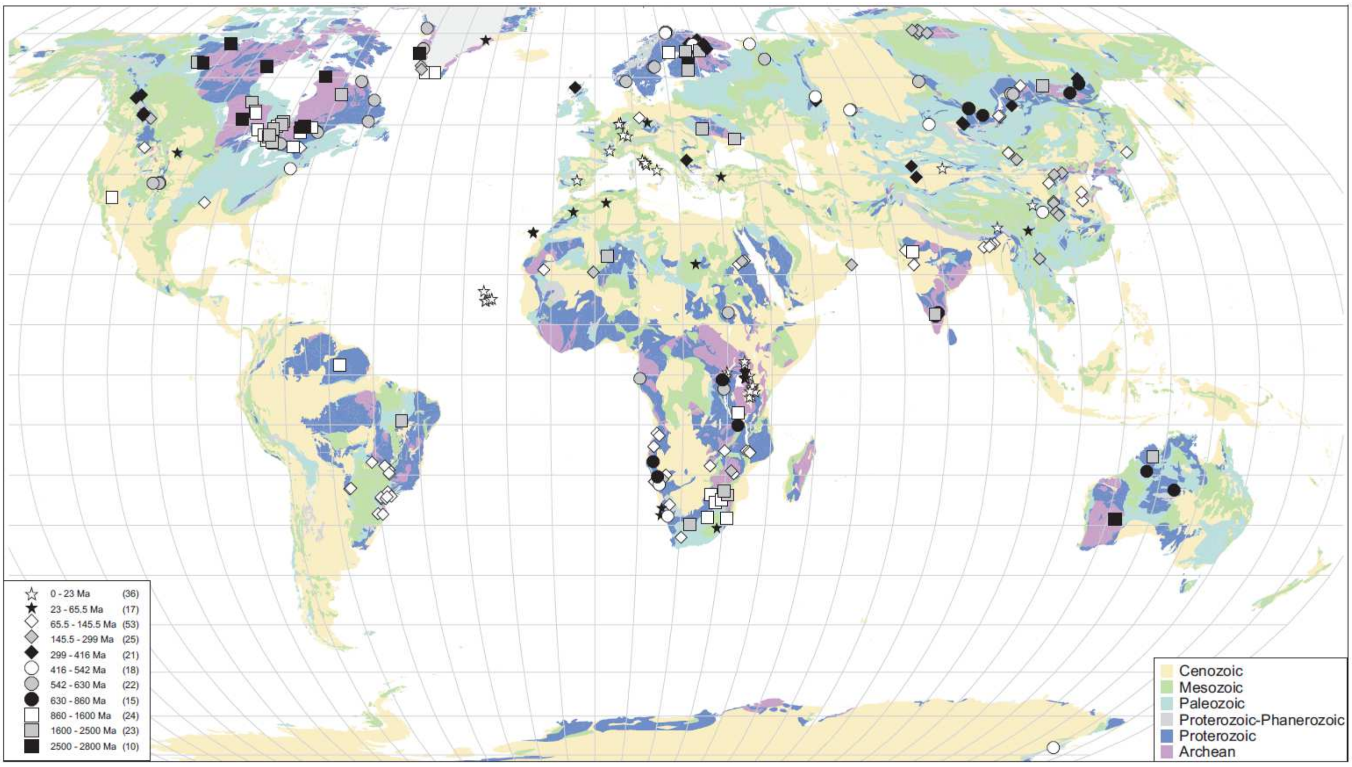

Figura 2.03. Distribuição global dos principais intervalos de idade dos carbonatitos (Wooley & Kjarsgaard, 2008).

2.3. ORIGEM E EVOLUÇÃO DOS COMPLEXOS CARBONATÍTICOS

A geração de complexos carbonatíticos normalmente ocorre via múltiplos estágios de intrusão, podendo se originar a partir de dois processos petrogenéticos principais: (i) originados diretamente da evolução de um líquido parental ultramáfico carbonatado, derivado do manto, ou (ii) como produto da evolução de um magma secundário gerado por diferenciação de um magma parental silicático rico em CO_2. Já a evolução dos complexos carbonatíticos pode ser extensamente afetada por hidrotermalismo e/ou metassomatismo (fenitização).

2.3.1. Carbonatito oriundo de fusão direta do Manto

Os magmas carbonatíticos são, com raras exceções, oriundos do manto sub-continental. Estudos experimentais evidenciam a produção de magma carbonatítico a partir da fusão parcial de um manto peridotítico carbonatado a profundidades de aproximadamente 70km (>25 kbar), com a geração de dolomita carbonatito (Dalton & Wood, 1993).

Carbonatitos calcíticos, por sua vez, são possivelmente produtos de reação metassomática entre os carbonatitos dolomíticos e harzburgitos do manto superior, assim como os carbonatitos sódicos seriam produtos de reação entre o carbonatito dolomítico e lherzolito do manto superior, conforme dados experimentais detalhados por Dalton & Wood (1993) e Wyllie & Lee (1998).

2.3.2. Séries petrogenéticas silicáticas associadas a complexos carbonatíticos

Apesar das evidências experimentais da possibilidade de geração dos carbonatitos a partir do manto, é mais comum a origem desses tipos de rochas em associação com magmatismo silicático, alcalino de alto teor de CO_2. Nesse caso, o magma carbonatítico pode ser gerado por separação de um líquido carbonático imiscível a partir do magma silicático parental, ou como resíduo final da cristalização fracionada de magma silicático. Segundo Woolley & Kjarsgaad (2008), cerca de 75% dos carbonatitos conhecidos estão associados com algum tipo de rocha silicática alcalina, formando complexos alcalino-carbonatíticos.

Considerando a afiliação geoquímica do magma silicático primitivo, rico em CO_2, que dá origem às diferentes associações de rochas, e que por sua vez gera diferentes tipos e estilos de mineralização presentes em complexos carbonatíticos, é importante entender a distinção entre os tipos de magmas silicáticos alcalinos, pois eles se associam aos tipos de carbonatitos, além de influenciarem na evolução petrológica e nos tipos de mineralização encontrados nesses complexos.

Há diversas propostas para interpretar a afinidade geoquímica das rochas silicáticas alcalinas associadas a carbonatitos (e.g. Woolley e Kjarsgaard, 2008). Ribeiro et al. (2014) propõem que as províncias alcalinas que circundam a Bacia do Paraná sejam petrogeneticamente divididas com base na associação de carbonatitos com rochas silicáticas alcalinas de afiliação sódica e potássica, e demonstram as implicações petrológicas e metalogenéticas desta divisão.

Complexos de afiliação sódica são caracterizados pela série ijolítica, derivados de magma nefelinítico, cuja sequência de diferenciação é clinopiroxenito alcalino (jacupiranguito) – melteigito – ijolito – urtito, termos petrográficos sucessivamente mais pobres em clinopiroxênio e mais ricos em nefelina (Figura 2.04), tendo como exemplo o complexo de Jacupiranga.

Em complexos de afiliação potássica as rochas silicáticas originam-se a partir de magmas primários ultrapotássicos, podendo produzir sequências bimodais (membros ultramáficos, como dunitos, clinopiroxenitos e bebedouritos, e félsicos, como sienitos). As rochas silicáticas desses complexos são representadas por cumulados com variações modais de diopsídio, olivina, perovskita, magnetita, apatita e flogopita. (Figura 2.05), definidos genericamente como bebedouritos. Exemplos típicos são complexos da Província Ígnea do Alto Paranaíba (Araxá, Tapira, Salitre, Serra Negra e Catalão).

A série kamafugítica representa o equivalente vulcânico da série bebedourítica (Figura 2.06), e é caracterizada por rochas ricas em olivina e clinopiroxênio e kalsilita, com variações modais dos feldspatóides kalsilita, melilita e leucita (Sahama, 1974).

Magmas kamafugíticos são típicos nas Províncias de Goiás e do Alto Paranaíba. Evidências petrográficas e litogeoquímicas indicam que essas rochas sejam magmas parentais dos complexos alcalino-carbonatíticos dessas províncias (Junqueira-Brod et al., 2002; Brod et al., 2000).

Tanto em complexos de afinidade sódica quanto potássica podem ocorrer rochas plutônicas ricas em apatita, derivadas da cristalização direta a partir de magma fosfático, ou como cumulados ricos em apatita formados a partir de magma carbonatítico ou silicático. Tais rochas são compostas essencialmente por olivina, apatita e magnetita (Figura 2.07) e classificadas genericamente como foscoritos (Krasnova et al., 2004).

Quando os carbonatitos estão associados a rochas exclusivamente félsicas, como sienitos, torna-se mais difícil estabelecer uma distinção entre as linhagens sódica e potássica. A presença de rochas ricas em melilita (melilititos e melilitolitos) também não é distintiva destes dois grandes grupos, podendo ocorrer tanto em complexos sódicos quanto em complexos potássicos.

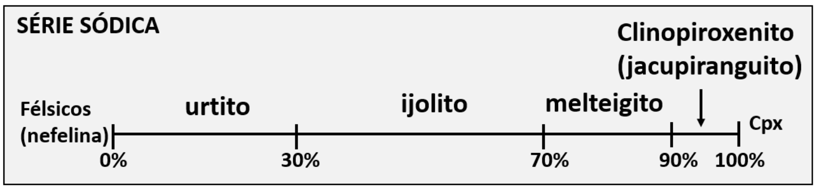

Figura 2.04. Série petrogenética plutônica silicática de composição sódica em complexos alcalino-carbonatíticos (Le Maitre, 2002).

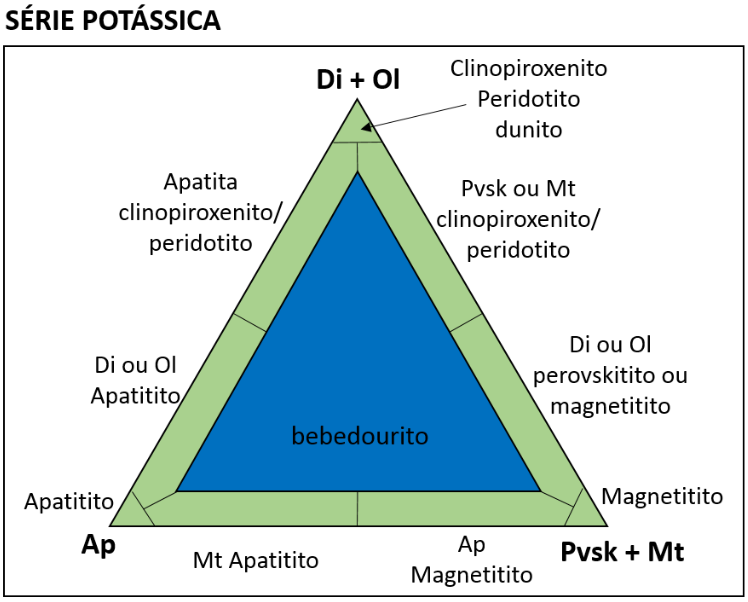

Figura 2.05. Gráficos ilustrando a série petrogenética plutônica silicática de composição potássica em complexos alcalino-carbonatíticos (Brod et al., 2004). Di = diopsidio, Ol = olivina, Ap = apatita, Pvsk = perovskita, Mt = Magnetita.

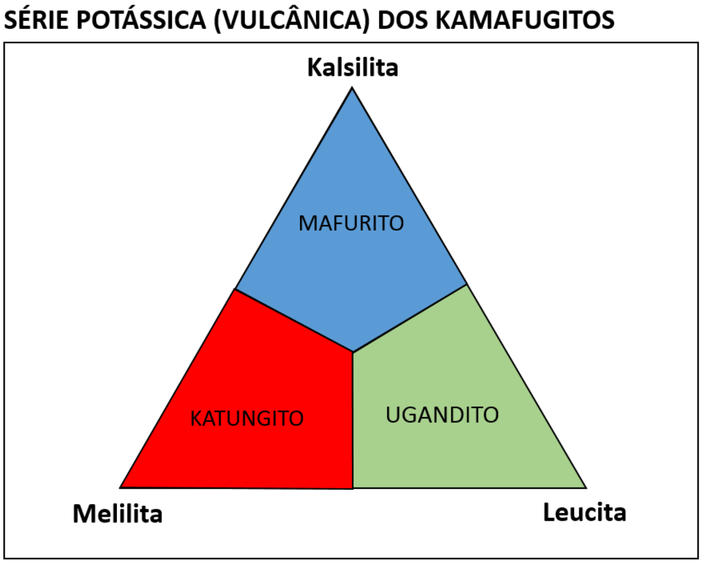

Figura 2.06. Gráfico de Sahama (1974) ilustrando a série petrogenética vulcânica dos kamafugitos.

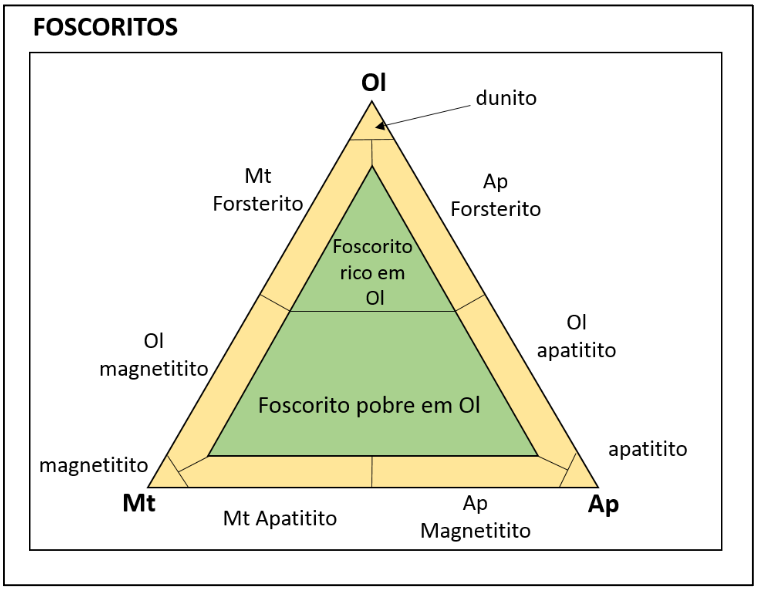

Figura 2.07. Gráfico ilustrando a série petrogenética foscorítica em complexos alcalino-carbonatíticos (Yegorov, 1993). Ol = olivina, Mt = magnetita, Ap = apatita

2.3.3. Geração de complexos carbonatíticos por imiscibilidade de líquidos:

A imiscibilidade de líquidos, reconhecida como um dos processos fundamentais que gera magma carbonatítico a partir de um magma parental insaturado em sílica a profundidades crustais (Le Bas, 1989; Kjarsgaard & Hamilton, 1989; Lee & Wyllie, 1994; Brod, 1999; Comin-Chiaramonti et al., 2007), ocorre quando um magma silicático carbonatado vai se tornando mais enriquecido em carbonato devido à cristalização progressiva de silicatos, óxidos e fosfatos, levando à saturação e separação de um líquido carbonático imiscível.

Em rochas alcalinas, esse processo pode ser evidenciado pela ocorrência de glóbulos (ocelos) ricos em carbonatos numa matriz de composição silicática, ou ainda por inclusões microscópicas de líquidos silicáticos e carbonáticos coexistindo dentro de cristais (Hall, 1996).

A presença de glóbulos de carbonato em diques de kamafugitos no complexo carbonatítico de Morro Preto sugere que um líquido carbonático imiscível possa ter se formado em estágio inicial na sequência de diferenciação desse magma silicato-carbonatado. Essas evidências também apontam para os kamafugitos do complexo como representantes do magma parental do complexo Morro Preto, associação já documentada em complexos carbonatíticos da APIP e da GAP (Brod, 1999; Brod et al., 2000; Brod et al., 2005).

A extensa associação espacial entre carbonatitos e rochas silicáticas alcalinas e texturas como bandamento magmático, segregações de apatita, silicatos e óxidos, sugerem que os líquidos carbonatíticos imiscíveis possam ser originados em magmas que já são, por si, produtos de cristalização fracionada.

Diferenciação, metassomatismo e hidrotermalismo em Complexos Carbonatíticos

Após a formação do magma carbonatítico, a diferenciação deste magma é normalmente caracterizada por múltiplos estágios de cristalização fracionada e desgaseificação, que contribuem, respectivamente, para o enriquecimento e empobrecimento de álcalis. Também são característicos o empobrecimento em magnésio e enriquecimento em ferro nas fases finais de evolução do magma carbonatítico.

A evolução de um complexo carbonatítico é influenciada pela variação da fO_2 durante o resfriamento e ascensão do magma carbonatítico, podendo gerar a sequência progressiva de magnesiocarbonatito, dolomítico, para ferrocarbonatito, enriquecido em ankerita (Woolley, 1989; Gittins, 1989; Le Bas, 1989).

No complexo carbonatítico de Morro Preto, existem evidências petrológicas e texturais da evolução de magnesiocarbonatitos para ferrocarbonatitos a partir de estudos preliminares da série carbonatítica, tópico que será abordado em maior detalhe no Capítulo 4.

O metassomatismo é um processo de alteração e/ou transformação química de uma rocha pela ação de uma fase fluida reativa, que resulta na entrada e/ou saída de componentes químicos da rocha, com modificação de seus minerais. Magmas carbonatíticos possuem quantidades consideráveis de voláteis dissolvidos. A altas pressões, a quantidade de CO_2 e outros constituintes voláteis dissolvida no magma pode ser alta, mas com a ascensão do magma a pressão diminui e os voláteis são exsolvidos (Hall, 1996), reagindo com as rochas encaixantes e provocando alterações metassomáticas, como fenitização.

Alguns autores associam a ocorrência de minerais da série magnesita-siderita em ferrocarbonatitos não somente à diferenciação magmática, mas também a processos de metassomatismo/hidrotermalismo (Buckley & Woolley, 1990) do próprio carbonatito já cristalizado, por eventos tardios.

Nos complexos carbonatíticos da APIP a intrusão de carbonatitos nas rochas silicáticas ultramáficas gerou zonas de reação cuja espessura varia de poucos centímetros a dezenas de metros, nas quais as rochas ultramáficas primárias foram convertidas em flogopititos (Brod, 1999, Brod et al., 2004). O complexo carbonatítico Morro Preto apresenta alterações e fenitizações em escala local, em diversos estágios.

2.4. MINERALOGIA DE COMPLEXOS ALCALINO-CARBONATÍTICOS

Aproximadamente 280 minerais são descritos em complexos carbonatíticos, dentre eles componentes primários e produtos de alteração (Hogarth, 1989). As fases mais abundantes são carbonatos (principalmente calcita, dolomita e ankerita), apatita, magnetita, ilmenita, pirocloro, flogopita, monazita, barita e sulfetos (pirita, pirrotita e calcopirita).

Os carbonatos se caracterizam por calcita com alto teor de Sr, e pela solução sólida dolomita-Fe dolomita-ankerita, além da solução sólida menos comum siderita-magnesita nos ferrocarbonatitos (Buckley & Woolley, 1990). Em carbonatitos vulcânicos não alterados, predominam os carbonatos alcalinos, como a gregoryita e nyerereita.

A apatita é a segunda fase mais abundante em carbonatitos. Muitos substituintes podem ser encontrados em todos os sítios cristaloquímicos da apatita. Geralmente diferentes espécies de apatita são classificadas por substituição aniônica no sítio do flúor: fluorapatita, hidroxiapatita e cloroapatita, sendo mais comum a fluorapatita (Toledo & Pereira, 2001). Sr, Mn e elementos terras raras são substitutos comuns do cálcio. Nas apatitas de carbonatitos, o carbonato é um substituinte comum do ânion fosfato. A monazita também é um fosfato comum encontrado nos carbonatitos do Brasil e pode estar ou não associada a eventos de alteração da apatita.

Produtos de substituição isomórfica podem ser diagnósticos, como a substituição da flogopita por tetra-ferriflogopita, caracterizada pela substituição de Al^{3+} por Fe^{3+} no sítio tetraédrico. A tetra-ferriflogopita apresenta concentrações muito baixas de alumínio, o que a torna muito comum em carbonatitos.

A magnetita, junto com a apatita e a olivina, é um dos primeiros minerais a se precipitar a partir de magma carbonatítico. Caracteriza-se por ser empobrecida em titânio nos estágios primários de diferenciação magmática (Le Bas, 1989).

Pirocloro pode ser um dos principais minerais acessórios em carbonatitos, formando mineralização em complexos carbonatíticos como nos casos de Araxá – MG e Catalão – GO, que respondem por cerca de 85% da produção mundial de Nb. Nestes casos o pirocloro pode formar concentrações de minério em magnesiocarbonatitos e nelsonitos. Pirocloro pode ser ainda concentrado durante o intemperismo, aumentando o potencial para mineralização de Nb.

Monazita, barita e sulfetos são minerais estratégicos devido ao seu potencial econômico, sendo mais comuns nos estágios tardios em complexos carbonatíticos, associados a ferrocarbonatitos, ou a estágios de alteração subsolidus, formando depósitos minerais de monazita (ETR), vermiculita, fluorita e barita.

Silicatos como olivina e clinopiroxênio comumente ocorrem na forma de fenocristais O piroxênio apresenta composição variando de cálcica a sódica. Anfibólios, quando magmáticos, variam de cálcicos a alcalinos, sendo comum anfibólios ricos em sódio (riebeckita – Hogarth, 1989), sendo esse último encontrado em carbonatitos do Complexo Morro Preto.

2.5. MINERALIZAÇÕES ASSOCIADAS A COMPLEXOS CARBONATÍTICOS

Diversos depósitos de fosfato, Nb, REE, Cu, fluorita, vermiculita, barita, urânio, tório, titânio, zircônio e molibdênio estão associados a carbonatitos.

A localização e contexto geológico dos carbonatitos influenciam no potencial econômico desses complexos. A distribuição das ocorrências de carbonatitos, por substância de interesse, está detalhada na Figura 2.08. Outros aspectos importantes a ser considerados são a influência do intemperismo e enriquecimento supergênico dos elementos de interesse nos depósitos minerais em carbonatitos, muito comum em regiões de clima tropical, como o Brasil.

Embora o fósforo esteja presente em numerosos minerais, apenas os da série da apatita constituem minerais de minério para este elemento. As variedades fluorapatita [$Ca_5(PO_4, CO_3,OH)_3.(F,OH)$], a hidroxiapatita [$Ca_5(PO_4)_3.(OH,F)$] e, mais raramente, a cloroapatita [$Ca_5(PO_4)_3.(Cl,OH)$] e a carbonato apatita [$Ca_5(PO_4,CO_3)_3(OH)$] podem ocorrer. A apatita é um mineral quase sempre presente nas rochas carbonatíticas. Em alguns carbonatitos, os minerais da série da apatita contêm a maior parte das terras raras, do F e do Sr (Toledo & Pereira, 2001).

Os carbonatitos já apresentam teores elevados de fósforo, devido à presença da apatita. Este mineral, embora cristalize nas fases precoces dos carbonatitos, pode persistir como mineralização tardia sob a forma de fluorapatitas ou carbonato-fluorapatitas, ricas em ETR e Sr. Monazita é outro fosfato importante e pode ser responsável por jazidas substanciais de ETR em carbonatitos.

O intemperismo dos complexos carbonatíticos, além de concentrar a apatita, pode resultar, se muito intenso, em formação de alumino-fosfatos, ricos em terras raras, sendo os mais comuns os do grupo da plumbogummita: crandalita [$CaAl_3(PO_4)_2(OH)_5.H_2O$], goyazita [$SrAl_3(PO_4)_2(OH)_5.H_2O$], gorceixita [$BaAl_3(PO_4)_2(OH)_5.H_2O$], florencita [$CeAl_3(PO_4)_2(OH)_6$] e plumbogumita [$PbAl_3(PO_4)_2(OH)_5$].

Em adição, o pirocloro, responsável pelas principais reservas mundiais de nióbio, pode ser concentrado em carbonatitos e termos evoluídos da série foscorítica. A barita, comum nas fases tardias de carbonatitos, e o titânio, acumulado após a transformação de perovskita em anatásio por intemperismo ou processos carbo-hidrotermais em rochas ultramáficas, são também importantes constituintes minerais associados aos complexos carbonatíticos ampliando seu potencial metalogenético.

Woolley & Kjarsgaard (2008) compilaram as ocorrências conhecidas de carbonatitos. Os dados fornecidos podem ser agrupados inicialmente de acordo com a ausência (carbonatito puro ou amplamente dominante) ou presença de rochas silicáticas alcalinas associadas (complexos alcalino-carbonatíticos). O segundo tipo pode ser adicionalmente subdividido de acordo com o tipo de rocha alcalina associada ao carbonatito.

A mesma base de dados lista 102 carbonatitos/complexos carbonatíticos mundiais mineralizados, incluindo recursos, minas ativas e minas inativas. A maioria das mineralizações descritas estão contidas em apenas 3 categorias: carbonatitos associados a rochas ultramáficas (24%); a nefelinitos e série ijolítica (35%) e carbonatitos isolados (17%).

Chama a atenção que, dentre carbonatitos associados a rochas ultramáficas com ou sem sienitos, 45% dos corpos listados por Woolley & Kjarsgaard (2008) contêm algum tipo de mineralização, ante 28% na classe dos carbonatitos associados a nefelinitos/ijolitos, 23% nos carbonatitos associados a melilititos-melilitolitos, 17 % nos carbonatitos isolados e 12 % nos carbonatitos associados a rochas félsicas (traquito-sienito + fonolito / sienito). A base de dados não registra mineralizações em carbonatitos associados unicamente a lamprófiros, associados a kimberlitos e associados a basanitos e gabros alcalinos.

Estes dados sugerem que associações entre rochas silicáticas e carbonatitos têm maior potencial para gerar mineralizações do que carbonatitos isolados, e que sistemas magmáticos mais primitivos (ultramáficos) podem ter maior potencial metalogenético (Ribeiro et al., 2014).

O Complexo Morro Preto possui mineralização de apatita associada a magnesiocarbonatitos, fornecendo, em amostragem de solo regional, até 1860 ppm Nb, 22,4% P_2O_5 e 1,19% REE_2O_3 total. As campanhas de sondagem no Complexo Morro Preto, realizadas pela Anglo American Brasil Ltda., interceptaram intervalos mineralizados de até 26m de extensão com teor médio de 20.6% P_2O_5. Parte do escopo do presente projeto inclui não somente entender a petrogênese do complexo, como também relacionar a distribuição das apatitas e o teor médio das diferentes gerações de apatita com o potencial econômico do Complexo.

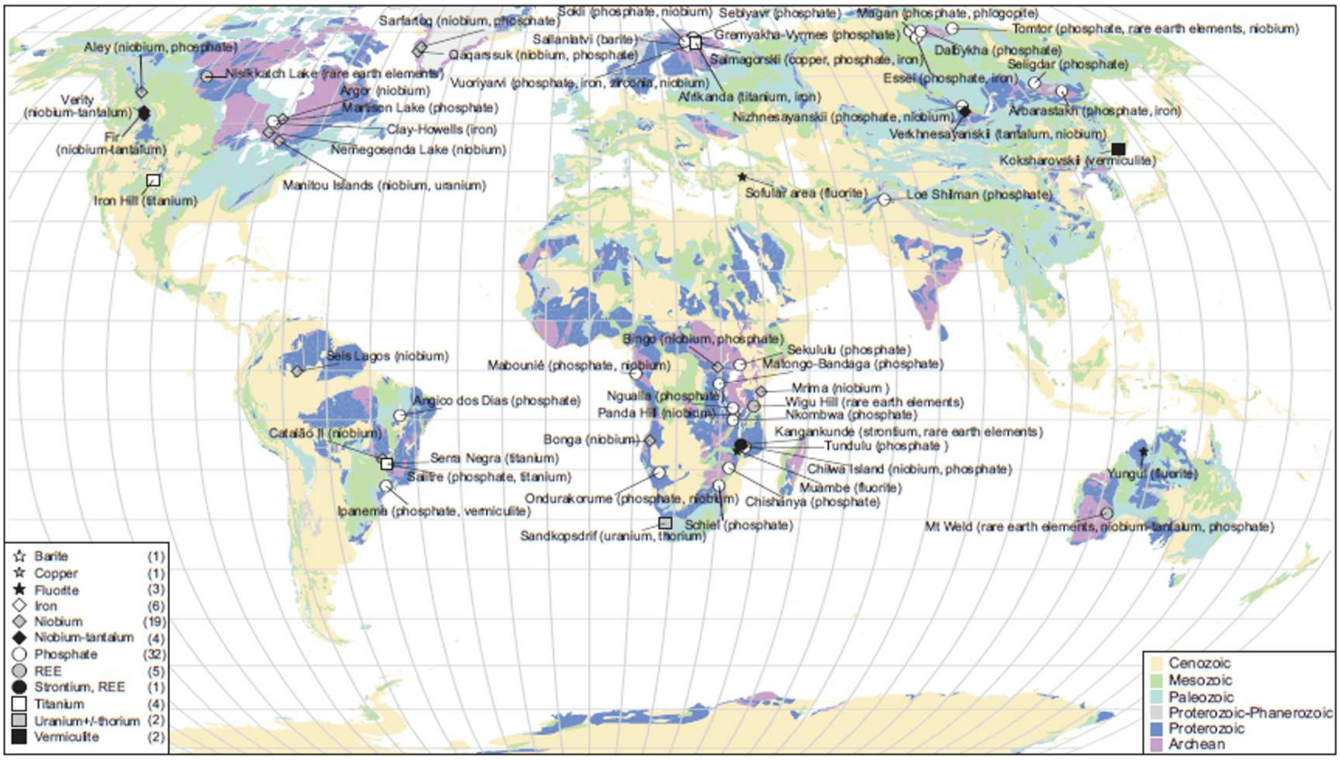

Figura 2.08: localização de carbonatitos, em escala global, que possuem depósitos de interesse econômico, por tipos de *commodities* (Extraído de Woolley & Kjarsgaard, 2008).

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CAPÍTULO 3: MATERIAIS E MÉTODOS

3.1. INTRODUÇÃO

Os principais métodos inclusos nesse trabalho são petrografia, geoquímica de rocha total, química mineral semi-quantitativa, imagens eletrônicas e mapeamento composicional.

As amostras foram selecionadas a partir de critérios texturais e geológicos em descrições de testemunhos furos de sonda do projeto de exploração da Anglo American Brasil Ltda. nas duas intrusões (Morro Preto Norte e Morro Preto Sul) do complexo.

As amostras foram obtidas serrando o testemunho de sondagem em duas metades iguais, mantendo uma duplicata em campo para a necessidade de futura reanálise. Os pedaços de testemunho de sondagem foram então cortados com makita no próprio local de amostragem, respeitando a direção da fábrica mineral.

Foram confeccionadas lâminas delgadas polidas em laboratório comercial externo à Universidade. As amostras analisadas por microssonda/microscopia eletrônica foram selecionadas a partir da análise petrográfica de 115 lâminas.

3.2. GEOQUÍMICA DE ROCHA TOTAL

Um total de 109 amostras de testemunho de sondagem foram selecionadas para análise geoquímica em laboratório comercial. Evitou-se amostras que correspondiam a contatos ou zonas de falha, as quais foram selecionadas somente para análise petrográfica.

As amostras foram preparadas no laboratório de preparação da ACME Brasil (Goiânia, GO) em 2012 seguindo a sequência de:

(i) Secagem da amostra em forno com temperatura < 105 ºC;

(ii) Britagem a 90% da amostra passante a < 6 mm, e após britagem da fração completa a 90% da amostra passante a < 2 mm, limpando os britadores com quartzo a cada amostra;

(iii) Quarteamento de 500g de amostra representativa, mantendo o rejeito da fração britada para qualquer necessidade de repreparação;

(iv) Pulverização da fração quarteada a uma granulometria < 105 µm em panelas de baixo cromo, limpando com quartzo a cada amostra;

(v) Quarteamento de 100g da amostra pulverizada, mantendo o rejeito da pulverização para qualquer necessidade de reanálise;

(vi) Amostragem de duplicatas da britagem e do quarteamento, e inserção de padrões e amostra branca a cada 20 amostras, para o controle de qualidade.

As amostras foram analisadas no laboratório comercial ACME em Vancouver, Canadá, por meio dos seguintes critérios:

(i) Análise dos principais óxidos (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, MnO TiO_2, P_2O_5, Cr_2O_3) por fusão com $LiBO_2$ usando 0,2g de amostra, análise por ICP-ES.

(ii) Amostras fundidas de acordo com a mesma técnica, foram analisadas por ICP-MS para determinação de elementos menores e traços (Ba, Cs, Ga, Hf, Nb, Sn, Sr, Ta, Sc, Th, U, V, W, Y, Zr, La, Ce, Pr, Nd, Sm, Eu, Gd, Tm, Dy, Ho, Er, Tm, Yb, Lu). Digestão via 4 ácidos (HNO_3, $HClO_4$, HF, H_2O) foi utilizada para análise de Ni por ICP-MS.

(iii) Elementos calcófilos e metais preciosos foram analisados via ICP-MS em amostras digeridas por água régia a quente utilizando 30g da polpa.

(iv) A perda ao fogo das amostras foi reportada em porcentagem a partir da calcinação de 1g de amostra. A análise de C e S total foi realizada utilizando forno LECO IR utilizando 0,2g de amostra.

O controle de qualidade das amostras foi realizado respeitando os parâmetros de amostras passantes entre o intervalo de 2 vezes o desvio padrão dos padrões analisados. Os limites de detecção dos métodos supracitados estão detalhados na Tabela 3.01 abaixo. Os resultados analíticos de todas as amostras encontram-se anexados a esse trabalho.

Element / Parameter	Det. Lim. Unit	Element / Parameter	Det. Lim. Unit	Element / Parameter	Det. Lim. Unit	Element / Parameter	Det. Lim. Unit	Element / Parameter	Det. Lim. Unit
SiO_2	0.01 %	Au	0.2 ppb	Hf	0.1 ppm	Re	1 ppb	Zr	0.1 ppm
Al_2O_3	0.01 %	Au	1 ppb	Hg	5 ppb	Sb	0.02 ppm	La	0.1 ppm
Fe_2O_3	0.04 %	Ag	2 ppb	In	0.02 ppm	Sc	0.1 ppm	Ce	0.1 ppm
CaO	0.01 %	As	0.1 ppm	Li*	0.1 ppm	Se	0.1 ppm	Pr	0.02 ppm
MgO	0.01 %	B*	20 ppm	Mn*	1 ppm	Sn	1 ppm	Nd	0.3 ppm
Na_2O	0.01 %	Ba	1 ppm	Mo	0.01 ppm	Sr	0.5 ppm	Sm	0.05 ppm
K_2O	0.01 %	Be*	0.1 ppm	Nb	0.1 ppm	Ta	0.1 ppm	Eu	0.02 ppm
MnO	0.01 %	Bi	0.02 ppm	Ni	10 ppm	Te	0.02 ppm	Gd	0.05 ppm
TiO_2	0.01 %	Cd	0.01 ppm	Ni*	0.1 ppm	Th	0.2 ppm	Tb	0.01 ppm
P_2O_5	0.001 %	Co	0.1 ppm	Pb	0.01 ppm	Tl	0.02 ppm	Dy	0.05 ppm
Cr_2O_3	0.002 %	Cr*	0.5 ppm	Pd*	10 ppb	U	0.1 ppm	Ho	0.02 ppm
LOI	0.1 %	Cs	0.1 ppm	Pd	0.5 ppb	V	8 ppm	Er	0.03 ppm
C	0.01 %	Cu	0.01 ppm	Pt*	2 ppb	W	0.5 ppm	Tm	0.01 ppm
S	0.01 %	Ga	0.5 ppm	Pt	0.2 ppb	Y	0.1 ppm	Yb	0.05 ppm
		Ge*	0.1 ppm	Rb	0.1 ppm	Zn	0.1 ppm	Lu	0.01 ppm

Methods and Specifications

Group		Description
Group 1F-MS		A 30 g subsample is digested in 180 mL of hot (95°C) modified Aqua Regia (1:1:1 $HCl:HNO_3:H_2O$) for 1 hour, cooled and made to 600 mL volume with 5% HCl. Solution is analysed by ICP-MS (Perkin Elmer Elan 6000 or 9000). *Some minerals of these elements may be only partly attacked.
Element	Unit	
Group 3B-MS		A 30g sample split is custom mixed with PbO fire assay fluxes and fired for 45 minutes at 1050°C. Molten Pb + slag is poured into an iron mold, cooled and Pb button recovered. Heating at 950°C in a MgO cupel renders a Ag ± Au, Pt, Pd dore bead. The bead is parted in hot HNO_3, digested by adding HCl and aspirated into a Perkin Elmer Elan 6000 ICP-MS to determine Au, Pt and Pd.
Element	Unit	
Group 4A-4B		A 0.2g sample split is fused at 1000°C with 1.5g of a 80:20 lithium metaborate/tetraborate mix. The cooled bead is digested in 100 mL of 5% HNO_3. ICP-ES analysis determines major element concentrations reported as the common oxides. Loss on Ignition (LOI) is report as % weight loss on a 1g split is ignited at 1000°C. LECO analysis determines total C and S on a 0.2g sample split.
Element	Unit	
Element	Unit	The same whole rock fusion solution is analysed byICP-MS (Perkin Elmer Elan 6000) to determine absolute concentrations of these trace elements.
Group 7TD		A 0.5g sample split is digested in 20 mL of 4-Acid solution ($HNO_3:HClO_4:HF:H_2O$) at 200°C and taken to dryness. Residue is dissolved in 16 mL of 50% HCl at ~95°C for 1 hour then made to volume in a 100 mL volumetric flask with 5% HCl. ICP-ES analysis determines total Ni.
Element	Unit	

Tabela 3.01. Relação dos limites de detecção mínima (L.D.) para os óxidos e elementos analisados, e cores relacionando os tipos de métodos analíticos, conforme especificados acima.

3.3. ANÁLISE EM MICROSSONDA ELETRÔNICA

A composição química de fases minerais de 12 amostras representativas, sendo 8 amostras de carbonatito e 4 amostras de kamafugito, foi determinada quantitativamente por WDS e semi-quantitativa por EDS utilizando a microssonda eletrônica JEOL JXA-8230 do Centro Regional de Desenvolvimento e Inovação (CRTI), na Universidade de Goiás (UFG).

A análise química do material é feita por meio da medida da energia e distribuição da intensidade de Raios-X gerados pela excitação dos elementos presentes, após a incidência do feixe de luz sobre a amostra. No presente trabalho foram utilizados detectores de Raios-X por EDS (Energy Dispersive Spectrometer) e WDS (Wave Dispersive Spectrometer).

Lâminas delgadas polidas de amostras selecionadas foram preparadas por metalização da superfície, utilizando carbono, para permitir condutividade e evitar variação dos efeitos de absorção.

As condições operacionais foram de 15kV de potência e 20nA de corrente, com o tempo analítico variando de 10 a 30 segundos para as análises de WDS, utilizando uma abertura de 1 µm de diâmetro do feixe de luz para as amostras de kamafugito, e de 5 µm para as amostras de carbonatito. As correções de absorção e de variação da matriz foram realizadas utilizando o método do algoritmo ZAF.

A composição dos minerais de kamafugitos foram determinadas de maneira semi-quantitativa por espectrometria de dispersão em energia (EDS). A determinação da composição dos carbonatos e apatitas do complexo Morro Preto foi realizada por espectrometria de dispersão em comprimento de onda (WDS). Nos dois casos, as análises foram realizadas com apoio de imagens de elétrons retroespalhados (BSE – backscattered electrons) e mapas composicionais de composição colorida, para permitir o reconhecimento de diferentes fases e de feições texturais. Mapas composicionais adicionais, não utilizados nos capítulos estruturados em artigos, encontram-se disponíveis em anexo, assim como as tabelas completas das análises em WDS.

Os dados brutos de química mineral são reportados em percentagem em peso (wt. %) de óxidos e as fórmulas estruturais são recalculadas com base na quantidade adequada de átomos de oxigênio (ou F, Cl, OH) para cada mineral. Os carbonatos foram recalculados com base em 6 oxigênios, a apatita com base em 25 oxigênios, o clinopiroxênio com base em 6 oxigênios e a olivina com base em 4 oxigênios.

CAPÍTULO 4

GEOLOGY, MINERALOGY AND LITHOGEOCHEMISTRY OF THE MORRO PRETO ALKALINE-CARBONATITIC COMPLEX, GOIÁS, BRAZIL

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ABSTRACT

The Morro Preto Alkaline-Carbonatite Complex is located in the northern portion of the Goias Alkaline Province (GAP) and is unique in the region due to the large predominance of carbonatites over other alkaline rocks. It comprises two circular intrusions (Morro Preto North and Morro Preto South) of magnetite apatite magnesiocarbonatites, which host phosphate mineralization, and gradually differentiate to barium-rich ferrocarbonatites, some containing carbonates of the magnesite-siderite series.

Kamafugite dykes crosscut the carbonatites. Minor occurrences of alkaline basalt are present in the area, but their relation to the carbonatite complex is unclear. Both carbonatite intrusions fenitized the Precambrian host rocks.

The magnetite apatite magnesiocarbonatites vary in texture and modal composition from magnetite-apatite cumulates (pseudophoscorites) to magnesiocarbonatites with only small amounts of magnetite and apatite. In the Ba-rich ferrocarbonatites, apatite is rare or absent, and the dominant carbonate varies from Fe-dolomite to ankerite. Carbonates of the magnesite-siderite series and traces of monazite and REE-carbonates are also present in the most evolved rocks.

SiO_2, Fe_2O_3, MnO, BaO:SrO and ΣREE increase from the magnesiocarbonatites to ferrocarbonatites, whereas the CaO, MgO and P_2O_5 contents decrease.

Kamafugites represent the most primitive rock type in the Morro Preto complex. They have a compositional range similar to the GAP mafurites and ugandites, indicating their relatively evolved position in the kamafugitic series, and distinguishing them from the regional MgO-rich alkaline picrites.. Carbonate globules (ocelli) in these rocks corroborate the silicate-carbonate liquid immiscibility hypothesis.

Geological, geochemical and mineral chemistry data are consistent with the evolution of the Morro Preto Complex by crystal fractionation, liquid immiscibility, metasomatic overprinting and late hydrothermal events. The Morro Preto Complex is an exception in northern GAP, since it is largely dominated by carbonatite.

Keywords: *Goiás Alkaline Province, carbonatite, kamafugite, phosphate mineralization.*

4.1. INTRODUCTION

The magmatism occurring in the northern part of the Late-Cretaceous Goiás Alkaline Province (GAP), central Brazil, comprises a series of alkaline ultramafic plutonic complexes, a small proportion of which contains carbonatite intrusions. The southern portion of the Province is dominated by poorly preserved ultrapotassic lavas and pyroclastic deposits, also locally containing carbonatites. The central portion of the Province is characterized by kamafugitic diatremes (Junqueira-Brod et al., 2004; Junqueira-Brod et al., 2004; Brod et al., 2005).

The plutonic complexes often display an oval to circular shape. When present, carbonatites tend to lie in the center of the intrusion or may be distributed as an external brecciated halo. The Morro Preto Carbonatitic Complex, 40 km to the north of the city of Piranhas, Goiás State, is exceptional in this context, in the sense that it contains abundant carbonatite intrusions.

Initial studies in the Morro Preto Complex, surveyed by the Brazilian Geological Survey (CPRM) in the 1980's, indicated substantial anomalies of phosphorous and barium in stream sediments, elements typically found in alkaline intrusions. The Iporá Airborne Geophysics Survey, also conducted by CPRM, confirmed alkaline-type magnetic and radiometric signatures for two separate intrusions in the area (Pereira et al., 1980; Justo, 1997).

Exploration work by Anglo American Brasil Ltda. from 2011 to 2015 detected anomalous phosphate in surface sampling and drill cores. The results indicated the continuity and the variability of apatite-carbonatites in the weathered profile, in the fresh magmatic rocks and in hydrothermal alteration zones.

We present geological, petrographic, mineralogical and geochemical data on the Morro Preto Complex, with an aim to investigate its origin and evolution.

4.2. THE GOIAS ALKALINE PROVINCE (GAP)

The Goiás Alkaline Province (GAP, Junqueira-Brod et al., 2002, Gaspar et al., 2003) is located along a regional NW-SE lineament at the northern border of the Phanerozoic Paraná Basin, at the limit between that Basin and the Precambrian Brasilia Fold Belt. Most alkaline rock occurrences are scattered along a N30°W lineament, but the entire region was also affected by the Cretaceous reactivation of a NE-trending Transbrasiliano lineament (Shobbenhaus Filho et al., 1975; Dutra et al., 2011).

Together with the Alto Paranaíba Igneous Province (APIP, Gibson et al. 1995), further to the Southeast, the GAP is one of the largest areas of kamafugite occurrence in the world (Junqueira-Brod et al., 2004; Junqueira-Brod et al., 2005). Although both the APIP and the GAP are typically ultrapotassic, they may show differences in the geochemical properties of their magmas, which result in different geological associations. Particularly noteworthy is the presence, in northern GAP, of mafic to intermediate plagioclase-bearing alkaline rocks, unknown in the APIP (Brod et al, 2005).

The GAP rocks have ages between 80 and 90 Ma (Gibson et al. 1995b, 1997), a slightly narrower range than previously assumed (75-90 Ma, Danni, 1978). The alkaline magmas intrude Neoproterozoic rocks of the Goiás Magmatic Arc and Phanerozoic sedimentary rocks of the Paraná Basin (Fig. 4.01), causing fenitization of the country rocks and contact brecciation.

Several researchers interpret the alkaline magmatism of this province, as well as that of other alkaline provinces surrounding the Paraná Basin, as a direct product of mantle plume activity. Early- and Late-Cretaceous alkaline provinces have been attributed respectively to the Tristão da Cunha and to the Trindade Plume systems (Comin-Chiaramonti et al., 2007; Danni, 1994; Gibson et al., 1995; Gibson et al, 1997; Van Decar et al., 1995).

According to Danni & Gaspar (1994), Junqueira-Brod et al. (2005) and Brod et al. (2005) the plutonic alkaline complexes are typical of the northern portion of GAP, whereas sub-volcanic to volcanic rocks dominate the central and southern portions of the Province. The intrusive rock types are mainly dunite, peridotite, pyroxenite, gabbro, nepheline syenite, carbonatite, and lamprophyres (Danni, 1994). The volcanic units comprise breccia or flows of leucitite, olivine leucitite, melaphelinite, nephelinite, alkali basalt, basanite, tefrite, lamprophyres, and trachyte. Kamafugites are an important rock type in the lavas and pyroclastic units, as well as in diatremes (Danni & Gaspar, 1994; Junqueira-Brod et al., 2005).

The weathering profiles developed on the GAP mafic-ultramafic alkaline complexes are known prospects for lateritic nickel. Nickel resources are reported from the Santa Fé, Morro do Engenho, Morro do Macaco, Água Branca and Montes Claros de Goiás complexes (Melfi et al., 1988; Ribeiro et al., 2014). These complexes share features like central dunites surrounded by more differentiated rocks. Ni mineralization is contained in the ferruginous saprolite and in the siliceous saprolite zones of the weathered profile (Oliveira, 1990).

Regional geophysics interpretation in the GAP by Moura (2007) identified carbonatite and syenite intrusive bodies, including the two intrusive bodies from the Morro Preto Complex by associating gammaspectrometric and highly magnetic signatures. Navarro et al. (2014) first provided detailed mineralogical and geochemical information on the Morro Preto South Intrusion. They describe the complex as variably weathered carbonatite and lamprophyre, as well as syenite and ferruginous alkaline basalt.

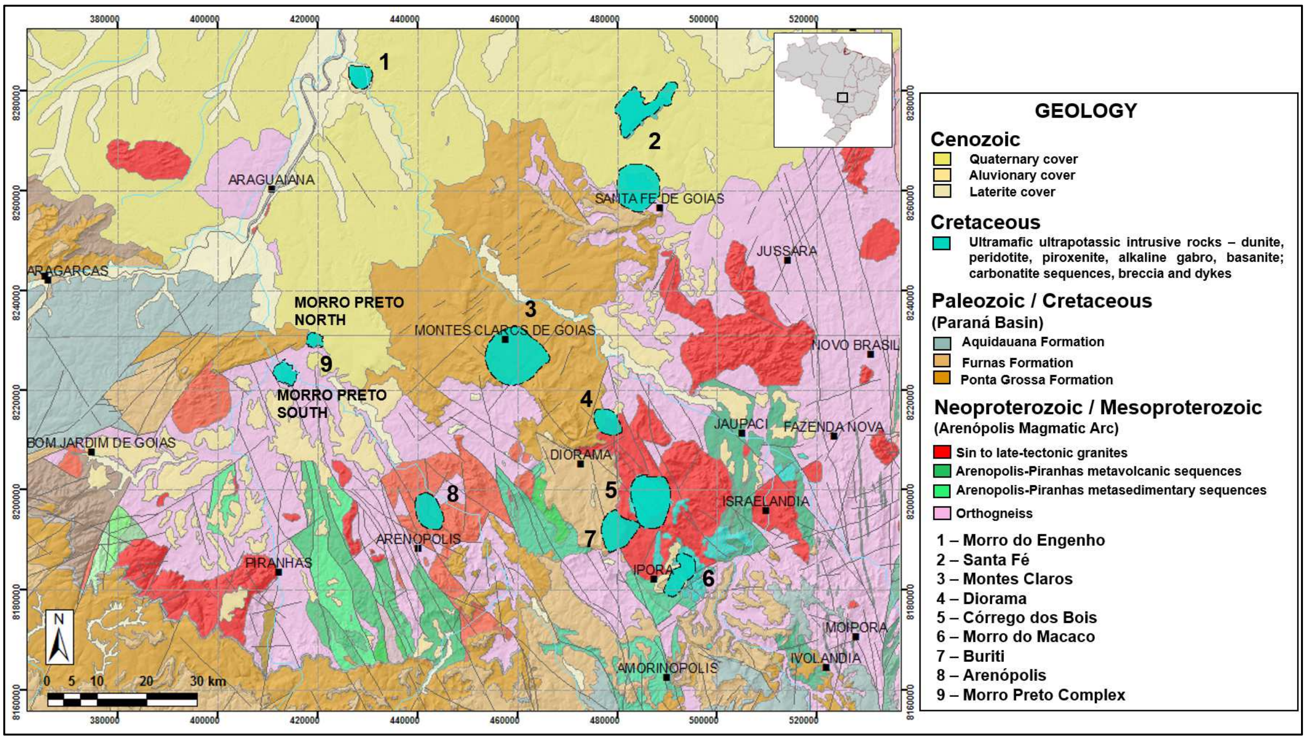

Fig. 4.01. Northern portion of the Goiás Alkaline Province (GAP). The main alkaline intrusions are highlighted with a dashed line contact defined by magnetic anomalies (*Modified from* Lacerda Filho et al., 2000).

4.3. METHODS

The rocks used for the petrographic, geochemical and mineral chemistry analyses were drill core samples from Anglo American Brazil Ltda – Brazil Exploration Office. The cores of 11 out of a group of 18 drill holes were sampled for whole-rock geochemistry. Petrographic analysis was carried out on a total of 115 polished thin sections, using transmitted and reflected polarized light.

A total of 109 drill core samples were analyzed for whole-rock major oxides and trace elements. Sample preparation was carried out in the Acme preparation facility at Goiânia, Brazil. Chemical analyses were conducted by Acme Labs at Vancouver, Canada, on samples fused at 1000°C using a mix of 0.2g of sample with 1.5g of 80:20 lithium metaborate:tetraborate. Major element oxides (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, MnO TiO_2, P_2O_5, Cr_2O_3) were determined by ICP-AES analysis. Trace elements (Ba, Cs, Ga, Hf, Nb, Sn, Sr, Ta, Sc, Th, U, V, W, Y, Zr, and the rare earths) were determined by ICP-MS analysis. Chalcophile elements and precious metals (Au, Ag, As, B, Be, Bi, Cd, Co, Cr, Cu, Ge, Hg, Ir, Li, Mn, Mo, Ni, Pb, Pd, Pt, Rb, Re, Sb, Se, Te, Tl, Zn) were digested in aqua regia using a 30g pulp, following by ICP-MS analysis. Loss on Ignition (LOI) is reported as a percentage of weight loss on a 1g sample split, ignited at 1000°C. Total carbon and sulfur were determined with LECO IR furnaces on a 0.2g sample split.

Twelve carbon-coated thin sections were analyzed by wavelength-dispersive X-Ray spectroscopy (WDS) and energy-dispersive X-ray spectroscopy (EDS) using a JEOL JXA-8230 electron probe microanalyzer (EPMA) at the Regional Center for Technological Development and Innovation (CRTI), Goiás University (UFG). Operating conditions were 15kV and 20nA.

4.4 MORRO PRETO CARBONATITE COMPLEX

The Morro Preto Complex comprises two well-defined sub-circular intrusive systems, 5km away from one another. They are located at the confluence between the Caiapó and Piranhas Rivers, approximately 38 km north from the Piranhas City. Fig. 4.02 shows the map distribution of carbonatites in both intrusions.

The southern intrusion (Morro Preto South) is 3km in surface diameter and crops out over 100m in height. The Morro Preto North intrusion is approximately 1.5km in diameter per 50m outcropping height. Both intrusions have ring-like characteristics, positive topography, and are hosted in Neoproterozoic orthogneiss and metavolcanic rocks (Arenópolis Magmatic Arc) plus anorogenic granites (Pimentel et al., 1997).

The northwestern portion of Morro Preto is in contact with the Devonian sandstones of the Furnas Formation, in agreement with the intrusion models of Junqueira-Brod et al. (2005). The deep weathering in the region resulted in a thick saprolite / soil layer on both intrusions.

4.4.1. Morro Preto North

Morro Preto North has a central intrusion ranging from magnesiocarbonatite to barium-rich ferrocarbonatite, with subordinate occurrences of magnetite apatite magnesiocarbonatite. The carbonatite intrusions are rarely cumulates of apatite and magnetite, usually brecciated and crosscut by dykes of kamafugite, alkali basalt and felsic lamprophyre. Bebedourite, a common rock-type in kamafugite-carbonatite complexes (e.g. Brod et al., 2000; Barbosa et al., 2012) occurs only as a xenolith in one of the studied kamafugite thin sections (Nascimento et al., 2018, in preparation), but this may be a very significant link with a possible bebedouritic complex at depth.

The apatite magnesiocarbonatites host phosphate mineralization. The soil survey showed anomalous areas (0.5 x 0.2 km) with 2 to 5.9 wt.% P_2O_5, and the phosphate grade in drill cores reached up to 7.19 wt.%.

Mafic to intermediate basement rocks, such as granodioritic gneisses and amphibolite/metagabbro, are the most common country-rock in the complex. Near the contact with carbonatites they are converted in felsic and mafic fenites, and sometimes occur as xenolith fragments in carbonatite breccia.

The regolith profile dominates Morro Preto North, with rare altered rounded outcrops in the central and topographically high portions of the area, comprising silicified ferruginous carbonatites with incipient banding. The regolith profile is divided from base to top in a clayish saprolite varying from a whitish-cream to reddish and brownish saprolite, depending on the apatite and/or iron content, respectively. The upper regolith profile is characterized by a silicified material (silexite) composed of goethite, with variable amounts of hematite, and fine-grained quartz filling part of the cavities.

The soil geochemistry and ground geophysics survey over Morro Preto North suggest it is a concentric body with the center dominated by carbonatite and an outer aureole of fenitized mafic-ultramafic rocks, although the latter does not crop out.

4.4.2. Morro Preto South

In the Morro Preto South, concentric carbonatites forma broad central portion, commonly covered by silexite. The carbonatite domain comprises cumulate-textured magnetite apatite magnesiocarbonatites, which are more common in the drill cores from the northwest and south-central portions of the intrusion, and grade to cryptocrystalline apatite Fe-dolomite magnesiocarbonatite, more brecciated and more common in the drill cores from the north-central portion and southwest area. To the east/southeast of this carbonatite domain there is a topographic high dominated by ankerite ferrocarbonatite containing minor siderite.

The entire carbonatite sequence is crosscut by kamafugite dykes. These dykes contain preserved magmatic features such as phenocrysts oriented by magmatic flow. Rare differentiated terms show an increase in groundmass carbonate.

The phosphate mineralization from the southern intrusion is defined by an area of 1.5 x 1km with phosphate values ranging from 5 to 22.5 wt.% P_2O_5 in soil. Drill core samples reached up to 22.36 wt.% P_2O_5 in a meter interval, and intercepts with up to 48m @ 11.4% P_2O_5 (Fig. 4.02).

Felsic and ultramafic fenites crop out in the external portion of Morro Preto South, where basement amphibolites and granodioritic to granitic gneisses, are converted into carbonatitic breccias or occur as carbonated xenoliths and xenocrysts inside the carbonatites. Even the earlier-formed carbonatites are locally fenitized by late carbonatite intrusions or fluids, locally resulting in scattered K-feldspar or K-feldspar veins, similarly to other carbonatite complexes (Le Bas, 1981; Pirajno et al., 2014).

The average soil thickness is 10 meters, but the silexite and saprolite layers may be tens of meters thick each. The silexite contains goethite and minor hematite, with fine-grained quartz filling interstices and part of the cavities. A thick reddish colluvial soil covers the topographic low on the northwestern portion. Navarro et al. (2014) describe the altered portion of Morro Preto South as saprolitic rocks filled with quartz and/or chalcedony, apatite and crandallite, and in minor proportion, carbonate, anatase and barite. It is possible to observe incipient layering, characterized by white bands grading to pinkish bands.

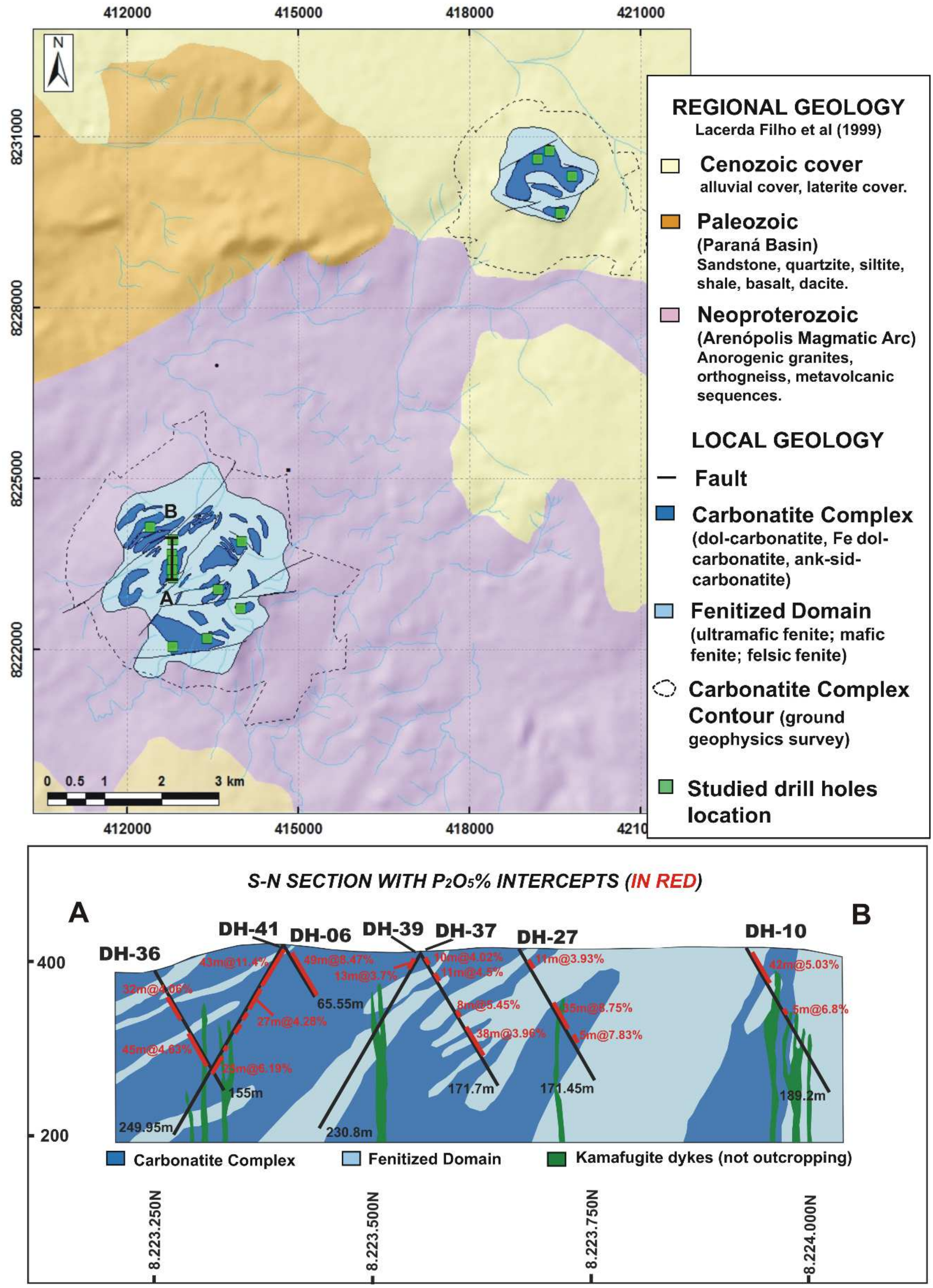

Figure 4.02. Morro Preto Complex simplified Geological Map and S-N section with P_2O_5% intercepts.

4.5. PETROGRAPHY

4.5.1. Carbonatites

The carbonatite series represents the majority of the alkaline lithotypes in outcrop and drill core intersections. Both Morro Preto South and North contain the same carbonatite sequence, organized into three main groups according to modal composition, petrographic characteristics and geochemical association (Table 4.01).

Magnetite apatite magnesiocarbonatite

The first group consists of banded (Fig. 4.03A) magnetite apatite magnesiocarbonatite, where magnetite-apatite cumulates often show dynamic textures such as magma flow (Fig. 3B), brecciated zones and xenoliths. Some specimens or intercepts may lack banding, showing a more isotropic aspect (Fig. 4.03C). In some cases, particularly in Morro Preto South, magmatic banding may produce end-member compositions, such as apatite-magnetite-rich cumulates (pseudonelsonite – Fig. 4.03D) and magnetitite. Boxwork texture (Fig. 4.03C) and xenoliths of earlier-stage carbonatites (Fig. 4.04D) are common and appear to be restricted to specific zones.

The rocks of this group vary widely in modal composition, consisting mainly of dolomite (up to 90%), Fe-dolomite (10 to 70%), apatite (2 to 45%) and magnetite (8 to 40%), with accessory amounts of barite (up to 2% of primary poikilitic barite), phlogopite, baddeleyite, zircon and pyrochlore. K-feldspar occur mainly as late veins crosscuting the magnesiocarbonatites (Figure 4E).

The carbonate bands comprise coarse-grained (0.1 to 1 mm), euhedral to anhedral carbonate, occurring as bands of coarse-grained clear dolomite (Fig. 4.04A), with or without coarse-grained apatite, and as fine-grained bands of microinclusion-rich (Fig. 4.04B and 4.04C) gererally associated with fine-grained to cryptocrystalline apatite (collophane).

Apatite also shows important grain size variations (Fig. 4.04A to 4.04C), grading from subhedral and coarse-grained (50 to 500 µm), to cryptocrystalline. Orientation of subhedral apatite aggregates by magma flow is common. In some samples, subhedral apatite contans fibrous inclusions parallel to the “c” axis. The dominant apatite type in the northern intrusion is collophane, with very rare occurrences of the coarse-grained variety of apatite.

The iron oxide / hydroxide minerals normally form a heterogeneous mass with apatite and carbonates, and, when subhedral, vary from 10 to 200 µm. They become modally important in pseudonelsonite and magnetitite cumulates (Fig. 4.04F), forming subhedral to euhedral magnetite aggregates, partially or totally altered to goethite, the latter reaching up to 10% in thin section. Some of the magnetite contain apatite inclusions.

Ba-rich ferrocarbonatite

The second carbonatite group (Fig. 4.03E) is a barium-rich ferrocarbonatite, composed mostly of medium to coarse-grained, equigranular Fe-dolomite (10 to 60%) and ankerite (10 to 40%). Xenoliths of both earlier carbonatite and basement rocks may occur. This group is enriched in secondary barite and poorer in magnetite cumulates than the previously described carbonatites. Monazite is rare. Apatite is rare or absent. Pyrrhotite and ilmenite occur as trace minerals.

Part of the iron and barium content in these rocks was originally contained in carbonates. Fe-dolomite grains appear in “clearer” carbonate bands, with grain size from 0.1 to 0.3 mm. Upon weathering secondary barite and euhedral Mn-rich siderite (10 to 20%) appear in or at the edges of dissolution cavities. Ferruginous alteration is common over the layers where ankerite and minor siderite predominate. Iron oxide/hydroxide (8 to 30 modal %) either replaces the Fe-rich carbonates (Fig. 4.04I), or is replaced by goethite, and rarely occurs as grain cumulates.

Late-stage Ba-rich ferrocarbonatite

The third carbonatite group represents the late-stage evolution of the barium-rich ankerite ferrocarbonatite. These rocks are porphyritic, with ankerite, siderite and lesser amounts of Fe-dolomite, poikilitic barite, and traces of apatite and magnetite (Fig. 4.03F). They are even richer in barium, thorium and rare earth element (REE) minerals than those of the second group (Fig. 4.04I). Sulfides, monazite and bastnaesite are common accessory phases.

All the carbonatite sequences were affected by variable degrees of silicification during weathering, invariably followed by precipitation of secondary barite and, in some cases, of secondary calcite, siderite, apatite and monazite. Silicification may occur in interstices of other minerals or as infilling in dissolution cavities, and is characterized by fine-grained quartz, that can reach up to 25 modal %. In extreme weathering conditions this can evolve to an entirely silicified rock with only a few carbonate remains. Dissolution cavities in the ferrocarbonatites have some proportion of goethite and rare calcite recrystallization at the edges, in addition to the secondary quartz and barite. Table 4.01 summarizes the modal composition for the main lithotypes of the Morro Preto carbonatite series.

LITHOTYPE	MODAL COMPOSITION (%)						
	Apatite	dolomite	Fe-dolomite	Ankerite	Magnesite-Siderite series	Iron oxide/ hydroxide	barite
Ap Mg CBT CUMULATES							
Ba Ank Mg CBT							
Late Ba Ank Mg CBT							
	20 50 80	20 50 80	20 50 80	20 50 80	20 50 80	20 50 80	20 50 80

Table 4.01. Modal composition ranges (%) for the carbonatites. The crosses represent the average content of each mineral.

4.5.2. Silicate Rocks

Dykes of alkaline silicate rocks occur in both Morro Preto South and Morro Preto North intrusions. They comprise kamafugites, with rare felsic dykes and alkali basalts.

Kamafugites

Kamafugite dykes crosscut both the country-rock and the carbonatites. They contain phenocrysts of olivine and clinopyroxene, set in a groundmass composed of clinopyroxene, leucite/kalsilite, apatite, phlogopite, magnetite, carbonate and minor perovskite and nepheline. Most sampled kamafugites are mafurites, some ugandites occur locally, and katungites were not found.

The kamafugites may contain 5% to 20% of carbonate immiscible globules, up to 1mm in size (Fig. 4.05A and 4.05B), composed of aggregates of micro to cryptocrystalline carbonate, suggesting an immiscibility link between silicate and carbonatite magma.

The least-differentiated kamafugite dykes are characterized by phenocrysts of olivine (Fig. 4.05B) and minor (up to 5% of the total phenocrysts) clinopyroxene set in a cryptocrystalline to microcrystalline groundmass, composed of serpentinized olivine, clinopyroxene, phlogopite, magnetite and carbonates. Clinopyroxene also occurs as glomeroporphyritic aggregates of microphenocrysts. Magnetite locally contains chromite inclusions. Olivine and clinopyroxene are variably altered to serpentine, phlogopite, and chlorite.

These kamafugite magmas evolve through an increase in the amount of clinopyroxene phenocrysts, which are often zoned and may be oriented by magmatic flow. The groundmass contains the same minerals as in the earlier kamafugites, but may become richer in carbonate.

More evolved kamafugites were intercepted in drill cores from Morro Preto South. They lack olivine, and contain both clinopyroxene and apatite phenocrysts, the latter with carbonate melt inclusions, consistent with the coexistence of immiscible carbonate and silicate liquids. The most evolved members of the kamafugite series are ugandites containing leucite phenocrysts, sampled from Morro Preto North. They host xenoliths of clinopyroxene + perovskite + phlogopite cumulates, which are petrographically very similar to the bebedourites that characterize the kamafugite-carbonatite association in the nearby Alto Paranaíba Igneous Province (Brod et al., 2000).

Alkaline basalts

Mafic silicate rocks occurring in the Morro Preto Complex comprise rare rocks of basaltic composition (Morro Preto South), characterized by zoned plagioclase and a carbonatized groundmass rich in Fe-dolomite. These rocks have variable amounts of vesicles filled with Mg-rich siderite, Fe-rich magnesite and beidellite.

Felsic alkaline rocks

A felsic, globular rock (Fig. 4.05C) intercepted in drill core, is composed of rounded, millimeter- to centimeter-sized domains of reddish brown color set in a greenish groundmass. The brown "halos" consist of radial aggregates of K-feldspar microphenocrysts in an aphanitic groundmass. The dominant, greenish matrix contains traces of tetra-ferriphlogopite, rutile, and altered amphibole (riebeckite) in a Fe-dolomite- and beidellite- rich groundmass. These domains are intensely altered, their different compositions and their textural relationships suggest the coexistence of compositionally different liquids from which they crystallized.

A dyke of altered felsic (leucitite?) rock was intercepted in Morro Preto North. This rock contains leucite megacrysts and olivine phenocrysts, the latter altered to talc and serpentine. The groundmass is composed of K-feldspar, olivine, dolomite and traces of rutile and pyrite.

4.5.3. Fenites

The drill cores from both Morro Preto bodies intercepted fenites of ultramafic to felsic composition, produced by carbonatite metasomatism, at the contacts with the basement country rocks (Figs. 4.05D to 4.05F). In Morro Preto South, the original country rocks such as amphibolite, diorite, granodiorite and felsic mylonites developed carbonated zones grading, closer to the contact, to carbonatite breccia with some partly preserved xenoliths from the host-rock.

Ultramafic to mafic fenites derive from basement metagabbro and amphibolite. They are locally characterized by the development of chlorite and carbonate monomineralic bands with plagioclase and hornblende relicts.

The felsic fenites are characterized by an argillic alteration replacing the original fabric, with rare plagioclase and K-feldspar relicts. Carbonate and barite veins crosscut the fenites and are usually associated with an alteration halo enriched in amphibole, epidote and phyllosilicates.

4.5.4. Silexites

A thick silexite layer characterizes the Morro Preto Complex weathering profile. The silexite consists of iron oxide and hydroxide minerals, mostly goethite, surrounded by fine-grained quartz. Cavities are common, suggesting its derivation, at least partially, from the dissolution of carbonatite.

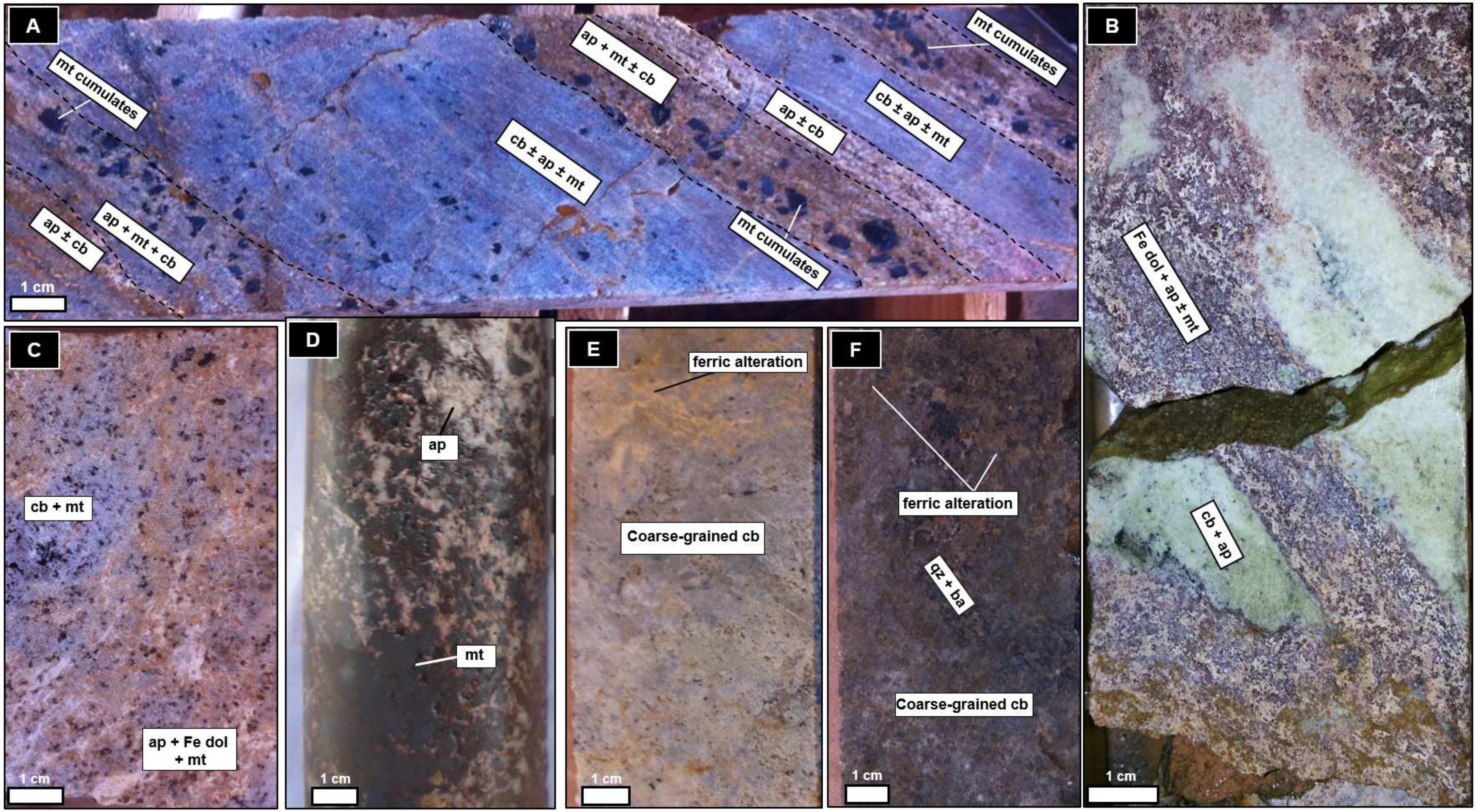

Fig. 4.03: Drill core intercepts of carbonatite from the Morro Preto Complex. (A) apatite magnetite magnesiocarbonatite cumulate, showing millimeter- to centimeter-thick magmatic layering of alternating apatite dolomite carbonatite and magnetite Fe-dolomite carbonatite. (B) magmatic layering in the apatite dolomite carbonatite disturbed by magmatic flow. (C): non-banded apatite magnetite magnesiocarbonatite. The brownish zones represent ferruginous alteration with boxwork fabric. (D): apatite- and magnetite-rich cumulate (pseudonelsonite). (E): silicified ferrocarbonatite. (F): Late-stage barium-rich ferrocarbonatite (ap = apatite; ba = barite; cb = carbonate; Fe dol = iron-rich dolomite; mt = magnetite; qz=quartz; sid = siderite).

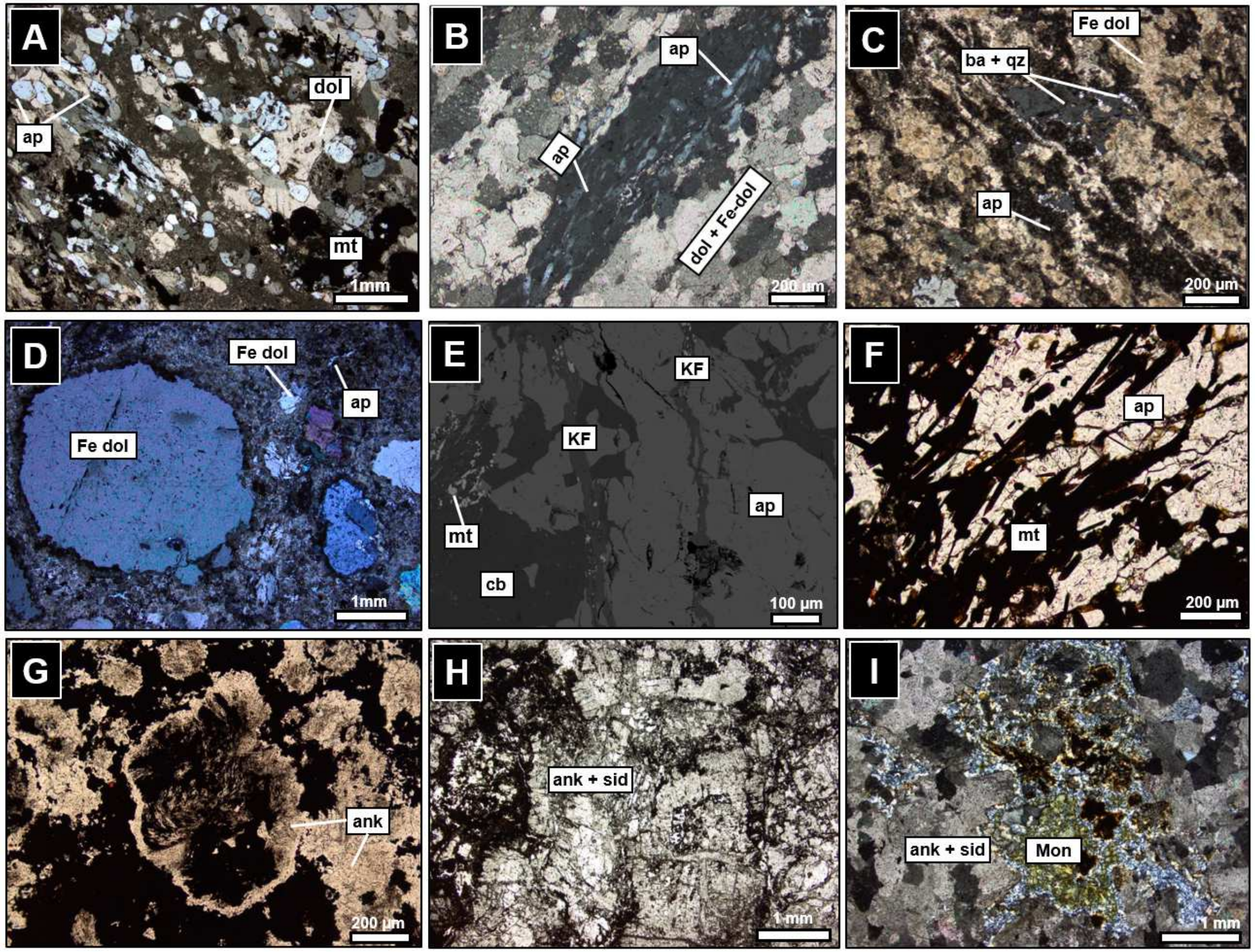

Fig. 4.04: (A to C) Photomicrographs of magnetite apatite magnesiocarbonatite cumulate, altering from dolomite-rich and subhedral apatite, to magnesiocarbonatite with Fe-dolomite and cryptocrystalline apatite or collophane. (D) Apatite magnesiocarbonatite with Fe-dolomite xenocrysts whose rounded irregular shapes indicate resorption by the carbonatitic magma. (E) Microprobe image of K-feldspar veins crosscutting apatite and dolomite in magnesiocarbonatite. (F) Oriented magnetite and apatite bands from a “pseudonelsonite”. (G) Ankerite in ferrocarbonatite being replaced by iron oxide/hydroxide. (H) Late-stage barium-rich ferrocarbonatite, with ankerite partly replaced by siderite. (I) Dissolution cavity with monazite, galena and quartz (ank= ankerite; goet= goethite; kf= k-feldspar; mon= monazite; other mineral abbreviations as in Fig. 3).

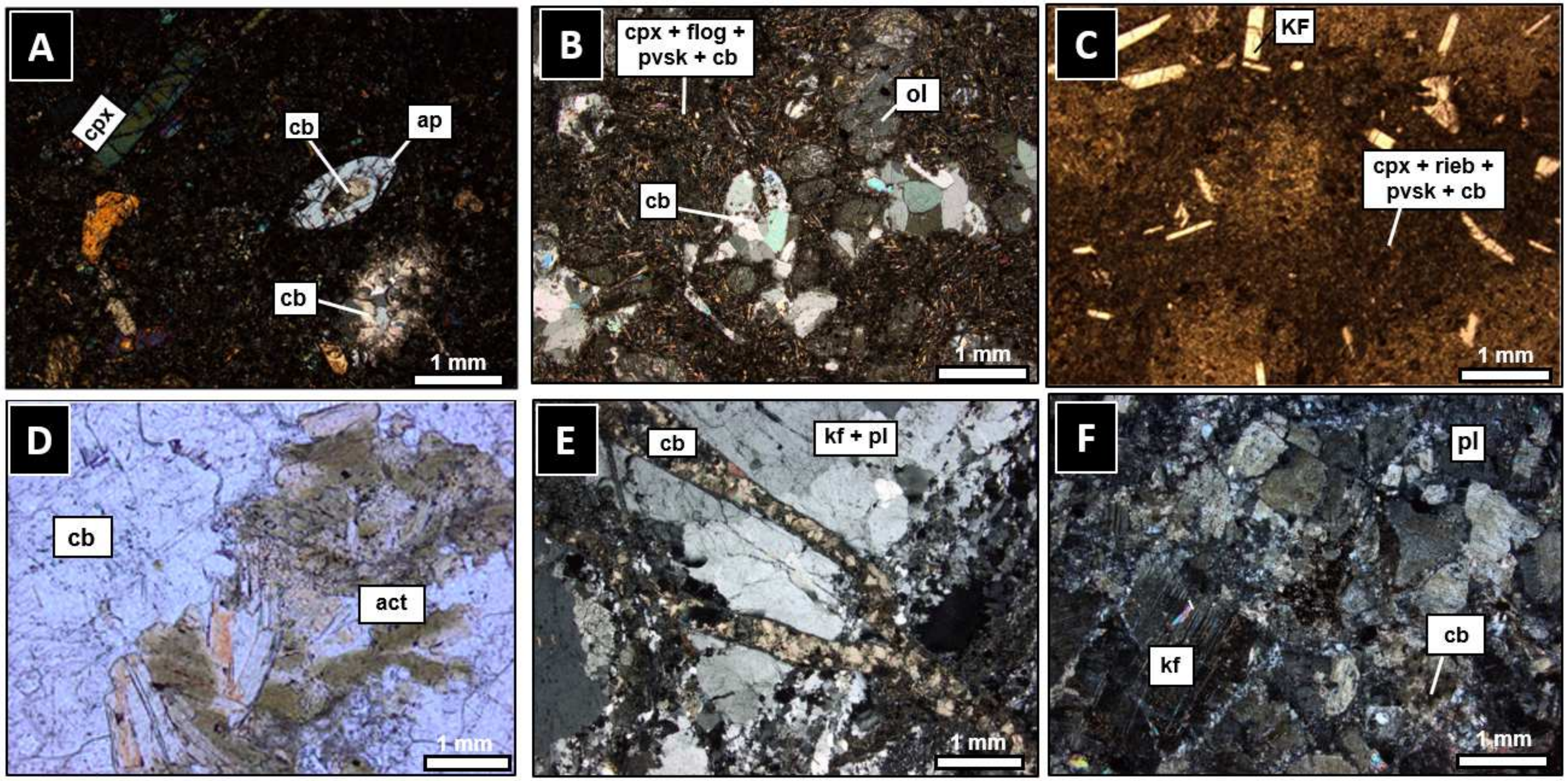

Fig. 4.05. (A) and (B): photomicrographs of carbonate globules and carbonate inclusion in apatite from kamafugites. (C) Felsic dyke with K-feldspar microphenocrysts in a brownish groundmass surrounding lighter-colored patches rich in carbonate. (D) Amphibolite xenolith in carbonatite. (E) and (F) distal fenitization of the host rocks, with carbonatization and brecciation. (amp= amphibole (actinolite+hornblende); cpx= clinopyroxene; flog= phlogopite; ol= olivine; pl= plagioclase; pvsk= perovskite; rieb= riebekite; other mineral abbreviations as in Figs. 3 and 4).

4.6. LITHOGEOCHEMISTRY

4.6.1. Carbonatites

With the exceptions of carbonatite breccia, silicified and altered rocks, the great majority of the analyzed carbonatites have less than 10 wt.% SiO_2, and less than 1 wt.% each of TiO_2 and Al_2O_3. The concentrations of alkalis is lower than 0.3 wt.% for Na_2O and for K_2O, consistent with the absence of micas. The MgO and CaO contents are in good agreement with modal variations. The representative carbonatite assays are displayed in Table 4.02.

The SiO_2, Fe_2O_3 and MnO contents increase from magnesiocarbonatites to ferrocarbonatites. Average Al_2O_3 is significantly low throughout the carbonatite range. The higher iron (up to 44 wt.% Fe_2O_3) and lower magnesium (<1 to 18 wt.% MgO) in the ferrocarbonatites correspond to higher ankerite and siderite contents.

The apatite magnesiocarbonatites have, on average, higher CaO (up to 39 wt.%) than the ferrocarbonatites (<1 to 29 wt.%), which results mostly from higher apatite contents in the former, with some contribution from secondary Mg-calcite in veins and cavities. The phosphorus contents are strongly controlled by apatite fractionation in apatite-magnetite-rich cumulates, varying widely, from 0.5 to up to 24.9 wt.% P_2O_5.

Although a few high SrO values (>2%) are found in the ferrocarbonatites, there isn't a systematic SrO variation among them. However, the BaO:SrO ratio varies from 0.02 to 3.38 in the magnesiocarbonatites and from 0.08 to 10.87 in the ferrocarbonatites, and may be a better indicator of magma differentiation.

The analytical results for the entire carbonatite range from Morro Preto show a strong increase in Th (up to 1113 ppm), Ba (up to 13%) and ΣREE (up to 2.18%) as the carbonatites evolve from apatite magnesiocarbonatites to ferrocarbonatites. Magnesiocarbonatites are characterized by high P_2O_5 (up to 24.9%), with some anomalous values for Sr, Nb and Ta. Ferrocarbonatites have lower P_2O_5 (0.08 to 1.26 wt.%) and Sr (less than 0.75%), although in some of the late-stage ferrocarbonatites, phosphorus may increase due to the presence of monazite.

LREE/HREE fractionation increases from the apatite magnesiocarbonatite (La(n)/Lu(n) from 8.9 to 194) to the ferrocarbonatites (42.3 to 2196) and Ba-rich ferrocarbonatites (41.47 to 2863). The increase in total REE in the late-stage carbonatites indicates that REE content does not relate exclusively to the apatite abundance, which is consistent with the presence of monazite and REE carbonates, such as bastnaesite.

The chemical compositions of Morro Preto carbonatites are plotted on the Woolley and Kempe's (1989) classification diagram (Fig. 4.06A). An evolution pattern is recognizable in this diagram, with the apatite magnesiocarbonatites plotting near the CaO apex, and the more evolved lithotypes showing a progressive decrease first in CaO and then in both CaO and MgO, with increasing FeO + MnO.

Although the Ba-rich ferrocarbonatites plot mostly in the magnesiocarbonatite field, the ferrocarbonatite designation was kept for this group due to their much greater mineralogical and textural similarities with the late-stage ferrocarbonatites than with the early-stage apatite magnesiocarbonatites.

The variation observed in P_2O_5, BaO and REE contents (Fig. 4.06B) are consistent with a cumulate character for the apatite magnesiocarbonatites, but cannot discriminate well carbonatites from the two more evolved groups, although it is clear that most of these samples plot along a line of varying BaO at nearly constant P_2O_5/REE. Fig. 4.06C compares the Morro Preto carbonatites with the various stages of evolution in carbonatites from the nearby Alto Paranaíba Igneous Province (Gomide et al., 2016). The Morro Preto samples are consistent with an evolving trend from the apatite magnesiocarbonatites, through the Ba-rich ferrocarbonatites to the late-stage Ba-rich ferrocarbonatites.

Fig. 4.07 shows chondrite-normalized trace-element diagrams chondrite-normalized REE diagrams for the different carbonatite groups. Normalized Nb/Ta in the apatite magnesiocarbonatites is variable, but mostly <1, there are negative spikes at Rb, K_2O, and TiO_2, and a positive spike at P_2O_5. The Rb and K_2O negative spikes may be a characteristic of the source (e.g. phlogopite-rich mantle) and are widespread in the province (see Brod et al., 2005), whereas the negative spike in Ti may represent some degree of perovskite or ilmenite fractionation, and the positive spike in P_2O_5 represents accumulation of apatite.

The ferrocarbonatites have Sr and P_2O_5 negative anomalies, showing enhanced Rb and K_2O negative spikes, produced by increased Ba and Th contents rather than actual decrease in K_2O and Rb. The negative P_2O_5 anomaly indicates that they may be the residue of the apatite-rich magnesiocarbonatite cumulates. A small Sr negative anomaly is also present in some of the samples and may be related to the incorporation of Sr in apatite or in early-stage carbonates.

The REE diagrams show a progressive increase in LREE/HREE fractionation from apatite magnesiocarbonatites through ferrocarbonatites to late-stage ferrocarbonatites. A feature suggestive of tetrad effect appears in the heavy rare-earth range of some of the latter.

4.6.2. Silicate Rocks

Alkaline silicate rocks associated with the Morro Preto carbonatites occur as fine-grained dykes and comprise kamafugites, alkali basalts and felsic lamprophyres.

The kamafugites are silica-undersaturated (31.28 to 44.9 wt. % SiO_2), enriched in CaO (up to 16.2 wt.%), carbonate-rich (CO_2 up to 16.8 wt. %) and ultrapotassic (K_2O varying from 1.12 to 5.19 wt. %. Their MgO content varies from 6.7 to 12.6 wt. %, their average K_2O/Na_2O ratio >3 and they are enriched in incompatible elements, such as Ba, Sr and ΣREE, the latter reaching up to 826 ppm. All values and ranges (Table 4.02) are consistent with their kamafugitic character and with other kamafugite rocks from the Province (Sgarbi & Gaspar, 2002, Brod et al., 2005). All kamafugite samples studied here have <13% MgO and MgO/(MgO+FeO) <0.7, indicating that they are more differentiated then the alkaline picrites described from the region by Danni (1994).

The Morro Preto kamafugites have spiderdiagrams (Fig. 4.08A) with a small positive Sr anomaly and small negative anomalies for Rb and K_2O, in an otherwise smooth pattern. Their REE pattern (Fig. 4.08B) shows a La(n)/Lu(n) range between 28.3 and 15.9, in accordance with other GAP kamafugites (Danni, 1985; Danni & Gaspar, 1994; Brod et al., 2005). Despite the higher Rb, Th and K_2O and a small positive Sr anomaly, the Morro Preto kamafugites have a compositional range similar to other kamafugitic rocks from the GAP.

The Morro Preto basaltic rocks classify in the TAS diagram as basalt and hawaiite (Fig. 4.09). They range in SiO_2 from 44.9 to 48.5 wt. %. Their lower alkalis content (Na_2O + K_2O below 6 wt. %), higher MgO (up to 5.4% wt. %), Fe_2O_3 (up to 13.5 wt. %) and a marked positive Sr anomaly (Sr up to 9180 ppm) distinguish them from the felsic dykes and also from other GAP feldspar-bearing rocks. They have relatively low REE concentration, and La(n)/Lu(n) < 18 (Figs. 4.08C and 4.08D).

The globular felsic alkaline dykes, previously named as lamprophyres, were found in the Morro Preto North Complex and are typically alkaline, with SiO_2 contents ranging from 51.5 to 52.3 wt.% and alkalis (Na_2O + K_2O) around 7 wt.%, classifying as trachyandesite in the Total alkalis-silica (TAS) diagram (Fig. 4.09). Their spiderdiagrams show steep negative anomalies for P_2O_5 and TiO_2, and a high concentration of Ba (up to 0.16 wt. %), Zr (up to 756 ppm) and REE (up to 519 ppm – Fig. 4.08E). The REEs show a smooth pattern, enriched in LREE (Fig. 4.08F), with La(n)/Lu(n) ranging up to 37.

	Ap MgCBT	Ba-rich Ank FeCBT	Late Ba-rich Ank FeCBT	Magnetitite	Kamafugite	Alk. Felsic dyke	Alkali Basalt
SiO_2	0.47	4.55	8.82	14.19	40.02	52.30	48.50
TiO_2	0.02	0.05	0.02	0.36	2.62	0.28	3.16
Al_2O_3	0.07	0.30	0.09	0.34	10.56	19.77	15.20
Fe_2O_3	4.66	21.81	26.57	74.18	11.60	4.08	11.98
MnO	0.27	1.34	2.53	0.30	0.19	0.20	0.18
MgO	16.39	13.92	10.70	1.61	12.40	2.36	4.88
CaO	33.44	21.44	14.09	2.58	11.11	2.93	7.65
Na_2O	0.06	0.01	0.02	0.01	3.14	0.82	3.48
K_2O	0.01	0.01	0.04	0.01	2.16	6.96	2.12
P_2O_5	7.03	0.10	0.54	0.10	0.57	0.09	0.45
BaO	0.02	1.90	1.17	1.37	0.12	0.16	0.09
SrO	0.24	0.47	0.16	0.09	0.14	0.09	0.40
LOI	37.30	33.70	33.90	4.60	5.00	9.70	1.70
TOT	99.69	99.60	98.65	99.74	99.63	99.74	99.79
CO_2	38.10	33.64	36.06	3.70	3.85	3.48	1.47
S	0.07	0.40	0.41	0.32	0.04	0.02	0.03
Ni	0.50	4.90	23.30	13.90	235.90	38.50	3.80
Sc	7.00	8.00	6.00	4.00	25.00	1.00	20.00
Rb	0.60	0.10	0.60	0.20	41.00	235.50	47.50
Zr	26.10	36.10	68.00	81.90	262.50	624.40	249.30
Hf	0.30	0.20	1.30	0.30	6.80	10.90	6.00
Nb	5.30	80.00	91.60	599.90	81.30	228.00	52.70
Ta	1.30	0.50	0.80	0.60	5.20	5.00	3.00
Th	1.40	163.50	250.30	85.60	7.70	38.60	6.10
Y	23.90	49.80	18.30	12.40	21.20	36.40	24.30
La	46.70	265.30	2672.20	21.30	74.90	174.10	51.30
Ce	117.20	513.30	4494.00	63.20	141.40	240.50	105.10
Pr	15.36	54.97	413.27	12.18	16.06	19.64	12.69
Nd	63.90	197.20	1161.70	78.30	59.40	54.70	48.00
Sm	11.81	37.94	98.72	22.66	9.74	7.35	8.20
Eu	3.59	11.12	18.81	5.20	2.70	1.99	2.44
Gd	10.72	30.62	42.38	11.55	7.55	5.98	6.75
Tb	1.33	3.07	2.57	0.93	0.97	0.87	0.95
Dy	6.11	12.96	7.49	3.70	4.65	5.86	4.93
Ho	1.00	1.71	0.38	0.41	0.81	1.07	0.88
Er	2.07	3.79	0.51	0.96	2.04	2.79	2.19
Tm	0.28	0.46	0.13	0.14	0.27	0.48	0.31
Yb	1.48	2.76	0.84	0.82	1.63	3.44	1.96
Lu	0.21	0.31	0.10	0.09	0.23	0.50	0.30

Table 4.02. Representative analysis from the Morro Preto Complex main lithotypes. Major oxides, CO_2 and S displayed in %; minor and trace elements displayed in ppm.

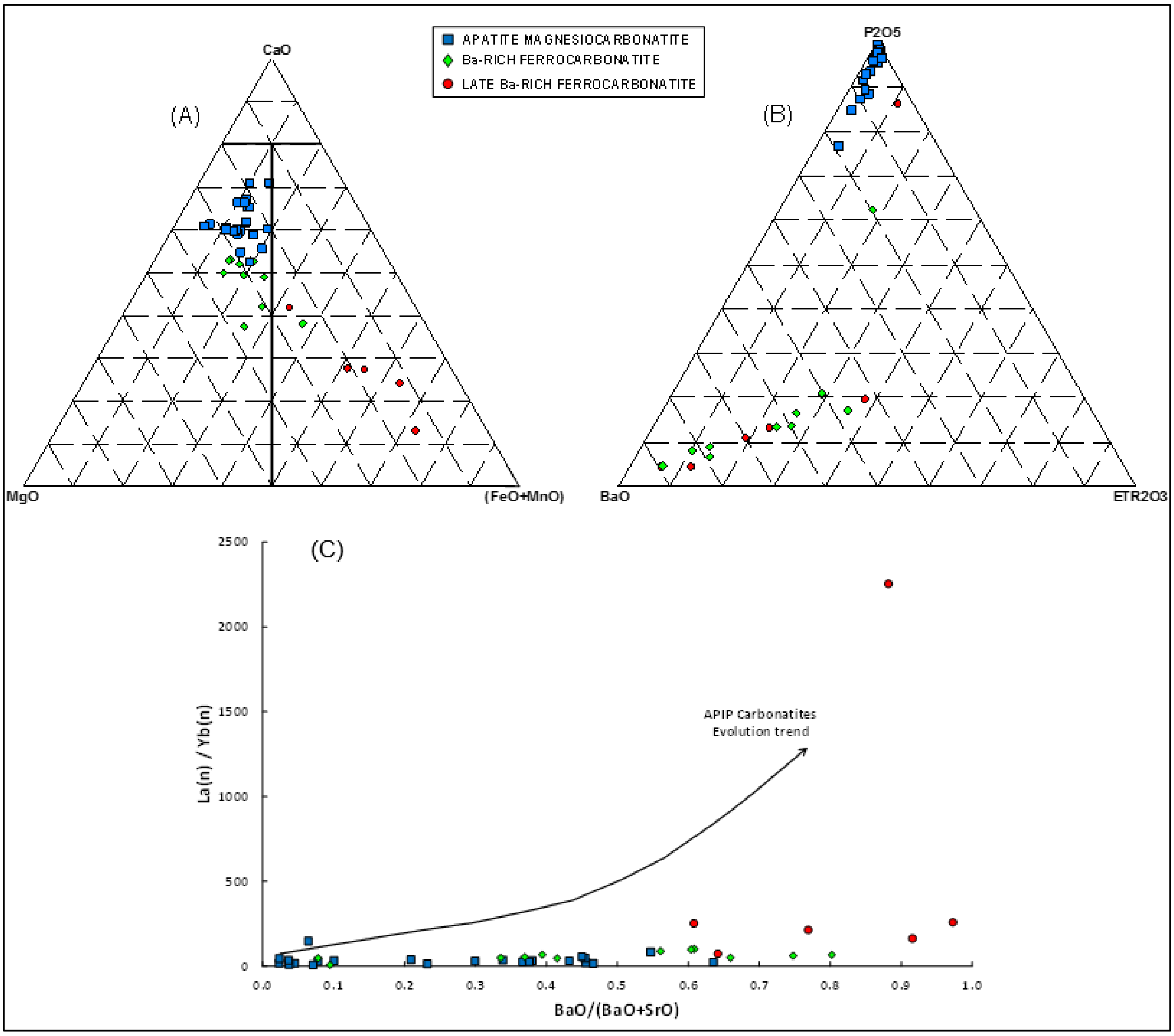

Fig. 4.06. (A) Carbonate classification diagram after Woolley & Kempe (1989) for the Morro Preto Complex carbonatites, indicating Fe_2O_3 increase with differentiation. (B) Triangular diagrams for the different carbonatites, P_2O_5, BaO and REE increase with magmatic evolution. (C) Variations in the BaO/(BaO+SrO) ratio and in the degree of LREE/HREE fractionation with magma evolution, compared with the trend of the APIP carbonatites from Gomide et al. (2016).

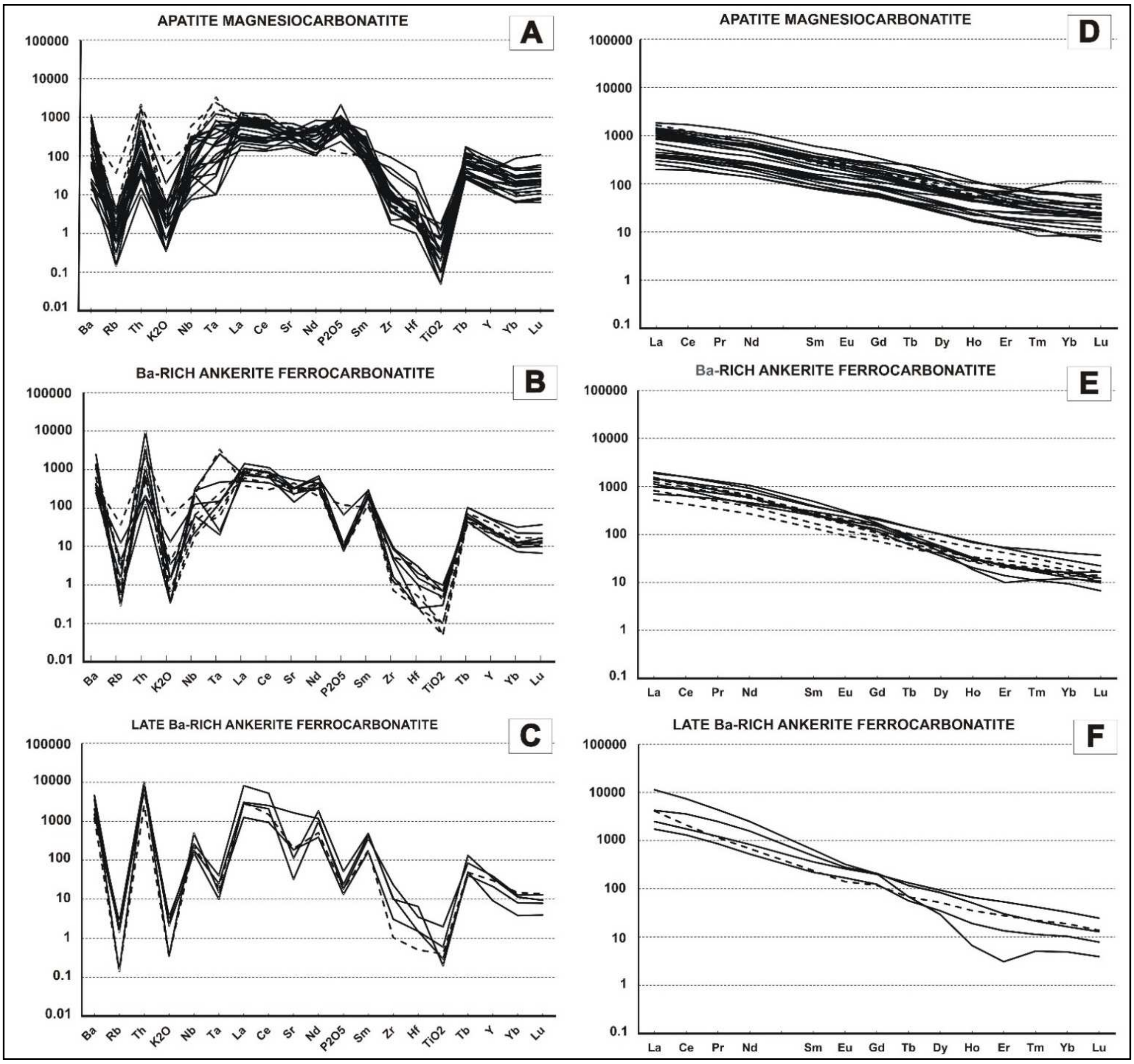

Fig. 4.07. From A to C: multi-element diagrams (Thompson, 1982), and D to F: Chondrite normalized REE patterns (McDonough & Sun, 1995) for the carbonatits from the Morro Preto Complex. Carbonatite types as described in each diagram title. The dashed lines represent samples from Morro Preto North; the continuous lines represent Morro Preto South.

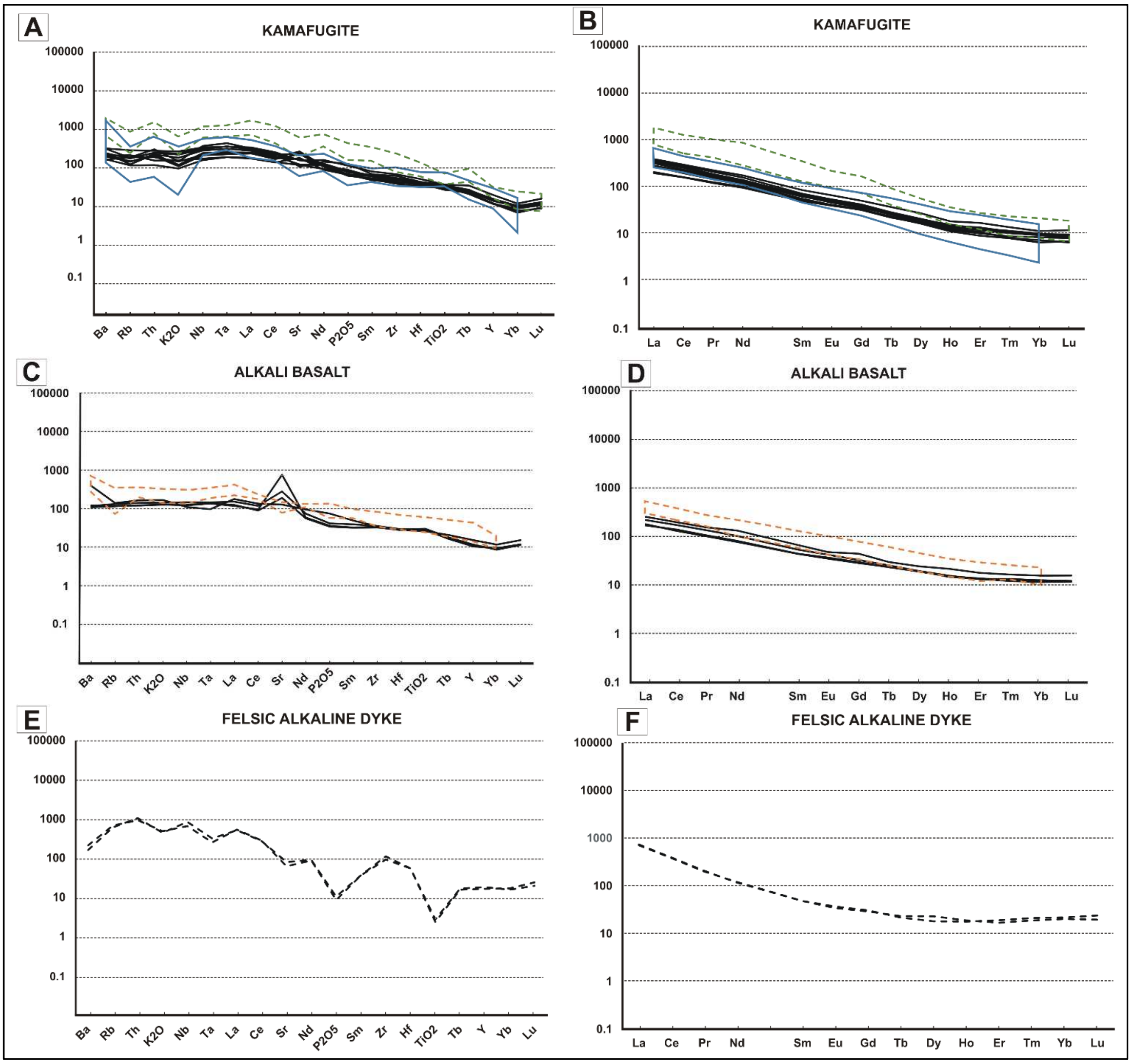

Fig. 4.08. (A) Multi-element diagrams (Thompson, 1982) and **(B)** chondrite normalized REE patterns (McDonough & Sun, 1995) for the Morro Preto kamafugites. The blue area defines the range of GAP kamafugities, and the green dashed-line area defines phlogopite picrite samples from the APIP. **(C)** Multi-element diagrams (Thompson, 1982) and **(D)** chondrite normalized REE patterns (McDonough & Sun, 1995) for Morro Preto alkali basalts. GAP basanites and alkali basalts composition are outlined by the orange dashed-line area. **(E)** Multi-element diagrams (Thompson, 1982) and **(F)** chondrite normalized REE patterns (McDonough & Sun, 1995) for the lamprophyre samples. The dashed lines represent samples from Morro Preto North; the continuous lines represent samples from Morro Preto South. Data source for the GAP and APIP samples: Brod et al., 2005).

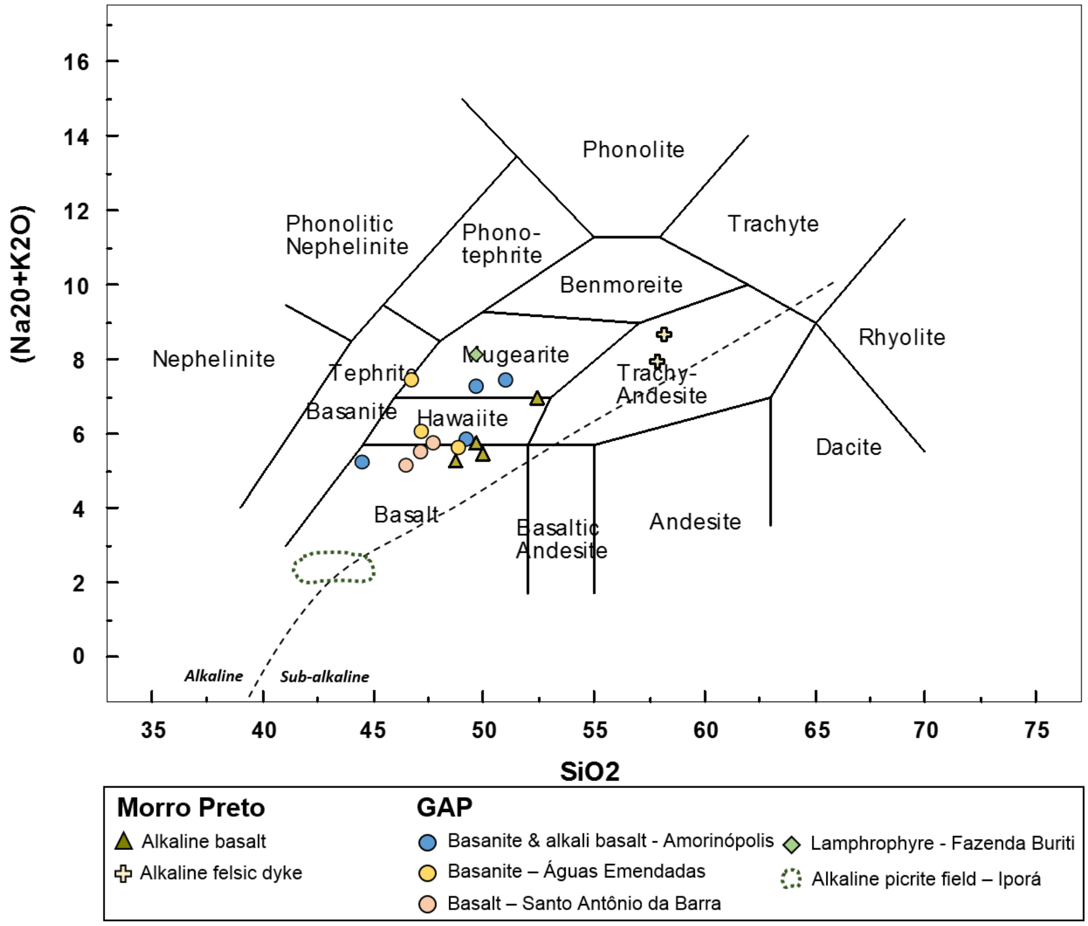

Fig. 4.09. Total alkalis-silica (TAS) classification diagram for the felsic lamprophyre and alkaline basalt rocks from the Morro Preto Complex, and the distribution of other sub-volcanic rocks from GAP. Data source for GAP samples: Junqueira-Brod (1998), Danni (1978), Danni (1994) and Moraes (1984).

4.7. MINERAL CHEMISTRY OF CARBONATES AND APATITE

4.7.1. Carbonates

Carbonates in the Morro Preto carbonatites are solid solutions between ankerite and dolomite and between magnesite and siderite.

The main textural relationships between the different carbonates are detailed in Fig. 4.10. Coarse-grained dolomite grains are invariably zoned and form complex intergrowths with Fe-dolomite in the apatite magnesiocarbonatites (Fig. 4.10A). Fe-dolomite varies from homogeneous coarse grains to zoned grains with iron increase toward the rims (Fig. 4.10D).

Ankerite occurs in late-stage carbonatites. Ankerite grains are often enveloped in siderite (Fig. 4.10C). Another siderite variety is associated with veinlets and dissolution cavities and is richer in magnesium, varying between Mg-siderite and Fe-magnesite.

Representative analyses of carbonate minerals from the different carbonatites are listed in Table 4.03, and their compositional evolution is summarized in Fig. 4.11.

Carbonate evolution in the Morro Preto Complex comprises the following succession (from earliest to latest): dolomite → dolomite + Fe-dolomite → Fe-dolomite + ankerite → Fe-dolomite + ankerite + siderite → Fe-dolomite + ankerite + magnesite-siderite series. This trend reflects a Ca → Mg → Fe+Mg → Mn+Fe transition through the evolution of carbonatites, as proposed by Hogarth (1989).

The subdivision of the dolomite types adopted in this work is arbitrary, based on the following ranges of Mg:Ca (a.p.f.u.) and Fe+Mn (a.p.f.u.):

- 0.8-0.9 Mg:Ca and (Fe+Mn) between 0 and 0.1 for dolomite;
- 0.7-0.8 Mg:Ca and (Fe+Mn) between 0.05 and 0.35 for Fe-dolomite
- 0.6-0.7 Mg:Ca and (Fe+Mn) between 0.1 and 0.4 for type II Fe-dolomite.
- 0.4-0.6 Mg:Ca and (Fe+Mn) >0.4 for ankerites.

The magnesite-siderite series was subdivided at Mg:Fe values of 0.75, 0.5 and 0.25 corresponding to magnesite, ferroan magnesite, magnesian siderite, and siderite, as suggested by Buckley and Woolley (1990).

Dolomite varies from near-stoichiometric to iron-bearing (FeO up to 3.6 wt.%) the former being more common in magnesiocarbonatite. This type of dolomite contains up to 1.6 wt.% MnO and up to 1.5 wt.% SrO.

Fe-dolomite is the dominant mineral in the ferrocarbonatites and the modally dominant carbonate in the Complex. The FeO content in this variety is up to 11.87 wt.%, and the most ferrous individuals also show MnO contents up to 6.17 wt.%. SrO content reaches 1.31%. This Fe-dolomite gradually evolves towards a variety even more enriched in irons (type II Fe-Dolomite) in the ferrocarbonatites, as indicated by concentric zoning patterns (Fig. 4.10 and Fig. 4.11).

Ankerite is much poorer in SrO (< 0.28 wt.%) than dolomite. It contains up to 16 wt.% FeO, CaO is less than 27.8 wt.% and MgO less than 12.8 wt.%.

Siderite is Mg-rich, with a positive correlation between MgO and MnO, as FeO decreases. CaO is less than 0.02 wt.%, FeO ranges from 33 to 53 wt.%, MgO from 0.6 to 14 wt.% and MnO is up to 6.5 wt.%. Siderite occurs both in equilibrium with ankerite and in cavities and veins, the cavity-filling variety

(Fig. 4.10B) showing magnesium enrichment. Bastnaesite and monazite are commons minerals associated with the siderite-bearing ferrocarbonatites, similarly to the associations described by Sokolov (1985) and Hogarth (1989).

Calcite is rare, associated only with quartz-filled dissolution cavities, and interpreted as a late-stage or secondary mineral. Its composition is homogeneous and limited, with less than 0.5 wt.% MgO and less than 0.57 wt.% FeO. SrO is below detection and MnO can reach 1.67 wt.%.

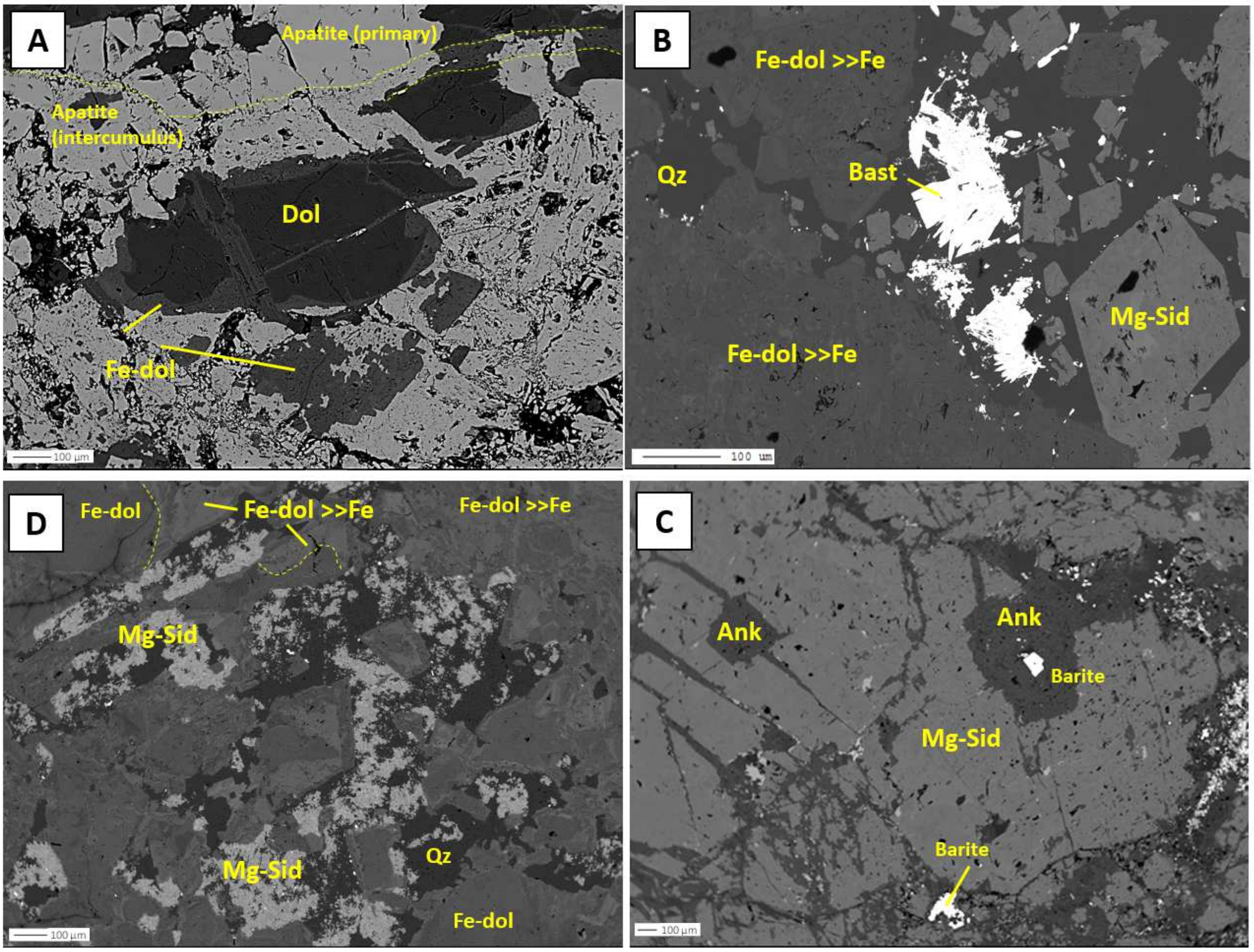

Fig. 4.10. Backscattering electron (BSE) images obtained with EPMA, showing textural relationships between carbonates. (A) dolomite showing a Fe-dolomite rim, (B) type II Fe-dolomite rims on Fe-dolomite, (C) ankerite and traces of barite enveloped by Mg-siderite and (D) Fe-magnesite inside dissolution cavities.

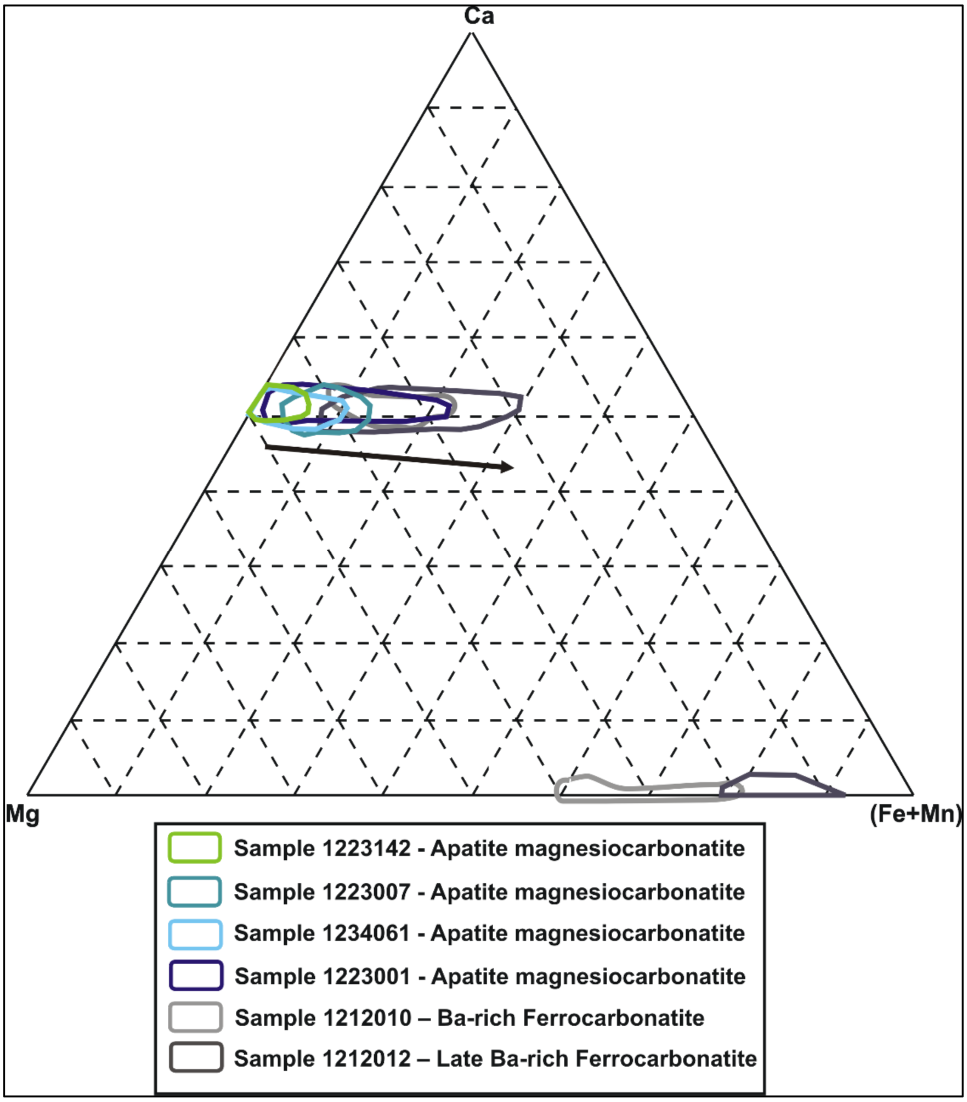

Fig. 4.11. Ca-Mg-(Fe+Mn) (a.p.f.u.) diagram with the fields of Morro Preto carbonates, indicating an evolution path from the magnesiocarbonatites to the ferrocarbonatites and Ba-rich ferrocarbonatites.

Oxides (wt.%)	Dolomite (Apatite Mg-carbonatite)	Fe-dolomite (Apatite Mg-carbonatite)	Fe-dolomite (Ba-rich ankerite Fe-carbonatite)	Ankerite (Late Ba-rich ankerite Fe-carbonatite)	Siderite (Late Ba-rich ankerite Fe-carbonatite)
SiO_2	-	-	0.03	0.03	0.03
Al_2O_3	0.03	0.01	0.14	0.01	0.02
FeO	0.05	7.51	10.75	15.67	47.96
MnO	-	0.18	2.25	3.18	4.85
MgO	18.38	15.45	12.56	8.58	4.31
CaO	33.02	28.55	27.99	27.43	0.04
BaO	0.01	0.01	-	0.02	-

SrO	0.10	0.18	0.07	-	0.01
La_2O_3	-	0.01	-	-	-
Ce_2O_3	0.06	0.05	0.05	0.04	0.07
TOTAL	51.65	51.94	53.84	54.95	57.30
CO_2	46.07	43.97	42.30	40.50	34.13
SUM%	97.72	95.91	96.14	95.45	91.43
Cations (a.p.f.u.)					
Si	-	-	-	0.0017	-
Al	0.0001	-	0.0100	0.0001	-
Fe	0.0001	0.2100	0.3100	0.4700	0.6700
Mn	-	0.0001	0.0700	0.1010	0.0700
Mg	0.8700	0.7700	0.6400	0.4500	0.1100
Ca	1.1200	1.0180	1.0300	1.0500	-
Ba	0.0004	0.0003	-	0.0000	-
Sr	0.0009	0.0001	-	-	-
La	0.0001	0.0001	0.0001	-	-
Ce	0.0007	0.0013	0.0006	-	-
TOTAL	2.001	2.004	2.047	2.065	2.400
C	2.00	2.00	1.97	1.97	1.55

Table 4.03. Representative carbonate analyses from the Morro Preto carbonatite. Structural formulae calculated on the basis of 6 O.

4.7.2. Apatite

Apatite analyses are from the apatite magnesiocarbonatites located in the Morro Preto South intrusion. Representative values are given in Table 4.04. Textural properties and relationships with carbonates are shown in Fig. 4.12. Four apatite varieties are recognized:

(i) Type 1: subhedral apatite phenocrysts, in equilibrium with magnetite, dolomite and, less frequently, with Fe-dolomite. This variety is more common in apatite cumulates in magnesiocarbonatites, and interpreted as primary. Pyrochlore and baddeleiyte inclusions are common (Fig. 4.12A).

(ii) Type 2: turbid and fractured apatite associated with Fe-dolomite as an intercumulus phase or as a rim on type 1 apatite. Occurs in magnesiocarbonatites where the carbonate is strongly zoned from dolomite to Fe-dolomite (Fig. 4.10A; Fig. 4.12B).

(iii)Type 3: very fine-grained apatite, as interstitial grains in a Fe-dolomite fabric (Fig. 4.12C), associated with fine-grained magnetite. This apatite type has a homogeneous aspect and is distinctively enriched in sodium. Sodium-rich accessory minerals, such as riebeckite, are common in the carbonatites containing type 3 apatite.

(iv) Type 4: fine-grained to cryptocrystalline apatite, occurring in veinlet zones or silicified dissolution cavities. This variety fills interstices of primary minerals or occurs as comb-layered aggregates at the edge of cavities, indicating its secondary origin (Fig. 4.12D).

These textural varieties correspond to different compositions, in terms of SrO, F and Na_2O (Fig. 13). Type 1 apatite has low SrO (< 0.4 wt. %), F (< 2 wt. %) and Na2O (< 0.44 wt.%), and higher CaO and P_2O_5 contents than the other apatite types (up to 55.23 wt.% and 41.85 wt.%, respectively). It is also slightly richer in Cl (up to 0.04 wt.%).

The intercummulus, type 2 apatites are fluorapatites (F from 2.08 to 5.6 wt.%) with SrO from 0.4 to 2.14 wt.% and Na_2O < 0.51 wt.%.

Type 3 apatite has moderate SrO (up to 1.98 wt.%) and F (0.12 to 3.7 wt.%), and lower CaO and P_2O_5 (< 53.2 wt.% and 39.5 wt.%, respectively) than types 1 and 2, but significantly higher Na_2O (0.4 to 1.3 wt.%). These apatites yield lower analytical totals (less than 96%), indicating a probable increase in CO_2 (carbonate hydroxyl-apatite?).

Type 4 apatite has relatively low CaO and P_2O_5 (< 53 and 39.7 wt.%, respectivelly), moderate F values (0.3 to 4.3 wt.%), less than 0.49 wt.% Na_2O, and the highest SrO content (1.8 to 6.44 wt.%). Both type 3 and 4 have higher ΣLREE (0.11 to 1.17 wt.% and from 0.05 to 1.18 wt.%, respectively) than types 1 and 2 (0.09 to 0.63 wt.% and 0.01 to 0.48% wt.%, respectively).

Oxides (wt.%)	**Type 1 apatite**	**Type 2 apatite**	**Type 3 apatite**	**Type 4 apatite**
SiO_2	-	0.05	0.03	-
Al_2O_3	0.01	0.05	0.03	-
FeO	0.03	0.23	0.48	0.02
MnO	0.01	0.04	0.12	0.02
MgO	0.02	-	-	-
CaO	55.23	53.45	51.39	51.94
BaO	-	-	0.02	-
SrO	0.17	0.92	1.03	4.17
Na_2O	0.15	0.49	1.26	0.12
P_2O_5	41.34	38.47	37.57	39.31
La_2O_3	0.04	-	0.08	-
Ce_2O_3	0.17	0.05	0.21	0.05
SO_3	0.01	0.06	0.10	0.04
F	1.41	4.76	1.91	3.15
Cl	-	0.02	-	-
SUM%	98.14	96.65	93.63	97.59

Cations (a.p.f.u.)				
Si	-	0.0090	0.0060	-
Al	0.0003	0.0110	0.0060	0.0010
Fe	0.0040	0.0350	0.0700	0.0030
Mn	0.0020	0.0060	0.0190	0.0040
Mg	0.0050	-	-	-
Ca	10.0500	10.2200	10.0300	9.8500
Ba	0.0000	-	0.0020	0.0001
Sr	0.0200	0.1000	0.1100	0.4300
Na	0.0490	0.1690	0.4450	0.0420
P	5.9410	5.8120	5.7900	5.8870
La	0.0020	-	0.0050	0.0020
Ce	0.0110	0.0030	0.0100	0.0040
S	0.0010	0.0080	0.0100	0.0050
F	0.7300	2.4300	1.0500	1.6500
Cl	0.0004	0.0050	0.0020	-
TOTAL	16.8310	18.8010	17.5820	17.8700

Table 4.04. Representative apatite analyses from Morro Preto Complex.

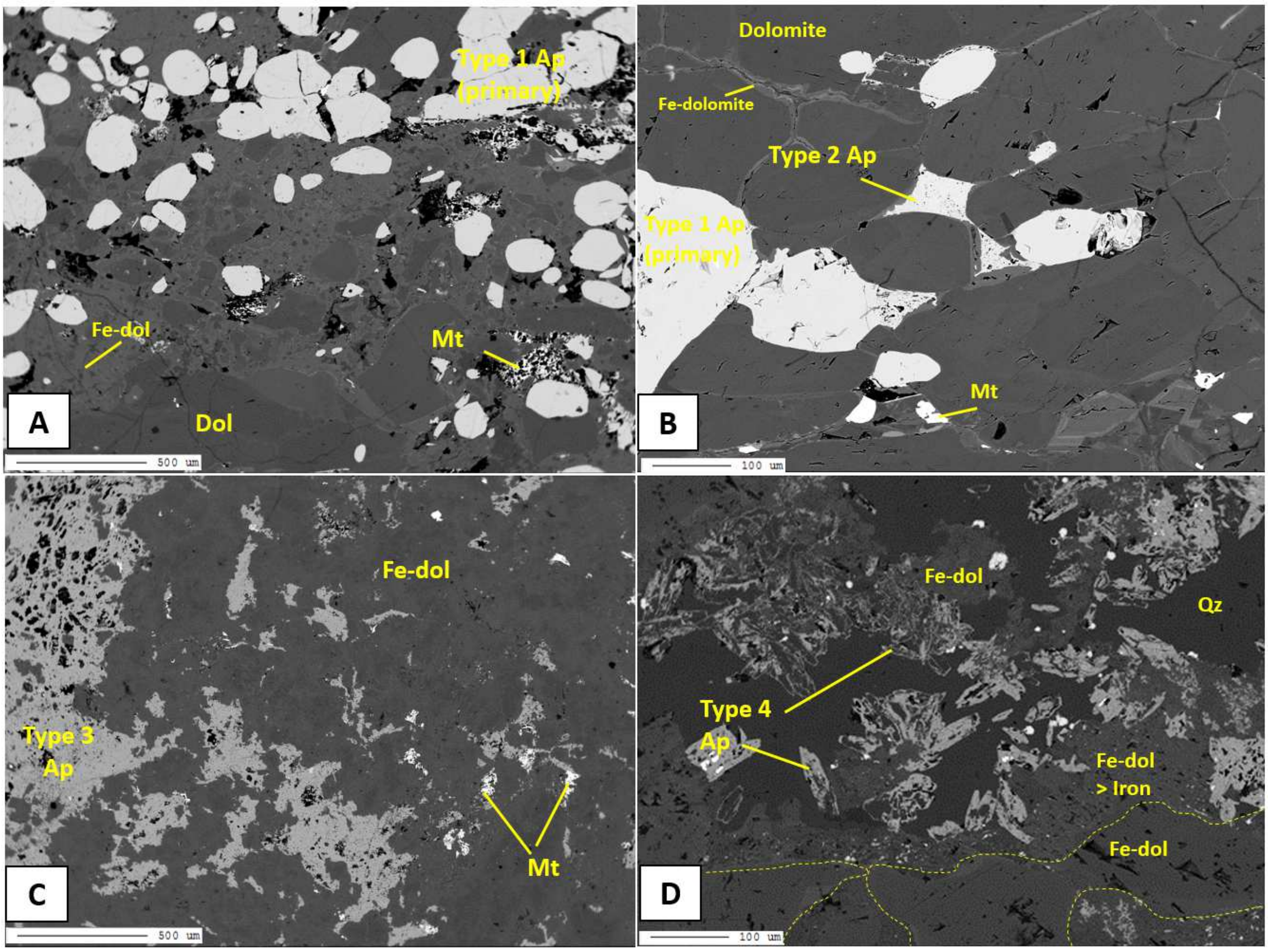

Fig. 4.12. (A) Primary subhedral apatites (Type 1), associated with altered magnetite and dolomite. (B) Intercumulus apatite (Type 2) in equilibrium with Fe-dolomite and fine-grained magnetite. (C) High- Na_2O type 3 apatite in contact with homogeneous Fe-dolomite. (D) High-SrO type 4 apatite forming in dissolution cavities (Ap = apatite; Dol = dolomite; Mt = magnetite; Qz = quartz).

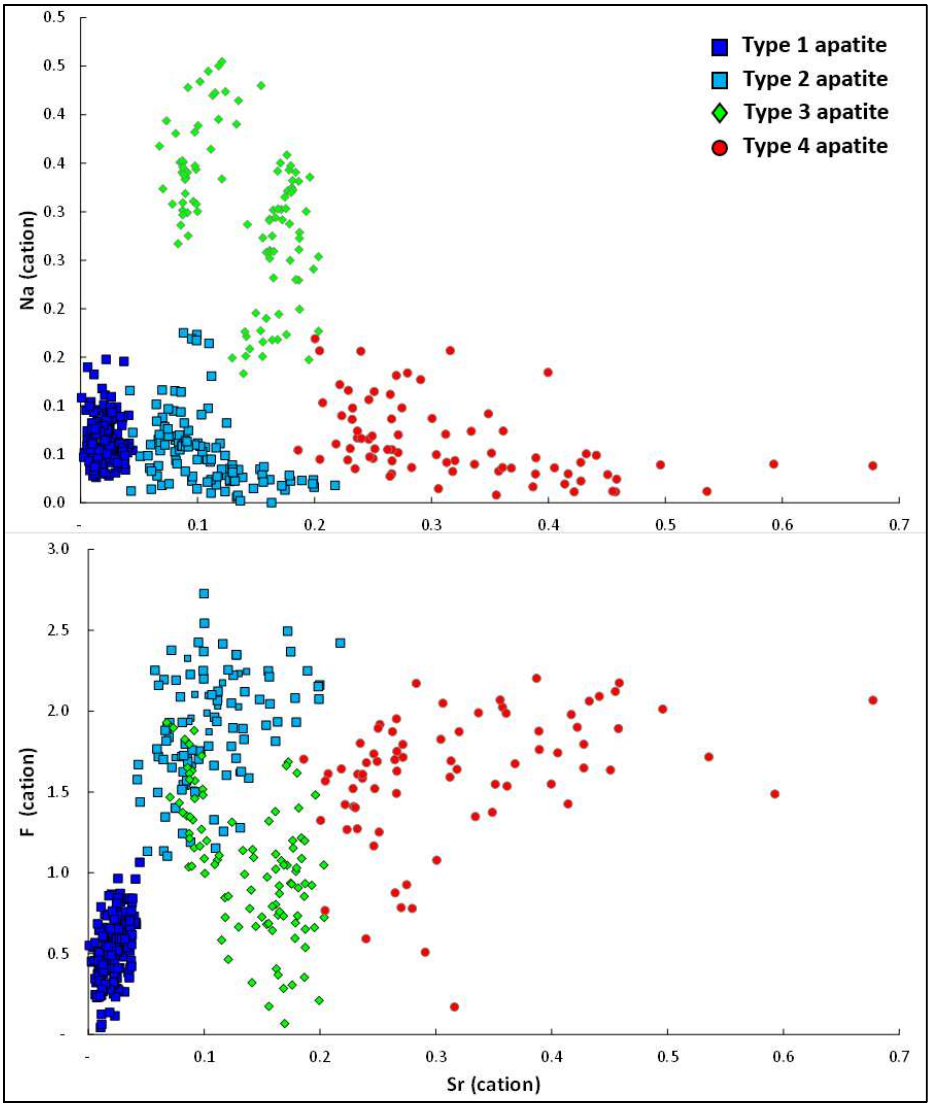

Fig. 4.13. Compositional difference between the apatite groups in the Morro Preto Complex.

4.8. DISCUSSION

Carbonate composition in the Morro Preto carbonatites starts as dolomite in magnesiocarbonatites, evolving to Fe-dolomite, type II Fe-dolomite and then Fe-dolomite with ankerite in ferrocarbonatite. In late-stage, Ba-rich ferrocarbonatite the carbonate species are ankerite and siderite-magnesite with minor Fe-dolomite. This evolution sequence is typical in carbonatite complexes and broadly described in the literature (LeBas, 1981; Sokolov, 1985; Hogarth, 1989; Woolley & Kempe, 1989), but an early calcite carbonatite stage is apparently missing in the Morro Preto Complex.

The textural relationships in cumulates (Fig. 4.02A), and mineral chemistry indicate an evolution starting with type 1 apatite + dolomite ± Fe-dolomite in the early magnesiocarbonatites, grading to type 2 apatite + Fe-dolomite + accessory ankerite in the early-stage ferrocarbonatites.

Whole-rock geochemistry indicates magma evolution through CaO, MgO and P_2O_5 decrease, and Th, LREE and BaO:SrO increase from magnesiocarbonatites to ferrocarbonatites, as also observed by Woolley & Kempe (1989) for worldwide carbonatites. The same patterns relate the evolution of Morro Preto carbonatites with those of the APIP carbonatites, as illustrated in Fig. 6C and described by Gomide et al (2016).

Although the siderite-magnesite series is not common in ferrocarbonatites, it has been described from other world occurrences (Buckley & Woolley, 1990; Woolley & Buckley, 1993; Zaitsev, 1996). It is still no clear wether the Morro Preto magnesite-siderite occurrences are formed during primary (magmatic) or metasomatic / hydrothermal stages, of a hybrid product of both. LeBas (1981) indicates a metasomatic association for at least part of the iron-rich carbonates. Other authors (Buckley & Woolley, 1990; Zaitsev, 1996; Chakhmouradian et al., 2016) also associate iron-rich carbonates (siderite, magnesite and even ankerite) to subsolidus and to postmagmatic events.

Elliot et al. (2018) detail the influence of metasomatic (fenitization) events in the evolution of carbonatite complexes. They consider fenites as the result of multiple pulses of alkali-rich fluid expelled from the cooling alkaline/carbonatite melt, and, as such, fenites may bring additional insights in the evolution of an alkaline complex evolution. The fenitization process may include other forms of localized metasomatic events, such as autometasomatism in the already crystallized intrusion border, contact metasomatism between the intrusion and the host rocks, or near-vein metasomatism on both contexts.

Similarly, in the Morro Preto carbonatites, the observed differences in texture, mineral chemistry and whole-rock chemistry in the magnesiocarbonatite-ferrocarbonatite transition, might be representatives of not only fractional crystallization, but also of metasomatic reworking:

- Metasomatic overprint in the Morro Preto Complex is evidenced by the extent of fenitization with an aureole of over 800m wide (see Fig. 4.02). Fenitized xenoliths from the country rocks in the carbonatites and carbonatitic breccia are a common feature in Morro Preto (Figs. 4.05D to 4.05F). The brittle aspect of the breccia and the clasts attests to the explosive release of fluids and volatiles from multiple intrusions, leading to hydrothermal alteration of not only the country-rock but also of the pre-existing carbonatites. In this sense, breccia pipes are considered effective pathways and possible hosts for latter carbonatite magma injections.

- Scattered K-feldspar or even K-feldspar veins crosscutting early carbonatites (Fig. 4.04F) show a potassic alteration similar to other carbonatite complexes with potassic fenitization (Le Bas, 1981; LeBas, 2008; Pirajno et al., 2014; Elliot et al., 2018). LeBas (2008) indicate pseudotrachytes as ultimate products of potassic fenitization, and this cannot be ruled out as a possibility for the origin of the Morro Preto felsic alkaline dykes.
- The conversion of dolomite to Mg-Fe carbonates in the carbonatites appears to be a product of magmatic differentiation increasingly combined with metasomatic reworking. The mineral dissolution and CO_2 release (degassing) during carbonatite differentiation gives origin to the cavernous appearance in some of the carbonatites with ferruginous alteration (Fig. 4.03C), similar to boxwork fabrics in hydrothermal events, as also observed by Chakhmourandian et al. (2017).
- The F and SrO increase from type 1 to type 4 apatite is apparently related to compositional changes to magmatic differentiation (Hogarth, 1989). The Na_2O variation, however, is not consensus: Hogarth (1989) associates higher Na_2O content to early-stages (primary) apatite, but Chakhmouradian et al. (2017) interpret Sr (±LREE, Na)-rich hydrothermal apatites as the result of replacement zones and overgrowths on igneous apatite from Kovdor magnesiocarbonatites.
- Chakhmouradian et al. (2017) also correlate some high Sr and Na apatites with local crystallization in dissolution microcavities, similar to the type-4 apatites observed in Morro Preto. Part of the quartz and barite-rich microcavities seen in Morro Preto might be a local by-product of subsolidus reactions, as cited by Elliot et al. (2008). The same principle can be applied for the Mg-siderite and magnesite grains in dissolution microcavities.

The occurrence of liquid immiscibility at Morro Preto Complex is suggested by the presence of carbonate globules in the kamafugite dykes crosscutting the Complex (e.g. Morbidelli et al., 1995; Ivanikov et al., 1998). This indicates that the parental magma of the Morro Preto carbonatites is ultramafic, of kamafugite affinity, and that liquid immiscibility was probably involved in its origin and evolution. Immiscible carbonate globules are a common feature in the kamafugite-carbonatite association from the APIP (Brod et al., 2005; 2013), and in the kamafugite lavas from Santo Antônio da Barra, in the southern

GAP (Junqueira-Brod et al., 2005). In both cases this feature is interpreted as a strong evidence for the coexistence of immiscible carbonate and silicate liquids.

Liquid immiscibility might also be traceable in the carbonatites, even after postmagmatic processes. Brod et al. (2013) suggest geochemical tools to investigate fingerprints of liquid immiscibility in the carbonatites, such as high Ba and Sr values, decoupling of the paired trace elements Nb-Ta and depletion of Zr-Hf in the carbonatitic magma, generated by the partition between silicate and carbonate liquid.

The entire Morro Preto carbonatite sequence has a steep Zr-Hf depletion. The ferrocarbonatites have a higher Nb/Ta ratio (up to 578) than the apatite-rich magnesiocarbonatites, with variable, but mostly <1 Nb/Ta. The late-stage ferrocarbonatites have enhanced Sr and P2O5 negative anomalies, and a new Ta anomaly appears due to Nb/Ta fractionation probably during a liquid immiscibility event (e.g. Brod et al., 2013).

A full account of the evolution model for Morro Preto geology is beyond the scope of this work. However, the present results point out to a preliminary understanding of its history. There are important aspects to consider in terms of the Morro Preto emplacement level at the current erosional level: the Complex is characterized by the absence of strongly undersaturate silicate magma representatives, other than the kamafugite dykes crosscutting the carbonatites. It is restricted to magnesiocarbonatite stocks and ferrocarbonatites, associated with fenitized basement rocks on its surroundings and in between the carbonatite stocks, along with a brittle structural system represented by brecciated carbonatites with clasts from the host rocks.

This lithological association is similar to what Santos & Clayton (1995) described for shallow-seated carbonatites, such as Mato Preto carbonatite Complex in the Ponta Grossa alkaline Province, southern Brazil. Those authors also correlate shallower carbonatite complexes with an increase in the amount of metasomatic alteration, due to higher interaction between the magmatic crystallized rocks and the H_2O-CO_2- rich fluids in crustal levels. Lower lithostatic pressure would also be consistent with this. The evidence presented here suggests that the Morro Preto complex is a sub-volcanic portion of the alkaline-carbonatite intrusive system, according to the conceptual model proposed by LeBas (1977).

Despite carbonate alteration overprint, the mineral fabric and textures present in the alkali basalts, as well as their chemical classification, indicate their magmatic nature, but their association with the Morro Preto Complex is still unclear.

4.9. CONCLUSIONS

The Morro Preto complex, similar to many other carbonatite complexes worldwide, resulted from the combination of multiple-stage petrogenetic processes, such as liquid immiscibility, crystal fractionation, magma mixing and metasomatism/degassing.

The compositional variations of carbonates and apatite indicate an evolution path from more primitive magnesiocarbonatites (dolomite and Fe-dolomite), grading towards magnesiocarbonatites with Fe-dolomite. The increase in the Fe content represent the transition from magnesiocarbonaties to ferrocarbonatites.

The ferrocarbonatites from the Morro Preto Complex are interpreted as the end-members of magmatic differentiation in association with subsequent subsolidus processes such as autometassomatism and hydrothermal alteration The negative P_2O_5 anomaly also indicates the ferrocarbonatites as the residue of the apatite-rich magnesiocarbonatite cumulates.

The occurrence of carbonate globules in the kamafugite rocks is an evidence of silicate-carbonate liquid immiscibility. Due to their composition, the kamafugite rocks represent the most primitive rock type in the Morro Preto complex. However, there are more primitive members of the kamafugite series in the province (e.g. katungites), which are lacking at Morro Preto, suggesting that parental liquids of this complex are already a product of fractional crystallization.

The Morro Preto Complex stands out in the northern GAP, not only due to its unusual carbonatite-dominated geology, but also due to its potential for economic phosphate deposits in the magnetite apatite magnesiocarbonatite cumulates.

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CAPÍTULO 5

THE KAMAFUGITE-CARBONATITE ASSOCIATION IN THE MORRO PRETO COMPLEX, GOIÁS ALKALINE PROVINCE, BRAZIL

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The Upper Cretaceous Goiás Alkaline Province (GAP) and the Alto Paranaíba Igneous Province (APIP) are two of the largest kamafugite provinces in the world. However, they show some important petrologic and metallogenetic differences: the APIP contains a number of carbonatite-bearing plutonic complexes containing large P-Nb-REE(-Ti-Ba-Fe-U) deposits, whereas the GAP often contain ultramafic to intermediate, plagioclase-bearing alkaline rocks and host mostly Ni laterite mineralization.

The Morro Preto Alkaline-Carbonatite Complex in northern GAP is an exception in that it is characterized by an intrusive carbonatite-kamafugite association and contain significant phosphate mineralization.

This paper focus on the petrography, geochemistry and mineral chemistry of the Morro Preto kamafugite dykes, their genetic relation to the Morro Preto carbonatite series, and the similarities observed between the Morro Preto kamafugites, the kamafugite series from other GAP intrusive and extrusive bodies, and the kamafugite series from the APIP.

The comparison between the bebedourite xenoliths from the Morro Preto kamafugites and the bebedourites occurring in the APIP provides a link between kamafugitic and carbonatitic magmatism in the GAP. Additional exploration work directed towards the identification of yet undiscovered carbonatite complexes in the GAP should take into account the Morro Preto broader metallogenetic affinity.

Keywords: *Goiás Alkaline Province, Alto Paranaiba Igneous Province, carbonatite, kamafugite, bebedourite.*

5.1. INTRODUCTION

The Brazilian alkaline provinces located at the northern border of the Paraná Basin are a product of voluminous alkaline magmatism occurred in the Late-Cretaceous. Among these are two of the largest kamafugitic provinces, namely the Alto Paranaíba Igneous Province (APIP, Gibson et al. 1995), and the Goiás Alkaline Province (GAP, Junqueira-Brod et al., 2002, Gaspar et al., 2003). A comparison of these two provinces shows some petrological differences, particularly the presence, in the GAP, of associations of mafic to intermediate, plagioclase-bearing alkaline rocks that are unknown in the APIP (Brod et al, 2005), which probably affects their metallogenetic potential (e.g. Ribeiro et al., 2014).

The Morro Preto Carbonatite Complex, located in the northern portion of the GAP, is a product of the kamafugite-carbonatite association in the region. It is remarkable among GAP plutonic complexes because it is dominated by carbonatite and because it contains important phosphate mineralization. In this work, we investigate the possible links between the Morro Preto phosphate occurrence and the phosphate occurrences and deposits from the nearby APIP. We focus on the petrography, geochemistry and mineral chemistry of the Morro Preto kamafugite dykes and bebedourite xenoliths, their relation with the carbonatite sequence and their comparison with similar rocks from the GAP and APIP.

5.2. GEOLOGICAL SETTING

The Goias Alkaline Province (GAP) (Junqueira-Brod et al., 2002; Gaspar et al., 2003) and the Alto Paranaíba Igneous Province (APIP) (Gibson et al., 1995) consist of alkaline magmas emplaced along the northern margin of the Paraná Basin. They are structurally controlled by regional NW suture zones, and their magmatism is restricted to the Late-Cretaceous, between 80 and 90 Ma (Gibson et al. 1995, 1997).

The magmatism of the alkaline provinces surrounding the Paraná Basin is often considered as a direct product of mantle plume activity. The Tristão da Cunha and Trindade Plume systems affected the Brazilian shield respectively in the Early and Late Cretaceous age (Gibson et al., 1995; Van Decar et al., 1995; Gibson et al., 1997).

The GAP and APIP are typically ultrapotassic in composition, with extensive kamafugitic activity recorded in both provinces. Alkaline provinces located more to the South, along the western and eastern margins of the Paraná Basin tend to show sodic affinity, containing mostly nefelinites, basanites and ijolites (Ribeiro et al., 2014).

5.2.1. The Alto Paranaíba Alkaline Province (APIP)

The APIP has several large carbonatite-bearing ultramafic complexes hosting world class multi-*commodity* mineralization, such as the Araxá Nb-P-REE-Ba(-U-Ti-Fe) deposit in western Minas Gerais, and Catalão I and II P-Nb-REE-Ti-Ba-vermiculite(-Ba-U-Fe) deposits in southern Goiás (Ribeiro et al., 2014).

The APIP carbonatite complexes consist of plutonic silicate rocks (dunites, wherlites, clinopyroxenites, bebedourites and syenites) phoscorites and carbonaties. Bebedourite, a hallmark of the alkaline-carbonatite complexes in the Province (Brod et al., 2000), is a mostly cumulate rock consisting mainly of diopside with variable amounts of phlogopite, perovskite, apatite, magnetite, melanite and sphene. The Salitre Complex illustrates different facies for this rock type, as compiled by Barbosa et al. (2012), and contains a P-Ti-Nb(-Fe) deposit.

Phlogopite picrites are considered the primitive liquids that produced the APIP carbonatite complexes (Brod et al., 2000). These rocks contain a carbonate-rich groundmass, evolving to carbonate globules or “pockets” of irregular shape, suggesting the separation of an immisciblecarbonate-rich liquid from the alkaline silicate magma.

The APIP kamafugites crop out mostly as the Mata da Corda Formation, consisting of lavas and pyroclastics (Sgarbi & Valença, 1993). These rocks often contain clasts or xenoliths of ultrabasic plutonic rocks, such as dunites, clinopyroxenites and bebedourites, typical rock types present in the APIP carbonatite complexes. Seer and Moraes (1988) suggested the association of these xenoliths to carbonatite-bearing complexes at depth.

5.2.2. The Goiás Alkaline Province (GAP)

The Goiás Alkaline Province (GAP) is located at the limit between the northern border of the Phanerozoic Paraná Basin and the Precambrian Brasilia Fold Belt, along a regional NW-trending lineament. Together with the APIP, the GAP is one of the largest areas of kamafugite occurrence in the world (Junqueira-Brod et al., 2004; Junqueira-Brod et al., 2005).

The GAP magmas intrude both Neoproterozoic Goiás Magmatic Arc and in Phanerozoic sedimentary rocks of the Paraná Basin (Fig. 5.01). Plutonic rock types dominate in the northern portion of the province, forming a series of ultramafic to mafic intrusions comprising dunite, peridotite, pyroxenite, gabbro, nepheline syenite, carbonatite, and lamprophyres. A representative example is the

Iporá (Morro do Macaco) intrusion, characterized by a dunite-wehrlite-clinopyroxenite-gabbro-nepheline syenite fractionation series (Danni, 1994).

Subvolvanic units are dominant in the central part of GAP. They occur in two main areas: near the Amorinópolis City and in the Águas Emendadas region. The magmas are perpotassic to sodic-potassic. The Amorinópolis occurrence is characterized by cylindrical intrusions of basanitic to tephritic composition, with radial melanephelinite and melaleucitite dykes preceding the main intrusion (Brod et al., 2005).

Volcanic units dominate the southern region of the GAP. The main rocks types are breccia pipes, leucitite flows, melaphelinite, alkali basalt, lamprophyre and trachyte, distributed in the vicinities of the Santo Antônio da Barra city. Kamafugites are an important rock type in the lavas and pyroclastics sequence, as well as in diatremes (Danni & Gaspar, 1994).

Junqueira-Brod et al. (2005) associated the chemical characteristics of the GAP kamafugitic magmas to a two-stage magma ascent, with stops and differentiation by fractional crystallization, liquid immiscibility and magma mixing in both deep and shallow magma chambers. Part of this study relate the carbonate globules and vesicles present in these rocks with the preliminary process of carbonatite-silicate liquid immiscibility.

Due to the extensive weathering profiles developed in the region, the northern GAP ultramafic alkaline complexes are known prospects for lateritic Nickel. Nickel resources (Santa Fé, Morro do Engenho, Morro do Macaco, Água Branca and Montes Claros de Goiás complexes - Melfi et al., 1988; Ribeiro et al., 2014) are reported in the ferruginous saprolite and in the siliceous saprolite zones of the weathered profile (Oliveira, 1990). Morro Preto is an exception in the region, not only due to its carbonatite nature, but also due to the phosphate mineralization present in the magnesiocarbonatite sequences, both in fresh rock and in the weathering profile.

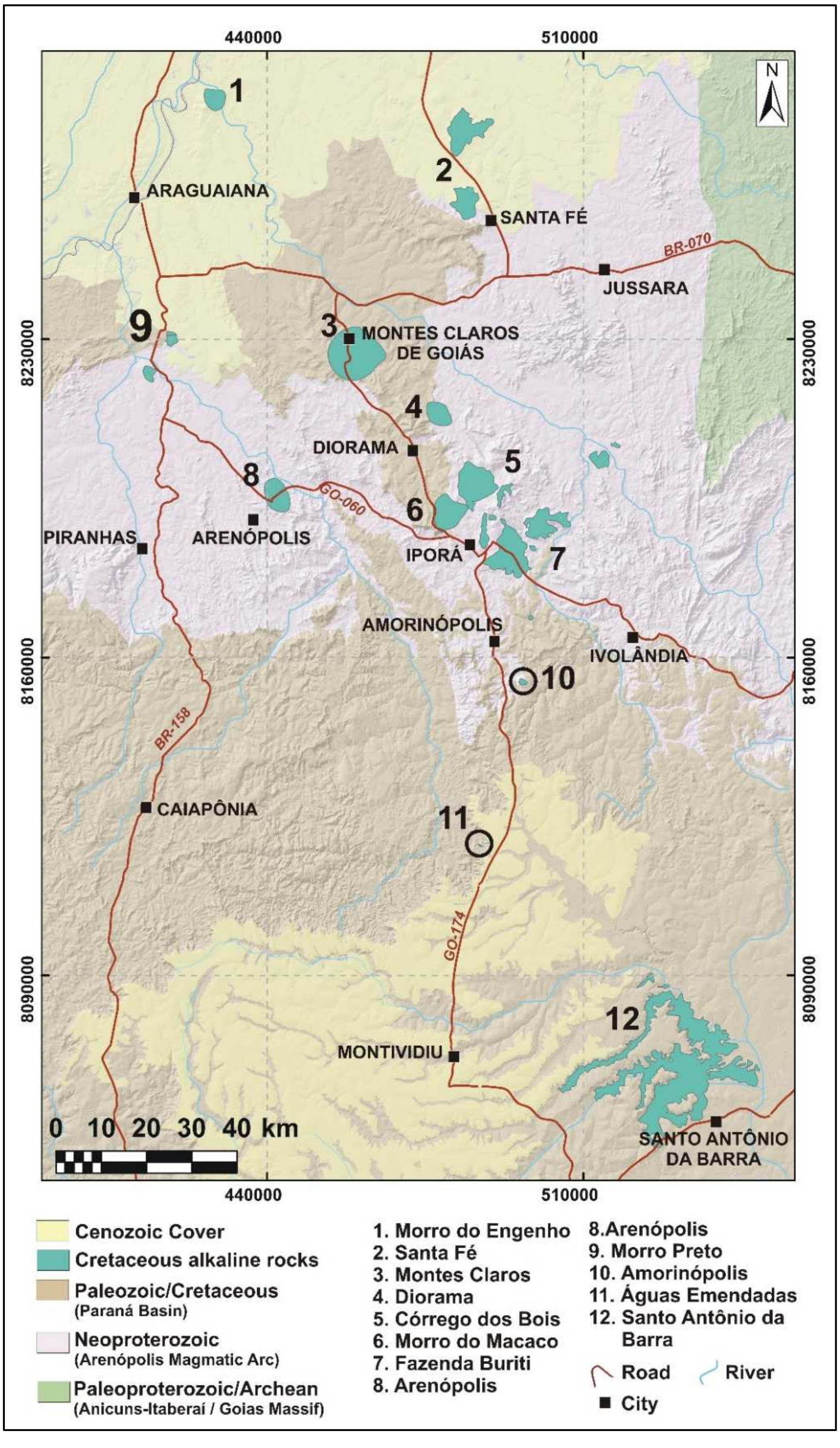

Fig. 5.01. Simplified geological map of the Goias Alkaline Province with the main locations of the northern plutonic complexes, including Morro Preto Complex, the subvolcanic rocks in the central portion and the volcanic pyroclastics in the southern portion. (Modified from Lacerda Filho et al., 1999, and Brod et al., 2005).

5.2.3. The Morro Preto Carbonatite Complex

The Morro Preto Complex, located in the northwestern margin of GAP, consists of two sub-circular intrusions 5km away from one another (Fig. 5.02), at approximately 38 km north from Piranhas City. Both intrusions have ring-like characteristics, positive topography (50 to 100m in height), and are hosted in orthogneiss and metavolcanic rocks from the Neoproterozoic Arenópolis Magmatic Arc (Pimentel et al., 1997). Part of the northern intrusion is also in contact with Devonian sandstones of the Furnas Formation.

The carbonatites are dominant in the Complex and comprise magnesiocarbonatite to barium-rich ferrocarbonatite. They vary from cumulate-textured magnetite apatite magnesiocarbonatites, locally grading into apatitite and magnetitite, to magnesiocarbonatite with Fe-dolomite and cryptocrystalline apatite (Nascimento et al., 2018). The topographic highs are dominated by ankerite ferrocarbonatite containing minor siderite. The apatite magnesiocarbonatites host phosphate mineralization, with a grade of up to 22.36 wt.% P_2O_5 in a meter interval, and intercepts with up to 48m @ 11.4% P_2O_5 (Fig. 5.02).

Near the contact with carbonatites, mafic to intermediate basement rocks are converted in felsic and mafic fenites, and sometimes incorporated as fragments in a carbonatite breccia. Xenoliths of carbonatized basement rocks may occur within the carbonatites. Earlier-formed carbonatites are locally fenitized by late carbonatite intrusions or other alkaline-related fluids.

Kamafugite dykes commonly crosscut the entire complex, but predominate in the southern intrusion. They were observed mostly in drill cores, with rare outcrop occurrences in the Morro Preto South (Fig. 5.02). Due to the limited information from drill core data, we were not able to establish the distribution of these dykes in the geological map.

Magmatic features such as flow orientation of phenocrysts are common. Rare differentiated terms show an increase in groundmass carbonate, sometimes evolving to a silicocarbonatite. Part of these dykes host carbonate globules.

Bebedourite, a common rock-type in kamafugitic carbonatite complexes (e.g. Brod et al., 2000; Barbosa et al., 2012), was found as a xenolith in one thin section of a carbonate-rich kamafugite.

The deep weathering in the region resulted in a thick saprolite / soil profile, often overlain by silexite. Navarro et al. (2014) describe the altered portion of the Morro Preto South as a saprolite filled with quartz and/or chalcedony, apatite and crandallite, and in minor proportion, carbonate, anatase and barite.

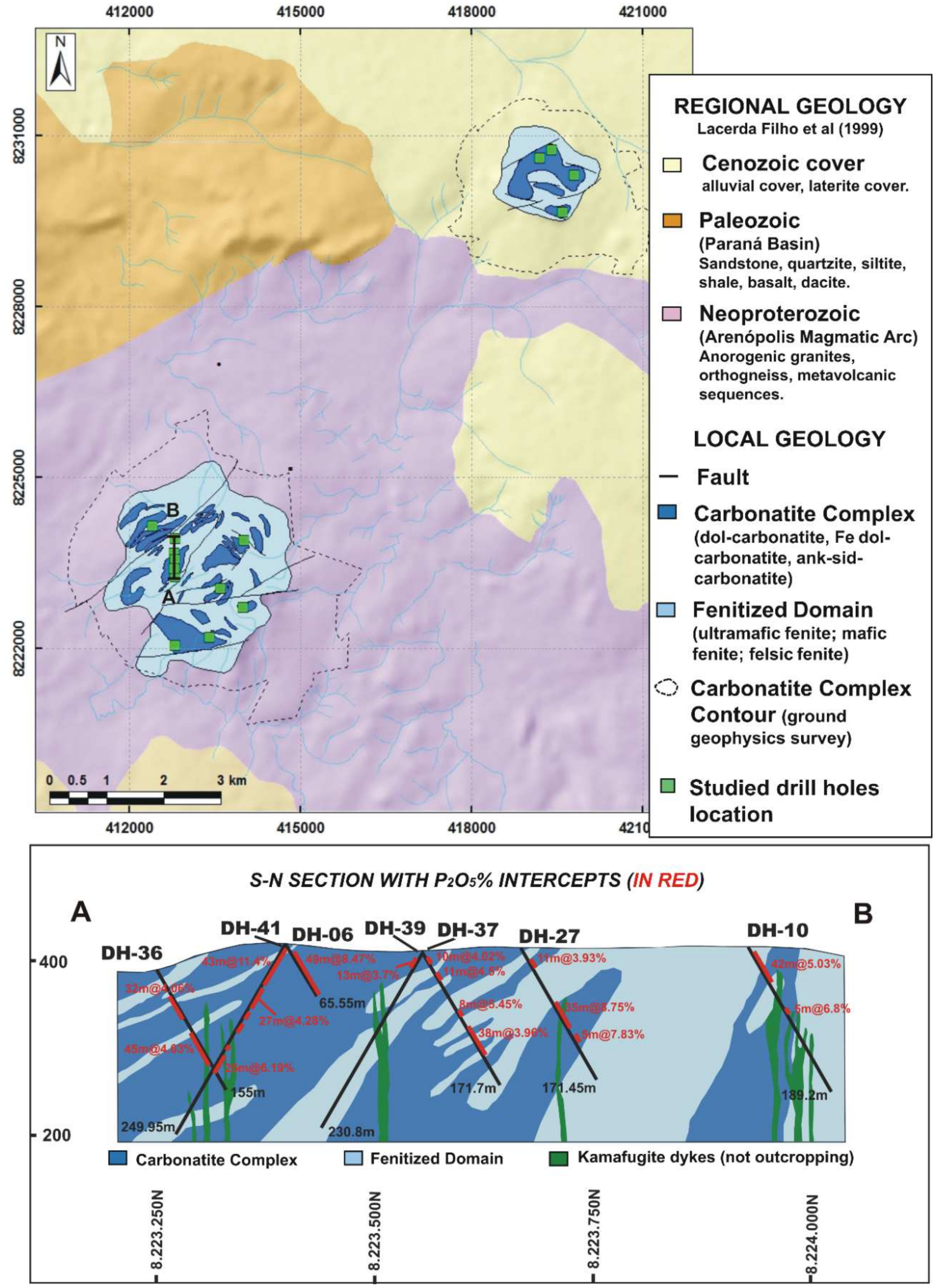

Fig. 5.02. Simplified Geological Map of the Morro Preto Complex and S-N section in the central part of Morro Preto South, highlighting the kamafugite dykes intercepted in the drill cores and the phosphate grade intercepted.

5.3. METHODS

The rocks used for the petrographic, geochemical and microprobe analyses were drill core samples from Anglo American Brazil Ltda. – Brazil Exploration Office. 19 samples out of a group of 9 drill cores were thin-sectioned for transmitted and reflected polarizing light petrography, and crushed for whole-rock geochemistry. Sample preparation was carried out at the Acme preparation facility in Goiânia, Brazil. Chemical analyses were conducted by Acme Labs in Vancouver, Canada, on samples fused at 1000°C using a mix of 0.2g of sample and 1.5g of 80:20 lithium metaborate/tetraborate. Major element oxides were determined by ICP-AES and 29 trace elements by ICP-MS. 27 chalcophile elements and precious metals were determined following digestion in aqua regia using a 30g pulp. Loss on Ignition (LOI) is reported as a percentage of weight loss on a 1g sample split, ignited at 1000°C. Total carbon and sulfur were determined with LECO IR furnaces on a 0.2g sample split. Total errors for the reference material were validated inside the 2α level parameter.

Four carbon-coated thin sections were selected for compositional maps and semi-quantitative mineral chemistry analysis by energy-dispersive X-ray spectroscopy (EDS) with a JEOL JXA-8230 electron probe microanalyzer (EPMA) at the Regional Center for Technological Development and Innovation (CRTI), Goiás University (UFG). Operating conditions were 15kV and 20nA.

5.4. PETROGRAPHY

The kamafugite dykes from the Morro Preto Carbonatite Complex vary from aphanitic to strongly porphyritic. The main phenocrysts phases are olivine, clinopyroxene and apatite. Three rock varieties were recognized:

- The least differentiated samples are mafurites (Fig. 5.03A and 5.03B), with olivine (10 to 25 modal %) and clinopyroxene phenocrysts (max. 5 % of the total phenocrysts), set in a cryptocrystalline to microcrystalline groundmass of serpentinized olivine, clinopyroxene, apatite, phlogopite, Ti-magnetite, variable amounts of feldspathoids and carbonate, and minor perovskite and melilite. Olivine and clinopyroxene are variably altered to serpentine, phlogopite, and chlorite.
- Evolved kamafugites are mafurites to ugandites (Fig. 5.03C), with 5 to 25 modal % of clinopyroxene phenocrysts, sometimes oriented by magmatic flow. Olivine phenocrysts are rare or absent. These samples also have apatite phenocrysts with carbonate melt inclusions.

The groundmass is enriched in clinopyroxene, feldspathoids (melilite, leucite and nepheline) with K-feldspar and zeolite intergrowths, apatite, phlogopite, Ti-magnetite and minor carbonate.

- Carbonate-rich kamafugites are often altered, with clinopyroxene and olivine pseudomorphosed by a mixture of clay minerals and carbonate (Fig. 5.03D). The groundmass is cryptocrystalline and enriched in carbonate, with minor amounts of chlorite, phlogopite and serpentine.

Olivine phenocrysts and groundmass grains are often subhedral to euhedral, with rare occurrences of larger (up to 0.5 cm), zoned phenocrysts with corroded borders, sulphide inclusions and often altering to serpentine.

Clinopyroxene phenocrysts are usually euhedral and zoned, having variable apatite, sulphide (pyrite) and magnetite inclusions. Part of the phenocrysts have corroded borders. The microcrysts in the groundmass occur both individually, sometimes zoned, and as glomeroporphyritic aggregates.

Ti-magnetite and minor perovkite occur mostly as euhedral phenocrysts in the groundmass. These euhedral Ti-magnetite grains have chromite inclusions in the kamafugites with higher olivine content (mafurites). Chromite is also present as inclusions in both olivine and clinopyroxene phenocrysts.

Clinopyroxene microcrysts, phlogopite and intergrowths of feldspathoids-K-feldspar-zeolite are the main intersticial phase in the groundmass, along with minor Ti-magnetite. Phlogopite usually occurs as euhedral microcrysts or forming aggregates with Ti-magnetite, and more rarely in agglomerates of Ti-magnetite, leucite pseudomorphs and clinopyroxene (Fig. 5.03F). Junqueira-Brod et al (2005) also report “cloudy” masses of leucite and pseudoleucite (K-feldspar-analcime-nepheline intergrowths) in mafurites from GAP.

Interstitial glassy material is always present in the groundmass and often shows a “cracked” appearance and a silica-aluminous composition suggesting the presence of clay minerals in the devitrified material.

All three types of Morro Preto kamafugites contain 5 to 20 modal % of immiscible carbonate globules (Fig. 5.03E), up to 1mm in size. The globules consist of aggregates of microcrystalline zoned carbonate grains, commonly with euhedral crystals (pseudoleucite/zeolites?) in the borders (Fig. 5.03E).

Similar features were described from the APIP. Seer & Moraes (1988) reported clinopyroxenite xenoliths with euhedral nepheline and zeolite in irregular cavities in the Mata da Corda volcanics, and Sgarbi & Valença (1993) mentioned euhedral hexagonal grains as kalsilite pseudomorphs (altering to harmononite), also from Mata da Corda. In the Morro Preto rocks the carbonate globules are usually surrounded by an alteration halo formed by an aluminous silicatic mass, and more rarely in contact with phlogopite and clinopyroxenes microcrysts.

The Morro Preto kamafugites contain cm-sized xenoliths of apatite magnesiocarbonatite and xenoliths of clinopyroxene + phlogopite cumulates (Fig. 5.03D), which are petrographically similar to the bebedourites described from the kamafugite-carbonatite association in the nearby Alto Paranaíba Igneous Province (Brod et al., 2000; Barbosa et el., 2012).

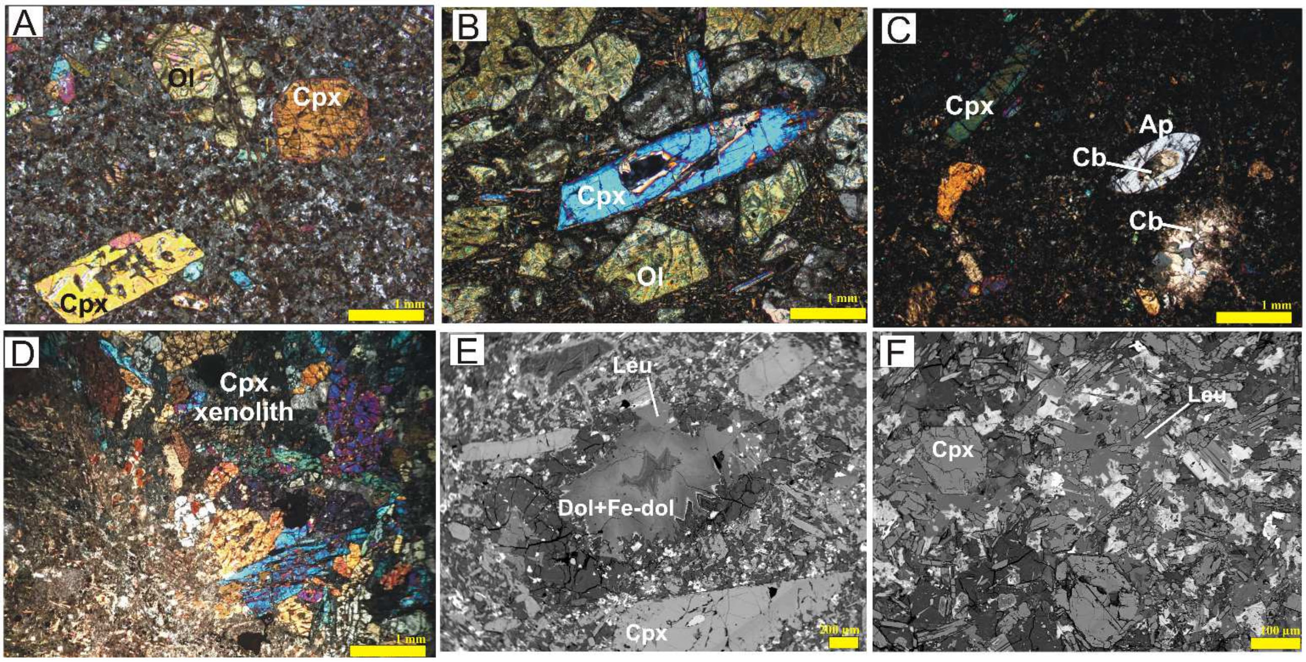

Fig. 5.03. Thin sections from Morro Preto Complex kamafugite samples. (A) Mafurite with zoned clinopyroxene phenocrysts and minor serpentinized olivine phenocrysts. (B) mafurite with olivine and clinopyroxene phenocrysts, with their orientation defining a flow texture. (C) Mafurite with immiscible carbonate globules and carbonate melt inclusions in apatite phenocrysts. (D) Bebedourite xenolith in carbonated mafurite. (E) Backscattered electron image of carbonate globule with a halo enriched in carbon, silica and alumina. (F) Backscattered electron image of aggregates of anhedral leucite, clinopyroxene and phlogopite scattered in the amorphous dark grey groundmass (Ap=apatite, cb=carbonate, chr=chromite, cpx=clinopyroxene, Dol=dolomite, Fe-dol=Fe-dolomite ks=kalsilite, leu=leucite, mel=melilite, mt=magnetite, ol=olivine).

5.5. MINERAL CHEMISTRY

5.5.1. Compositional Maps

The mineralogy of Morro Preto kamafugites was detailed using a combination of EDS analyses and compositional maps. The latter allowed the understanding of textural features such as compositional variation and intergrowths in the groundmass, zoning of phenocrysts and the mineralogical variety in possivle melt inclusions and in carbonate globules.

The primary constituent of the groundmass is composed of anhedral masses of alumino-silicate material with subordinate CaO, MgO and FeO. The “cracked” appearance of these masses indicates that the original material (possibly glass) was replaced by a clay mineral, with associated volume changes. Scattered throughout these masses are anhedral to subhedral olivine and clinopyroxene microcrysts, subhedral Ti-magnetite, phlogopite altering to tetraferriphlogopite, apatite lamellae, feldspathoids, and traces of carbonate and perovskite. The orignal feldspathoids (melilite, leucite/kalsilite) are often altered to sodic phases (nepheline+analcime) intergrown with K-feldspar (Fig. 5.04A to 5.04F). Part of these intergrowths are also enriched in carbonates.

The zoned clinopyroxenes consist of diopside cores, with the augite component increasing toward the rims (see section 5.2.2).

The carbonates from the immiscible globules have a composition range similar to that of carbonates in the Morro Preto carbonatites (Fig. 5.05A to 5.05C), consisting of dolomite cores and Fe-dolomite rims, with minor strontianite. Part of these globules probably underwent late-stage alteration, forming secondary phases, such as siderite, barite and traces of quartz. The glassy halo surrounding most part of these globules have a bulk composition similar to the main aphanitic matrix material, but with higher C content (Fig. 5.05B). A carbonate rounded inclusion within an apatite phenocryst shows composition and zoning patterns similar to those found in the globules. These inclusions possibly represent a crystallized carbonate melt inclusion (Figs. 5.05C to 5.05F). The fracture filling with an aluminous phase both in the apatite and in the inclusion attest to a late-stage alteration.

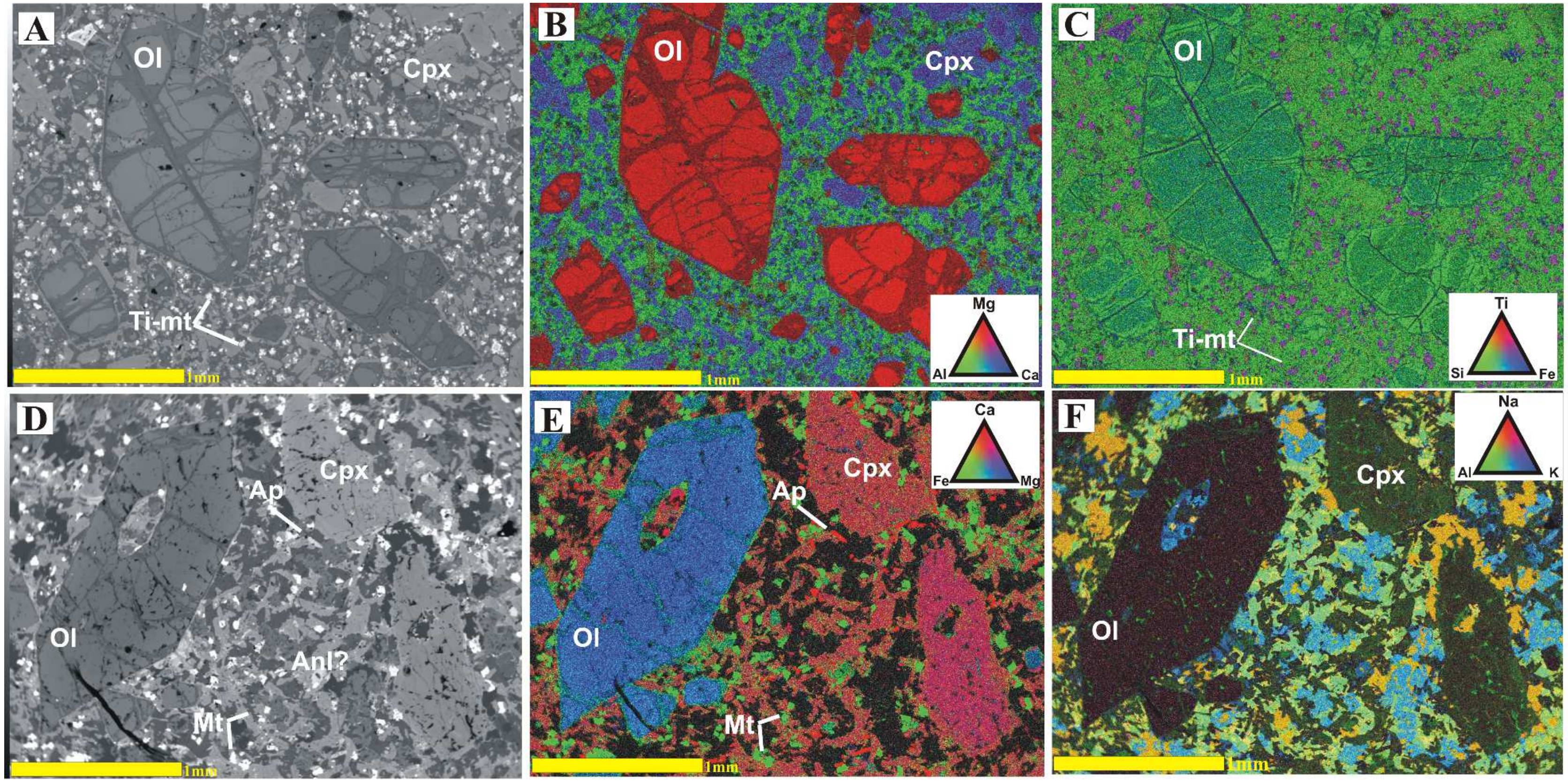

Fig. 5.04. (A) Backscattered electron imaging (BSE) of a phenorcyst-rich domain in a mafurite sample, characterized by (B) Mg-rich olivine (red) and diopside clinopyroxene phenocrysts (light blue) in an aphanitic mass of aluminous-silicate composition (green), and (C) Ti-magnetite grains (purple) scattered in the groundmass. (D) BSE image of a mafurite sample with Mg-olivine phenocrysts, diopside phenocrysts with a (E) background enriched in Ti-magnetite (green) and apatite lamellae (red). (F) Discrete Al and Fe increase in the clinopyroxene rims (dark green core grading to a light green rim), and anhedral K-feldspar + melilite + analcime + leucite/kalsilite intergrowth (light blue) altering to K-feldspar-nepheline+analcime intergrowth in the background (yellow). Ti-mt= Ti-magnetite; other minerals abbreviations as in Fig. 5.03.

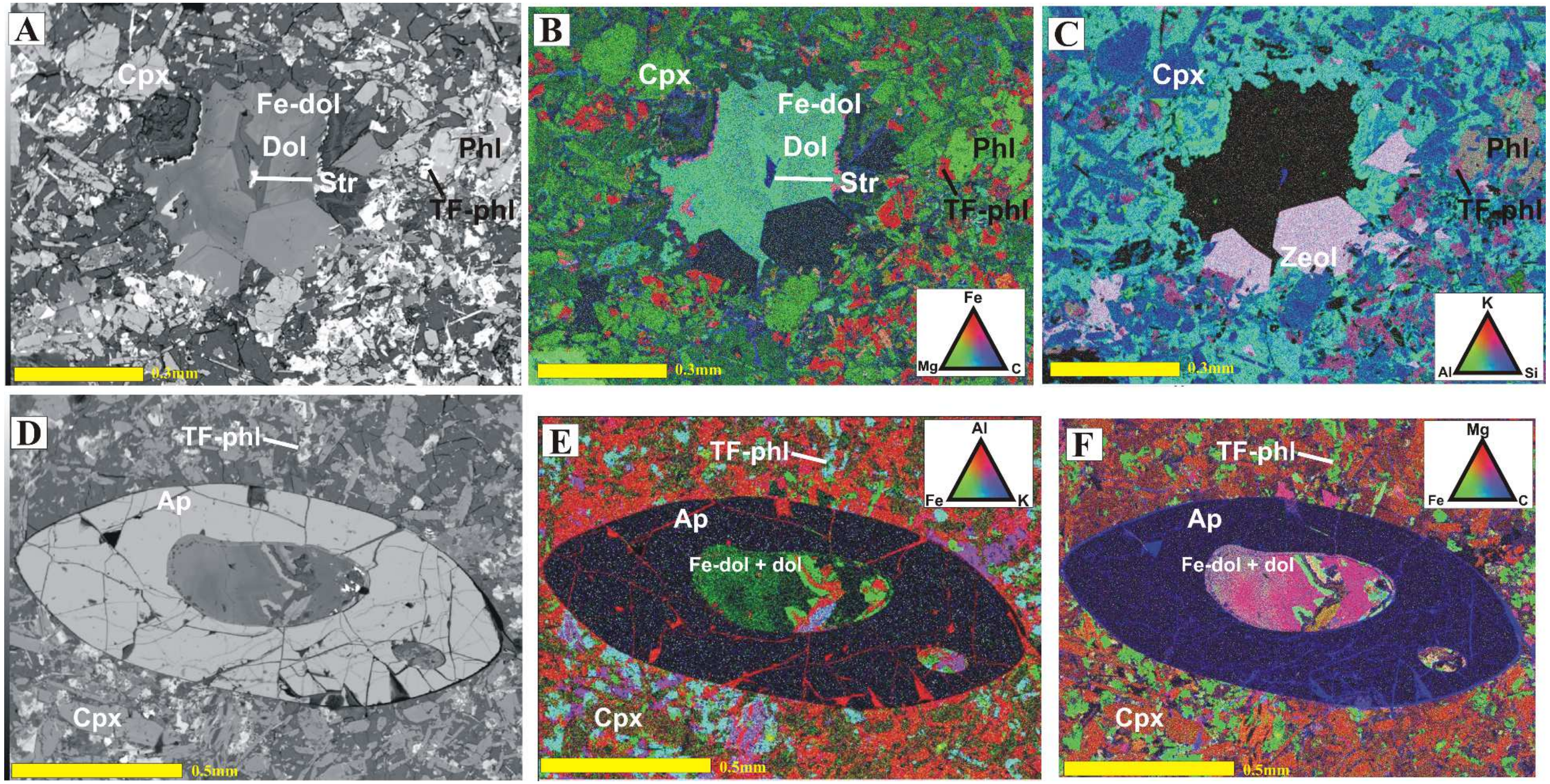

Fig. 5.05. (A) Backscattered electron imaging (BSE) of a carbonate globule, in a leucite mafurite-ugandite sample, with (B) internal iron zoning patterns and euhedral pseudoleucite/zeolite grains surrounding the globule. Detail of the (C) aluminous-silicate composition of the aphanitic matrix (light blue), increasing the carbon content in the globule halo. (D) apatite phenocryst with carbonatite melt inclusion, showing (E and F) iron zoning in the carbonate domain (Phl= phlogopite, TF-phl= tetraferriphlogopite, Str=strontianite; Zeol=zeolith (montessomaite); other minerals abbreviations as in Fig. 5.03).

5.5.2. EDS analyses

Semi-quantitative, energy-dispersive X-ray spectroscopy (EDS) analyses of clinopyroxenes and olivines from the Morro Preto kamafugite dykes indicate that the compositional ranges of these minerals is comparable to the available data in kamafugite samples from both GAP and APIP. The data for GAP kamafugites from Santo Antônio da Barra, Águas Emendadas, Amorinópolis and Fazenda Buriti were extracted from Brod et al. (2005), and the and data for the APIP phlogopite picrites and Mata da Corda kamafugites from Brod et al. (2005), Sgarbi & Valença (1993) and Sgarbi et al. (2000).

Tables 5.01 and 5.02 display the EDS semi-quantitative results of 4 thin sections. Two of the samples are mafurites (1234029 and 1234053), enriched in olivine and minor clinopyroxene phenocrysts. One of the samples is a carbonatized kamafugite with a bebedourite (clinopyroxenite + phlogopite) xenolith (1234039); and the forth sample is a ugandite rich in carbonate globules and containing clinopyroxene phenocrysts but lacking olivine phenocrysts, (1234046). This latter sample also contains minor apatite phenocrysts with carbonate melt inclusions.

Olivine

The Morro Preto olivine phenocrysts have a chrysolite composition, ranging from Fo_{75} to Fo_{90} (Fig. 5.06A), consistent with the ultramafic character of the host rock. They show a composition range similar to that observed in olivine contained in mafurites from Águas Emendadas and Santo Antônio da Barra (Brod et al., 2005). Their forsterite content range is wider than other GAP kamafugites (76.9 to 83.5 mol% Fo – Brod et al., 2005), and higher than that of olivines in the ultramafic silicate complexes of the northern GAP.

The forsterite content correlates positively with NiO and Cr_2O_3 wt.%, and negatively with CaO and MnO. The high CaO, MnO (up to 0.52 and 0.78 wt.%, respectively) and the relatively low NiO contents is consistent with that observed in other kamafugite-carbonatite association rocks. Fig. 5.06B shows the Ca variation with forsterite content for olivine, indicating a significant Ca variation for a restricted Fo content, as also observed for the GAP mafurites (Brod et al., 2005).

The Morro Preto kamafugite olivines vary notably in one single sample. The euhedral to subhedral olivine phenocrysts (Fig. 5.04A to C) have up to 17.2 wt.% FeO whereas larger corroded olivine crystals in the same sample an average of 12 wt.% FeO.

There is no evidence of large compositional variation between the phenocrystic and groundmass olivine. Even though zoning was not observed optically in phenocrysts, the EDS results show a subtle decrease in forsterite content from core to rim of the larger and corroded phenocrysts, similar to the olivines with normal zoning from the Águas Emendadas kamafugites (Junqueira-Brod et al., 2000).

Pyroxene

The composition of the pyroxenes from Morro Preto kamafugites plot in the range of the quadrilateral Ca-Mg-Fe (Q) pyroxene group in the Q x J diagram (Fig. 5.07A) and in the diopside field in the quadrilateral pyroxene diagram (Morimoto et al., 1988 - Fig. 5.07B). No systematic difference was observed between phenocrysts and groundmass grains.

The Morro Preto diopside has variable contents of Al_2O_3 (3 to 14.36 wt.%) and TiO_2 (0.85 to 3.88 wt.%). Diopside from the most evolved (olivine-lacking) rocks has the highest alumina content (6.32 to 14.36 wt.% Al_2O_3), which is higher than in clinopyroxene from other GAP kamafugites (0.55-8.5 wt.%). Na_2O (0.36 to 1.36 wt.%), Cr_2O_3 (0 to 0.6 wt.%) and NiO (up to 0.44 wt.%) contents are also present in minor amounts.

As detailed in Fig. 5.04D to 5.04F, part of the kamafugites contain normally-zoned phenocrysts, i.e., diopsidic cores with increasing aegirine-augite component toward the rims. The iron zoning, however, may be oscillatory in some cases, suggesting the influence of both hedenbergite and aegirine-augite molecules.

The composition of the clinopyroxenes in the bebedourite xenolith is similar to the kamafugite clinopyroxenes, but displays a narrower range in the Ca-Mg-Fe and in the Na-Mg-Fe systems (Fig. 7.07C and 7.07C). Their Al_2O_3 (2.75 to 8.12 wt.%) and TiO_2 (0.98 to 2.88 wt.%) content are lower than those in kamafugite pyroxenes.

Figure 5.07D shows a comparison of Morro Preto clinopyroxenes with those of other alkaline-carbonatite complexes (Salitre – Barbosa et al., 2012) and carbonatite provinces (Reguir et al., 2012), in the the aegirine (Ae)-diopside (Di) -hedenbergite (Hd) system. The Morro Preto analyses show a moderate Hd enrichment, as also observed in Salitre bebedourites and in GAP kamafugites, but without the typical aegirine enrichment of pyroxenes in carbonatites.

SAMPLE	Img2-053_Ol_EDS_6	Img4-053_Ol_INC_16	Img4-053_Ol_INC_34	Img1_029_EDS_14
	Ol1	**Ol2-CORE**	**Ol2-RIM**	**Ol2**
SiO2	39.21	40.22	42.92	44.01
TiO2	0.04	-	0.12	0.2

Al2O3	0.14	0.16	0.58	0.63
Cr2O3	0	0.15	-	0.07
FeO	16.71	10.15	11.91	10.92
NiO	0.33	0.3	0.38	0.16
MnO	0.36	0.26	0.22	0.32
MgO	42.46	48.24	43.36	43.05
CaO	0.42	0.18	0.31	0.33
Na2O	0.34	0.31	0.2	0.21
K2O	-	0.03	-	0.1
Total	100	100	100	100
a.p.f.u.				
Si	1.989	1.966	2.240	2.331
Ti	0.002	-	0.005	0.008
Al	0.008	0.009	0.036	0.039
Cr	0.000	0.006	-	0.003
Fe	0.709	0.415	0.520	0.484
Ni	0.013	0.012	0.016	0.007
Mn	0.015	0.011	0.010	0.014
Mg	3.210	3.515	3.374	3.399
Ca	0.023	0.009	0.017	0.019
Na	0.033	0.029	0.020	0.022
K	0.000	0.002	-	0.007
Total	4.013	4.008	3.992	3.993

Table 5.01. Composition of the olivine from Morro Preto kamafugites. Microprobe EDS semi-quantitative data.

SAMPLE	Img1-053_CPX_EDS_11	Img1-053_CPX_EDS_16	Img4_046_CPXE_12	Img5_039_CPX_13
	CORE	**RIM**	**CPX_PHENO**	**CPX_XEN**
SiO2	49.19	45.85	45.75	48.09
TiO2	1.23	2.76	2.73	2.05
Al2O3	5.39	7.99	6.77	5.59
Cr2O3	0.39	-	-	0.14
FeO	5.07	7.19	9.28	5.74
NiO	0.18	0.19	0.06	0.15
MnO	0.07	0.09	0.54	0.32
MgO	15.17	11.98	10.66	13.16
CaO	22.87	23.31	23.30	23.81
Na2O	0.40	0.51	0.91	0.91
K2O	0.04	0.12	-	0.04
Total	100.00	100.00	100.00	100.00
a.p.f.u.				
Si	1.820	1.723	1.742	1.797
Ti	0.034	0.078	0.078	0.058
Al	0.235	0.354	0.304	0.246

Cr	0.011	-	-	0.004
Fe	0.157	0.226	0.296	0.179
Ni	0.005	0.006	0.002	0.005
Mn	0.002	0.003	0.017	0.010
Mg	0.837	0.671	0.605	0.733
Ca	0.906	0.939	0.951	0.953
Na	0.014	0.019	0.034	0.033
K	0.001	0.003	-	0.001
Total	4.023	4.022	4.028	4.020

Table 5.02. Composition of the pyroxene from Morro Preto kamafugites and bebedourite xenoliths. Microprobe EDS semi-quantitative data.

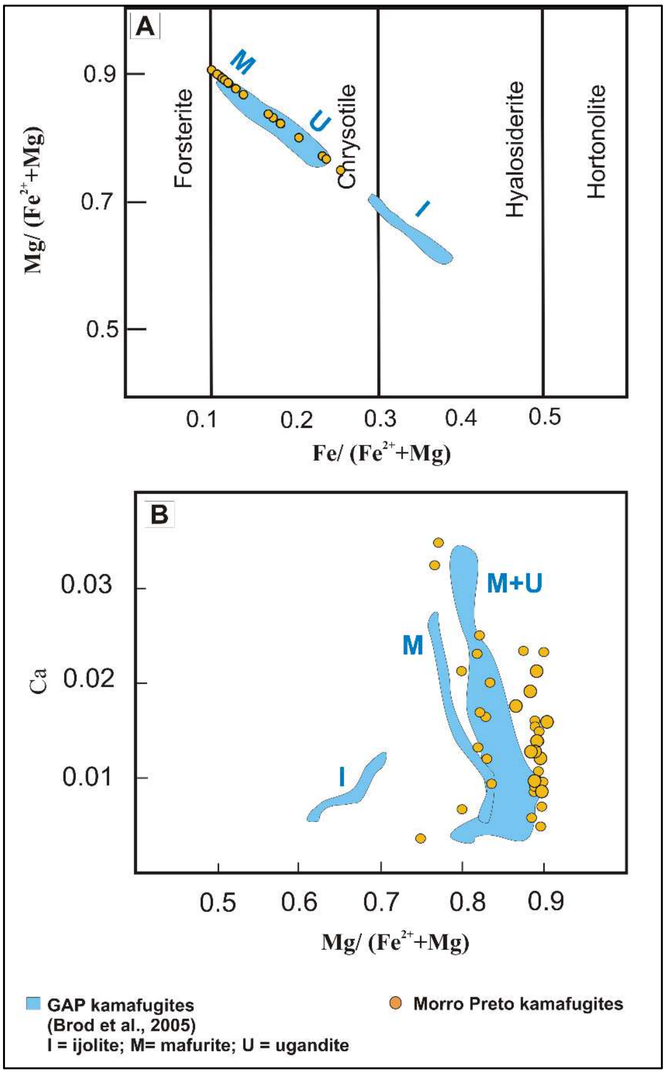

Fig. 5.06: (A) classification and zoning patterns of olivines from Morro Preto kamafugites, and comparison with the main kamafugite occurrences from GAP. (B) Ca (a.f.u.) versus Fo (mol%) in olivine from the Morro Preto kamafugites compared

with the GAP kamafugites. Data sources: Danni & Gaspar (1994), Cerqueira & Danni (1994), Junqueira-Brod (1998) and Brod et al. (2005).

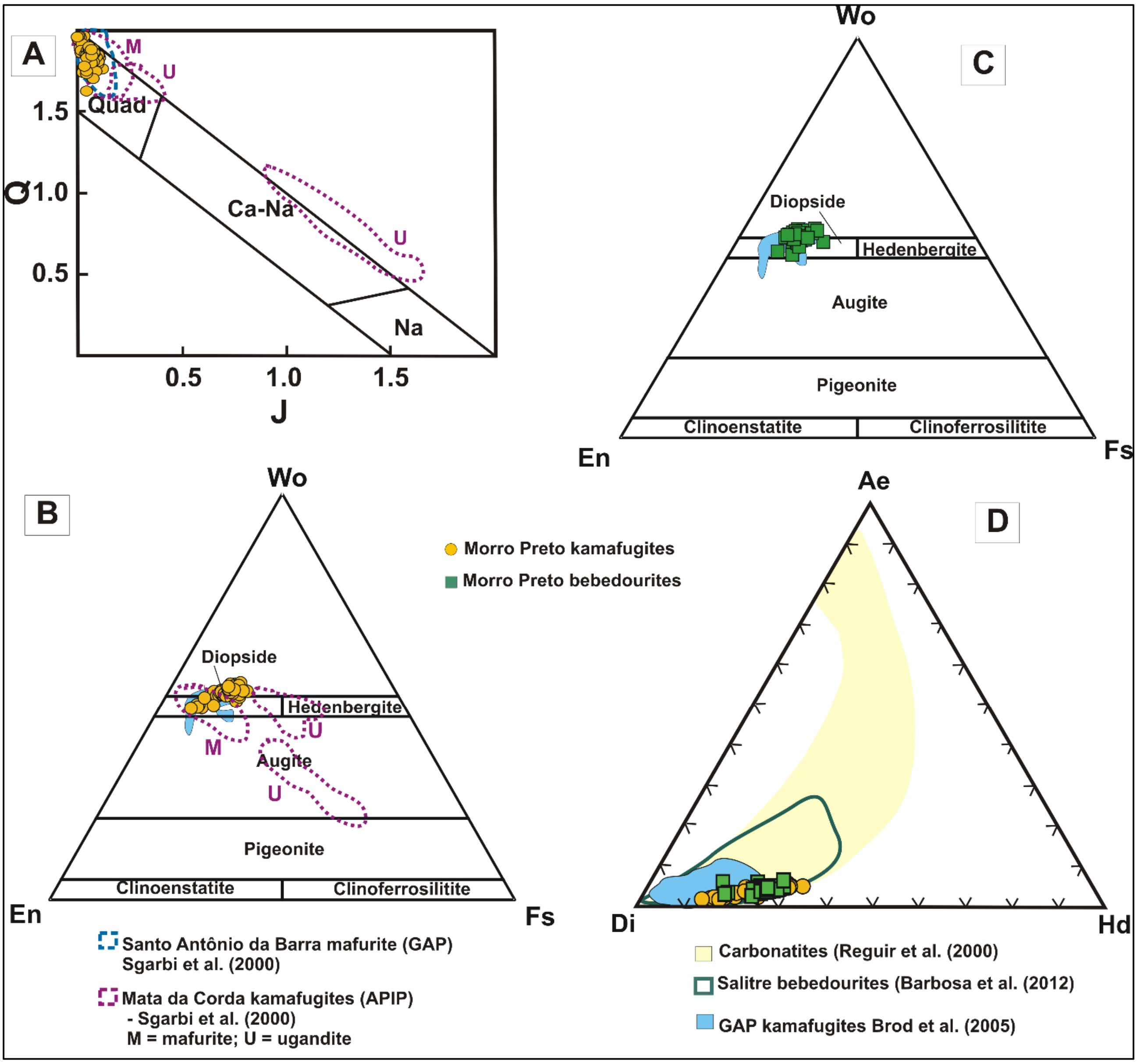

Fig. 5.07. Morro Preto kamafugite pyroxenes plotted in the (A) Q x J diagram quadrilateral and in the (B) wollastonite (Wo)-Enstatite (En)-Ferrosilite (Fs) diagram, compared with the Santo Antônio da Barra and Mata da Corda pyroxenes. (C) Wollastonite (Wo)-Enstatite (En)- Ferrosilite (Fs) diagram and (D) Aegirine (Ae) –diopside– (Di) hedenbergite (Hd) diagram showing the composition of pyroxenes in the Morro Preto bebedourite xenolith, in comparison with the GAP kamafugites, Salitre bebedourites and worldwide carbonatites.

5.6. GEOCHEMISTRY

A total of 18 drill core samples were selected for whole-rock chemical analysis (Table 5.03). The Morro Preto kamafugites are ultrabasic, silica-undersaturated (SiO_2 varying from 31.28 to 44.9 wt. %), ultrapotassic (K_2O varying from 1.12 to 5.19 wt. %), enriched in CaO (up to 16.2 wt.%) and carbonate (CO_2 up to 16.8 wt. %), with moderate TiO_2 content (0.38 to 2.93 wt.%). Their MgO content varies from 6.7 to 12.6 wt. % which is, on average, lower than the MgO content from the GAP alkaline picrites (Danni, 1994). All samples have <13% MgO and MgO/(MgO+FeO) <0.7, indicating a more differentiated composition when comparing with the GAP alkaline picrites. Their K_2O/Na_2O ratio are on average >3, and they are enriched in incompatible elements, such as Ba, Sr and ΣREE.

Figure 5.08 shows the Morro Preto kamafugite samples in the classification diagrams of Foley et al. (1987) for ultrapotassic rocks. For these diagrams we constrained the Morro Preto samples to >9 wt.% MgO, as suggested by Brod et al. (2005), in order to exclude evolved rocks. The fields of GAP and APIP kamafugites are plotted for comparison. The majority our samples plot within the field of kamafugites (Group II of Foley et al., 1987), in generally good agreement with the kamafugites from GAP and from APIP. The Na_2O scattering in the Morro Preto kamafugites observed in Fig. 5.08 might be due to the sodic metasomatism overprint, as exemplified by the leucite-analcime transformation in the kamafugite rocks from Iporá (Danni, 1990; Brod et al., 2005), and also observed in the Morro Preto samples. Some of the samples are slightly more aluminousthan the GAP and APIP kamafugites.

Figure 5.09 shows that the major oxides of the Morro Preto samples follow the general trend shown by the GAP kamafugites. TiO_2 is an exception, with Morro Preto rocks plotting below the GAP kamafugite values. Sgarbi and Gaspar (2002) compared the Santo Antônio da Barra and the San Venanzo-Cupaello (Italy) kamafugites, observing a similarly low TiO_2 trend for the italian kamafugites.

Although the alkalis behave somewhat erratically, SiO_2, Al_2O_3, CaO, Fe_2O_3 and P_2O_5 depict a normal crystal fractionation trend, as magnesium decreases, following the removal of olivine, at first, and then olivine + cpx during kamafugite differentiation (Brod et al., 2005).

On average, the mineralogy and compositional range of the Morro Preto rocks are similar to the GAP mafurites and leucite mafurites (Junqueira-Brod et al., 2005), indicating their intermediate position in the kamafugite series. As also observed for the SAB kamafugites, the negative correlation of MgO, NiO, Cr_2O_3 with the Al_2O_3 and K_2O contents indicate the gradation from mafurites, rich in olivine, to ugandites, rich in feldspathoids and zeolites and poor in olivine (Sgarbi & Gaspar, 2002).

Figure 5.10 shows that the Morro Preto kamafugites, as well as the other GAP and the APIP kamafugites plot in the higher end of the enriched mantle compositions, away from subduction-related signatures, indicating that they derive from a relatively old, metasomatized lithospheric mantle that was not chemically involved in the Brasiliano orogenic cycle.

Kamafugite spiderdiagrams (Figure 5.11-A) have a small positive Sr anomaly, and small negative anomalies for Rb and K_2O, in an otherwise smooth pattern. The REE diagram pattern (Figure 5.11-B) shows a $La_{(n)}/Lu_{(n)}$ range between 28.3 and 15.9, in accordance with the other GAP kamafugites (Danni, 1985; Danni & Gaspar, 1994; Brod et al., 2005). Despite the higher Rb, Th and K_2O and a small positive Sr anomaly, the Morro Preto kamafugites have a compositional range similar to other kamafugitic rocks from GAP and from APIP (Sgarbi & Gaspar, 2002; Brod et al., 2005).

SAMPLE	1234007	1234025	1234020	1234046	1234029	1234066
(wt .%)						
SiO2	35.90	37.37	40.02	39.43	41.3	39.23
TiO2	2.43	2.18	2.62	2.86	2.53	2.93
Al2O3	8.48	6.98	10.56	13.37	11.56	11.63
Cr2O3	0.20	0.23	0.11	0.07	0.11	0.08
Fe2O3	11.09	11.54	11.6	11.17	11.44	12.57
MnO	0.17	0.18	0.19	0.16	0.19	0.22
MgO	12.20	12.56	12.4	8.63	11.61	8.63
CaO	12.59	14.43	11.11	8.97	10.83	11.17
Na2O	0.77	0.42	3.14	0.17	2.46	0.84
K2O	1.83	1.12	2.16	1.75	2.62	3.2
P2O5	0.58	0.56	0.57	1.09	0.65	0.96
BaO	0.13	0.10	0.12	0.14	0.20	0.20
SrO	0.13	0.21	0.14	0.12	0.27	0.18
LOI	13.3	11.90	5	11.7	4.00	7.8
TOT	99.56	99.54	99.54	99.4	99.33	99.28
CO2	11.3	9.34	3.8	5.2	2.31	5.4
S	0.14	0.10	0.04	0.18	0.05	0.21
(ppm)						
Ni	325.1	518.9	235.9	211.8	213.9	137.9
Sc	31	35.00	25	24	23	25
Rb	61.2	32.70	41	53.4	51.9	82.8
Zr	207.9	221.60	262.5	335.1	288.6	370.5
Hf	5.1	6.30	6.8	6.8	6.8	8.1
Nb	49.6	45.20	81.3	107.9	88.1	98.4
Ta	3.1	3.10	5.2	7.3	6	5.9
Th	5.3	4.00	7.7	10.5	8.5	9.6
Y	17.9	18.40	21.2	22.6	22.1	30.5
La	48.9	46.50	74.9	86.30	81.1	92
Ce	98.2	97.30	141.4	173.30	155.1	180.9
Pr	11.95	11.49	16.06	19.82	17.11	21.36
Nd	47.10	44.90	59.4	74.00	62.9	81.9

Sm	8.08	7.70	9.74	11.01	10.05	13.11
Eu	2.43	2.34	2.7	3.17	2.88	3.87
Gd	6.99	6.73	7.55	8.74	8.08	10.51
Tb	0.86	0.89	0.97	1.09	1.02	1.41
Dy	4.26	4.40	4.65	5.36	5.1	7.05
Ho	0.65	0.75	0.81	0.87	0.91	1.06
Er	1.54	1.86	2.04	2.04	2.11	2.87
Tm	0.21	0.21	0.27	0.27	0.3	0.36
Yb	1.14	1.28	1.63	1.63	1.76	1.99
Lu	0.18	0.17	0.23	0.22	0.23	0.31

Table 5.03. Representative analysis from the Morro Preto Complex kamafugite dykes.

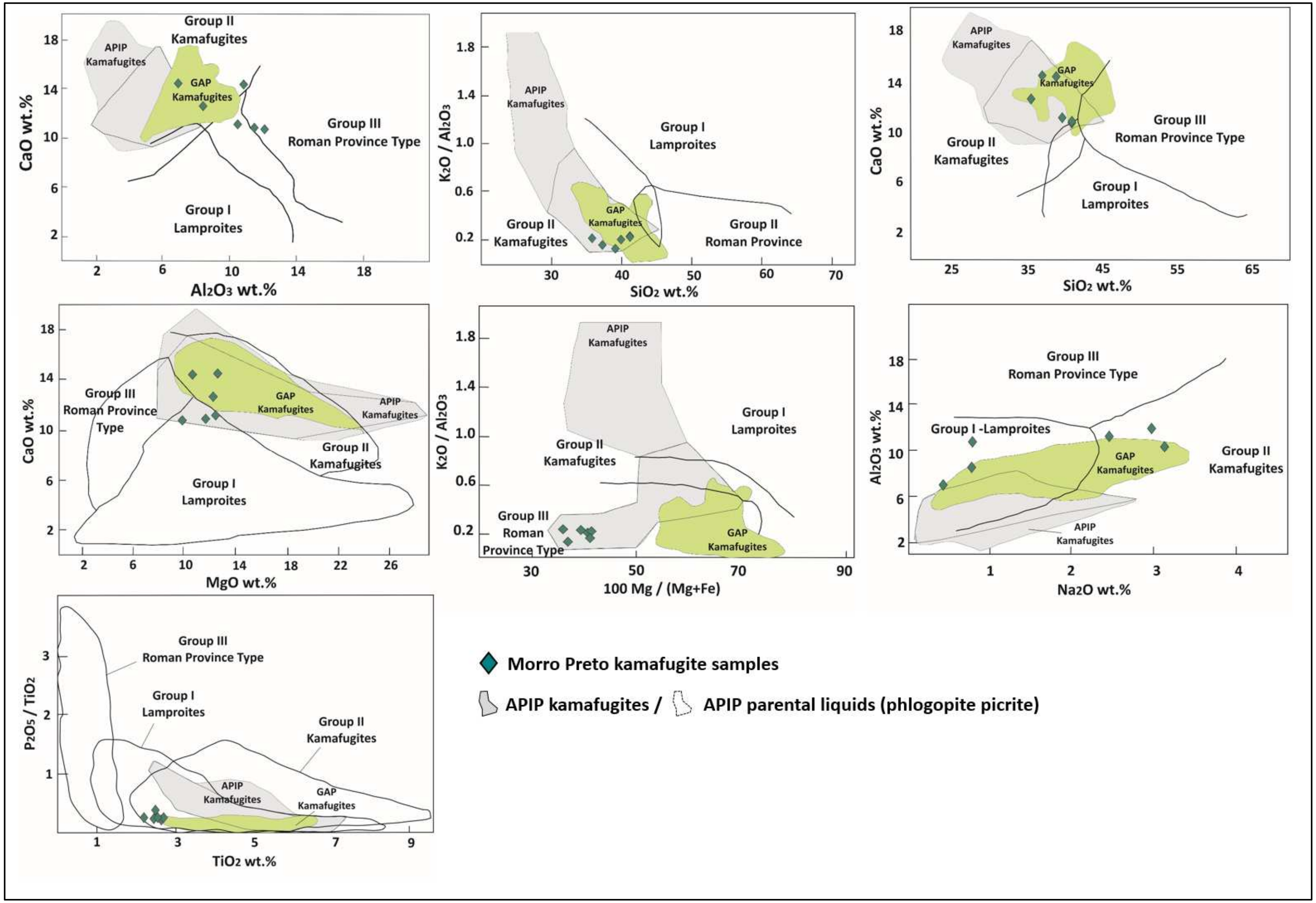

Figure 5.08. Ultrapotassic rock classification diagrams (Foley et al., 1987). The plotted Morro Preto samples are constrained by MgO > 9 wt.%. Data sources: Moraes (1984), Sgarbi & Gaspar (2002), Brod et al. (2005). *Adapted from*: Brod et al. (2005).

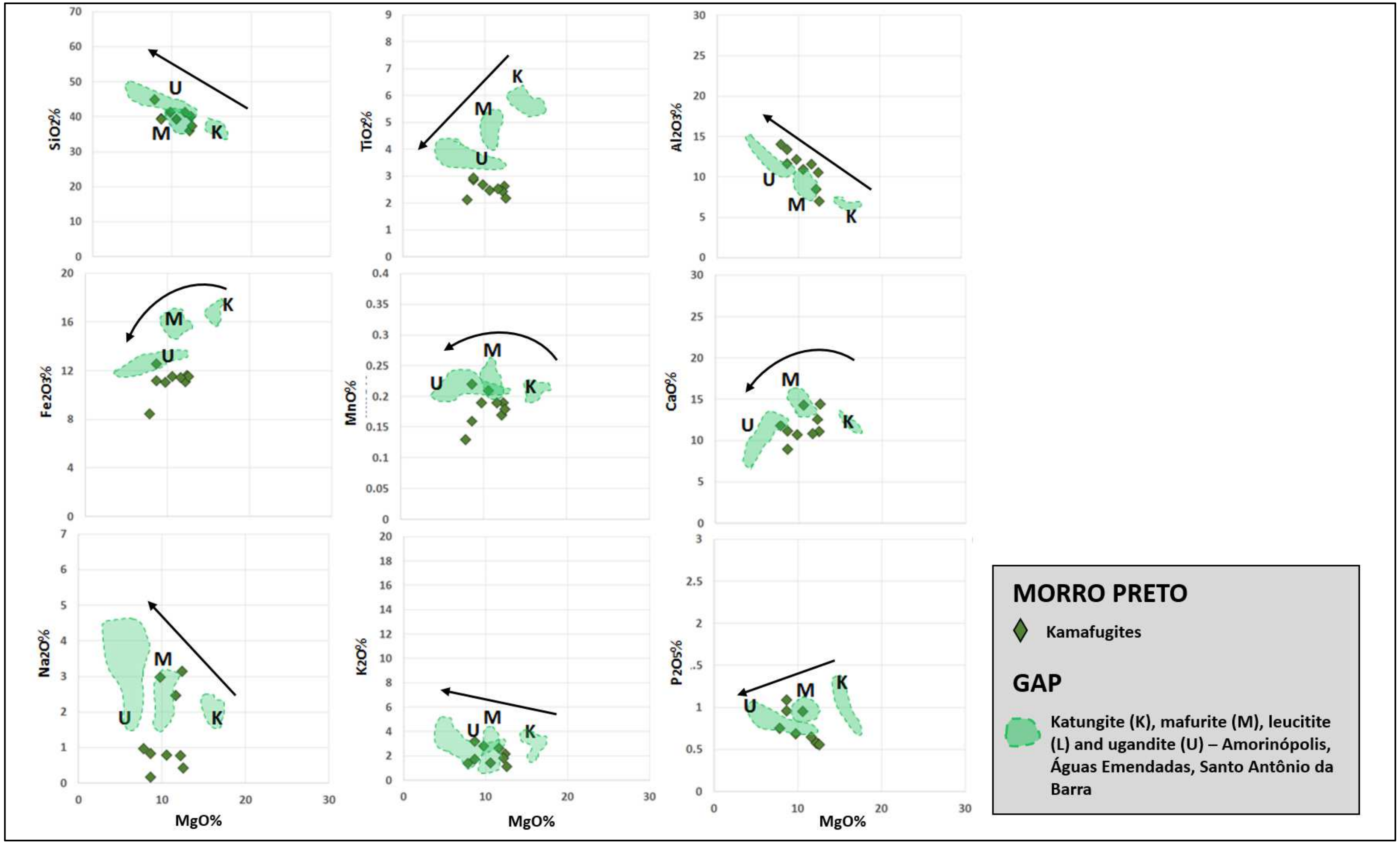

Figure 5.09 Variation diagrams of major oxides with MgO for the Morro Preto kamafugites, compared with the GAP kamafugites. The black arrows represent the GAP kamafugite evolution trend along fractional crystallization. Data source: Moraes (1984), Danni (1985), Danni & Gaspar (1994), Junqueira-Brod et al. (1998), Sgarbi & Gaspar (2000) and Brod et al. (2005). *Adapted from*: Brod et al. (2005).

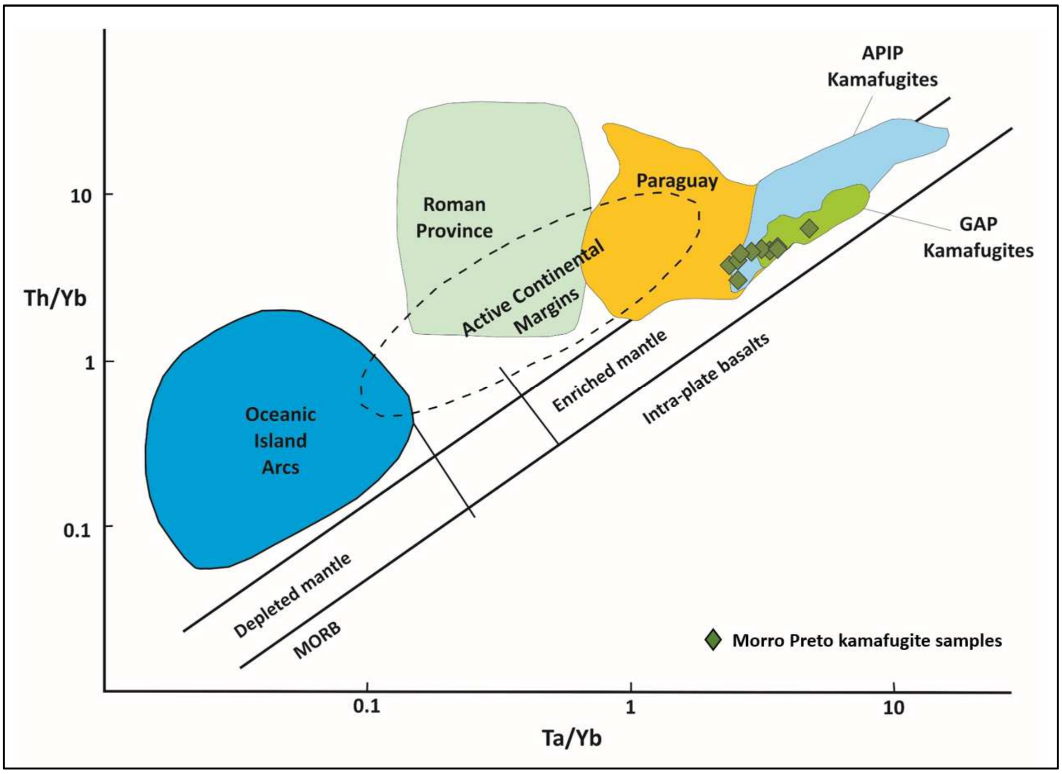

Figure 5.10. Th/Yb vs Ta/Yb diagram. The Morro Preto kamafugites plot in the enriched mantle field along with the APIP and GAP kamafugites. Data source: GAP: Junqueira-Brod et al. (1998). Alkaline rocks from Paraguay: Comin-Chiaramonti et al. (1997) and Brod et al. (2000). *Adapted from*: Brod et al. (2005).

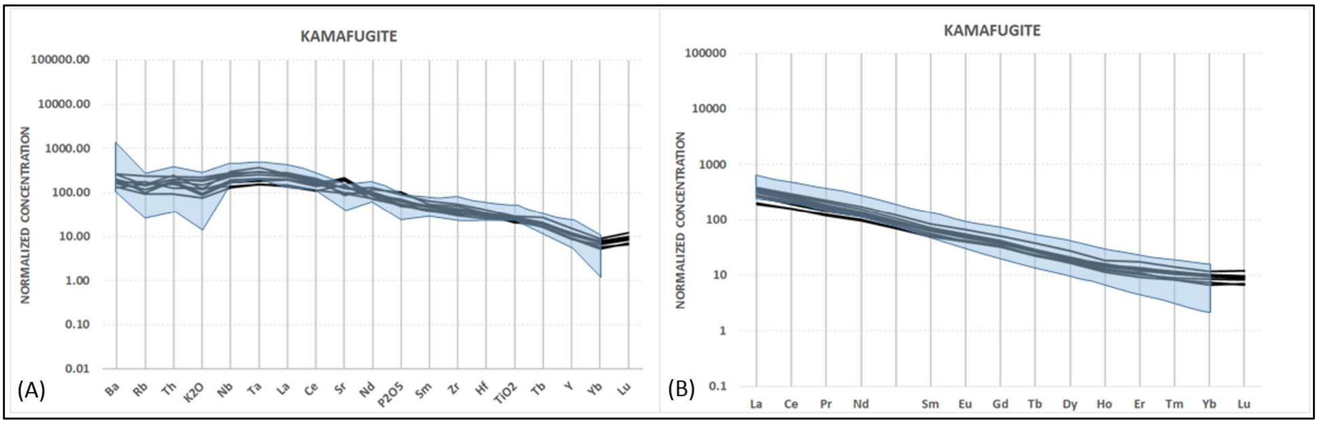

Figure 5.11. (A) Multi-element diagrams (Thompson, 1982) and **(B)** chondrite normalized REE patterns (McDonough & Sun, 1995) for the Morro Preto kamafugites. The blue area defines the GAP kamafugitic rocks composition (Data source: Brod et al., 2005).

5.7. DISCUSSION AND CONCLUSIONS

The kamafugite dykes from Morro Preto carbonatite Complex range from mafurite to leucite mafurite. The mafurites are richer in olivine phenocrysts, with a primitive composition (Fo_{75} to Fo_{90}) and minor clinopyroxene. The chromite inclusions in the magnetites, found in the less differentiated kamafugite (mafurite) samples, is similar to the magnetite-chromite relation observed in the SAB mafurites (Sgarbi & Sgarbi, 2003).

The leucite mafurites have little or no olivine, with an increase in felsic (feldspathoids) minerals. Some Fe and Na enrichment observed in diopside is in good agreement with the evolution of kamafugites (Morbidelli, 1995).

The feldspathoids in the groundmass show textural signs of alteration, such as silica-alumina-sodium enrichment and K_2O depletion. This results in intergrown K-feldspar-melilite-analcime-leucite(-kalsilite) or K-feldspar-analcime-nepheline(-kalsilite), with traces of phlogopite and carbonate.

Comin-Chiaramonti et al. (2009) detail the complex analcime intergrowths in the alkaline rock suites of Iran, Brazil and Eastern Paraguay. Both types of intergrowths mentioned above (sometimes with plagioclase) are common in ultrapotassic rocks occurring as lava flows or as dykes, with multiple stages of igneous activity and metasomatic overprint. The same authors argue that the intergrowths could have formed from a pre-existing, homogeneous, solid phase, with change in bulk composition, either by sub-solidus replacement / breakdown or by reaction with a fluid phase. A combination of H_2O-rich and CO_2-rich fluids is considered to be responsible for the development of these mineral intergrowths.

The primitive character of the Morro Preto kamafugites, along with the presence of carbonate globules, and the compositional similarities between carbonate globules and carbonatites, indicate that the kamafugite magmas may have given origin to the associated carbonatites by liquid immiscibility.

The carbonate globules are interpreted as primarilly spheroid immiscible droplets of carbonatite. Trace of secondary mineralization in some of these globules indicates late-stages of mineral replacement.

The occurrence of such carbonate globules (ocelli) in silicate alkaline rocks, such as kamafugites, is an evidence of silicate-carbonate liquid immiscibility (e.g. Morbidelli et al., 1995; Ivanikov et al., 1998) and a common feature in the kamafugite-carbonatite association from the APIP (Brod et al, 2013). The kamafugitic lavas from Santo Antônio da Barra, in the southern GAP, also contain a large amount of carbonate globules, interpreted as resulting from carbonate-silicate liquids immiscibility (Junqueira-Brod et al., 2005).

The minerals observed in the carbonate globules represent an interlocking mosaic of minerals, forming a gradient of Fe-dolomite in the rim to dolomite+strontianite(+barite) in the core. Semi-quantitative EDS analyses in the carbonate globules show zoning in CaO (from 39.49 to 46.7 wt.%), MgO (from 21.07 to 27.13 wt.%) and FeO (3.96 to 14.15 wt.%) grades, and also extreme variations in the carbonate globule core, from dolomite to pure strontianite. These variations are significant in a millimeter-scale globule.

Guo et al (2014) observed the same wide variation in carbonate composition in carbonate occeli from the West Qinling kamafugite suite, concluding that the zonning pattern observed (calcite-dolomite) results from a tendency towards equilibrium with the host kamafugitic rock, considering that such large compositional gradient would not be possible in the solid state.

In addition, for carbonate globules to be interpreted as carbonatite melts, their mineral composition needs to be consistent with the known high-concentration of certain trace elements in carbonatites (Gittins, 1988). The high Sr-Ba content in Morro Preto globules, and their textural equilibrium with typical groundmass minerals, as observed in clinopyroxene and phlogopite microcrysts in contact with the globules, are consistent with an origin of the globules as parcels of trapped carbonatite melt.

Due to their composition, the kamafugite rocks represent the most primitive rock type in the Morro Preto complex. However, there are more primitive members of the kamafugite series in the province (e.g. katungites), suggesting that the Morro Preto kamafugites are already a product of fractional crystallization.

Regionally, these kamafugite occurrences in the Morro Preto Complex attest the kamafugite-carbonatite association in the GAP, proposed by several authors in their study of the kamafugites from SAB (Sgarbi et al., 2000) and Águas Emendadas (Junqueira-Brod et al., 2000).

Junqueira-Brod et al (2005) also detailed the kamafugite-carbonatite association in the GAP by studying the association between density barriers and magma ascending events. The authors associate a carbonatite immiscibility event in the upper crust increasing the silicate magma density before reaching the rocks near surface.

The composition of the clinopyroxene from the described bebedourite xenolith closely resembles that of clinopyroxenes in the bebedourites from the Salitre complex, in APIP (Barbosa et al., 2012). Bebedourite xenoliths in pyroclastic rocks of the Mata da Corda Formation, in that same province, provide another link between kamafugitic and carbonatitic magmatism (Brod et al., 2000).

The Morro Preto carbonatite complex and its association with kamafugite dykes containing bebedourite xenoliths widens the metallogenetic potential of northern GAP magmatism to contain APIP-type large, multi-commodity deposits, in addition to the phosphate and Ni laterite mineralization types recorded so far. Although, at the current level of knowledge, the Morro Preto Complex is an exception within GAP, due to its carbonatite-dominated nature, additional exploration work is required, taking into account this broader metallogenetic affinity, particularly where indirect methods have detected other potential prospects at depth (Dutra et al., 2012, Marangoni & Mantovani, 2013).

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CAPÍTULO 6: CONCLUSÕES

O complexo carbonatítico Morro Preto, localizado na porção noroeste da GAP, representa uma ocorrência única na província, devido à predominância de carbonatitos nas rochas estudadas, à associação entre carbonatitos-e kamafugitos, e também devido à presença de ferrocarbonatitos no complexo, ocorrência até agora desconhecida nas províncias alcalinas a norte da Bacia do Paraná (GAP e APIP).

O principal objetivo do presente trabalho foi caracterizar o Complexo Morro Preto, detalhando a geologia local e a litogeoquímica do Complexo, a química mineral dos carbonatos e apatita dos carbonatitos, e da olivina e piroxênio dos kamafugitos, a associação entre rochas kamafugíticas e carbonatíticas, e a partir dos dados processados, uma interpretação preliminar da evolução do complexo carbonatítico.

As duas intrusões circulares do Complexo Morro Preto possuem magnetita apatita magnesiocarbonatitos, com variações texturais desde cumulados de apatita e/ou magnetita a magnesiocarbonatitos com texturas heterogêneas e com evidências de fluxo magmático. Essas rochas são ricas em dolomita, Fe-dolomita, apatita, magnetita e, em menor proporção, barita, tetraferriflogopita, badeleíta, zircão e pirocloro.

A sequência de magnesiocarbonatitos grada para composições mais ricas em ferro, predominando ferrocarbonatitos com ankerita e siderita, com proporção menor em Fe-dolomita e magnetita, barita e monazita secundária, traços de sulfetos ricos em ferro (pirrotita, pirita), e apatita rara a ausente. Alteração ferruginosa é muito comum, com a presença de óxido / hidróxido de ferro substituindo os carbonatos ricos em ferro. Em condições tardias, é comum a presença de siderita rica em manganês, por vezes englobando a ankerita, e por vezes preenchendo cavidades de dissolução juntamente com magnesita, barita e monazita. Sulfetos, monazita e bastnaesita são minerais acessórios comuns.

O Complexo Morro Preto possui evidências de ter se originado a partir de múltiplos estágios de processos petrogenéticos. As relações texturais nos cumulados de apatita e magnetita, indicam evolução dos carbonatitos a partir de apatitas + dolomita ± Fe-dolomita nos magnesiocarbonatitos, evoluindo para apatitas ricas em flúor em associação com Fe-dolomita ± ankerita nos estágios transicionais entre magnesiocarbonatito-ferrocarbonatito, seguindo de ferrocarbonatito rico em ankerita + siderita ± magnesita e traço de carbonatos ricos em terras raras (bastnaesita).

A geoquímica de rocha total corrobora a diferenciação acima, que resultou em decréscimo em CaO, MgO, P_2O_5, e aumento em Th ETR, BaO e SrO na evolução dos magnesiocarbonatitos para ferrocabonatitos. Está, também, está de acordo com a literatura sobre a diferenciação de complexos carbonatíticos (Woolley & Kempe, 1989). Os mesmos parâmetros geoquímicos foram observados no estudo geoquímico e isotópico de carbonatitos de diversos complexos alcalinos carbonatíticos da APIP, realizado por Gomide et al. (2015).

Além das evidências petrográficas e geoquímicas relacionadas à cristalização fracionada, levando à evolução magnesiocarbonatito-ferrocarbonatito, esta tese também aborda evidências da influência de reações *sub-solidus* (metassomatismo, degaseificação e hidrotermalismo) na geração dos ferrocarbonatitos, como as destacadas abaixo:

(i) Halo extenso de fenitização (~800m) nas rochas hospedeiras, brechação e clastos de rocha hospedeira e de carbonatitos dentro da sequência carbonatítica, evidenciando estágios multi-intrusivos e influência rúptil de degaseificação e liberação de fluidos;

(ii) Fenitização potássica sobre os carbonatitos evidenciado pelos veios de K-feldspato cortando os magnesiocarbonatitos (Le Bas, 1981; LeBas, 2008; Pirajno et al., 2014; Elliot et al., 2018);

(iii) Dissolução mineral durante a degaseificação gerando texturas tipo “boxwork” nas rochas com alteração ferruginosa, e

(iv) Variações composicionais relacionadas a reações sub-solidus na apatita (aumento no teor de Na_2O e ETR - Chakhmouradian et al., 2017).

O caráter rúptil da instalação (*emplacement*) do complexo Morro Preto, evidenciado pelos stocks de carbonatito fenitizando as rochas hospedeiras (em texturas de brechas e clastos), juntamente com a aparente ausência de rochas silicáticas plutônicas associadas ao complexo (com exceção dos diques de kamafugito e raras ocorrências de basalto alcalino e diques félsicos alcalinos), indicam que nível erosional atual do Complexo Morro Preto é relativamente raso, e que a parte aflorante do complexo provavelmente representa a porção sub-vulcânica de um sistema intrusivo carbonatítico, de acordo com o modelo proposto por LeBas (1977).

Os diques de kamafugito representam a rocha mais primitiva do Complexo. Essas rochas possuem um intervalo composicional similar aos mafuritos e leucita mafuritos da GAP, indicando que já são, em si, rochas mais evoluídas do que os katungitos ou os picritos ricos em magnésio, comuns em toda a província.

Os kamafugitos de Morro Preto são comumente porfiríticos, com matriz afanítica e fenocristais de olivina, clinopiroxênio e apatita. Podem se subdividir em mafuritos mais primitivos, ricos em fenocristais de olivina muito magnesiana (Fo_{75} a Fo_{90}) conforme análise semi-quantitativa em EDS, e raros fenocristais de clinopiroxênio associados. A matriz deste litotipo apresenta microcristais de olivina, clinopiroxênio, Ti-magnetita com inclusões de cromita, e proporções variáveis de feldspatóides em intercrescimento com zeólitas e feldspato (ortoclásio). A matriz também apresenta, em menor proporção, flogopita, apatita e carbonatos.

O outro tipo de kamafugito encontrado consiste em rochas ricas em fenocristais de clinopiroxênio, com olivina rara a ausente, e matriz mais enriquecida em flogopita, apatita, feldspatóides e carbonato. Os feldspatóides dos kamafugitos mais diferenciados (ugandítos), originalmente leucita, estão substituídos por intercrescimento de K-feldspato, analcima e nefelina, com traços de tetraferriflogopita e carbonato.

Glóbulos de carbonato são comuns em todos os intervalos composicionais dos kamafugitos, sendo aqui interpretados como representativos de líquido carbonatítico imiscível. Alguns pontos favorecem essa interpretação:

(i) Glóbulos de carbonato imiscíveis são comuns não apenas em outras ocorrências de kamafugitos intrusivos e extrusivos da GAP, como também estão presentes em complexos com a associação carbonatito-kamafugito da APIP, sendo que em ambos os casos essa feição é considerada como evidência de coexistência entre líquido carbonatítico e silicático durante a cristalização (Junqueira-Brod et al., 2005; Brod et al., 2000).

(ii) Os tipos de carbonatos encontrados nos glóbulos, analisados por EDS, possuem a mesma variação composicional dos carbonatos encontrados na série carbonatítica do Morro Preto. Os carbonatos foram um gradiente extremo do núcleo para a borda dos glóbulos, com os seguintes intervalos composicionais: estroncianita – dolomita – Fe-dolomita, com traços de barita e ankerita. Essa variação composicional em larga escala indica processos magmáticos primários associados à formação desses glóbulos (Guo et al., 2017). A presença de Ba e Sr também atesta a associação co-genética entre os glóbulos de carbonato e a série carbonatítica (Gittins, 1988).

(iii) Imiscibilidade entre líquido carbonatítico e líquido silicático também pode ser verificada por meio de razões geoquímicas. A separação entre os elementos Nb e Ta, evidenciada pela correlação negativa, e a depleção de Zr-Hf em amostras representativas do magma carbonatítico, indicam o processo de separação entre líquido carbonatítico e silicático (Brod et al., 2013).

Essas evidências atestam o link entre os diques de kamafugito e a série carbonatítica do Complexo Morro Preto, sendo os kamafugitos considerados como representativos do líquido parental do magma carbonatítico do complexo.

A associação carbonatito-kamafugito foi detalhado por Brod et al (2000) na APIP, onde os autores observaram similaridades petrográficas e geoquímicas entre as rochas silicáticas dos complexos alcalino-carbonatíticos e entre xenólitos de mesma composição em rochas kamafugíticas.

O mesmo exercício foi realizado no capítulo 5 desta tese, evidenciando similaridades geoquímicas e de química mineral entre as rochas kamafugíticas da APIP, da GAP e do complexo Morro Preto.

A composição dos clinopiroxênios dos xenólitos de bebedourito presente nos kamafugitos do complexo Moro Preto se assemelha à dos bebedouritos localizados na APIP (Complexo Salitre – Barbosa et al., 2012), e também se assemelha aos xenólitos de bebedouritos em rochas kamafugíticas piroclásticas da Formação Mata da Corda, promovendo o link entre o magmatismo alcalino e carbonatítico na APIP, e entre a GAP e a APIP.

Essa associação amplia o potencial metalogenético da GAP, considerando que o mesmo tipo de magmatismo que gerou os complexos alcalinos carbonatíticos da APIP e suas mineralizações em P-Nb-ETR(-Ti-Ba-Fe-U), também gerou a associação kamafugito-carbonatito no Complexo Morro Preto.

O magmatismo carbonatítico do Complexo Morro Preto ainda é exceção na GAP, contudo, as evidências listadas sugerem que o aprofundamento da exploração mineral na região proverá, com o tempo, a descoberta de novas intrusões alcalinas de associação carbonatítica-kamafugítica.

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ANEXOS

ANEXO A – GEOQUÍMICA DE ROCHA TOTAL
ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS
ANEXO C – QUÍMICA MINERAL – WDS – APATITA

ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Project: Project None Given
Report Date: June 20, 2013

Page: 2 of 3 Part: 1 of 1

CERTIFICATE OF ANALYSIS GOI13000524.1

	Method	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B
	Analyte	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	Ni	Sc	LOI	Sum	Ba	Be	Co	Cs	Ga
	Unit	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	%	%	ppm	ppm	ppm	ppm	ppm
	MDL	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.002	20	1	-5.1	0.01	1	1	0.2	0.1	0.5
1223001	Drill Core	4.13	0.21	11.07	11.20	32.57	0.06	0.07	0.08	9.66	0.39	<0.002	<20	13	29.8	99.26	1525	2	20.9	<0.1	1.9
1223002	Drill Core	14.05	0.18	34.45	6.38	12.53	0.13	0.03	0.01	5.36	2.40	0.002	<20	3	22.8	98.36	1661	2	21.0	0.1	2.9
1223006	Drill Core	1.09	0.11	6.29	16.78	29.00	0.11	<0.01	0.02	2.31	0.77	<0.002	<20	11	42.4	98.93	1019	<1	10.9	<0.1	0.8
1223007	Drill Core	2.48	0.26	7.19	12.89	32.46	0.23	<0.01	0.04	8.46	0.82	0.002	<20	8	34.0	98.86	3728	<1	11.4	<0.1	2.1
1223008	Drill Core	2.34	0.34	43.58	0.92	28.16	0.10	0.07	0.55	19.04	0.14	0.003	<20	6	4.2	99.48	192	<1	37.2	<0.1	3.4
1223009	Drill Core	6.91	0.02	13.94	12.05	25.26	0.03	<0.01	0.01	0.52	1.19	<0.002	<20	4	39.2	99.08	2206	1	9.8	<0.1	1.3
1223010	Drill Core	8.82	0.09	26.57	10.70	14.09	0.02	0.04	0.02	0.54	2.53	<0.002	36	6	33.9	97.33	10519	6	48.3	<0.1	3.3
1223011	Drill Core	35.16	0.04	35.07	3.06	6.70	<0.01	<0.01	0.03	0.26	3.48	0.003	<20	16	11.2	95.04	37124	2	15.7	<0.1	4.4
1223012	Drill Core	6.11	0.04	29.29	9.51	14.86	0.01	<0.01	0.03	0.14	3.63	<0.002	21	12	32.6	96.24	25072	4	15.3	<0.1	4.5
1223014	Drill Core	25.03	0.19	40.94	1.96	5.87	<0.01	<0.01	0.14	0.12	1.50	0.003	<20	5	9.1	84.85	>50000	7	12.0	<0.1	3.7
1223015	Drill Core	52.29	11.75	9.90	1.87	4.15	3.76	7.32	0.41	1.31	0.18	<0.002	<20	21	5.9	98.83	5698	6	6.1	0.3	15.1
1223016	Drill Core	56.11	17.29	4.53	2.35	2.62	5.53	2.95	0.04	0.17	0.24	<0.002	<20	2	7.4	99.23	3766	1	6.9	0.4	11.9
1223017	Drill Core	21.65	0.15	34.28	6.76	6.02	0.06	0.05	0.20	0.19	3.26	0.003	<20	7	20.8	93.45	31714	3	19.5	<0.1	3.3
1223131	Drill Core	17.85	0.09	6.09	15.13	21.69	0.05	0.02	0.07	0.08	1.19	<0.002	<20	12	35.5	97.79	8579	<1	7.2	<0.1	2.3
1223132	Drill Core	32.48	0.32	9.21	22.34	4.60	3.42	1.20	0.07	0.04	0.59	0.318	1265	10	23.7	98.43	7885	20	60.1	0.2	1.5
1223133	Drill Core	47.77	13.84	11.75	3.65	4.02	3.86	2.50	2.73	0.81	0.19	<0.002	<20	19	8.2	99.31	2761	2	27.1	0.9	19.7
1223135	Drill Core	14.19	0.34	74.18	1.61	2.58	0.01	0.01	0.36	0.10	0.30	0.004	<20	4	4.6	98.29	12264	7	9.7	<0.1	2.1
1223136	Drill Core	16.05	0.21	45.66	10.90	0.90	0.05	0.03	0.13	0.04	2.68	<0.002	31	5	22.9	99.53	1180	3	29.0	<0.1	3.5
1223137	Drill Core	4.55	0.30	21.81	13.92	21.44	0.01	<0.01	0.05	0.10	1.34	<0.002	<20	8	33.7	97.20	17015	4	12.1	0.1	1.3
1223138	Drill Core	7.35	0.65	6.78	12.03	31.06	0.24	0.28	0.13	11.03	0.91	<0.002	<20	11	28.0	98.49	748	4	9.2	0.1	2.0
1223142	Drill Core	1.53	0.12	8.36	8.20	39.40	0.08	0.04	0.12	22.36	0.20	<0.002	<20	11	18.6	98.97	471	7	13.8	<0.1	0.6
1223143	Drill Core	1.09	0.17	7.52	14.35	32.69	0.06	0.08	0.08	8.34	0.33	<0.002	<20	6	34.5	99.24	172	2	13.5	<0.1	<0.5
1223146	Drill Core	13.59	0.05	9.68	14.54	23.06	0.02	<0.01	0.08	0.28	0.62	<0.002	<20	13	37.3	99.28	305	<1	19.2	<0.1	<0.5
1223326	Drill Core	32.50	2.19	13.56	6.28	16.93	0.04	0.06	0.25	3.33	0.84	0.013	140	8	20.7	96.66	1321	5	38.5	<0.1	4.9
1223328	Drill Core	58.19	11.91	8.90	1.77	1.41	0.24	7.78	0.50	0.47	0.07	0.003	<20	14	7.5	98.75	7719	2	10.0	0.2	18.0
1223329	Drill Core	10.42	0.03	16.27	12.42	20.27	0.04	<0.01	0.04	0.19	1.22	<0.002	<20	4	37.3	98.21	8330	<1	9.3	<0.1	<0.5
1223330	Drill Core	4.28	1.33	10.51	12.12	28.00	0.06	0.03	0.07	5.25	0.79	0.005	<20	11	35.5	97.95	6900	2	15.1	<0.1	3.1
1223331	Drill Core	11.41	0.75	20.58	4.30	27.81	0.04	0.03	0.02	6.32	0.84	<0.002	<20	19	24.6	96.71	19759	3	21.6	<0.1	1.3
1223332	Drill Core	51.49	20.18	3.87	2.35	3.41	0.67	6.35	0.24	0.11	0.21	<0.002	24	<1	10.6	99.52	1107	5	10.5	3.2	29.6
1223333	Drill Core	52.30	19.77	4.08	2.36	2.93	0.82	6.96	0.28	0.09	0.20	0.009	38	1	9.7	99.51	1450	11	11.0	6.5	30.4

This report supersedes all previous preliminary and final reports with this file number dated prior to the date on this certificate. Signature indicates final approval; preliminary reports are unsigned and should be used for reference only.

ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Project: Project None Given
Report Date: June 20, 2013

Page: 2 of 3 Part: 2 of 1

CERTIFICATE OF ANALYSIS GOI13000524.1

Method		4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B
Analyte		Hf	Nb	Rb	Sn	Sr	Ta	Th	U	V	W	Zr	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb
Unit		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
MDL		0.1	0.1	0.1	1	0.5	0.1	0.2	0.1	8	0.5	0.1	0.1	0.1	0.1	0.02	0.3	0.05	0.02	0.05	0.01
1223001	Drill Core	7.8	112.9	1.1	2	2488	5.8	6.2	14.9	57	0.9	634.5	88.8	218.6	441.2	52.37	208.0	35.33	10.40	30.83	3.75
1223002	Drill Core	0.3	109.6	0.9	<1	5223	6.2	70.5	17.7	<8	3.4	39.5	56.7	1938	2793	250.9	674.7	59.87	13.09	30.36	2.90
1223006	Drill Core	0.3	39.6	0.3	<1	4038	14.6	6.2	5.4	<8	1.3	42.3	86.7	271.8	593.2	71.58	304.9	46.60	13.44	35.73	4.03
1223007	Drill Core	0.4	72.2	0.3	<1	4204	24.8	6.4	13.3	20	1.4	33.9	116.2	295.5	603.1	69.94	287.6	44.42	12.19	33.79	4.01
1223008	Drill Core	6.7	64.4	1.1	4	1787	2.9	6.4	13.9	284	2.1	790.5	45.7	111.2	276.6	36.26	148.8	25.17	7.38	21.14	2.46
1223009	Drill Core	0.2	634.6	0.2	<1	2378	7.8	16.0	7.5	11	0.5	14.8	8.1	141.0	280.9	29.88	105.0	13.29	2.89	6.86	0.53
1223010	Drill Core	1.3	91.6	0.6	<1	1330	0.8	250.3	57.6	36	<0.5	68.0	18.3	2672	4494	413.3	1162	98.72	18.81	42.38	2.57
1223011	Drill Core	0.3	570.7	<0.1	<1	1634	0.4	443.2	1.6	35	4.3	24.4	67.1	394.6	921.3	99.96	307.9	40.39	10.60	30.87	2.87
1223012	Drill Core	0.3	173.4	<0.1	<1	2178	0.3	381.4	0.9	28	3.0	21.1	42.5	409.8	802.0	81.36	245.1	33.69	9.82	25.53	2.12
1223014	Drill Core	0.7	276.4	0.3	<1	2568	0.2	128.8	1.9	40	24.2	121.2	20.6	6.9	21.9	6.19	66.2	33.01	3.74	13.95	0.97
1223015	Drill Core	3.8	336.6	84.7	4	2748	1.9	56.6	9.3	139	1.3	194.4	93.1	86.2	137.7	13.36	42.2	8.81	3.38	12.38	2.04
1223016	Drill Core	2.0	22.4	46.7	<1	2103	0.2	17.9	0.4	<8	1.0	105.3	12.4	59.3	87.0	7.70	24.6	3.60	0.89	3.31	0.42
1223017	Drill Core	0.7	63.1	0.5	<1	19333	0.5	324.6	3.0	32	23.7	159.5	78.3	1003	2179	235.4	736.9	74.09	16.21	43.06	4.39
1223131	Drill Core	0.3	21.7	0.1	<1	6347	0.4	48.2	0.7	12	3.7	65.8	49.9	350.4	688.2	78.08	273.9	38.81	10.02	26.40	2.89
1223132	Drill Core	0.8	130.2	7.8	<1	1653	<0.1	13.1	<0.1	27	<0.5	156.6	17.1	106.9	126.0	10.33	30.5	3.90	1.07	4.20	0.56
1223133	Drill Core	5.8	39.7	50.4	2	1553	2.0	7.1	1.3	267	0.6	248.5	31.7	59.9	120.1	14.56	61.7	10.18	2.76	9.07	1.11
1223135	Drill Core	0.3	599.9	0.2	<1	726.3	0.6	85.6	7.7	56	38.4	81.9	12.4	21.3	63.2	12.18	78.3	22.66	5.20	11.55	0.93
1223136	Drill Core	0.3	82.9	0.9	<1	291.3	<0.1	30.7	<0.1	13	11.1	64.5	6.5	8.4	25.7	4.26	22.2	6.91	1.98	4.78	0.45
1223137	Drill Core	0.2	80.0	0.1	<1	3962	0.5	163.5	3.1	13	7.5	36.1	49.8	265.3	513.3	54.97	197.2	37.94	11.12	30.62	3.07
1223138	Drill Core	0.8	67.3	4.7	<1	8322	7.7	40.0	19.9	16	5.6	119.2	125.0	276.9	595.7	72.51	283.3	45.34	13.46	38.65	5.08
1223142	Drill Core	3.1	104.2	0.7	2	5819	3.6	12.1	20.6	38	2.4	336.1	74.6	82.1	185.9	22.85	96.7	18.88	5.92	18.49	2.47
1223143	Drill Core	0.3	95.0	1.2	<1	3434	10.3	4.2	9.3	19	1.2	26.5	45.2	87.8	205.2	26.16	115.4	20.33	5.86	17.03	2.00
1223146	Drill Core	1.2	104.7	<0.1	<1	3181	0.8	5.6	0.7	11	0.8	59.8	10.6	35.5	74.0	9.16	38.3	5.42	1.56	3.77	0.43
1223326	Drill Core	<0.1	210.1	2.0	2	3014	1.6	166.9	19.5	192	7.0	26.8	693.3	7931	10004	814.5	2298	271.9	68.32	206.7	24.93
1223328	Drill Core	6.8	406.1	90.6	5	1507	4.4	40.1	3.8	73	2.8	251.9	20.8	67.7	98.1	10.68	40.3	8.00	2.34	6.66	0.83
1223329	Drill Core	0.1	81.5	<0.1	<1	2362	0.4	108.8	1.6	17	<0.5	7.1	60.2	978.6	1291	108.9	318.2	36.59	8.19	24.34	2.53
1223330	Drill Core	0.4	204.6	0.4	<1	8565	48.1	77.6	27.9	19	<0.5	30.6	116.6	313.9	630.8	70.70	268.5	41.42	11.65	34.08	4.72
1223331	Drill Core	0.9	196.5	0.9	<1	5526	39.2	136.1	13.4	130	0.7	46.8	97.9	484.7	912.6	96.69	352.3	45.85	12.15	32.80	3.63
1223332	Drill Core	10.9	291.9	211.8	1	931.5	6.3	43.5	4.2	<8	1.6	755.9	32.9	168.0	232.9	18.89	56.3	7.39	2.14	6.31	0.81
1223333	Drill Core	10.9	228.0	235.5	1	728.5	5.0	38.6	6.3	11	0.8	624.4	36.4	174.1	240.5	19.64	54.7	7.35	1.99	5.98	0.87

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ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Client: **Anglo American Brasil Ltda.**
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Project: Project None Given
Report Date: June 20, 2013

Page: 2 of 3 Part: 3 of 1

CERTIFICATE OF ANALYSIS GOI13000524.1

	Method	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	4A-4B	2A Leco	2A Leco	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX
	Analyte	Dy	Ho	Er	Tm	Yb	Lu	TOT/C	TOT/S	Mo	Cu	Pb	Zn	Ni	As	Cd	Sb	Bi	Ag	Au	Hg
	Unit	ppm	ppm	ppm	ppm	ppm	ppm	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm
	MDL	0.05	0.02	0.03	0.01	0.05	0.01	0.02	0.02	0.1	0.1	0.1	1	0.1	0.5	0.1	0.1	0.1	0.1	0.5	0.01
1223001	Drill Core	19.31	3.33	8.04	1.09	6.17	0.88	8.27	0.27	1.8	0.3	11.1	106	<0.1	1.2	0.4	<0.1	<0.1	0.2	2.4	<0.01
1223002	Drill Core	13.38	1.87	3.88	0.46	2.35	0.23	6.85	0.05	1.2	0.5	36.0	242	0.7	6.2	0.9	<0.1	<0.1	<0.1	10.6	<0.01
1223006	Drill Core	19.18	3.12	7.08	0.86	4.83	0.58	11.59	0.04	0.9	0.4	13.7	45	3.2	0.5	0.7	<0.1	<0.1	0.3	17.2	<0.01
1223007	Drill Core	20.49	3.98	11.56	1.79	10.60	1.30	9.25	0.10	1.5	2.2	19.4	67	3.9	1.5	1.1	<0.1	<0.1	0.5	19.8	<0.01
1223008	Drill Core	12.62	1.82	3.84	0.49	2.76	0.31	0.74	<0.02	3.4	2.3	8.3	64	2.5	1.5	0.2	<0.1	<0.1	0.3	<0.5	<0.01
1223009	Drill Core	1.99	0.28	0.82	0.11	0.89	0.13	11.00	0.06	19.9	0.2	4.3	123	2.1	1.0	0.4	<0.1	<0.1	0.1	2.2	<0.01
1223010	Drill Core	7.49	0.38	0.51	0.13	0.84	0.10	9.84	0.41	3.6	0.7	15.4	427	23.3	1.4	0.7	<0.1	<0.1	0.1	1.1	<0.01
1223011	Drill Core	12.32	1.89	4.37	0.60	3.54	0.49	2.44	0.83	1.8	0.6	234.9	1644	4.1	1.0	0.5	0.1	0.2	<0.1	2.8	0.02
1223012	Drill Core	8.94	1.09	2.24	0.29	1.77	0.20	9.36	0.63	0.8	0.8	251.8	1856	3.7	0.9	0.6	<0.1	0.2	<0.1	4.5	<0.01
1223014	Drill Core	4.35	0.58	1.44	0.22	1.12	0.14	2.07	1.88	4.5	1.3	99.4	629	5.8	6.1	0.2	0.3	0.7	0.5	12.6	<0.01
1223015	Drill Core	13.10	2.75	8.23	1.08	6.11	0.78	0.92	0.16	2.4	2.0	27.1	234	3.7	0.8	0.4	0.1	1.0	0.2	2.7	<0.01
1223016	Drill Core	1.96	0.37	1.06	0.12	0.79	0.10	0.97	0.06	0.2	22.9	18.5	191	8.3	0.7	0.4	<0.1	0.2	0.1	2.1	<0.01
1223017	Drill Core	21.25	2.91	5.04	0.55	2.80	0.33	6.00	0.76	1.0	1.5	122.5	319	4.6	3.0	4.3	0.1	<0.1	0.2	3.9	<0.01
1223131	Drill Core	14.43	1.85	3.51	0.43	2.77	0.42	9.81	0.21	0.5	1.3	24.7	355	2.8	2.5	1.0	<0.1	<0.1	<0.1	1.4	<0.01
1223132	Drill Core	3.43	0.53	1.44	0.21	1.21	0.21	6.05	0.17	0.1	2.7	10.3	234	710.6	<0.5	0.1	<0.1	<0.1	<0.1	1.9	<0.01
1223133	Drill Core	6.18	1.22	2.95	0.42	2.66	0.40	1.93	0.14	1.0	19.3	6.3	148	13.7	<0.5	0.1	<0.1	<0.1	<0.1	<0.5	<0.01
1223135	Drill Core	3.70	0.41	0.96	0.14	0.82	0.09	1.01	0.32	4.4	1.8	90.3	331	13.9	4.2	0.3	0.3	0.9	0.6	4.4	<0.01
1223136	Drill Core	1.84	0.25	0.54	0.07	0.40	0.05	6.95	0.03	1.6	1.3	17.4	652	26.5	1.0	<0.1	0.1	<0.1	0.3	14.7	<0.01
1223137	Drill Core	12.96	1.71	3.79	0.46	2.76	0.31	9.18	0.40	1.4	1.0	68.2	160	4.9	1.4	0.5	0.1	0.2	0.1	7.1	<0.01
1223138	Drill Core	27.76	4.51	10.57	1.25	6.87	0.97	7.66	<0.02	0.8	8.0	66.9	125	1.9	2.1	0.7	0.1	0.2	0.2	2.9	<0.01
1223142	Drill Core	14.35	2.39	6.75	1.06	6.64	0.92	4.94	<0.02	0.8	0.6	48.3	70	<0.1	2.3	0.2	<0.1	<0.1	<0.1	11.5	<0.01
1223143	Drill Core	9.68	1.60	4.18	0.57	3.56	0.49	9.51	<0.02	0.2	1.4	17.8	61	<0.1	<0.5	0.2	<0.1	<0.1	<0.1	<0.5	<0.01
1223146	Drill Core	2.27	0.38	0.84	0.13	0.82	0.10	10.63	0.31	1.2	1.0	18.7	259	3.1	0.9	0.5	<0.1	<0.1	0.4	<0.5	<0.01
1223326	Drill Core	134.9	21.61	51.09	6.25	30.51	3.49	4.80	0.04	40.4	16.0	203.2	273	148.1	20.7	1.8	2.3	3.4	1.9	7.4	0.03
1223328	Drill Core	4.82	0.68	1.41	0.18	1.23	0.11	1.69	1.09	3.1	5.8	102.5	387	21.1	2.2	0.7	<0.1	1.7	0.7	6.5	<0.01
1223329	Drill Core	13.32	2.01	4.62	0.57	3.22	0.35	10.67	0.24	0.5	0.3	65.6	141	4.9	0.9	0.1	<0.1	<0.1	<0.1	1.8	<0.01
1223330	Drill Core	25.01	4.19	9.65	1.22	6.88	0.80	9.58	0.23	0.9	3.2	36.3	101	16.3	<0.5	0.6	<0.1	<0.1	0.6	12.7	<0.01
1223331	Drill Core	19.64	3.41	8.74	1.17	6.75	0.89	5.78	0.46	3.3	1.9	94.5	221	15.9	0.8	1.6	0.1	<0.1	0.6	<0.5	<0.01
1223332	Drill Core	4.61	1.01	3.16	0.54	3.71	0.61	1.05	0.03	0.2	0.9	13.4	53	14.8	<0.5	0.4	<0.1	<0.1	<0.1	2.9	<0.01
1223333	Drill Core	5.86	1.07	2.79	0.48	3.44	0.50	0.95	<0.02	0.7	4.1	25.8	82	38.5	12.8	0.3	<0.1	<0.1	<0.1	2.0	<0.01

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ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Goiania 74.672-360 BRASIL

Project: Project None Given
Report Date: June 20, 2013

Page: 2 of 3 Part: 4 of 1

CERTIFICATE OF ANALYSIS GOI13000524.1

	Method	1DX	1DX	WGHT	DRY WT
	Analyte	Tl	Se	Wgt	Wgt
	Unit	ppm	ppm	kg	kg
	MDL	0.1	0.5	0.01	0.01
1223001	Drill Core	<0.1	<0.5	0.35	0.35
1223002	Drill Core	<0.1	<0.5	0.20	0.20
1223006	Drill Core	<0.1	<0.5	0.60	0.60
1223007	Drill Core	<0.1	<0.5	0.35	0.35
1223008	Drill Core	<0.1	<0.5	0.45	0.45
1223009	Drill Core	<0.1	<0.5	0.30	0.30
1223010	Drill Core	<0.1	<0.5	0.50	0.50
1223011	Drill Core	<0.1	<0.5	0.50	0.50
1223012	Drill Core	<0.1	<0.5	0.30	0.30
1223014	Drill Core	<0.1	<0.5	0.45	0.45
1223015	Drill Core	<0.1	<0.5	0.35	0.35
1223016	Drill Core	<0.1	0.9	0.20	0.20
1223017	Drill Core	<0.1	<0.5	0.60	0.60
1223131	Drill Core	<0.1	<0.5	0.45	0.45
1223132	Drill Core	<0.1	<0.5	0.30	0.30
1223133	Drill Core	<0.1	<0.5	0.25	0.25
1223135	Drill Core	<0.1	<0.5	0.20	0.20
1223136	Drill Core	<0.1	<0.5	0.15	0.15
1223137	Drill Core	<0.1	<0.5	0.45	0.45
1223138	Drill Core	<0.1	<0.5	0.40	0.40
1223142	Drill Core	<0.1	<0.5	0.15	0.15
1223143	Drill Core	<0.1	<0.5	0.25	0.25
1223146	Drill Core	<0.1	<0.5	0.35	0.35
1223326	Drill Core	0.1	<0.5	0.30	0.30
1223328	Drill Core	<0.1	<0.5	0.25	0.25
1223329	Drill Core	<0.1	<0.5	0.40	0.40
1223330	Drill Core	<0.1	<0.5	0.35	0.35
1223331	Drill Core	<0.1	<0.5	0.25	0.25
1223332	Drill Core	<0.1	<0.5	0.25	0.25
1223333	Drill Core	<0.1	<0.5	0.30	0.30

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Project: Project None Given
Report Date: June 05, 2014

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CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200
	Analyte	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	Ba	Sc	Sum	Cs	Ga	Hf	Nb	Rb	Sn
	Unit	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.002	1	1	0.01	0.1	0.5	0.1	0.1	0.1	1
1234001	Drill Core	56.04	14.89	7.52	4.64	7.19	4.20	1.02	0.84	0.50	0.13	0.017	685	16	99.72	2.2	16.3	1.0	8.5	22.6	<1
1234002	Drill Core	2.21	0.09	9.52	15.69	29.61	0.05	0.01	0.07	2.51	0.33	<0.002	57	12	99.61	<0.1	<0.5	0.4	19.4	0.2	1
1234003	Drill Core	0.47	0.07	4.66	16.39	33.44	0.06	0.01	0.02	7.03	0.27	<0.002	146	7	99.69	<0.1	<0.5	0.3	5.3	0.6	<1
1234004	Drill Core	7.27	0.40	9.27	12.01	30.90	0.08	0.03	0.08	7.62	0.30	<0.002	76	10	99.57	<0.1	0.6	1.0	24.8	1.1	1
1234005	Drill Core	1.06	0.14	9.29	16.70	29.41	0.02	0.07	0.02	0.09	0.76	<0.002	59	7	99.66	<0.1	<0.5	<0.1	36.3	1.1	<1
1234006	Drill Core	3.13	0.04	7.00	11.72	34.65	0.14	<0.01	0.02	11.78	0.26	<0.002	138	11	99.50	<0.1	<0.5	0.5	11.4	<0.1	<1
1234007	Drill Core	35.90	8.48	11.09	12.20	12.59	0.77	1.83	2.43	0.58	0.17	0.202	1180	31	99.56	5.1	12.4	5.1	49.6	61.2	1
1234008	Drill Core	1.10	0.18	8.87	5.41	40.55	0.82	0.01	0.05	24.94	0.77	<0.002	5708	4	97.79	0.1	<0.5	<0.1	19.7	0.6	<1
1234009	Drill Core	1.07	0.13	8.77	16.56	27.95	0.08	0.04	0.04	0.27	1.09	<0.002	1971	13	98.85	<0.1	<0.5	<0.1	46.7	1.3	<1
1234011	Drill Core	6.79	<0.01	12.16	18.23	18.51	0.05	<0.01	0.01	0.14	1.77	<0.002	5480	11	98.73	<0.1	0.9	<0.1	6.1	<0.1	<1
1234012	Drill Core	1.65	0.23	10.82	14.53	28.27	0.10	0.19	0.03	0.70	1.07	<0.002	1990	16	99.09	<0.1	0.9	<0.1	44.0	4.3	<1
1234013	Drill Core	75.13	10.66	2.93	0.49	1.25	2.99	4.25	0.13	0.21	0.03	<0.002	1187	2	99.70	0.3	10.7	3.8	50.5	61.7	<1
1234014	Drill Core	40.69	17.29	14.72	5.64	11.48	2.60	1.36	0.79	1.17	0.21	<0.002	594	44	99.66	7.1	14.8	0.1	13.9	24.0	<1
1234015	Drill Core	50.45	18.15	6.82	4.04	5.44	4.96	2.41	0.98	1.07	0.08	0.003	1542	11	99.49	2.0	21.1	7.3	34.5	63.2	2
1234017	Drill Core	4.59	0.12	13.51	14.53	26.33	0.04	<0.01	0.10	0.09	0.65	<0.002	2757	5	99.26	<0.1	<0.5	0.4	108.8	0.2	<1
1234018	Drill Core	43.09	16.37	13.67	6.96	8.70	3.19	1.47	1.79	1.06	0.15	0.024	1924	21	99.40	1.0	20.3	7.8	14.0	23.6	1
1234019	Drill Core	40.34	13.51	15.16	7.90	9.88	2.60	1.60	2.67	1.62	0.17	0.028	695	30	99.55	1.0	22.5	8.3	23.2	26.1	4
1234020	Drill Core	40.02	10.56	11.60	12.40	11.11	3.14	2.16	2.62	0.57	0.19	0.113	1110	25	99.54	2.9	15.1	6.8	81.3	41.0	2
1148789	Core Pulp	36.00	1.15	33.18	1.38	9.74	0.05	0.05	3.53	7.39	0.69	0.068	9085	72	96.57	0.3	7.5	58.3	2390.0	4.7	69
1148790	Drill Core	98.89	0.01	0.96	<0.01	<0.01	0.03	<0.01	0.02	0.02	<0.01	<0.002	2	<1	99.95	<0.1	<0.5	<0.1	0.4	0.1	<1
1234021	Drill Core	41.29	12.18	11.04	9.76	10.71	2.98	2.83	2.68	0.69	0.19	0.087	1360	24	99.46	2.8	15.6	6.7	95.2	50.0	2
1234022	Drill Core	31.28	9.21	6.00	10.93	13.50	0.63	1.28	2.53	0.52	0.18	0.260	1236	35	99.42	1.5	12.9	6.2	60.9	42.0	1
1234023	Drill Core	2.00	0.31	7.13	14.01	31.65	0.21	0.10	0.03	4.45	0.86	0.003	3388	8	98.92	<0.1	<0.5	0.3	9.5	1.5	<1
1234024	Drill Core	34.85	9.58	11.20	11.13	12.78	0.25	1.71	2.35	0.69	0.18	0.132	916	29	99.53	1.8	12.5	5.6	61.9	54.4	1
1234025	Drill Core	37.37	6.98	11.54	12.56	14.43	0.42	1.12	2.18	0.56	0.18	0.234	934	35	99.54	0.6	10.0	6.3	45.2	32.7	2
1234026	Drill Core	2.80	0.04	5.87	11.75	34.97	0.29	0.02	0.01	10.65	0.73	<0.002	2095	7	99.02	<0.1	<0.5	0.5	2.6	0.3	<1
1234027	Drill Core	16.72	0.09	36.98	6.04	15.95	0.10	<0.01	0.31	2.96	0.46	0.002	1297	4	99.52	<0.1	0.5	0.2	43.4	0.1	3
1234028	Drill Core	6.45	<0.01	4.98	12.15	34.15	0.31	<0.01	0.02	10.21	0.56	<0.002	2503	6	98.91	<0.1	<0.5	0.4	38.5	<0.1	<1
1234029	Drill Core	41.30	11.56	11.44	11.61	10.83	2.46	2.62	2.53	0.65	0.19	0.105	1765	23	99.33	3.4	15.4	6.8	88.1	51.9	1
1234030	Drill Core	4.71	0.04	5.61	11.08	34.56	0.32	0.03	0.01	11.42	0.79	<0.002	7890	10	98.36	<0.1	<0.5	0.4	3.1	0.4	<1

This report supersedes all previous preliminary and final reports with this file number dated prior to the date on this certificate. Signature indicates final approval; preliminary reports are unsigned and should be used for reference only.

ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Project: Project None Given
Report Date: June 05, 2014

CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200
	Analyte	Sr	Ta	Th	U	V	W	Zr	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm
	Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.5	0.1	0.2	0.1	8	0.5	0.1	0.1	0.1	0.1	0.02	0.3	0.05	0.02	0.05	0.01	0.05	0.02	0.03	0.01
1234001	Drill Core	827.5	0.3	0.6	0.3	168	0.6	40.1	9.1	10.7	22.4	2.77	11.8	2.60	0.84	2.51	0.35	1.94	0.37	0.84	0.13
1234002	Drill Core	2247.6	1.4	0.6	11.8	75	<0.5	86.1	30.7	71.0	159.8	19.34	75.9	14.23	4.10	11.98	1.53	7.57	1.26	3.31	0.45
1234003	Drill Core	1988.8	1.3	1.4	1.2	29	<0.5	26.1	23.9	46.7	117.2	15.36	63.9	11.81	3.59	10.72	1.33	6.11	1.00	2.07	0.28
1234004	Drill Core	2411.8	2.0	1.3	2.8	59	0.5	101.3	45.6	90.7	202.4	26.39	108.7	20.23	5.99	18.35	2.30	11.28	1.83	4.52	0.56
1234005	Drill Core	2266.3	10.5	<0.2	8.1	<8	<0.5	5.1	4.6	54.8	88.9	8.28	25.0	2.10	0.48	1.45	0.17	0.87	0.16	0.50	0.08
1234006	Drill Core	3375.0	0.2	0.4	9.5	30	<0.5	87.4	43.5	59.4	128.6	15.56	64.0	12.30	3.83	11.62	1.59	8.54	1.58	4.32	0.65
1234007	Drill Core	1136.3	3.1	5.3	1.0	275	<0.5	207.9	17.9	48.9	98.2	11.95	47.1	8.08	2.43	6.99	0.86	4.26	0.65	1.54	0.21
1234008	Drill Core	9066.5	1.2	10.6	22.2	<8	<0.5	33.2	227.8	769.7	1563.4	194.33	745.5	122.51	33.19	99.05	12.50	58.77	8.95	18.85	2.18
1234009	Drill Core	3876.8	7.2	12.1	15.1	<8	<0.5	27.7	140.9	861.7	1515.7	174.56	649.4	96.87	26.73	71.93	8.46	36.72	5.44	11.79	1.46
1234011	Drill Core	2890.7	<0.1	8.9	0.1	<8	<0.5	7.5	96.3	590.8	1073.6	115.98	389.4	55.35	15.17	41.15	4.98	23.81	3.79	8.91	1.08
1234012	Drill Core	3720.7	3.0	8.9	5.9	<8	<0.5	30.8	97.1	342.9	736.5	92.34	364.1	58.19	16.43	44.20	5.33	25.58	3.98	8.51	0.96
1234013	Drill Core	349.2	0.6	11.3	0.6	12	<0.5	152.1	5.2	69.2	120.2	11.26	33.5	4.19	0.74	2.68	0.28	1.31	0.20	0.51	0.07
1234014	Drill Core	1069.3	<0.1	5.7	0.9	446	0.7	9.4	10.5	3.6	5.2	0.64	2.8	0.71	0.43	0.82	0.17	1.33	0.34	1.30	0.23
1234015	Drill Core	1403.3	1.4	7.2	0.4	129	<0.5	331.0	14.5	95.8	178.9	18.95	67.1	9.63	2.23	6.28	0.72	3.35	0.50	1.31	0.17
1234017	Drill Core	1676.0	50.8	5.0	55.0	52	3.2	57.7	30.8	231.2	532.3	67.94	275.4	40.86	10.48	23.68	2.27	9.00	1.14	2.28	0.28
1234018	Drill Core	1482.7	0.6	1.3	0.5	248	<0.5	313.9	22.7	46.4	103.8	13.91	60.8	10.64	3.03	8.00	0.99	5.00	0.82	2.06	0.29
1234019	Drill Core	1067.7	0.6	1.8	0.9	314	0.6	360.8	33.4	72.2	170.0	22.08	93.4	16.85	4.22	12.40	1.48	7.48	1.33	3.03	0.44
1234020	Drill Core	1165.7	5.2	7.7	1.7	280	<0.5	262.5	21.2	74.9	141.4	16.06	59.4	9.74	2.70	7.55	0.97	4.65	0.81	2.04	0.27
1148789	Core Pulp	2316.3	117.1	423.5	100.5	377	44.3	2235.1	121.7	2399.0	4850.7	539.31	1873.2	235.17	56.01	131.93	12.41	45.85	4.74	7.86	0.90
1148790	Drill Core	1.9	<0.1	<0.2	<0.1	<8	<0.5	1.1	0.3	0.5	0.9	0.07	<0.3	<0.05	<0.02	0.07	<0.01	<0.05	<0.02	<0.03	<0.01
1234021	Drill Core	1518.7	5.9	8.6	1.9	288	1.2	293.8	23.8	84.9	162.8	17.71	65.3	10.30	3.00	8.00	1.06	5.34	0.87	2.30	0.29
1234022	Drill Core	2211.3	3.7	6.9	2.2	281	0.9	234.7	17.6	63.8	119.7	13.79	53.9	8.60	2.42	6.70	0.84	4.37	0.70	1.72	0.23
1234023	Drill Core	3843.0	4.8	9.2	4.1	<8	<0.5	38.3	101.3	335.8	737.0	93.01	388.7	64.84	18.84	50.08	6.10	27.72	4.00	8.17	0.95
1234024	Drill Core	1649.6	3.8	6.5	1.5	251	<0.5	236.1	22.6	67.1	127.1	14.68	56.7	9.85	2.86	8.09	1.05	5.17	0.88	2.02	0.27
1234025	Drill Core	1741.7	3.1	4.0	0.9	221	0.8	221.6	18.4	46.5	97.3	11.49	44.9	7.70	2.34	6.73	0.89	4.40	0.75	1.86	0.21
1234026	Drill Core	4625.9	0.2	5.4	8.7	<8	<0.5	55.7	111.7	254.9	565.3	72.01	298.8	53.16	15.73	43.34	5.79	28.01	4.43	9.46	1.06
1234027	Drill Core	997.3	27.7	3.5	18.5	320	1.0	38.7	52.7	172.1	370.0	46.89	192.1	32.89	9.33	24.39	2.93	13.87	2.14	4.42	0.56
1234028	Drill Core	3859.5	12.0	4.7	11.2	18	<0.5	23.3	65.8	198.5	432.5	52.85	217.4	37.15	10.70	28.02	3.55	16.20	2.58	5.66	0.75
1234029	Drill Core	2297.7	6.0	8.5	1.9	266	0.8	288.6	22.1	81.1	155.1	17.11	62.9	10.05	2.88	8.08	1.02	5.10	0.91	2.11	0.30
1234030	Drill Core	4278.3	0.6	6.2	7.1	<8	<0.5	72.8	147.8	312.1	671.8	82.46	334.1	56.79	17.25	47.51	6.38	33.28	5.90	14.39	1.76

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ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Project: Project None Given
Report Date: June 05, 2014

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CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	MA370	TG001	TC000	TC000	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252
	Analyte	Yb	Lu	Ni	LOI	TOT/C	TOT/S	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	As	Au	Cd	Sb	Bi	Cr
	Unit	ppm	ppm	ppm	%	%	%	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm
	MDL	0.05	0.01	10	-5.1	0.01	0.01	0.01	0.01	0.01	0.1	2	0.1	0.1	1	0.1	0.2	0.01	0.02	0.02	0.5
1234001	Drill Core	0.72	0.11	50	2.7	0.32	<0.01	0.27	134.41	1.95	53.8	75	30.3	15.5	498	0.2	3.1	0.06	<0.02	0.21	63.9
1234002	Drill Core	2.87	0.41	43	39.5	11.49	0.50	0.87	2.71	8.83	132.5	338	37.7	26.7	2358	1.9	1.1	0.33	0.03	<0.02	1.5
1234003	Drill Core	1.48	0.21	<10	37.3	10.40	0.07	0.18	0.78	1.55	16.9	106	0.5	6.2	1919	1.0	*	0.19	<0.02	<0.02	1.2
1234004	Drill Core	3.16	0.44	33	31.6	8.79	0.47	1.71	1.52	15.26	97.3	466	28.8	19.8	2142	2.0	<0.2	0.30	<0.02	<0.02	0.6
1234005	Drill Core	0.61	0.12	15	42.1	12.76	0.02	0.28	0.70	3.21	85.0	67	4.6	9.8	5302	0.3	0.2	0.49	<0.02	<0.02	8.2
1234006	Drill Core	4.26	0.63	27	30.7	8.64	0.16	9.43	0.01	4.52	64.2	63	23.9	12.1	1865	0.2	0.9	0.27	<0.02	<0.02	<0.5
1234007	Drill Core	1.14	0.18	386	13.3	3.09	0.14	1.01	64.96	1.97	67.3	30	325.1	46.1	918	0.4	0.7	0.09	<0.02	<0.02	88.0
1234008	Drill Core	10.70	1.25	<10	15.1	4.01	0.14	7.40	0.93	43.85	89.3	174	5.8	12.7	5523	<0.1	*	0.87	<0.02	0.03	2.7
1234009	Drill Core	6.97	0.83	<10	42.8	12.19	0.24	1.85	0.50	25.02	65.9	417	4.0	13.1	7658	0.2	<0.2	0.85	<0.02	0.02	1.4
1234011	Drill Core	5.61	0.63	<10	41.1	11.54	0.14	0.24	0.12	33.52	94.8	43	4.0	9.1	>10000	0.2	<0.2	0.92	<0.02	0.03	0.8
1234012	Drill Core	4.90	0.56	<10	41.5	11.96	0.42	0.78	5.69	18.31	50.5	696	6.7	26.0	7500	0.3	0.9	0.82	<0.02	<0.02	2.4
1234013	Drill Core	0.42	0.06	<10	1.6	0.17	0.03	3.59	2.84	3.94	51.5	32	2.0	1.4	222	<0.1	<0.2	0.11	<0.02	<0.02	5.1
1234014	Drill Core	1.49	0.20	<10	3.7	0.55	0.37	0.77	149.02	6.29	58.1	107	7.7	30.9	855	2.1	<0.2	0.11	0.04	0.21	6.0
1234015	Drill Core	1.24	0.18	21	5.1	0.63	0.23	0.12	26.81	6.27	118.6	79	20.4	17.2	545	0.6	<0.2	0.08	<0.02	<0.02	13.0
1234017	Drill Core	1.59	0.17	33	39.3	11.06	0.23	0.42	0.95	16.82	72.7	330	25.9	18.5	4788	1.0	<0.2	0.57	<0.02	<0.02	1.3
1234018	Drill Core	1.70	0.25	73	2.9	0.15	0.57	0.13	197.27	3.60	106.8	107	58.6	35.2	432	1.2	0.8	0.17	0.02	<0.02	85.3
1234019	Drill Core	2.61	0.37	106	4.1	0.48	0.56	0.28	155.27	4.12	117.4	97	77.9	39.1	640	1.1	0.5	0.09	<0.02	0.06	97.2
1234020	Drill Core	1.63	0.23	277	5.0	1.05	0.04	1.03	59.06	4.40	57.2	42	235.9	38.2	848	0.5	<0.2	0.07	<0.02	<0.02	84.3
1148789	Core Pulp	4.75	0.51	358	3.3	0.12	0.15	10.18	191.16	128.44	289.8	857	335.5	101.7	4298	16.7	*	0.55	1.23	0.55	214.1
1148790	Drill Core	<0.05	<0.01	<10	0.0	0.01	<0.01	0.16	0.33	0.41	1.3	<2	1.0	0.2	64	0.3	<0.2	<0.01	0.02	<0.02	2.8
1234021	Drill Core	1.73	0.25	209	5.0	0.90	0.07	10.99	65.35	5.93	64.4	45	175.1	34.5	858	1.5	<0.2	0.07	0.06	<0.02	81.6
1234022	Drill Core	1.47	0.21	500	23.0	4.54	0.05	1.21	80.42	2.82	64.2	55	417.5	43.9	1298	0.1	<0.2	0.09	<0.02	<0.02	511.5
1234023	Drill Core	4.86	0.56	33	38.2	10.83	0.25	1.05	5.27	43.31	55.0	123	28.4	10.0	6077	0.5	15.0	0.72	<0.02	<0.02	6.6
1234024	Drill Core	1.69	0.24	308	14.6	2.92	0.18	0.62	57.92	3.68	60.4	93	266.7	54.3	1130	0.6	<0.2	0.11	<0.02	<0.02	165.8
1234025	Drill Core	1.28	0.17	608	11.9	2.55	0.10	0.60	45.59	2.20	70.7	25	518.9	54.3	1075	0.1	<0.2	0.09	<0.02	<0.02	150.2
1234026	Drill Core	5.89	0.76	21	31.9	8.92	0.19	2.13	0.82	17.89	58.8	92	19.8	8.8	5277	0.3	<0.2	0.52	<0.02	<0.02	3.7
1234027	Drill Core	3.10	0.38	<10	19.9	4.86	0.03	1.51	1.52	9.60	52.3	613	4.7	21.5	3354	<0.1	*	0.47	<0.02	<0.02	3.0
1234028	Drill Core	4.32	0.58	<10	30.1	8.28	0.07	0.55	0.10	14.80	35.7	118	3.4	6.3	4305	<0.1	*	0.52	<0.02	<0.02	0.8
1234029	Drill Core	1.76	0.23	257	4.0	0.63	0.05	2.12	60.15	4.96	62.1	41	213.9	35.2	880	0.9	<0.2	0.09	0.03	<0.02	100.1
1234030	Drill Core	9.38	1.14	25	29.8	8.41	0.31	1.23	4.14	28.01	48.9	84	24.2	7.8	5577	<0.1	<0.2	0.80	<0.02	<0.02	1.7

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ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Project: Project None Given
Report Date: June 05, 2014

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CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	WGHT
	Analyte	B	Tl	Hg	Se	Te	Ge	In	Re	Be	Li	Pd	Pt	Wgt
	Unit	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppb	ppb	kg
	MDL	1	0.02	5	0.1	0.02	0.1	0.02	1	0.1	0.1	10	2	0.01
1234001	Drill Core	<1	0.16	<5	<0.1	0.02	0.1	<0.02	<1	0.4	7.9	<10	<2	0.30
1234002	Drill Core	<1	0.28	17	<0.1	0.09	<0.1	0.05	45	6.0	0.5	<10	<2	0.18
1234003	Drill Core	<1	<0.02	<5	<0.1	0.06	<0.1	<0.02	2	0.2	0.4	<10	<2	0.18
1234004	Drill Core	<1	0.07	<5	<0.1	0.15	<0.1	0.05	2	5.6	0.7	<10	<2	0.30
1234005	Drill Core	<1	<0.02	5	<0.1	0.16	<0.1	0.06	<1	0.5	0.2	<10	<2	0.22
1234006	Drill Core	<1	<0.02	<5	<0.1	0.09	<0.1	0.04	<1	7.8	0.4	<10	<2	0.22
1234007	Drill Core	<1	1.12	<5	<0.1	0.05	<0.1	0.02	<1	2.2	14.4	<10	<2	0.44
1234008	Drill Core	<1	<0.02	8	3.2	0.15	0.4	0.03	<1	3.7	0.6	22	<2	0.20
1234009	Drill Core	<1	<0.02	<5	<0.1	0.29	0.2	0.05	<1	0.5	3.6	<10	<2	0.24
1234011	Drill Core	<1	<0.02	<5	<0.1	0.18	<0.1	0.04	<1	0.4	0.3	<10	<2	0.30
1234012	Drill Core	<1	0.16	5	<0.1	0.29	0.2	0.13	2	1.1	0.4	12	<2	0.30
1234013	Drill Core	<1	0.03	<5	<0.1	<0.02	<0.1	<0.02	<1	0.5	1.6	<10	<2	0.18
1234014	Drill Core	2	0.64	<5	0.2	0.08	<0.1	<0.02	<1	0.4	16.2	<10	<2	0.54
1234015	Drill Core	1	0.54	7	<0.1	0.05	<0.1	0.04	<1	1.2	22.9	<10	<2	0.20
1234017	Drill Core	<1	0.04	<5	<0.1	0.11	<0.1	<0.02	<1	2.8	0.5	31	<2	0.52
1234018	Drill Core	<1	0.66	<5	0.1	0.04	0.2	0.03	<1	0.4	20.8	<10	<2	0.36
1234019	Drill Core	<1	0.70	<5	<0.1	0.06	0.1	0.06	<1	0.9	14.3	<10	<2	0.28
1234020	Drill Core	<1	0.23	<5	<0.1	<0.02	<0.1	<0.02	<1	1.0	20.3	18	2	0.46
1148789	Core Pulp	<1	0.66	<5	<0.1	0.04	1.1	0.60	<1	10.5	1.4	<10	3	0.03
1148790	Drill Core	<1	<0.02	<5	<0.1	<0.02	<0.1	<0.02	<1	<0.1	<0.1	<10	<2	0.10
1234021	Drill Core	2	0.32	<5	<0.1	0.02	0.2	<0.02	<1	1.2	19.9	<10	<2	0.42
1234022	Drill Core	<1	0.25	6	<0.1	0.04	<0.1	0.04	<1	1.5	9.3	<10	<2	0.16
1234023	Drill Core	<1	0.03	<5	<0.1	0.14	<0.1	0.04	<1	1.8	0.5	<10	<2	0.14
1234024	Drill Core	<1	0.12	<5	<0.1	0.06	0.1	0.04	<1	1.7	14.7	<10	2	0.24
1234025	Drill Core	1	0.26	<5	<0.1	0.04	0.1	0.03	<1	0.7	21.5	<10	<2	0.44
1234026	Drill Core	<1	0.02	<5	<0.1	0.11	<0.1	0.04	<1	2.7	0.5	16	<2	0.26
1234027	Drill Core	<1	<0.02	<5	<0.1	0.09	0.1	0.02	<1	0.4	0.2	<10	<2	0.40
1234028	Drill Core	<1	<0.02	8	<0.1	0.14	0.1	0.03	<1	0.8	0.2	<10	<2	0.28
1234029	Drill Core	1	0.67	7	<0.1	0.06	<0.1	<0.02	<1	0.8	30.5	26	<2	0.36
1234030	Drill Core	<1	<0.02	<5	<0.1	0.08	<0.1	0.04	<1	2.4	0.6	27	<2	0.24

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ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Client: **Anglo American Brasil Ltda.**
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Goiania 74.672-360 BRASIL

Project: Project None Given
Report Date: June 05, 2014

Page: 3 of 4 Part: 1 of 4

CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200
	Analyte	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	Ba	Sc	Sum	Cs	Ga	Hf	Nb	Rb	Sn
	Unit	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.002	1	1	0.01	0.1	0.5	0.1	0.1	0.1	1
1234032	Drill Core	7.53	0.81	8.40	14.82	25.34	0.08	0.06	0.01	0.12	1.03	<0.002	9310	13	98.38	<0.1	1.0	<0.1	23.1	1.1	<1
1234033	Drill Core	50.65	20.03	4.94	2.43	2.64	0.16	8.89	0.38	0.04	0.29	<0.002	627	2	99.51	0.3	41.4	30.0	474.9	321.7	4
1234034	Drill Core	11.74	0.20	13.12	14.77	20.07	0.07	<0.01	<0.01	0.10	1.22	<0.002	4232	12	98.99	<0.1	<0.5	<0.1	11.6	0.3	<1
1234035	Drill Core	10.82	0.24	8.08	11.68	28.30	0.06	0.08	0.01	5.73	0.78	<0.002	5604	12	98.33	<0.1	<0.5	0.8	79.0	1.3	<1
1234036	Drill Core	16.93	0.07	6.51	13.71	23.09	0.10	<0.01	<0.01	0.11	0.73	<0.002	2379	5	98.93	<0.1	0.8	0.2	6.4	0.2	<1
1234037	Drill Core	34.47	12.18	11.78	6.14	7.85	0.16	5.19	2.04	1.56	0.38	0.037	2030	18	99.21	1.0	14.8	11.0	195.1	103.0	2
1234038	Drill Core	36.23	11.73	11.01	6.11	8.84	0.34	4.28	1.49	1.64	0.34	0.029	2814	15	99.12	1.9	16.6	5.2	213.4	101.3	3
1234039	Drill Core	33.46	11.46	10.24	6.76	16.22	0.90	2.65	1.82	1.56	0.29	0.038	2020	12	99.11	147.4	14.5	5.4	170.5	395.8	2
1148791	Core Pulp	16.34	0.83	41.88	1.14	16.21	0.06	0.05	2.57	12.39	0.79	0.035	18277	73	95.45	0.3	8.5	51.0	2544.7	4.4	41
1148792	Drill Core	98.82	<0.01	0.95	<0.01	<0.01	0.02	<0.01	0.01	0.01	<0.01	<0.002	5	<1	100.03	<0.1	<0.5	<0.1	1.2	0.1	<1
1234041	Drill Core	0.35	0.07	10.56	15.04	28.45	0.06	0.01	0.01	0.08	0.83	<0.002	7331	12	98.33	0.1	<0.5	0.1	15.1	0.9	<1
1234042	Drill Core	4.66	0.03	38.31	5.10	2.93	0.02	<0.01	<0.01	0.12	2.05	<0.002	>50000	6	77.62	<0.1	5.0	2.1	9.8	<0.1	<1
1234043	Drill Core	51.74	18.12	5.71	2.55	2.62	0.28	6.88	0.78	0.63	0.09	<0.002	9346	8	98.62	2.6	22.7	11.1	424.0	145.2	2
1234044	Drill Core	7.56	1.18	9.53	13.83	25.57	0.06	0.85	0.04	1.26	0.77	<0.002	2826	25	98.70	<0.1	1.6	0.6	80.9	12.8	1
1234045	Drill Core	16.39	0.14	35.54	7.22	7.21	0.04	0.03	0.02	<0.01	1.85	<0.002	29483	5	96.19	<0.1	1.8	1.1	50.7	1.3	<1
1234046	Drill Core	39.43	13.37	11.17	8.63	8.97	0.17	1.75	2.86	1.09	0.16	0.066	1279	24	99.40	1.5	17.0	6.8	107.9	53.4	2
1234047	Drill Core	7.22	0.29	9.88	15.67	25.05	0.09	0.05	0.03	0.12	1.06	0.002	2938	20	98.67	<0.1	1.3	<0.1	8.0	1.5	<1
1234048	Drill Core	6.83	0.14	3.90	17.61	27.21	0.09	0.08	0.01	0.12	0.62	<0.002	2581	4	98.99	<0.1	<0.5	0.7	183.4	1.2	<1
1234049	Drill Core	74.25	11.11	2.40	0.75	0.84	1.94	6.59	0.16	0.01	0.04	<0.002	456	3	99.89	0.2	12.6	1.6	31.5	106.8	<1
1234050	Drill Core	67.80	13.28	3.35	0.81	1.27	3.00	7.60	0.23	0.21	0.04	<0.002	825	5	99.80	0.4	14.2	3.2	41.3	104.7	<1
1234051	Drill Core	60.19	16.95	6.58	2.89	3.77	4.14	2.60	0.72	0.23	0.12	0.007	613	12	99.77	2.2	16.8	4.8	10.3	77.3	<1
1234052	Drill Core	50.34	20.95	4.09	2.12	2.57	0.45	9.90	0.49	0.05	0.20	<0.002	2170	<1	99.36	2.8	23.7	6.9	187.6	237.2	<1
1234053	Drill Core	39.22	10.92	11.52	10.57	14.34	0.78	1.42	2.47	0.95	0.21	0.114	1134	27	99.42	40.7	13.4	6.0	67.2	219.0	2
1234055	Drill Core	6.23	0.10	7.43	15.59	26.88	0.05	0.02	0.03	0.32	1.17	<0.002	1509	12	98.33	<0.1	0.8	0.1	92.2	0.9	<1
1234056	Drill Core	49.18	0.26	44.39	0.03	0.07	0.02	0.03	0.06	0.25	1.79	0.003	14293	9	97.77	<0.1	2.0	0.3	53.7	0.9	<1
1234057	Drill Core	44.96	16.08	13.45	5.39	3.85	2.92	1.90	3.03	0.37	0.16	0.012	862	23	99.39	0.4	20.5	5.7	44.0	42.6	2
1234058	Drill Core	45.18	16.88	11.78	3.78	4.27	3.05	1.88	2.93	0.39	0.12	0.013	772	23	98.61	0.9	19.5	5.7	45.6	41.5	2
1234059	Drill Core	49.61	10.74	14.22	1.28	4.11	2.23	8.73	0.58	1.94	0.22	0.004	8666	28	98.37	<0.1	9.8	9.4	1410.5	103.4	15
1234060	Drill Core	5.79	0.12	7.33	16.62	27.23	0.04	0.02	0.07	0.08	1.09	<0.002	1709	12	98.96	<0.1	<0.5	0.6	99.9	0.5	<1
1148793	Core Pulp	12.01	0.67	35.77	1.31	23.84	0.08	0.03	2.14	17.41	0.77	0.021	5299	63	96.90	0.1	7.6	46.5	3237.8	1.8	33

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Project: Project None Given
Report Date: June 05, 2014

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CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200
	Analyte	Sr	Ta	Th	U	V	W	Zr	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm
	Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.5	0.1	0.2	0.1	8	0.5	0.1	0.1	0.1	0.1	0.02	0.3	0.05	0.02	0.05	0.01	0.05	0.02	0.03	0.01
1234032	Drill Core	2968.8	4.8	19.7	4.6	<8	<0.5	8.5	77.5	332.9	661.1	77.65	295.5	44.11	11.81	32.10	3.84	18.37	3.00	6.86	0.79
1234033	Drill Core	224.3	32.0	52.1	14.8	14	1.9	1875.7	22.5	14.5	34.2	3.99	13.9	3.00	0.98	3.05	0.60	3.88	0.84	2.66	0.47
1234034	Drill Core	2620.8	1.2	29.8	4.4	<8	<0.5	4.9	43.5	361.4	689.9	82.38	308.4	40.85	9.22	21.76	2.31	10.18	1.57	3.74	0.46
1234035	Drill Core	6469.6	31.9	68.9	11.9	<8	0.9	47.1	87.1	387.9	767.4	87.67	327.9	51.49	14.41	37.89	4.51	21.57	3.34	7.42	0.91
1234036	Drill Core	3453.0	1.8	29.0	2.2	20	<0.5	7.1	55.4	293.5	583.1	69.64	264.6	37.08	9.46	23.62	2.78	12.98	1.90	4.79	0.60
1234037	Drill Core	1603.2	8.7	35.2	7.8	201	7.0	596.5	58.0	198.8	352.0	37.57	131.5	19.48	5.63	15.98	2.14	11.02	2.00	5.18	0.75
1234038	Drill Core	2102.8	26.2	21.4	8.2	303	2.4	249.4	38.1	146.4	255.7	26.33	96.9	13.58	4.17	11.69	1.53	7.96	1.35	3.44	0.48
1234039	Drill Core	2419.5	9.1	26.0	5.3	301	3.0	316.5	47.8	213.3	376.3	38.96	135.0	19.86	5.64	15.31	1.99	9.94	1.64	4.17	0.57
1148791	Core Pulp	3874.6	164.2	395.7	123.3	499	29.3	2211.2	163.9	1966.0	4271.2	502.00	1845.5	246.98	61.73	151.23	15.10	56.97	6.06	10.45	1.21
1148792	Drill Core	2.6	0.2	<0.2	<0.1	<8	<0.5	0.5	0.1	0.5	0.9	0.09	0.4	<0.05	<0.02	0.06	<0.01	<0.05	<0.02	<0.03	<0.01
1234041	Drill Core	3576.8	3.1	122.1	1.3	44	<0.5	10.1	48.5	193.3	384.7	46.80	179.0	26.06	6.87	18.54	2.44	11.75	1.76	3.98	0.50
1234042	Drill Core	869.1	1.6	1113.4	4.3	45	<0.5	119.8	72.4	100.6	550.0	108.68	530.7	96.89	20.83	51.66	5.83	22.91	2.67	4.69	0.54
1234043	Drill Core	600.7	2.0	43.3	3.8	54	2.5	432.1	27.2	88.2	173.2	19.58	70.5	12.17	2.49	8.99	1.20	5.90	1.00	2.52	0.32
1234044	Drill Core	5210.3	66.9	89.4	20.2	26	<0.5	36.7	42.0	122.3	259.7	32.19	124.8	20.59	5.46	14.95	1.90	10.10	1.50	3.35	0.44
1234045	Drill Core	804.8	0.4	160.0	1.3	57	<0.5	50.9	54.2	23.5	95.6	18.54	96.1	21.37	5.78	16.48	2.29	12.66	2.07	4.43	0.48
1234046	Drill Core	1019.2	7.3	10.5	2.1	325	<0.5	335.1	22.6	86.3	173.3	19.82	74.0	11.01	3.17	8.74	1.09	5.36	0.87	2.04	0.27
1234047	Drill Core	3907.5	2.7	7.8	6.1	<8	<0.5	11.1	102.2	465.1	960.6	114.13	425.5	60.20	16.24	41.28	5.29	25.29	3.81	8.81	1.22
1234048	Drill Core	2254.0	7.7	9.0	8.2	21	<0.5	92.4	42.5	183.7	368.9	44.01	171.7	27.37	7.31	19.45	2.15	9.86	1.53	3.58	0.46
1234049	Drill Core	146.3	0.8	8.0	4.3	13	<0.5	50.4	3.5	61.3	107.8	10.29	31.3	4.04	0.87	2.51	0.25	0.99	0.11	0.25	0.03
1234050	Drill Core	343.4	0.7	9.5	1.0	34	<0.5	119.1	5.9	70.7	114.4	11.00	33.3	4.25	0.86	2.89	0.32	1.36	0.19	0.48	0.07
1234051	Drill Core	473.0	0.4	2.4	0.6	111	<0.5	184.2	17.1	11.0	22.7	2.60	10.3	2.13	0.93	2.58	0.47	2.92	0.63	1.99	0.28
1234052	Drill Core	1778.8	6.0	22.9	3.2	48	1.1	423.9	21.7	123.0	184.4	16.18	46.5	5.78	1.65	4.32	0.67	3.86	0.76	2.26	0.34
1234053	Drill Core	1009.4	4.4	7.5	1.7	291	0.6	263.1	25.6	68.7	136.5	15.93	59.4	9.82	2.91	8.11	1.10	5.66	0.92	2.30	0.32
1234055	Drill Core	4597.6	19.1	25.9	15.7	<8	<0.5	25.5	67.0	2090.5	2616.0	214.29	597.0	64.47	16.85	42.97	4.39	18.12	2.42	4.95	0.60
1234056	Drill Core	378.9	0.2	415.7	2.6	72	58.8	73.2	69.0	912.6	1789.4	199.83	624.2	91.85	26.36	67.45	6.87	26.22	2.79	4.83	0.53
1234057	Drill Core	2303.1	2.8	5.2	1.1	347	<0.5	229.2	21.6	42.1	79.7	9.55	36.1	6.71	2.03	5.83	0.88	4.79	0.86	2.27	0.32
1234058	Drill Core	9178.4	2.8	5.3	1.0	334	0.7	240.4	22.1	39.8	84.9	9.99	37.9	6.76	2.13	6.09	0.87	4.90	0.83	2.21	0.34
1234059	Drill Core	1803.5	27.4	91.5	14.6	155	1.5	323.4	65.1	164.6	275.3	29.15	101.0	20.96	6.93	22.14	3.45	16.42	2.28	4.08	0.40
1234060	Drill Core	2754.8	9.4	417.0	5.7	12	0.6	61.0	51.8	164.1	386.5	51.95	213.2	45.95	13.45	33.48	3.61	14.26	1.77	3.54	0.42
1148793	Core Pulp	4664.5	146.9	386.0	200.4	441	17.4	1992.4	157.7	1496.9	3633.8	459.12	1680.9	246.57	63.81	149.82	15.52	56.48	5.81	9.88	1.07

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Project: Project None Given
Report Date: June 05, 2014

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CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	MA370	TG001	TC000	TC000	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252
	Analyte	Yb	Lu	Ni	LOI	TOT/C	TOT/S	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	As	Au	Cd	Sb	Bi	Cr
	Unit	ppm	ppm	ppm	%	%	%	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm
	MDL	0.05	0.01	10	-5.1	0.01	0.01	0.01	0.01	0.01	0.1	2	0.1	0.1	1	0.1	0.2	0.01	0.02	0.02	0.5
1234032	Drill Core	3.77	0.41	<10	40.2	11.28	0.33	3.17	0.34	21.96	62.5	138	6.1	8.0	7218	0.2	<0.2	0.58	0.05	0.02	4.5
1234033	Drill Core	3.30	0.53	<10	9.1	1.41	0.31	0.38	0.30	37.16	36.4	69	10.2	1.1	2177	0.7	<0.2	0.10	0.07	0.14	0.7
1234034	Drill Core	2.56	0.27	<10	37.7	10.78	0.30	0.27	0.53	7.80	99.2	384	5.8	13.6	8502	0.6	0.5	0.40	<0.02	0.08	2.6
1234035	Drill Core	4.80	0.55	<10	32.5	9.01	0.16	0.53	0.80	39.43	62.7	343	3.0	8.4	5617	0.3	*	0.49	0.03	0.13	2.2
1234036	Drill Core	3.05	0.31	<10	37.7	10.80	0.21	0.17	0.57	8.19	59.0	342	2.2	10.6	5625	0.3	<0.2	0.49	<0.02	<0.02	1.6
1234037	Drill Core	4.70	0.72	104	17.4	4.48	0.28	1.83	47.75	15.41	149.7	161	86.9	32.5	2885	1.5	<0.2	0.28	0.05	0.04	52.4
1234038	Drill Core	2.78	0.37	129	17.1	4.58	0.37	8.58	32.66	20.93	143.2	245	98.8	42.0	2510	5.0	6.0	0.34	0.12	0.14	37.3
1234039	Drill Core	3.36	0.44	112	13.7	2.62	0.30	8.49	41.08	10.64	117.5	72	98.4	32.3	1907	1.0	<0.2	0.16	0.05	0.12	86.9
1148791	Core Pulp	6.14	0.67	197	3.1	0.11	0.38	7.86	318.36	149.53	269.5	953	171.5	140.7	5254	12.6	*	0.70	0.92	0.60	110.6
1148792	Drill Core	<0.05	<0.01	<10	0.2	<0.01	<0.01	0.11	0.43	0.42	1.1	<2	1.2	0.1	80	0.3	<0.2	<0.01	0.02	<0.02	3.4
1234041	Drill Core	2.67	0.35	<10	42.9	12.40	0.30	0.61	0.36	47.30	260.0	200	3.5	11.5	6104	0.4	<0.2	0.40	<0.02	0.12	2.6
1234042	Drill Core	2.63	0.26	18	24.4	8.13	3.41	0.56	0.92	258.58	843.1	320	16.3	26.9	>10000	2.4	12.9	0.54	0.16	0.13	9.8
1234043	Drill Core	1.73	0.27	<10	9.2	1.54	0.34	1.40	6.65	41.42	344.2	175	8.5	11.3	741	1.1	1.1	0.28	0.04	0.21	3.9
1234044	Drill Core	2.35	0.31	14	38.0	10.80	0.13	2.06	2.28	41.91	86.3	390	7.1	10.5	5837	0.2	<0.2	0.54	0.04	<0.02	9.3
1234045	Drill Core	2.15	0.25	11	27.7	8.27	0.79	2.32	2.21	206.89	1252.2	1279	11.4	21.2	>10000	0.5	2.9	0.62	0.02	2.67	7.0
1234046	Drill Core	1.63	0.22	243	11.7	1.43	0.18	0.17	62.53	5.78	102.6	60	211.8	41.8	949	0.2	0.3	0.09	<0.02	<0.02	89.0
1234047	Drill Core	6.94	0.93	<10	39.2	11.20	0.19	1.60	0.48	28.16	67.8	290	4.6	11.7	7862	0.7	0.7	0.83	0.02	<0.02	1.3
1234048	Drill Core	2.38	0.31	<10	42.4	11.90	0.07	0.13	0.88	12.02	126.7	112	0.7	4.9	4739	0.7	<0.2	0.81	<0.02	0.03	0.8
1234049	Drill Core	0.14	0.02	<10	1.8	0.38	0.10	0.72	13.32	9.42	24.0	39	2.3	2.2	331	0.2	<0.2	<0.01	0.02	<0.02	6.1
1234050	Drill Core	0.44	0.06	<10	2.2	0.39	0.05	5.99	16.19	10.43	95.7	32	3.0	2.5	322	0.6	<0.2	0.18	<0.02	<0.02	5.7
1234051	Drill Core	1.89	0.32	29	1.5	0.18	0.20	1.73	89.63	2.46	78.3	112	30.3	16.5	854	0.6	<0.2	0.02	<0.02	<0.02	46.6
1234052	Drill Core	2.29	0.35	16	8.2	1.41	0.03	0.09	1.20	12.90	87.9	19	9.7	3.4	1532	0.4	<0.2	0.46	<0.02	<0.02	0.6
1234053	Drill Core	1.82	0.26	310	6.9	1.07	0.15	2.14	72.20	4.28	93.5	53	251.3	58.7	1208	0.2	<0.2	0.09	<0.02	<0.02	121.2
1234055	Drill Core	3.12	0.37	<10	40.5	11.80	0.24	0.58	0.69	35.40	66.2	371	1.5	13.4	8688	0.2	0.5	1.16	<0.02	0.03	1.7
1234056	Drill Core	2.49	0.24	23	1.7	0.04	0.26	3.41	11.86	129.59	404.0	988	22.2	55.2	>10000	2.6	10.7	0.81	0.17	0.08	7.8
1234057	Drill Core	2.13	0.31	58	7.3	0.93	0.24	1.35	50.37	2.79	178.0	42	61.2	53.5	1145	0.9	<0.2	0.09	0.03	0.02	74.9
1234058	Drill Core	2.14	0.31	63	8.3	1.32	0.22	1.02	47.04	7.01	200.6	37	56.8	59.6	792	0.7	<0.2	0.07	0.04	<0.02	65.9
1234059	Drill Core	1.88	0.20	<10	4.7	0.71	0.18	1.33	4.92	125.10	273.5	227	9.2	14.9	1668	3.1	<0.2	0.31	0.11	0.52	17.7
1234060	Drill Core	2.12	0.25	<10	40.6	11.70	0.04	0.48	2.28	24.29	359.2	536	2.6	10.7	7882	1.4	<0.2	0.72	0.04	0.07	2.2
1148793	Core Pulp	5.53	0.60	135	2.8	0.26	0.04	8.00	336.65	123.42	254.2	*	122.7	117.5	5275	11.7	*	0.93	0.97	0.48	77.5

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ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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Client: **Anglo American Brasil Ltda.**
Avenida Interlandia, 502
Setor Santa Genoveva
Goiania 74.672-360 BRASIL

Project: Project None Given
Report Date: June 05, 2014

CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	WGHT
	Analyte	B	Tl	Hg	Se	Te	Ge	In	Re	Be	Li	Pd	Pt	Wgt
	Unit	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppb	ppb	kg
	MDL	1	0.02	5	0.1	0.02	0.1	0.02	1	0.1	0.1	10	2	0.01
1234032	Drill Core	<1	<0.02	<5	<0.1	0.34	0.1	0.06	<1	0.8	0.4	<10	<2	0.16
1234033	Drill Core	<1	0.13	<5	<0.1	0.03	<0.1	0.04	<1	1.3	2.9	<10	<2	0.24
1234034	Drill Core	<1	<0.02	<5	<0.1	0.48	0.1	0.04	<1	0.9	0.4	<10	<2	0.14
1234035	Drill Core	<1	<0.02	<5	<0.1	0.71	<0.1	0.05	<1	1.3	0.2	11	<2	0.18
1234036	Drill Core	<1	<0.02	<5	<0.1	0.56	0.2	0.04	2	1.2	0.3	<10	<2	0.18
1234037	Drill Core	<1	0.04	6	<0.1	0.13	0.1	0.10	3	2.3	3.6	<10	<2	0.10
1234038	Drill Core	<1	0.11	<5	<0.1	0.25	0.1	0.07	6	2.8	3.0	<10	<2	0.14
1234039	Drill Core	<1	1.45	<5	<0.1	0.16	0.2	0.02	5	2.8	14.9	<10	<2	0.18
1148791	Core Pulp	<1	0.76	<5	<0.1	0.34	1.1	0.43	1	12.1	0.8	54	8	0.03
1148792	Drill Core	<1	<0.02	<5	<0.1	0.05	<0.1	<0.02	<1	<0.1	<0.1	<10	<2	0.10
1234041	Drill Core	<1	<0.02	<5	<0.1	0.42	<0.1	0.07	<1	1.3	0.2	<10	<2	0.20
1234042	Drill Core	<1	0.07	14	<0.1	0.05	0.3	0.52	2	0.7	0.2	<10	<2	0.22
1234043	Drill Core	<1	0.12	7	<0.1	0.06	<0.1	0.06	6	1.9	1.5	<10	<2	0.12
1234044	Drill Core	<1	<0.02	<5	<0.1	0.66	<0.1	0.07	2	1.0	0.3	11	<2	0.14
1234045	Drill Core	<1	<0.02	7	<0.1	0.11	0.2	0.34	<1	1.7	0.2	<10	<2	0.20
1234046	Drill Core	<1	<0.02	<5	<0.1	0.08	0.1	0.05	1	5.8	44.0	<10	<2	0.22
1234047	Drill Core	<1	<0.02	<5	<0.1	0.53	0.1	0.04	2	0.7	0.6	<10	<2	0.16
1234048	Drill Core	<1	<0.02	<5	<0.1	0.45	<0.1	0.06	4	0.4	0.6	<10	<2	0.20
1234049	Drill Core	<1	<0.02	<5	<0.1	<0.02	0.1	<0.02	<1	0.7	1.3	11	<2	0.18
1234050	Drill Core	<1	<0.02	<5	<0.1	0.12	<0.1	<0.02	<1	0.8	1.7	14	<2	0.14
1234051	Drill Core	<1	0.33	<5	<0.1	0.07	0.3	0.02	3	0.5	21.9	<10	<2	0.16
1234052	Drill Core	<1	0.14	<5	<0.1	0.13	<0.1	0.02	3	1.9	1.2	<10	<2	0.22
1234053	Drill Core	<1	0.41	<5	<0.1	0.12	0.1	0.02	<1	1.4	23.7	<10	<2	0.26
1234055	Drill Core	<1	<0.02	<5	<0.1	0.57	0.4	0.06	2	0.2	0.3	<10	<2	0.18
1234056	Drill Core	<1	2.11	6	<0.1	0.13	0.4	0.27	<1	3.6	0.3	<10	<2	0.26
1234057	Drill Core	<1	0.20	9	<0.1	0.16	0.1	0.05	2	3.1	18.3	<10	<2	0.12
1234058	Drill Core	<1	0.08	<5	<0.1	0.71	0.1	0.07	<1	2.8	15.3	<10	<2	0.14
1234059	Drill Core	<1	<0.02	<5	<0.1	0.17	0.2	0.10	<1	5.3	0.6	<10	<2	0.14
1234060	Drill Core	<1	<0.02	<5	<0.1	0.39	<0.1	0.06	<1	1.2	1.6	23	<2	0.12
1148793	Core Pulp	<1	1.11	18	<0.1	0.26	0.8	0.39	5	11.1	1.1	53	5	0.03

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Client: **Anglo American Brasil Ltda.**
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Goiania 74.672-360 BRASIL

Project: Project None Given
Report Date: June 05, 2014

CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200
	Analyte	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	Ba	Sc	Sum	Cs	Ga	Hf	Nb	Rb	Sn
	Unit	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.002	1	1	0.01	0.1	0.5	0.1	0.1	0.1	1
1148794	Drill Core	98.77	<0.01	1.10	<0.01	<0.01	0.02	<0.01	<0.01	0.01	<0.01	<0.002	4	<1	100.02	<0.1	<0.5	<0.1	1.3	0.2	<1
1234061	Drill Core	6.48	0.32	6.95	14.12	30.63	0.22	0.02	0.18	7.49	0.76	<0.002	1890	9	98.71	<0.1	<0.5	0.7	109.3	0.7	<1
1234062	Drill Core	48.50	15.20	11.98	4.88	7.65	3.48	2.12	3.16	0.45	0.18	<0.002	834	20	99.30	0.4	18.5	6.0	52.7	47.5	1
1234063	Drill Core	2.20	0.19	5.79	15.56	32.46	0.05	0.06	0.02	5.92	0.36	<0.002	373	5	99.24	<0.1	<0.5	0.3	16.4	1.1	<1
1234064	Drill Core	10.38	0.09	6.15	13.45	29.14	0.10	0.02	<0.01	5.19	0.71	<0.002	1087	7	99.04	<0.1	<0.5	0.6	12.4	0.1	<1
1234065	Drill Core	22.80	0.07	4.92	9.16	27.40	0.18	0.01	<0.01	8.27	0.93	<0.002	6413	6	98.23	<0.1	1.0	0.6	9.5	0.2	<1
1234066	Drill Core	39.23	11.63	12.57	8.63	11.17	0.84	3.20	2.93	0.96	0.22	0.075	1824	25	99.28	2.0	17.7	8.1	98.4	82.8	2
1234067	Drill Core	44.91	14.06	8.47	7.81	11.79	0.97	1.40	2.12	0.75	0.13	0.101	1382	25	99.25	1.0	16.5	6.1	69.5	34.8	1
1234068	Drill Core	6.27	0.11	5.37	11.03	33.10	0.21	0.03	<0.01	10.42	0.72	<0.002	5743	6	98.22	<0.1	<0.5	0.5	22.5	0.4	<1
1234069	Drill Core	21.86	0.01	4.14	8.08	30.35	0.10	<0.01	<0.01	12.28	0.56	<0.002	614	4	98.64	<0.1	<0.5	0.8	5.5	0.2	<1
1234070	Drill Core	1.01	0.16	3.57	16.89	32.86	0.05	0.07	<0.01	4.59	0.46	<0.002	94	4	99.21	<0.1	0.6	0.2	5.4	1.2	<1
1234071	Drill Core	11.62	0.11	6.69	13.25	29.29	0.06	<0.01	0.03	7.41	0.30	<0.002	1982	10	99.03	<0.1	<0.5	2.6	15.5	0.2	1
1234072	Drill Core	2.53	0.40	5.90	15.49	31.74	0.06	<0.01	0.03	5.81	0.35	<0.002	139	7	99.21	<0.1	<0.5	1.0	12.5	0.2	<1
1234073	Drill Core	3.56	<0.01	2.73	17.19	31.68	0.04	<0.01	<0.01	4.03	0.58	<0.002	352	7	99.15	<0.1	<0.5	0.5	7.5	0.2	<1
1234074	Drill Core	3.40	0.24	6.12	18.19	29.26	0.03	0.15	0.02	0.13	1.15	<0.002	228	6	99.07	<0.1	<0.5	0.3	19.8	1.0	<1
1234075	Drill Core	7.67	0.11	6.05	14.07	30.25	0.12	0.06	0.01	5.14	0.86	<0.002	418	7	99.09	<0.1	0.6	1.3	26.6	0.4	1
1148795	Core Pulp	36.04	1.12	33.20	1.39	9.67	0.05	0.05	3.53	7.51	0.69	0.069	8817	75	96.60	0.4	<0.5	58.5	2398.6	4.5	66
1148796	Drill Core	98.70	<0.01	0.86	<0.01	0.01	0.03	<0.01	<0.01	0.02	<0.01	<0.002	2	<1	100.03	<0.1	<0.5	<0.1	0.6	0.3	<1

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Project: Project None Given
Report Date: June 05, 2014

Page: 4 of 4 Part: 2 of 4

CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200	LF200
	Analyte	Sr	Ta	Th	U	V	W	Zr	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm
	Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	MDL	0.5	0.1	0.2	0.1	8	0.5	0.1	0.1	0.1	0.1	0.02	0.3	0.05	0.02	0.05	0.01	0.05	0.02	0.03	0.01
1148794	Drill Core	2.3	<0.1	<0.2	<0.1	<8	<0.5	<0.1	<0.1	0.3	0.5	0.05	0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01
1234061	Drill Core	5900.6	10.2	18.7	14.9	23	7.2	130.0	80.5	105.0	245.4	31.46	129.6	23.96	7.76	21.97	3.36	18.21	2.99	6.72	0.89
1234062	Drill Core	3380.5	3.0	6.1	1.5	298	0.9	249.3	24.3	51.3	105.1	12.69	48.0	8.20	2.44	6.75	0.95	4.93	0.88	2.19	0.31
1234063	Drill Core	3147.5	16.9	1.5	4.7	21	<0.5	25.9	35.9	94.8	222.1	29.20	114.7	19.27	5.82	15.87	1.95	9.10	1.35	2.99	0.36
1234064	Drill Core	3882.4	4.3	3.0	17.3	9	1.2	47.7	64.4	211.4	465.7	58.57	214.1	31.01	8.88	22.60	3.11	15.44	2.45	5.66	0.69
1234065	Drill Core	5016.9	0.7	4.4	12.9	9	0.6	77.8	103.0	431.7	1029.4	134.06	530.3	91.32	27.56	69.00	8.55	33.90	3.93	6.80	0.68
1234066	Drill Core	1502.5	5.9	9.6	2.1	316	1.2	370.5	30.5	92.0	180.9	21.36	81.9	13.11	3.87	10.51	1.41	7.05	1.06	2.87	0.36
1234067	Drill Core	2585.5	4.2	7.7	1.7	250	1.0	273.8	24.2	66.8	132.6	15.24	56.8	9.56	2.79	7.69	1.04	5.09	0.84	2.21	0.30
1234068	Drill Core	6216.9	12.6	21.1	44.6	9	<0.5	62.8	170.7	233.7	522.2	67.27	269.3	52.26	17.94	56.13	9.06	44.58	6.38	13.05	1.56
1234069	Drill Core	8410.1	0.1	8.3	11.3	<8	<0.5	81.2	17.9	253.6	542.7	68.34	270.8	46.40	12.63	27.57	2.20	6.38	0.55	1.08	0.14
1234070	Drill Core	3685.1	1.3	1.3	1.5	<8	<0.5	11.7	24.1	93.2	205.7	25.97	100.4	16.86	4.74	12.85	1.51	6.48	0.92	2.09	0.21
1234071	Drill Core	3106.8	4.0	4.0	13.1	49	<0.5	245.0	67.8	162.7	329.6	41.07	171.2	29.75	8.99	26.82	3.33	15.90	2.60	6.08	0.74
1234072	Drill Core	3442.7	1.7	1.3	4.8	42	<0.5	68.9	38.9	123.9	253.8	31.79	125.5	22.18	6.26	17.81	2.28	10.40	1.57	3.19	0.42
1234073	Drill Core	3920.1	2.2	1.7	3.4	<8	<0.5	15.0	27.8	92.4	196.9	23.60	90.8	14.11	3.98	10.86	1.44	6.73	0.99	2.38	0.30
1234074	Drill Core	2762.0	5.4	6.3	8.7	33	<0.5	22.4	35.3	440.1	966.4	121.99	488.1	74.64	17.74	35.19	3.28	10.97	1.04	1.64	0.29
1234075	Drill Core	3762.1	16.2	6.1	42.9	17	<0.5	62.1	85.1	229.9	500.4	65.00	261.3	43.86	12.14	30.61	3.74	17.37	2.83	10.37	2.25
1148795	Core Pulp	2168.8	111.5	412.9	94.9	395	46.8	2320.1	129.2	2461.4	5042.8	560.37	1948.4	244.13	57.03	118.63	11.90	41.38	4.26	6.52	0.83
1148796	Drill Core	2.0	0.1	<0.2	<0.1	<8	<0.5	0.3	<0.1	0.2	0.4	0.05	<0.3	<0.05	<0.02	<0.05	<0.01	<0.05	<0.02	<0.03	<0.01

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Client: **Anglo American Brasil Ltda.**
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Project: Project None Given
Report Date: June 05, 2014

Page: 4 of 4 Part: 3 of 4

CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	LF200	LF200	MA370	TG001	TC000	TC000	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252
	Analyte	Yb	Lu	Ni	LOI	TOT/C	TOT/S	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	As	Au	Cd	Sb	Bi	Cr
	Unit	ppm	ppm	ppm	%	%	%	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm
	MDL	0.05	0.01	10	-5.1	0.01	0.01	0.01	0.01	0.01	0.1	2	0.1	0.1	1	0.1	0.2	0.01	0.02	0.02	0.5
1148794	Drill Core	<0.05	<0.01	<10	0.1	<0.01	<0.01	0.16	0.42	0.42	1.0	<2	1.2	0.2	89	0.1	<0.2	<0.01	<0.02	<0.02	3.9
1234061	Drill Core	4.95	0.63	<10	31.5	9.05	0.05	0.75	4.53	60.47	80.2	255	2.1	7.2	6015	1.8	*	0.74	0.11	0.13	2.9
1234062	Drill Core	1.96	0.30	<10	1.7	0.40	0.03	1.59	9.76	1.54	57.5	60	3.8	21.0	582	0.7	0.9	0.06	0.05	0.03	5.9
1234063	Drill Core	2.01	0.27	<10	36.6	10.70	0.08	0.16	0.12	4.81	27.0	120	<0.1	6.5	2967	<0.1	*	0.30	0.02	<0.02	0.6
1234064	Drill Core	3.85	0.55	<10	33.8	9.75	0.03	0.79	0.79	9.38	47.8	69	0.1	7.5	5555	1.6	*	0.66	0.05	<0.02	1.4
1234065	Drill Core	3.65	0.46	<10	24.5	7.05	0.17	0.94	0.18	19.50	48.3	157	2.7	5.4	7073	<0.1	*	1.13	0.03	<0.02	1.1
1234066	Drill Core	1.99	0.31	160	7.8	1.46	0.21	2.49	52.70	6.90	143.6	50	137.9	39.5	1266	0.2	<0.2	0.17	0.04	0.04	90.5
1234067	Drill Core	1.70	0.25	212	6.7	0.21	0.12	1.48	65.73	4.65	150.5	57	179.5	53.7	514	<0.1	<0.2	0.04	<0.02	<0.02	65.6
1234068	Drill Core	10.02	1.50	<10	31.0	8.28	0.16	1.93	1.86	20.12	109.6	90	3.8	7.3	5855	<0.1	*	0.75	0.05	<0.02	1.5
1234069	Drill Core	1.21	0.14	<10	21.2	5.87	0.02	7.94	0.71	15.47	55.8	81	0.7	4.7	4443	<0.1	1.2	0.58	0.03	<0.02	1.3
1234070	Drill Core	1.43	0.16	<10	39.5	11.43	0.04	0.08	0.13	1.91	20.1	40	<0.1	4.9	3541	<0.1	0.7	0.31	<0.02	<0.02	<0.5
1234071	Drill Core	4.37	0.61	<10	30.3	8.71	0.05	2.63	0.07	5.22	75.3	136	0.9	15.5	2380	<0.1	<0.2	0.27	0.02	<0.02	0.7
1234072	Drill Core	2.51	0.32	<10	36.9	10.43	0.15	0.66	0.25	8.93	84.4	219	1.8	14.1	2714	<0.1	<0.2	0.28	0.03	<0.02	<0.5
1234073	Drill Core	1.37	0.19	<10	39.3	11.15	0.07	0.30	0.38	3.21	17.8	68	0.5	4.5	4505	<0.1	*	0.38	<0.02	<0.02	1.4
1234074	Drill Core	2.03	0.27	<10	40.4	11.81	<0.01	0.47	3.03	7.96	42.8	52	5.7	10.3	7844	0.3	*	0.60	<0.02	<0.02	1.4
1234075	Drill Core	19.24	2.77	<10	34.7	10.00	0.01	0.42	0.61	9.91	60.4	410	1.2	10.7	6558	0.5	*	0.76	0.02	<0.02	2.4
1148795	Core Pulp	5.21	0.53	353	3.2	0.13	0.13	9.88	192.68	128.46	288.2	923	321.5	99.0	4147	16.5	<0.2	0.61	1.23	0.60	202.9
1148796	Drill Core	<0.05	<0.01	<10	0.4	<0.01	<0.01	0.12	0.41	0.37	0.6	<2	1.0	0.1	71	<0.1	0.3	<0.01	<0.02	<0.02	2.9

This report supersedes all previous preliminary and final reports with this file number dated prior to the date on this certificate. Signature indicates final approval; preliminary reports are unsigned and should be used for reference only.

ANEXO A – GEOQUÍMICA DE ROCHA TOTAL

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PHONE (604) 253-3158

Client: **Anglo American Brasil Ltda.**
Avenida Interlandia, 502
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Goiania 74.672-360 BRASIL

Project: Project None Given
Report Date: June 05, 2014

CERTIFICATE OF ANALYSIS GOI14000296.1

	Method	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	AQ252	WGHT
	Analyte	B	Tl	Hg	Se	Te	Ge	In	Re	Be	Li	Pd	Pt	Wgt
	Unit	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppb	ppb	kg
	MDL	1	0.02	5	0.1	0.02	0.1	0.02	1	0.1	0.1	10	2	0.01
1148794	Drill Core	<1	<0.02	<5	<0.1	0.06	<0.1	<0.02	<1	<0.1	<0.1	<10	<2	0.11
1234061	Drill Core	1	<0.02	<5	<0.1	0.63	0.2	0.03	<1	2.6	6.6	25	<2	0.18
1234062	Drill Core	<1	<0.02	<5	<0.1	0.18	<0.1	<0.02	<1	0.3	3.3	<10	<2	0.20
1234063	Drill Core	<1	<0.02	<5	0.8	0.39	0.1	0.03	<1	0.4	0.2	18	<2	0.28
1234064	Drill Core	<1	<0.02	<5	<0.1	0.39	0.1	0.05	1	1.1	0.3	27	<2	0.36
1234065	Drill Core	<1	<0.02	<5	<0.1	0.44	0.1	0.04	<1	1.7	0.3	41	2	0.28
1234066	Drill Core	<1	0.10	<5	<0.1	0.14	0.2	0.03	<1	3.9	29.1	<10	3	0.22
1234067	Drill Core	1	0.52	<5	<0.1	0.13	<0.1	0.02	<1	2.9	15.8	<10	<2	0.16
1234068	Drill Core	<1	<0.02	8	<0.1	0.52	<0.1	0.05	2	1.5	0.8	12	<2	0.24
1234069	Drill Core	<1	<0.02	<5	<0.1	0.68	0.2	0.03	<1	4.5	0.4	39	<2	0.20
1234070	Drill Core	<1	<0.02	<5	<0.1	0.40	<0.1	0.03	<1	0.1	0.2	<10	<2	0.18
1234071	Drill Core	<1	<0.02	<5	<0.1	0.30	<0.1	0.03	<1	3.0	0.2	<10	<2	0.18
1234072	Drill Core	<1	0.13	<5	16.6	0.44	0.1	0.07	<1	1.0	0.3	<10	<2	0.20
1234073	Drill Core	<1	<0.02	<5	1.3	0.48	<0.1	0.04	<1	0.5	0.2	<10	<2	0.22
1234074	Drill Core	<1	<0.02	<5	<0.1	0.34	0.1	0.03	<1	1.3	0.2	<10	<2	0.22
1234075	Drill Core	<1	<0.02	<5	<0.1	0.48	0.1	0.11	<1	0.7	0.6	12	<2	0.34
1148795	Core Pulp	<1	0.61	23	<0.1	0.33	1.1	0.50	<1	11.9	1.5	<10	<2	0.03
1148796	Drill Core	<1	<0.02	<5	<0.1	0.04	<0.1	<0.02	<1	<0.1	<0.1	<10	<2	0.10

This report supersedes all previous preliminary and final reports with this file number dated prior to the date on this certificate. Signature indicates final approval; preliminary reports are unsigned and should be used for reference only.

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223142_CARBZON_1	1223142_CARBZON_4	1223142_CARBZON_5	1223142_CARBZON_7	1223142_CARBZON_8	1223142_CARBZON_9	1223142_CARBZON_11	1223142_CARBZON_12	1223142_CARBZON_18	1223142_CARBINTER_19	1223142_CARBINTER_20	1223142_CARBINTER_22
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.01	0.00
Al2O3(Mass%)	0.00	0.03	0.00	0.00	0.04	0.00	0.02	0.02	0.13	0.02	0.00	0.00
FeO(Mass%)	1.05	0.07	0.06	0.03	0.02	0.05	2.43	0.12	2.51	0.71	0.46	0.73
MnO(Mass%)	0.06	0.64	0.32	0.00	0.00	0.00	0.11	0.34	0.43	0.26	0.30	0.28
MgO(Mass%)	19.12	20.00	20.10	18.28	18.59	18.27	18.93	19.98	18.55	19.63	19.77	19.45
CaO(Mass%)	30.96	29.67	29.90	32.86	32.53	32.72	29.27	30.00	29.11	30.02	29.99	30.02
BaO(Mass%)	0.01	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02
SrO(Mass%)	0.38	0.00	0.46	0.08	0.03	0.13	0.64	0.22	0.36	0.10	0.04	0.06
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.04	0.03	0.02	0.03	0.06	0.03	0.05	0.03	0.02	0.02	0.01	0.03
SO3(Mass%)	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.03	0.00	0.01
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00
TOTAL	51.63	50.47	50.89	51.29	51.29	51.21	51.45	50.71	51.15	50.82	50.84	50.59
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.11	0.00
TOTAL	51.63	50.47	50.89	51.29	51.29	51.21	51.45	50.71	51.15	50.82	50.74	50.59
CO2	45.99	45.18	45.66	45.81	45.86	45.72	45.40	45.53	44.80	45.48	45.42	45.28
sum%	97.62	95.64	96.55	97.10	97.15	96.93	96.85	96.24	95.95	96.30	96.16	95.87

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223142_CARBZON_1	1223142_CARBZON_4	1223142_CARBZON_5	1223142_CARBZON_7	1223142_CARBZON_8	1223142_CARBZON_9	1223142_CARBZON_11	1223142_CARBZON_12	1223142_CARBZON_18	1223142_CARBINTER_19	1223142_CARBINTER_20	1223142_CARBINTER_22
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.03	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.07	0.02	0.01	0.02
Mn	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Mg	0.91	0.96	0.96	0.87	0.88	0.87	0.91	0.96	0.90	0.94	0.94	0.94
Ca	1.06	1.03	1.03	1.13	1.11	1.12	1.01	1.03	1.02	1.03	1.03	1.04
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
TOTAL	2.00	2.01	2.01	2.00	2.00	2.00	2.00	2.01	2.01	2.01	2.02	2.01
F=O												
TOTAL												
CO2(N.O.)	2.00	1.99	2.00	2.00	2.00	2.00	2.00	2.00	1.99	2.00	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	223142_CARBINTER_2	223142_CARBINTER_2	223142_CARBINTER_2	223142_CARBINTER_2	1223142_CARBINTER_2	223142_CARBINTER_2	1223142_CARBINTER_2	1223142_CARBINTER_3	1223142_CARBINTER_3	1223142_CARBINTER_32	1223142_CARBOXFE_1	1223142_CARBOXFE_2
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Al2O3(Mass%)	0.22	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.10	0.01	0.00	0.01
FeO(Mass%)	0.76	0.61	0.63	0.77	0.62	0.72	0.44	0.67	0.69	0.66	0.32	0.33
MnO(Mass%)	0.29	0.23	0.27	0.28	0.30	0.25	0.32	0.29	0.33	0.29	0.00	0.00
MgO(Mass%)	18.78	19.95	20.07	19.71	19.96	19.82	19.87	19.70	19.64	19.57	18.47	18.08
CaO(Mass%)	29.60	29.76	30.06	30.44	29.74	29.81	29.92	29.92	29.96	29.88	32.58	33.05
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.01	0.00	0.00	0.00	0.01
SrO(Mass%)	0.03	0.09	0.08	0.09	0.03	0.08	0.11	0.05	0.10	0.07	0.09	0.03
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Ce2O3(Mass%)	0.04	0.01	0.00	0.01	0.05	0.05	0.02	0.04	0.06	0.03	0.03	0.03
SO3(Mass%)	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
TOTAL	49.72	50.66	51.12	51.30	50.71	50.78	50.73	50.73	50.91	50.51	51.59	51.55
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	0.00
TOTAL	49.72	50.66	51.12	51.30	50.71	50.78	50.73	50.73	50.91	50.51	51.55	51.55
CO2	44.21	45.55	45.92	45.92	45.53	45.53	45.51	45.43	45.43	45.25	45.97	45.91
sum%	93.93	96.22	97.04	97.22	96.24	96.30	96.24	96.16	96.34	95.76	97.53	97.45

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	223142_CARBINTER_2	223142_CARBINTER_2	223142_CARBINTER_2	223142_CARBINTER_2	1223142_CARBINTER_2	223142_CARBINTER_2	1223142_CARBINTER_2	1223142_CARBINTER_3	1223142_CARBINTER_3	1223142_CARBINTER_32	1223142_CARBOXFE_1	1223142_CARBOXFE_2
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Mg	0.92	0.96	0.95	0.94	0.96	0.95	0.95	0.95	0.94	0.94	0.88	0.86
Ca	1.05	1.02	1.03	1.04	1.02	1.03	1.03	1.03	1.03	1.03	1.11	1.13
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
TOTAL	2.01	2.00	2.00	2.01	2.01	2.00	2.01	2.01	2.01	2.01	2.01	2.00
F=O												
TOTAL												
CO2(N.O.)	1.99	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.99	2.00	2.00	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223142_CARBOXFE_	1223142_CARBOXFE_4	1223142_CARBOXFE_5	1223142_CARBOXFE_6	1223142_CARBOXFE_7	1223142_CARBAPAT_8	1223142_CARBAPAT_9	1223142_CARBAPAT_10	1223142_CARBAPTMAS	1223142_CARBAPTMASS	1223142_CARBAPTMASS_	1223142_CARBAPTMASS_	1223142_CARBAPTMASS_5
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.02	0.00	0.02	0.00	0.02	0.06	0.00	0.01	0.00	0.00	0.00	0.01	0.00
Al2O3(Mass%)	0.48	0.00	0.07	0.00	0.02	0.98	0.06	0.00	0.01	0.00	0.11	0.17	0.00
FeO(Mass%)	0.78	0.85	0.95	0.35	0.23	1.33	1.68	1.43	0.96	0.51	1.52	1.35	0.48
MnO(Mass%)	0.27	0.26	0.22	0.00	0.01	0.45	0.58	0.28	0.27	0.32	0.38	0.32	0.31
MgO(Mass%)	19.10	19.64	19.61	18.56	18.48	18.45	18.32	19.61	19.40	20.01	18.98	19.29	19.94
CaO(Mass%)	30.06	29.65	29.77	32.85	32.86	29.38	29.93	29.48	29.85	29.87	29.63	29.89	29.85
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.03	0.00
SrO(Mass%)	0.11	0.11	0.08	0.13	0.11	0.03	0.06	0.11	0.10	0.07	0.35	0.12	0.09
La2O3(Mass%)	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Ce2O3(Mass%)	0.03	0.05	0.05	0.05	0.06	0.05	0.03	0.07	0.01	0.05	0.07	0.04	0.06
SO3(Mass%)	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
F(Mass%)	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	50.89	50.56	50.78	51.97	51.78	50.74	50.67	51.00	50.63	50.85	51.07	51.23	50.73
F=O	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	50.89	50.56	50.78	51.96	51.78	50.74	50.67	51.00	50.63	50.85	51.07	51.23	50.73
CO2	44.98	45.28	45.40	46.32	46.17	44.03	44.56	45.48	45.25	45.64	45.07	45.41	45.54
sum%	95.87	95.84	96.18	98.27	97.95	94.77	95.23	96.48	95.88	96.49	96.15	96.64	96.26

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223142_CARBOXFE_	1223142_CARBOXFE_4	1223142_CARBOXFE_5	1223142_CARBOXFE_6	1223142_CARBOXFE_7	1223142_CARBAPAT_8	1223142_CARBAPAT_9	1223142_CARBAPAT_10	1223142_CARBAPTMAS	1223142_CARBAPTMASS	1223142_CARBAPTMASS_	1223142_CARBAPTMASS_	1223142_CARBAPTMASS_5
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.02	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Fe	0.02	0.02	0.03	0.01	0.01	0.04	0.05	0.04	0.03	0.01	0.04	0.04	0.01
Mn	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.92	0.95	0.94	0.87	0.87	0.90	0.90	0.94	0.93	0.96	0.92	0.92	0.95
Ca	1.04	1.03	1.03	1.11	1.12	1.03	1.05	1.02	1.03	1.03	1.03	1.03	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.00	2.01	2.00	2.00	2.03	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O													
TOTAL													
CO2(N.O.)	1.99	2.00	2.00	2.00	2.00	1.98	1.99	2.00	2.00	2.00	1.99	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLMS	1234061_CARB_DOLMS	1234061_CARB_DOLMSU	1234061_CARB_DOLMSU	1234061_CARB_DOLMSU	1234061_CARB_DOLMSUJO_	1234061_CARB_DOLMSUJO_20
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.05	0.01	0.00	0.01	0.00
Al2O3(Mass%)	0.00	0.02	0.00	0.02	0.07	0.00	0.02	0.01	0.02	0.10	0.07	0.03	0.02	0.10
FeO(Mass%)	2.31	2.56	2.96	0.23	0.34	1.32	1.20	1.90	1.30	3.67	0.62	1.38	1.64	1.31
MnO(Mass%)	0.76	0.80	0.87	0.69	0.43	0.96	0.25	1.14	1.17	0.22	0.39	1.06	1.51	0.32
MgO(Mass%)	18.75	18.42	18.09	19.55	19.06	19.00	19.09	18.43	18.56	17.69	19.11	18.99	18.13	19.24
CaO(Mass%)	27.94	28.01	27.78	29.37	30.29	28.67	29.10	29.10	29.41	29.19	30.40	29.28	28.91	28.53
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.03	0.00	0.03	0.00	0.00	0.00
SrO(Mass%)	1.32	1.27	1.02	0.12	0.46	0.23	0.95	0.11	0.14	0.03	0.08	0.09	0.16	0.96
La2O3(Mass%)	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Ce2O3(Mass%)	0.04	0.03	0.07	0.04	0.01	0.04	0.06	0.07	0.05	0.00	0.03	0.05	0.06	0.01
SO3(Mass%)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.12	51.11	50.79	50.05	50.64	50.28	50.71	50.77	50.68	50.97	50.73	50.88	50.45	50.47
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.12	51.11	50.79	50.05	50.64	50.28	50.71	50.77	50.68	50.97	50.73	50.88	50.45	50.47
CO2	44.38	44.21	43.81	44.60	44.98	44.18	44.84	44.18	44.22	44.49	45.14	44.60	43.57	44.60
sum%	95.49	95.32	94.60	94.65	95.63	94.45	95.55	94.95	94.90	95.46	95.87	95.48	94.02	95.07

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLM	1234061_CARB_DOLMS	1234061_CARB_DOLMS	1234061_CARB_DOLMSU	1234061_CARB_DOLMSU	1234061_CARB_DOLMSU	1234061_CARB_DOLMSUJO_	1234061_CARB_DOLMSUJO_20
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.06	0.07	0.08	0.01	0.01	0.04	0.03	0.05	0.04	0.10	0.02	0.04	0.05	0.04
Mn	0.02	0.02	0.02	0.02	0.01	0.03	0.01	0.03	0.03	0.01	0.01	0.03	0.04	0.01
Mg	0.92	0.91	0.90	0.95	0.92	0.94	0.93	0.91	0.91	0.87	0.92	0.93	0.90	0.94
Ca	0.98	0.99	0.99	1.03	1.05	1.01	1.02	1.03	1.04	1.03	1.05	1.02	1.03	1.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.03	0.02	0.02	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.02	2.02	2.01	2.01	2.02	2.01	2.02	2.02	2.01	2.01	2.02	2.03	2.01
F=O														
TOTAL														
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.99	2.00	1.99	1.99	1.99	1.99	1.99	1.98	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1234061_CARB_DOLMCAV_1	1234061_CARB_DOLMCAV_2	1234061_CARB_DOLMCAV_3	1234061_CARB_DOLMZON_6	1234061_CARB_DOLMZON_9	1234061_CARB_DOLMZON_10	1234061_CARB_DOLMZON_11	1234061_CARB_DOLMSUJO_14	1234061_CARB_DOLMSUJO_15	1234061_CARB_DOLMSUJO_16	1234061_CARB_DOLMSUJO_17	1234061_CARB_DOLMSUJO_18	1234061_CARB_DOLMSUJO_19	1234061_CARB_DOLMSUJO_20
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.05	0.01	0.00	0.01	0.00
Al2O3(Mass%)	0.00	0.02	0.00	0.02	0.07	0.00	0.02	0.01	0.02	0.10	0.07	0.03	0.02	0.10
FeO(Mass%)	2.31	2.56	2.96	0.23	0.34	1.32	1.20	1.90	1.30	3.67	0.62	1.38	1.64	1.31
MnO(Mass%)	0.76	0.80	0.87	0.69	0.43	0.96	0.25	1.14	1.17	0.22	0.39	1.06	1.51	0.32
MgO(Mass%)	18.75	18.42	18.09	19.55	19.06	19.00	19.09	18.43	18.56	17.69	19.11	18.99	18.13	19.24
CaO(Mass%)	27.94	28.01	27.78	29.37	30.29	28.67	29.10	29.10	29.41	29.19	30.40	29.28	28.91	28.53
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.03	0.00	0.03	0.00	0.00	0.00
SrO(Mass%)	1.32	1.27	1.02	0.12	0.46	0.23	0.95	0.11	0.14	0.03	0.08	0.09	0.16	0.96
La2O3(Mass%)	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Ce2O3(Mass%)	0.04	0.03	0.07	0.04	0.01	0.04	0.06	0.07	0.05	0.00	0.03	0.05	0.06	0.01
SO3(Mass%)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.12	51.11	50.79	50.05	50.64	50.28	50.71	50.77	50.68	50.97	50.73	50.88	50.45	50.47
CO2	44.38	44.21	43.81	44.60	44.98	44.18	44.84	44.18	44.22	44.49	45.14	44.60	43.57	44.60
sum%	95.49	95.32	94.60	94.65	95.63	94.45	95.55	94.95	94.90	95.46	95.87	95.48	94.02	95.07

PROPORÇÃO
ATÔMICA PARA 6 O

AMOSTRA	1234061_CARB_DOLMCAV_1	1234061_CARB_DOLMCAV_2	1234061_CARB_DOLMCAV_3	1234061_CARB_DOLMZON_6	1234061_CARB_DOLMZON_9	1234061_CARB_DOLMZON_10	1234061_CARB_DOLMZON_11	1234061_CARB_DOLMSUJO_14	1234061_CARB_DOLMSUJO_15	1234061_CARB_DOLMSUJO_16	1234061_CARB_DOLMSUJO_17	1234061_CARB_DOLMSUJO_18	1234061_CARB_DOLMSUJO_19	1234061_CARB_DOLMSUJO_20
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.06	0.07	0.08	0.01	0.01	0.04	0.03	0.05	0.04	0.10	0.02	0.04	0.05	0.04
Mn	0.02	0.02	0.02	0.02	0.01	0.03	0.01	0.03	0.03	0.01	0.01	0.03	0.04	0.01
Mg	0.92	0.91	0.90	0.95	0.92	0.94	0.93	0.91	0.91	0.87	0.92	0.93	0.90	0.94
Ca	0.98	0.99	0.99	1.03	1.05	1.01	1.02	1.03	1.04	1.03	1.05	1.02	1.03	1.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.03	0.02	0.02	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.02	2.02	2.01	2.01	2.02	2.01	2.02	2.02	2.01	2.01	2.02	2.03	2.01
F=O														
TOTAL														
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.99	2.00	1.99	1.99	1.99	1.99	1.99	1.98	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223001_CARB_DOLCENTROZIRC_2	1223001_CARB_DOLCENTROZIRC_3	1223001_CARB_DOLCENTROZIRC_4	1223001_CARB_DOLQUATZ_1	1223001_CARB_DOLQUATZ_2	1223001_CARB_DOLFENO_1	1223001_CARB_DOLFENO_2	1223001_CARB_DOLFENO_3	1223001_CARB_DOLFENO_4	1234061_C2_DOL_2	1234061_C2_DOL_9	1234061_C2_DOL_10	1234061_C2_DOL_11
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.02	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.06	0.00
Al2O3(Mass%)	0.02	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01	0.05	0.00	0.02	0.00
FeO(Mass%)	1.38	1.59	1.30	1.70	1.65	1.77	1.57	1.55	1.61	2.28	0.65	1.30	1.26
MnO(Mass%)	0.28	0.31	0.30	0.32	0.30	0.28	0.30	0.31	0.32	0.66	0.61	1.07	1.21
MgO(Mass%)	19.94	19.37	19.55	19.20	19.26	18.97	19.30	19.38	18.89	18.46	18.91	19.11	18.69
CaO(Mass%)	29.36	29.53	29.51	29.58	29.52	29.69	29.50	29.38	29.57	27.35	28.48	28.60	28.31
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.02	0.02
SrO(Mass%)	0.08	0.11	0.04	0.15	0.15	0.17	0.18	0.18	0.20	1.08	0.67	0.42	0.44
La2O3(Mass%)	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.00
Ce2O3(Mass%)	0.07	0.05	0.01	0.05	0.05	0.03	0.02	0.05	0.04	0.10	0.01	0.01	0.00
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
F(Mass%)	0.09	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.15				
TOTAL	51.24	50.96	50.74	51.01	51.19	50.93	50.88	50.87	50.79	50.03	49.40	50.72	49.99
F=O	-0.04	0.00	0.00	0.00	-0.11	0.00	0.00	0.00	-0.06				
TOTAL	51.20	50.96	50.74	51.01	51.09	50.93	50.88	50.87	50.73	50.03	49.40	50.72	49.99
CO2	45.69	45.36	45.33	45.30	45.28	45.18	45.27	45.25	44.91	43.49	43.69	44.30	43.58
sum%	96.89	96.32	96.06	96.30	96.36	96.11	96.15	96.12	95.64	93.53	93.09	95.02	93.58

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223001_CARB_DOLCENTROZIRC_2	1223001_CARB_DOLCENTROZIRC_3	1223001_CARB_DOLCENTROZIRC_4	1223001_CARB_DOLQUATZ_1	1223001_CARB_DOLQUATZ_2	1223001_CARB_DOLFENO_1	1223001_CARB_DOLFENO_2	1223001_CARB_DOLFENO_3	1223001_CARB_DOLFENO_4	1234061_C2_DOL_2	1234061_C2_DOL_9	1234061_C2_DOL_10	1234061_C2_DOL_11
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.04	0.04	0.04	0.05	0.04	0.05	0.04	0.04	0.04	0.06	0.02	0.04	0.04
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03
Mg	0.95	0.93	0.94	0.92	0.92	0.92	0.93	0.93	0.91	0.92	0.94	0.94	0.93
Ca	1.00	1.02	1.02	1.02	1.02	1.03	1.02	1.02	1.03	0.98	1.02	1.01	1.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.02	2.01	2.01	2.01	2.02	2.01	2.01	2.02	2.02
F=O													
TOTAL													
CO2(N.O.)	1.99	2.00	2.00	2.00	1.99	2.00	2.00	2.00	1.99	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1234061_C2_DOL_12	1234061_C2_DOL_13	1234061_C2_DOL_16	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1223142_C2_DOL_1
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.03	0.00	0.12	0.02	0.00	0.03	0.03	0.00	0.05	0.01	0.00	0.00	0.00	0.00
Al2O3(Mass%)	0.01	0.03	0.03	0.02	0.00	0.00	0.00	0.02	0.25	0.16	0.12	0.00	0.04	0.00
FeO(Mass%)	0.36	0.35	0.85	0.00	0.12	0.06	0.09	2.35	0.10	0.21	0.34	0.45	0.36	0.96
MnO(Mass%)	1.39	0.47	0.64	1.12	0.99	1.54	1.18	1.15	1.58	1.17	0.64	0.49	1.21	0.24
MgO(Mass%)	19.00	19.38	19.03	19.57	18.88	18.64	19.40	18.00	18.96	19.11	19.17	19.02	19.00	19.12
CaO(Mass%)	28.25	28.67	28.91	28.91	28.47	27.90	28.31	28.37	28.45	28.45	28.89	28.54	28.60	29.10
BaO(Mass%)	0.06	0.00	0.06	0.01	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.07	0.04	0.09
SrO(Mass%)	0.64	0.33	0.80	0.45	0.52	0.48	0.38	0.21	0.43	0.41	0.27	1.21	0.42	0.15
La2O3(Mass%)	0.03	0.05	0.00	0.09	0.05	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.08
Ce2O3(Mass%)	0.01	0.11	0.00	0.01	0.01	0.00	0.03	0.00	0.07	0.11	0.03	0.04	0.01	0.00
SO3(Mass%)														
F(Mass%)														
TOTAL	49.82	49.51	50.45	50.24	49.12	48.70	49.44	50.15	50.07	49.68	49.46	49.90	49.70	49.77
F=O														
TOTAL	49.82	49.51	50.45	50.24	49.12	48.70	49.44	50.15	50.07	49.68	49.46	49.90	49.70	49.77
CO2	43.42	44.02	44.35	44.26	43.26	42.49	43.62	43.45	43.30	43.52	43.94	43.98	43.61	44.40
sum%	93.24	93.53	94.80	94.49	92.38	91.19	93.06	93.60	93.36	93.20	93.40	93.89	93.31	94.16

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1234061_C2_DOL_12	1234061_C2_DOL_13	1234061_C2_DOL_16	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1234061_C1_DOL_1 LINE 1	1223142_C2_DOL_1
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Fe	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.07	0.00	0.01	0.01	0.01	0.01	0.03
Mn	0.04	0.01	0.02	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.02	0.01	0.03	0.01
Mg	0.95	0.96	0.93	0.96	0.95	0.95	0.97	0.90	0.95	0.95	0.95	0.94	0.95	0.94
Ca	1.01	1.02	1.02	1.02	1.03	1.02	1.01	1.02	1.02	1.02	1.03	1.02	1.02	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.03	2.01	2.01	2.02	2.02	2.03	2.02	2.02	2.04	2.03	2.01	2.01	2.02	2.00
F=O														
TOTAL														
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.98	1.99	1.99	1.98	1.98	1.99	2.00	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223142_C2_DOL_2	1223142_C2_DOL_3	1223142_C2_DOL_4	1223142_C1_DOL_1	1223142_C1_DOL_2	1223142_C1_DOL_4	1223142_C1_DOL_5	1223142_C1_DOL_6	1223142_C1_DOL_7	1223142_C1_DOL_8	1223142_C1_DOL_9	1223142_C1_DOL_10	1223142_C1_DOL_11
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.04	0.01	0.03	0.00	0.01	0.00	0.04	0.02	0.00	0.02	0.00	0.07
Al2O3(Mass%)	0.00	0.02	0.02	0.05	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00
FeO(Mass%)	2.65	0.60	0.76	0.98	0.53	0.59	0.49	0.49	0.50	0.44	1.98	0.34	2.95
MnO(Mass%)	0.46	0.38	0.28	0.27	0.39	0.34	0.32	0.38	0.34	0.28	0.44	0.28	0.29
MgO(Mass%)	18.37	20.02	18.88	18.68	19.75	19.56	19.19	19.34	19.61	19.06	18.21	19.58	18.05
CaO(Mass%)	28.90	29.69	28.95	28.89	29.23	29.31	29.73	29.04	29.26	29.06	28.76	29.42	28.62
BaO(Mass%)	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
SrO(Mass%)	0.12	0.07	0.08	0.09	0.18	0.24	0.18	0.18	0.24	0.06	0.21	0.16	0.15
La2O3(Mass%)	0.00	0.02	0.06	0.02	0.08	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.02	0.01	0.04	0.04	0.00	0.08	0.04	0.01	0.07	0.02	0.00	0.07	0.00
SO3(Mass%)													
F(Mass%)													
TOTAL	50.52	50.86	49.14	49.12	50.28	50.15	50.02	49.55	50.07	48.93	49.62	49.85	50.14
F=O													
TOTAL	50.52	50.86	49.14	49.12	50.28	50.15	50.02	49.55	50.07	48.93	49.62	49.85	50.14
CO2	44.42	45.57	43.84	43.72	44.92	44.83	44.67	44.30	44.79	43.92	43.75	44.75	44.04
sum%	94.94	96.43	92.98	92.84	95.20	94.98	94.69	93.85	94.86	92.85	93.37	94.59	94.18

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223142_C2_DOL_2	1223142_C2_DOL_3	1223142_C2_DOL_4	1223142_C1_DOL_1	1223142_C1_DOL_2	1223142_C1_DOL_4	1223142_C1_DOL_5	1223142_C1_DOL_6	1223142_C1_DOL_7	1223142_C1_DOL_8	1223142_C1_DOL_9	1223142_C1_DOL_10	1223142_C1_DOL_11
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.07	0.02	0.02	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.06	0.01	0.08
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.90	0.96	0.94	0.93	0.96	0.95	0.94	0.95	0.95	0.95	0.91	0.95	0.89
Ca	1.02	1.02	1.03	1.03	1.02	1.02	1.04	1.03	1.02	1.04	1.03	1.03	1.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O													
TOTAL													
CO2(N.O.)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223142_C1_DOL_13	1223142_C1_DOL_14	1223142_C1_DOL_15	1223142_C1_DOL_16	1223001_C5_DOL_1	1223001_C5_DOL_2	1223001_C5_DOL_3	1223001_C5_DOL_4	1223001_C5_DOL_5	1223001_C5_DOL_6	1223001_C5_DOL_7	1223001_C5_DOL_8	1223001_C5_DOL_9	1223001_C4_DOL_1 LINE1
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.03	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.00
Al2O3(Mass%)	0.00	0.00	0.01	0.01	0.03	0.00	0.02	0.02	0.00	0.02	0.00	0.00	0.00	0.05
FeO(Mass%)	0.36	1.38	0.46	2.75	1.17	1.24	1.55	1.59	1.65	1.72	1.75	1.72	1.37	1.51
MnO(Mass%)	0.31	0.44	0.32	0.47	0.31	0.37	0.30	0.33	0.33	0.29	0.27	0.27	0.27	0.25
MgO(Mass%)	19.26	18.92	19.46	17.82	18.76	19.11	18.60	18.86	18.57	18.83	18.54	18.63	18.73	18.18
CaO(Mass%)	29.21	29.16	29.02	28.83	28.78	28.93	28.66	29.45	28.96	29.17	29.46	28.64	29.01	28.93
BaO(Mass%)	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
SrO(Mass%)	0.16	0.10	0.10	0.09	0.30	0.26	0.25	0.29	0.24	0.22	0.32	0.35	0.31	0.39
La2O3(Mass%)	0.01	0.01	0.00	0.00	0.04	0.02	0.00	0.02	0.00	0.00	0.00	0.05	0.00	0.00
Ce2O3(Mass%)	0.04	0.04	0.01	0.00	0.05	0.01	0.00	0.01	0.08	0.04	0.01	0.03	0.10	0.00
SO3(Mass%)														
F(Mass%)														
TOTAL	49.36	50.16	49.42	49.97	49.44	49.94	49.46	50.57	49.86	50.32	50.36	49.69	49.82	49.40
F=O														
TOTAL	49.36	50.16	49.42	49.97	49.44	49.94	49.46	50.57	49.86	50.32	50.36	49.69	49.82	49.40
CO2	44.25	44.45	44.35	43.80	43.92	44.44	43.86	44.79	44.13	44.61	44.57	44.02	44.20	43.65
sum%	93.61	94.61	93.77	93.77	93.37	94.38	93.32	95.36	93.99	94.93	94.93	93.72	94.02	93.05

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223142_C1_DOL_13	1223142_C1_DOL_14	1223142_C1_DOL_15	1223142_C1_DOL_16	1223001_C5_DOL_1	1223001_C5_DOL_2	1223001_C5_DOL_3	1223001_C5_DOL_4	1223001_C5_DOL_5	1223001_C5_DOL_6	1223001_C5_DOL_7	1223001_C5_DOL_8	1223001_C5_DOL_9	1223001_C4_DOL_1 LINE1
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.01	0.04	0.01	0.08	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.04
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.95	0.93	0.96	0.89	0.93	0.94	0.92	0.92	0.92	0.92	0.91	0.92	0.92	0.91
Ca	1.03	1.03	1.03	1.03	1.03	1.02	1.02	1.03	1.03	1.02	1.04	1.02	1.03	1.04
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O														
TOTAL														
CO2(N.O.)	2.00	1.99	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223001_C4_DOL_1 LINE2	1223001_C4_DOL_1 LINE3	1223001_C4_DOL_1 LINE4	1223001_C4_DOL_1 LINE5	1223001_C4_DOL_1 LINE8	1223001_C4_DOL_1 LINE9	1223001_C4_DOL_1 LINE10	1223001_C4_DOL_1 LINE11	1223001_C4_DOL_2 LINE2	1223001_C4_DOL_2 LINE3	1223001_C4_DOL_2 LINE4	1223001_C4_DOL_2 LINE5	1223001_C4_DOL_2 LINE6	1223001_C4_DOL_2 LINE7
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.04	0.00	0.00	0.00	0.00
Al2O3(Mass%)	0.04	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.02
FeO(Mass%)	1.55	1.64	1.53	1.49	1.06	1.14	1.34	1.40	1.51	1.80	1.87	1.91	1.25	1.15
MnO(Mass%)	0.33	0.31	0.32	0.24	0.35	0.34	0.35	0.25	0.31	0.30	0.28	0.27	0.26	0.29
MgO(Mass%)	18.58	18.74	18.53	18.74	18.60	19.03	19.04	18.72	18.82	18.31	18.41	18.66	18.75	18.70
CaO(Mass%)	28.68	28.43	28.67	28.98	28.92	29.03	28.94	28.71	29.08	29.29	28.91	29.11	29.15	29.09
BaO(Mass%)	0.00	0.07	0.00	0.00	0.02	0.04	0.02	0.04	0.06	0.02	0.00	0.00	0.00	0.00
SrO(Mass%)	0.18	0.29	0.13	0.27	0.29	0.27	0.36	0.26	0.18	0.22	0.35	0.32	0.43	0.38
La2O3(Mass%)	0.05	0.00	0.00	0.01	0.00	0.02	0.07	0.00	0.03	0.04	0.01	0.00	0.00	0.00
Ce2O3(Mass%)	0.02	0.05	0.06	0.08	0.00	0.06	0.04	0.00	0.01	0.00	0.02	0.00	0.04	0.02
SO3(Mass%)														
F(Mass%)														
TOTAL	49.45	49.61	49.27	49.84	49.26	50.00	50.20	49.40	50.02	50.17	49.89	50.31	49.95	49.67
F=O														
TOTAL	49.45	49.61	49.27	49.84	49.26	50.00	50.20	49.40	50.02	50.17	49.89	50.31	49.95	49.67
CO2	43.83	43.94	43.74	44.25	43.79	44.39	44.49	43.95	44.39	44.18	44.09	44.52	44.31	44.11
sum%	93.28	93.55	93.01	94.09	93.04	94.40	94.69	93.34	94.41	94.35	93.99	94.83	94.26	93.78

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223001_C4_DOL_1 LINE2	1223001_C4_DOL_1 LINE3	1223001_C4_DOL_1 LINE4	1223001_C4_DOL_1 LINE5	1223001_C4_DOL_1 LINE8	1223001_C4_DOL_1 LINE9	1223001_C4_DOL_1 LINE10	1223001_C4_DOL_1 LINE11	1223001_C4_DOL_2 LINE2	1223001_C4_DOL_2 LINE3	1223001_C4_DOL_2 LINE4	1223001_C4_DOL_2 LINE5	1223001_C4_DOL_2 LINE6	1223001_C4_DOL_2 LINE7
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.04	0.05	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.03	0.03
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.92	0.93	0.92	0.92	0.93	0.93	0.93	0.93	0.92	0.90	0.91	0.91	0.92	0.92
Ca	1.02	1.01	1.03	1.03	1.03	1.02	1.02	1.02	1.03	1.04	1.03	1.02	1.03	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.00	2.01	2.01	2.01	2.00	2.01	2.01	2.01	2.01	2.01	2.01
F=O														
TOTAL														
CO2(N.O.)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223001_C4_DOL_3	1223001_C4_DOL_4	1223001_C4_DOL_5	1223001_C4_DOL_6	1223001_C4_DOL_7	1223001_C3_DOL_1 LINE1	1223001_C3_DOL_1 LINE2	1223001_C3_DOL_1 LINE3	1223001_C3_DOL_1 LINE4	1223001_C3_DOL_1 LINE5	1223001_C3_DOL_1 LINE6	1223001_C3_DOL_1 LINE7	1223001_C3_DOL_1 LINE8	:3001_C3_DOL_1 LIN	23001_C2_DOL1_ LIN
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.05	0.00	0.01	0.00	0.00	0.00	0.03	0.06	0.00	0.01	0.00	0.00	0.02	0.01	0.00
Al2O3(Mass%)	0.00	0.01	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.06	0.03	0.00	0.01
FeO(Mass%)	1.56	1.56	1.57	1.57	1.82	1.20	1.18	1.13	2.32	1.72	1.59	1.82	1.90	1.66	1.90
MnO(Mass%)	0.32	0.30	0.37	0.28	0.26	0.32	0.30	0.32	0.29	0.39	0.38	0.28	0.28	0.38	0.36
MgO(Mass%)	18.63	18.77	18.49	18.02	18.69	18.80	18.50	18.83	18.17	18.84	18.69	18.57	18.38	18.75	18.70
CaO(Mass%)	28.78	28.63	28.92	28.42	29.19	29.04	29.28	28.80	28.53	29.02	28.87	29.37	29.47	28.63	28.84
BaO(Mass%)	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.04	0.00	0.06	0.05	0.03	0.02	0.00	0.00
SrO(Mass%)	0.25	0.32	0.37	0.21	0.36	0.26	0.22	0.16	0.26	0.21	0.26	0.35	0.21	0.25	0.35
La2O3(Mass%)	0.00	0.01	0.07	0.00	0.02	0.00	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Ce2O3(Mass%)	0.00	0.10	0.00	0.06	0.00	0.03	0.07	0.03	0.06	0.06	0.04	0.00	0.05	0.00	0.02
SO3(Mass%)															
F(Mass%)															
TOTAL	49.61	49.73	49.86	48.63	50.37	49.75	49.71	49.41	49.68	50.31	49.91	50.55	50.39	49.75	50.18
F=O															
TOTAL	49.61	49.73	49.86	48.63	50.37	49.75	49.71	49.41	49.68	50.31	49.91	50.55	50.39	49.75	50.18
CO2	44.00	44.06	44.01	43.04	44.58	44.16	44.00	43.93	43.77	44.50	44.17	44.59	44.46	44.06	44.36
sum%	93.61	93.79	93.87	91.67	94.94	93.91	93.71	93.34	93.45	94.81	94.08	95.14	94.85	93.81	94.54

AMOSTRA	1223001_C4_DOL_3	1223001_C4_DOL_4	1223001_C4_DOL_5	1223001_C4_DOL_6	1223001_C4_DOL_7	1223001_C3_DOL_1 LINE1	1223001_C3_DOL_1 LINE2	1223001_C3_DOL_1 LINE3	1223001_C3_DOL_1 LINE4	1223001_C3_DOL_1 LINE5	1223001_C3_DOL_1 LINE6	1223001_C3_DOL_1 LINE7	1223001_C3_DOL_1 LINE8	:3001_C3_DOL_1 LIN	23001_C2_DOL1_ LIN
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT	Ap Colop CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.04	0.04	0.04	0.04	0.05	0.03	0.03	0.03	0.06	0.05	0.04	0.05	0.05	0.05	0.05
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.92	0.93	0.92	0.91	0.91	0.93	0.92	0.93	0.91	0.92	0.92	0.91	0.90	0.93	0.92
Ca	1.02	1.02	1.03	1.03	1.03	1.03	1.04	1.03	1.02	1.02	1.02	1.03	1.04	1.02	1.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O															
TOTAL															
CO2(N.O.)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223001_C4_DOL_3	1223001_C4_DOL_4	1223001_C4_DOL_5	1223001_C4_DOL_6	1223001_C4_DOL_7	1223001_C3_DOL_1 LINE1	1223001_C3_DOL_1 LINE2	1223001_C3_DOL_1 LINE3	1223001_C3_DOL_1 LINE4	1223001_C3_DOL_1 LINE5	1223001_C3_DOL_1 LINE6	1223001_C3_DOL_1 LINE7	1223001_C3_DOL_1 LINE8	1223001_C3_DOL_1 LINE10	1223001_C2_DOL1_LINE8
CARBONATO	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita	Dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.05	0.00	0.01	0.00	0.00	0.00	0.03	0.06	0.00	0.01	0.00	0.00	0.02	0.01	0.00
Al2O3(Mass%)	0.00	0.01	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.06	0.03	0.00	0.01
FeO(Mass%)	1.56	1.56	1.57	1.57	1.82	1.20	1.18	1.13	2.32	1.72	1.59	1.82	1.90	1.66	1.90
MnO(Mass%)	0.32	0.30	0.37	0.28	0.26	0.32	0.30	0.32	0.29	0.39	0.38	0.28	0.28	0.38	0.36
MgO(Mass%)	18.63	18.77	18.49	18.02	18.69	18.80	18.50	18.83	18.17	18.84	18.69	18.57	18.38	18.75	18.70
CaO(Mass%)	28.78	28.63	28.92	28.42	29.19	29.04	29.28	28.80	28.53	29.02	28.87	29.37	29.47	28.63	28.84
BaO(Mass%)	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.04	0.00	0.06	0.05	0.03	0.02	0.00	0.00
SrO(Mass%)	0.25	0.32	0.37	0.21	0.36	0.26	0.22	0.16	0.26	0.21	0.26	0.35	0.21	0.25	0.35
La2O3(Mass%)	0.00	0.01	0.07	0.00	0.02	0.00	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.07	0.00
Ce2O3(Mass%)	0.00	0.10	0.00	0.06	0.00	0.03	0.07	0.03	0.06	0.06	0.04	0.00	0.05	0.00	0.02
F(Mass%)															
TOTAL	49.61	49.73	49.86	48.63	50.37	49.75	49.71	49.41	49.68	50.31	49.91	50.55	50.39	49.75	50.18
F=O															
TOTAL	49.61	49.73	49.86	48.63	50.37	49.75	49.71	49.41	49.68	50.31	49.91	50.55	50.39	49.75	50.18
CO2	44.00	44.06	44.01	43.04	44.58	44.16	44.00	43.93	43.77	44.50	44.17	44.59	44.46	44.06	44.36
sum%	93.61	93.79	93.87	91.67	94.94	93.91	93.71	93.34	93.45	94.81	94.08	95.14	94.85	93.81	94.54

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223001_C4_DOL_3	1223001_C4_DOL_4	1223001_C4_DOL_5	1223001_C4_DOL_6	1223001_C4_DOL_7	1223001_C3_DOL_1 LINE1	1223001_C3_DOL_1 LINE2	1223001_C3_DOL_1 LINE3	1223001_C3_DOL_1 LINE4	1223001_C3_DOL_1 LINE5	1223001_C3_DOL_1 LINE6	1223001_C3_DOL_1 LINE7	1223001_C3_DOL_1 LINE8	1223001_C3_DOL_1 LINE10	1223001_C2_DOL1_LINE8
CARBONATO	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL	DOL
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.04	0.04	0.04	0.04	0.05	0.03	0.03	0.03	0.06	0.05	0.04	0.05	0.05	0.05	0.05
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ca	1.02	1.02	1.03	1.03	1.03	1.03	1.04	1.03	1.02	1.02	1.02	1.03	1.04	1.02	1.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O															
TOTAL															
CO2(N.O.)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223142_CARBZON_3	1223142_CARBZON_6	1223142_CARBZON_13	1234042_CARB_SIDGRANDE Line 025	1234042_CARB_SIDGRANDE Line 027	1234042_CARB_SIDGRANDE Line 030	1234061_CARB_DOLZON_2	1234061_CARB_DOLZON_3	1234061_CARB_DOLZON_4	1234061_CARB_DOLZON_5	1234061_CARB_DOLZON_6	1234061_CARB_DOLZON_7	1234061_CARB_DOLZON_8
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.00	0.64	0.21	0.14	0.02	0.00	0.00	0.00	0.00	0.02	0.54	0.00
Al2O3(Mass%)	0.31	0.10	8.84	0.82	0.13	0.02	0.05	0.01	0.09	0.08	0.09	0.01	0.14
FeO(Mass%)	3.29	2.10	3.14	8.85	8.03	4.63	5.04	5.01	3.65	4.06	5.87	3.39	3.38
MnO(Mass%)	0.42	0.38	0.41	0.59	0.59	0.39	0.18	0.24	0.22	0.13	0.23	0.30	0.13
MgO(Mass%)	17.68	18.85	13.23	14.18	14.54	16.74	17.12	17.09	17.77	17.58	16.36	18.16	18.42
CaO(Mass%)	28.72	28.95	26.78	28.38	28.84	29.25	28.53	28.82	28.69	28.43	28.21	28.12	28.62
BaO(Mass%)	0.01	0.00	0.01	0.01	0.11	0.01	0.00	0.01	0.03	0.00	0.02	0.01	0.02
SrO(Mass%)	0.70	0.58	0.56	0.04	0.44	0.10	0.02	0.00	0.08	0.55	0.10	0.75	0.19
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.00	0.00	0.00	0.02	0.01	0.01
Ce2O3(Mass%)	0.01	0.05	0.05	0.06	0.11	0.02	0.03	0.01	0.05	0.04	0.03	0.04	0.03
SO3(Mass%)	0.00	0.00	0.05	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
TOTAL	51.15	51.09	53.72	53.16	52.96	51.21	51.00	51.19	50.57	50.88	51.00	51.33	50.95
F=O	0.00	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00
TOTAL	51.15	51.05	53.72	53.16	52.96	51.21	51.00	51.19	50.57	50.88	50.98	51.33	50.95
CO2	44.17	44.84	37.63	43.20	43.66	44.12	44.18	44.35	44.20	44.23	43.65	44.30	44.73
sum%	95.31	95.89	91.35	96.37	96.62	95.34	95.18	95.54	94.76	95.11	94.63	95.63	95.68

AMOSTRA	1223142_CARBZON_3	1223142_CARBZON_6	1223142_CARBZON_13	1234042_CARB_SIDGRANDE Line 025	1234042_CARB_SIDGRANDE Line 027	1234042_CARB_SIDGRANDE Line 030	1234061_CARB_DOLZON_2	1234061_CARB_DOLZON_3	1234061_CARB_DOLZON_4	1234061_CARB_DOLZON_5	1234061_CARB_DOLZON_6	1234061_CARB_DOLZON_7	1234061_CARB_DOLZON_8
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Al	0.01	0.00	0.36	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Fe	0.09	0.06	0.09	0.25	0.22	0.13	0.14	0.14	0.10	0.11	0.16	0.09	0.09
Mn	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00
Mg	0.87	0.91	0.69	0.71	0.72	0.83	0.84	0.84	0.88	0.87	0.82	0.89	0.90
Ca	1.02	1.01	1.00	1.02	1.03	1.04	1.01	1.02	1.02	1.01	1.01	0.99	1.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.20	2.03	2.02	2.01	2.00	2.00	2.01	2.00	2.01	2.01	2.01
F=O													
TOTAL													
CO2(N.O.)	1.99	1.99	1.80	1.97	1.99	2.00	2.00	2.00	2.00	2.00	1.99	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223142_CARBZON_3	1223142_CARBZON_6	1223142_CARBZON_13	1234042_CARB_SIDGRANDE Line 025	1234042_CARB_SIDGRANDE Line 027	1234042_CARB_SIDGRANDE Line 030	1234061_CARB_DOLZON_2	1234061_CARB_DOLZON_3	1234061_CARB_DOLZON_4	1234061_CARB_DOLZON_5	1234061_CARB_DOLZON_6	1234061_CARB_DOLZON_7	1234061_CARB_DOLZON_8
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.00	0.64	0.21	0.14	0.02	0.00	0.00	0.00	0.00	0.02	0.54	0.00
Al2O3(Mass%)	0.31	0.10	8.84	0.82	0.13	0.02	0.05	0.01	0.09	0.08	0.09	0.01	0.14
FeO(Mass%)	3.29	2.10	3.14	8.85	8.03	4.63	5.04	5.01	3.65	4.06	5.87	3.39	3.38
MnO(Mass%)	0.42	0.38	0.41	0.59	0.59	0.39	0.18	0.24	0.22	0.13	0.23	0.30	0.13
MgO(Mass%)	17.68	18.85	13.23	14.18	14.54	16.74	17.12	17.09	17.77	17.58	16.36	18.16	18.42
CaO(Mass%)	28.72	28.95	26.78	28.38	28.84	29.25	28.53	28.82	28.69	28.43	28.21	28.12	28.62
BaO(Mass%)	0.01	0.00	0.01	0.01	0.11	0.01	0.00	0.01	0.03	0.00	0.02	0.01	0.02
SrO(Mass%)	0.70	0.58	0.56	0.04	0.44	0.10	0.02	0.00	0.08	0.55	0.10	0.75	0.19
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.00	0.00	0.00	0.02	0.01	0.01
Ce2O3(Mass%)	0.01	0.05	0.05	0.06	0.11	0.02	0.03	0.01	0.05	0.04	0.03	0.04	0.03
SO3(Mass%)	0.00	0.00	0.05	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
TOTAL	51.15	51.09	53.72	53.16	52.96	51.21	51.00	51.19	50.57	50.88	51.00	51.33	50.95
F=O	0.00	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00
TOTAL	51.15	51.05	53.72	53.16	52.96	51.21	51.00	51.19	50.57	50.88	50.98	51.33	50.95
CO2	44.17	44.84	37.63	43.20	43.66	44.12	44.18	44.35	44.20	44.23	43.65	44.30	44.73
sum%	95.31	95.89	91.35	96.37	96.62	95.34	95.18	95.54	94.76	95.11	94.63	95.63	95.68

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223142_CARBZON_3	1223142_CARBZON_6	1223142_CARBZON_13	1234042_CARB_SIDGRANDE Line 025	1234042_CARB_SIDGRANDE Line 027	1234042_CARB_SIDGRANDE Line 030	1234061_CARB_DOLZON_2	1234061_CARB_DOLZON_3	1234061_CARB_DOLZON_4	1234061_CARB_DOLZON_5	1234061_CARB_DOLZON_6	1234061_CARB_DOLZON_7	1234061_CARB_DOLZON_8
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Al	0.01	0.00	0.36	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Fe	0.09	0.06	0.09	0.25	0.22	0.13	0.14	0.14	0.10	0.11	0.16	0.09	0.09
Mn	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00
Mg	0.87	0.91	0.69	0.71	0.72	0.83	0.84	0.84	0.88	0.87	0.82	0.89	0.90
Ca	1.02	1.01	1.00	1.02	1.03	1.04	1.01	1.02	1.02	1.01	1.01	0.99	1.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.20	2.03	2.02	2.01	2.00	2.00	2.01	2.00	2.01	2.01	2.01
F=O													
TOTAL													
CO2(N.O.)	1.99	1.99	1.80	1.97	1.99	2.00	2.00	2.00	2.00	2.00	1.99	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1234069_CARB_ZONBORDA_11	1234069_CARB_ZONBORDA_15	1234069_CARB_ZONBORDA_16	1234069_CARB_MASSA_1	1234069_CARB_MASSA_2	1234069_CARB_MASSA_3	1234069_CARB_MASSA_4	1234069_CARB_MASSA_6	1234069_CARB_MASSA_7	1234069_CARB_MASSA_8	1234069_CARB_MASSA_9	1234069_CARB_MASSA_10	1234069_CARB_MASSA_12	1234069_CARB_MASSA_13
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.01	0.00	0.04	0.01	0.02	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
Al2O3(Mass%)	0.02	0.01	0.08	0.11	0.25	0.01	0.08	0.09	0.00	0.00	0.01	0.21	0.02	0.05
FeO(Mass%)	7.73	4.74	6.88	5.17	5.07	4.98	4.22	3.46	0.97	5.99	3.56	5.25	5.24	5.99
MnO(Mass%)	1.14	0.68	1.21	0.95	1.11	0.72	0.32	0.55	0.88	2.18	0.85	2.41	0.80	0.75
MgO(Mass%)	14.71	16.77	15.14	16.13	16.11	16.23	17.43	17.27	17.83	15.15	17.42	15.54	16.76	16.50
CaO(Mass%)	28.56	28.58	28.47	28.76	29.02	29.05	27.91	29.57	29.14	28.22	29.14	28.07	28.28	28.39
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.01
SrO(Mass%)	0.00	0.32	0.02	0.26	0.10	0.52	1.65	0.65	0.27	0.15	0.17	0.62	0.13	0.08
La2O3(Mass%)	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
Ce2O3(Mass%)	0.04	0.08	0.04	0.04	0.00	0.04	0.04	0.07	0.05	0.03	0.02	0.03	0.04	0.02
SO3(Mass%)	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	52.23	51.20	51.88	51.45	51.68	51.57	51.65	51.66	49.12	51.74	51.22	52.14	51.28	51.80
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	52.23	51.20	51.88	51.45	51.68	51.57	51.65	51.66	49.12	51.74	51.22	52.14	51.28	51.80
CO2	43.22	43.80	43.10	43.47	43.51	43.80	44.23	44.46	43.04	42.43	44.15	42.48	43.77	44.01
sum%	95.45	94.99	94.98	94.92	95.19	95.37	95.88	96.12	92.16	94.16	95.37	94.62	95.05	95.81

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1234069_CARB_ZONBORDA_11	1234069_CARB_ZONBORDA_15	1234069_CARB_ZONBORDA_16	1234069_CARB_MASSA_1	1234069_CARB_MASSA_2	1234069_CARB_MASSA_3	1234069_CARB_MASSA_4	1234069_CARB_MASSA_6	1234069_CARB_MASSA_7	1234069_CARB_MASSA_8	1234069_CARB_MASSA_9	1234069_CARB_MASSA_10	1234069_CARB_MASSA_12	1234069_CARB_MASSA_13
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Fe	0.22	0.13	0.19	0.14	0.14	0.14	0.12	0.09	0.03	0.17	0.10	0.15	0.15	0.17
Mn	0.03	0.02	0.03	0.03	0.03	0.02	0.01	0.02	0.03	0.06	0.02	0.07	0.02	0.02
Mg	0.74	0.83	0.76	0.81	0.80	0.81	0.86	0.85	0.90	0.77	0.86	0.79	0.83	0.82
Ca	1.03	1.02	1.03	1.03	1.04	1.04	0.99	1.04	1.06	1.03	1.03	1.02	1.01	1.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.01	0.00	0.01	0.00	0.01	0.03	0.01	0.01	0.00	0.00	0.01	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.02	2.01	2.03	2.02	2.03	2.01	2.01	2.01	2.02	2.04	2.02	2.05	2.02	2.02
F=O														
TOTAL														
CO2(N.O.)	1.99	1.99	1.99	1.99	1.98	1.99	2.00	1.99	1.99	1.98	1.99	1.97	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1234063_CARB_MASSA_14	1234063_CARB_MASSA_15	1223001_CARB_DOLBORDA_1	1223001_CARB_DOLBORDA_2	1223001_CARB_DOLBORDA_3	1223001_CARB_DOLBORDA_4	1223001_CARB_DOLBORDA_5	1223001_CARB_DOLMASSA_1	1223001_CARB_DOLMASSA_2	1223001_CARB_DOLMASSA_3	1223001_CARB_DOLMASSA_4	1223001_CARB_DOLCAV_1	1223001_CARB_DOLCAV_2	1223001_CARB_DOLCAV_3	1223001_CARB_DOLCAV_4
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al2O3(Mass%)	0.24	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.09	0.09	0.11	0.11	0.12	0.05
FeO(Mass%)	2.40	2.63	6.23	4.65	3.26	3.28	7.51	5.60	5.31	6.09	5.82	4.66	4.86	5.85	5.87
MnO(Mass%)	1.34	0.92	0.32	0.41	0.41	0.37	0.18	0.39	0.58	0.41	0.16	0.07	0.16	0.41	0.38
MgO(Mass%)	14.32	18.09	16.32	17.38	17.56	17.36	15.45	16.31	16.41	16.08	16.64	17.18	16.55	16.17	16.39
CaO(Mass%)	28.99	29.09	29.02	28.52	29.96	30.19	28.55	29.24	29.03	29.09	29.21	29.44	29.13	28.96	29.17
BaO(Mass%)	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.05	0.00	0.00	0.02	0.01	0.01
SrO(Mass%)	0.00	0.15	0.07	0.28	0.14	0.11	0.18	0.12	0.23	0.19	0.01	0.15	0.03	0.15	0.17
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01
Ce2O3(Mass%)	0.05	0.02	0.02	0.03	0.04	0.08	0.05	0.05	0.06	0.04	0.04	0.07	0.04	0.06	0.03
SO3(Mass%)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	47.43	50.91	51.98	51.28	51.39	51.39	51.94	51.77	51.63	52.03	51.97	51.68	50.90	51.76	52.08
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	47.43	50.91	51.98	51.28	51.39	51.39	51.94	51.77	51.63	52.03	51.97	51.68	50.90	51.76	52.08
CO2	39.88	44.26	44.44	44.33	44.75	44.72	43.97	44.25	44.06	44.21	44.66	44.80	43.93	44.04	44.47
sum%	87.31	95.17	96.42	95.61	96.14	96.11	95.91	96.02	95.70	96.25	96.63	96.48	94.84	95.80	96.55

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1234063_CARB_MASSA_14	1234063_CARB_MASSA_15	1223001_CARB_DOLBORDA_1	1223001_CARB_DOLBORDA_2	1223001_CARB_DOLBORDA_3	1223001_CARB_DOLBORDA_4	1223001_CARB_DOLBORDA_5	1223001_CARB_DOLMASSA_1	1223001_CARB_DOLMASSA_2	1223001_CARB_DOLMASSA_3	1223001_CARB_DOLMASSA_4	1223001_CARB_DOLCAV_1	1223001_CARB_DOLCAV_2	1223001_CARB_DOLCAV_3	1223001_CARB_DOLCAV_4
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.07	0.07	0.17	0.13	0.09	0.09	0.21	0.15	0.15	0.17	0.16	0.13	0.14	0.16	0.16
Mn	0.04	0.03	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.01	0.01
Mg	0.78	0.89	0.80	0.85	0.86	0.85	0.77	0.80	0.81	0.79	0.81	0.84	0.82	0.80	0.80
Ca	1.13	1.03	1.02	1.01	1.05	1.06	1.02	1.03	1.03	1.03	1.02	1.03	1.04	1.03	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.03	2.02	2.01	2.01	2.01	2.01	2.00	2.01	2.01	2.01	2.00	2.00	2.01	2.01	2.01
F=O															
TOTAL															
CO2(N.O.)	1.98	1.99	2.00	2.00	2.00	2.00	2.00	2.00	1.99	1.99	2.00	2.00	2.00	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223001_CARB_DOLBORDAZIRC_5	1223001_CARB_DOLBORDAZIRC_6	1223001_CARB_DOLBORDAZIRC_7	1223001_CARB_DOLQUATZ_1	1223001_CARB_DOLQUATZ_2	1223001_CARB_DOLQUATZ_3	1223001_CARB_DOLQUATZ_4	1223001_CARB_DOLBORDAQUATZ_3	1223001_CARB_DOLBORDAQUATZ_4	1223001_CARB_DOLBORDAQUATZ_5	1223010_CARB_ASSOCQTZ_21	1223010_CARB_DOLPERFIL Line 001	1223010_CARB_DOLPERFIL Line 004	1223010_CARB_DOLPERFIL Line 005
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.00	0.00	0.00	0.03	0.07	0.03	0.01	0.01	0.06	0.06	0.00	0.00	0.00	0.00
Al2O3(Mass%)	0.02	0.01	0.00	0.02	0.01	0.16	0.05	0.01	0.01	0.01	0.01	0.00	0.01	0.01
FeO(Mass%)	5.67	6.57	7.47	4.66	4.94	5.50	5.14	5.32	8.75	7.12	9.53	9.28	9.25	7.80
MnO(Mass%)	0.33	0.36	0.37	0.37	0.41	0.04	0.31	0.72	0.60	0.57	1.75	1.44	1.28	1.05
MgO(Mass%)	16.48	16.01	15.57	17.36	17.39	16.60	16.77	16.52	14.49	15.65	13.52	13.79	14.04	15.24
CaO(Mass%)	29.00	28.89	29.17	28.66	28.52	29.35	28.90	29.16	29.19	29.00	28.14	28.11	28.09	28.36
BaO(Mass%)	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00
SrO(Mass%)	0.04	0.05	0.05	0.37	0.39	0.12	0.21	0.00	0.00	0.00	0.20	0.00	0.18	0.44
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.03	0.03	0.01	0.04	0.04	0.00	0.05	0.05	0.05	0.00	0.05	0.08	0.03	0.01
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.56	51.91	52.63	51.52	51.77	51.83	51.45	51.78	53.15	52.45	53.24	52.70	52.88	52.91
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.56	51.91	52.63	51.52	51.77	51.83	51.45	51.78	53.15	52.45	53.24	52.70	52.88	52.91
CO2	44.24	44.20	44.48	44.47	44.57	44.58	44.23	44.18	44.10	44.22	42.79	42.81	43.13	43.87
sum%	95.80	96.11	97.12	95.99	96.33	96.41	95.68	95.96	97.25	96.66	96.03	95.52	96.01	96.77

PROPORÇÃO ATÔMICA
PARA 6 O

AMOSTRA	1223001_CARB_DOLBORDAZIRC_5	1223001_CARB_DOLBORDAZIRC_6	1223001_CARB_DOLBORDAZIRC_7	1223001_CARB_DOLQUATZ_1	1223001_CARB_DOLQUATZ_2	1223001_CARB_DOLQUATZ_3	1223001_CARB_DOLQUATZ_4	1223001_CARB_DOLBORDAQUATZ_3	1223001_CARB_DOLBORDAQUATZ_4	1223001_CARB_DOLBORDAQUATZ_5	1223010_CARB_ASSOCQTZ_21	1223010_CARB_DOLPERFIL Line 001	1223010_CARB_DOLPERFIL Line 004	1223010_CARB_DOLPERFIL Line 005
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.16	0.18	0.21	0.13	0.14	0.15	0.14	0.15	0.24	0.20	0.27	0.26	0.26	0.22
Mn	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.02	0.02	0.05	0.04	0.04	0.03
Mg	0.81	0.79	0.76	0.85	0.85	0.81	0.83	0.81	0.71	0.77	0.68	0.70	0.71	0.76
Ca	1.03	1.02	1.03	1.01	1.00	1.03	1.02	1.03	1.04	1.03	1.02	1.02	1.02	1.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.01	2.00	2.01	2.01	2.01	2.01	2.03	2.03	2.02	2.02
F=O														
TOTAL														
CO2(N.O.)	2.00	2.00	2.00	2.00	1.99	2.00	2.00	1.99	1.99	1.99	1.98	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223010_CARB_DOLPERFIL Line 006	1223010_CARB_DOLPERFIL Line 015	1223010_CARB_DOLPERFIL Line 016	1223010_CARB_DOLPERFIL Line 017	1223010_CARB_DOLPERFIL Line 018	1223010_CARB_DOLPERFIL Line 021	1223010_CARB_DOLPERFIL Line 022	1223010_CARB_DOLPERFIL Line 023	1223010_CARB_DOLPERFIL Line 024	1223010_CARB_DOLPERFIL Line 025	1223010_CARB_DOLPERFIL Line 026	1223010_CARB_DOLPERFIL Line 027	1223010_CARB_DOLPERFIL Line 028	1223010_CARB_DOLPERFIL Line 029	1223010_CARB_DOLPERFIL Line 030
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.00	0.00	0.06	0.00	0.02	0.02	0.01	0.00
Al2O3(Mass%)	0.16	0.18	0.00	0.00	0.05	0.01	0.25	0.08	0.00	0.13	0.01	0.12	0.02	0.02	0.06
FeO(Mass%)	8.11	8.17	8.88	8.69	8.27	7.77	8.12	7.49	7.67	5.80	6.70	6.22	6.57	7.10	6.72
MnO(Mass%)	1.13	1.28	1.86	1.73	2.08	0.35	0.86	0.84	0.88	0.43	0.37	0.52	0.62	0.99	0.98
MgO(Mass%)	14.81	14.47	13.88	13.82	13.70	15.31	14.08	14.89	15.22	15.74	15.03	15.64	15.48	14.89	15.24
CaO(Mass%)	28.26	28.36	28.28	28.32	28.21	28.65	28.28	28.61	28.20	29.54	28.41	29.38	29.08	29.22	29.06
BaO(Mass%)	0.01	0.02	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
SrO(Mass%)	0.22	0.15	0.02	0.22	0.25	0.11	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
La2O3(Mass%)	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01
Ce2O3(Mass%)	0.05	0.02	0.06	0.06	0.05	0.04	0.07	0.04	0.04	0.02	0.03	0.01	0.05	0.06	0.03
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	52.75	52.66	52.98	52.84	52.63	52.29	51.74	51.95	52.09	51.75	50.56	51.90	51.87	52.29	52.11
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	52.75	52.66	52.98	52.84	52.63	52.29	51.74	51.95	52.09	51.75	50.56	51.90	51.87	52.29	52.11
CO2	43.42	43.13	42.81	42.74	42.28	44.02	42.56	43.31	43.48	43.92	42.82	43.94	43.77	43.55	43.57
sum%	96.17	95.79	95.80	95.58	94.91	96.31	94.30	95.27	95.57	95.67	93.37	95.84	95.64	95.84	95.68

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223010_CARB_DOLPERFIL Line 006	1223010_CARB_DOLPERFIL Line 015	1223010_CARB_DOLPERFIL Line 016	1223010_CARB_DOLPERFIL Line 017	1223010_CARB_DOLPERFIL Line 018	1223010_CARB_DOLPERFIL Line 021	1223010_CARB_DOLPERFIL Line 022	1223010_CARB_DOLPERFIL Line 023	1223010_CARB_DOLPERFIL Line 024	1223010_CARB_DOLPERFIL Line 025	1223010_CARB_DOLPERFIL Line 026	1223010_CARB_DOLPERFIL Line 027	1223010_CARB_DOLPERFIL Line 028	1223010_CARB_DOLPERFIL Line 029	1223010_CARB_DOLPERFIL Line 030
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Fe	0.23	0.23	0.25	0.25	0.24	0.22	0.23	0.21	0.22	0.16	0.19	0.17	0.18	0.20	0.19
Mn	0.03	0.04	0.05	0.05	0.06	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.02	0.03	0.03
Mg	0.74	0.73	0.70	0.70	0.70	0.76	0.72	0.75	0.76	0.78	0.77	0.77	0.77	0.74	0.76
Ca	1.01	1.02	1.03	1.03	1.04	1.02	1.04	1.03	1.01	1.05	1.04	1.05	1.04	1.05	1.04
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.02	2.03	2.04	2.03	2.04	2.01	2.02	2.02	2.02	2.01	2.01	2.01	2.01	2.02	2.02
F=O															
TOTAL															
CO2(N.O.)	1.99	1.98	1.98	1.98	1.98	2.00	1.99	1.99	1.99	1.99	2.00	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1234047_CARB_DOL_1	1234047_CARB_DOL_2	1234047_CARB_DOL_3	1234047_CARB_DOL_4	1234047_CARB_DOL_5	1234047_CARB_DOL_6	1234047_CARB_DOL_7	1234047_CARB_DOL_12	1234047_CARB_DOL_13	1234047_CARB_DOL_15	1234047_CARB_DOL_9	1234047_CARB_DOL_10	1234047_CARB_DOL_11	1234047_CARB_DOL_12	1234047_CARB_DOL_13	1234047_CARB_DOL_14
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
SiO2(Mass%)	0.00	0.00	0.00	0.00	0.01	0.11	0.00	0.03	0.04	0.12	0.00	0.00	0.00	0.00	0.05	0.05
Al2O3(Mass%)	0.84	0.09	0.09	0.18	0.26	0.07	0.01	1.41	0.01	1.10	0.01	0.03	0.00	0.00	0.99	0.89
FeO(Mass%)	4.82	7.98	8.11	5.86	5.13	7.19	5.60	5.16	4.79	7.29	5.12	4.98	5.27	5.49	5.72	5.24
MnO(Mass%)	0.83	0.57	0.76	1.51	0.86	0.54	1.20	0.88	0.67	0.50	0.95	1.06	1.49	1.02	1.02	0.95
MgO(Mass%)	16.38	14.56	14.01	15.66	16.71	14.88	16.42	16.30	16.52	14.74	16.92	17.05	15.81	16.58	16.16	16.53
CaO(Mass%)	28.58	28.77	28.82	28.20	27.94	29.12	27.75	27.72	28.28	29.00	27.89	28.00	27.62	28.16	27.47	27.26
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.02	0.03	0.01	0.01	0.01	0.00	0.01	0.05
SrO(Mass%)	0.33	0.20	0.13	0.33	0.25	0.16	0.60	0.26	0.68	0.14	0.18	0.22	1.31	0.29	0.33	0.28
La2O3(Mass%)	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.03	0.03	0.07	0.05	0.04	0.04	0.06	0.05	0.03	0.08	0.06	0.02	0.05	0.06	0.02	0.05
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.80	52.20	52.01	51.79	51.20	52.12	51.67	51.82	51.02	52.99	51.14	51.37	51.55	51.60	51.76	51.31
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.80	52.20	52.01	51.79	51.20	52.12	51.67	51.82	51.02	52.99	51.14	51.37	51.55	51.60	51.76	51.31
CO2	43.41	43.45	42.94	42.96	43.42	43.58	43.41	42.83	43.46	43.39	43.59	43.74	42.73	43.70	42.85	42.80
sum%	95.21	95.65	94.95	94.76	94.62	95.70	95.08	94.65	94.48	96.39	94.73	95.11	94.28	95.30	94.61	94.10

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1234047_CARB_DOL_1	1234047_CARB_DOL_2	1234047_CARB_DOL_3	1234047_CARB_DOL_4	1234047_CARB_DOL_5	1234047_CARB_DOL_6	1234047_CARB_DOL_7	1234047_CARB_DOL_12	1234047_CARB_DOL_13	1234047_CARB_DOL_15	1234047_CARB_DOL_9	1234047_CARB_DOL_10	1234047_CARB_DOL_11	1234047_CARB_DOL_12	1234047_CARB_DOL_13	1234047_CARB_DOL_14
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.03	0.00	0.00	0.01	0.01	0.00	0.00	0.06	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.04
Fe	0.13	0.22	0.23	0.17	0.14	0.20	0.16	0.14	0.13	0.20	0.14	0.14	0.15	0.15	0.16	0.15
Mn	0.02	0.02	0.02	0.04	0.02	0.02	0.03	0.02	0.02	0.01	0.03	0.03	0.04	0.03	0.03	0.03
Mg	0.81	0.73	0.71	0.79	0.83	0.74	0.82	0.82	0.83	0.73	0.84	0.85	0.80	0.82	0.81	0.83
Ca	1.02	1.04	1.05	1.02	1.00	1.04	1.00	1.00	1.02	1.03	1.00	1.00	1.01	1.01	0.99	0.99
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.03	0.01	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.03	2.01	2.02	2.03	2.02	2.01	2.02	2.05	2.01	2.03	2.02	2.02	2.03	2.02	2.04	2.04
F=O																
TOTAL																
CO2(N.O.)	1.98	1.99	1.99	1.98	1.99	1.99	1.99	1.96	1.99	1.97	1.99	1.99	1.99	1.99	1.97	1.97

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1234047_CARB_DOL_15	1234047_CARB_DOL_16	1234047_CARB_DOL_17	1223146_C1_DOL1 Line 001	1223146_C1_DOL1 Line 002	1223146_C1_DOL1 Line 003	1223146_C1_DOL1 Line 004	1223146_C1_DOL1 Line 005	1223146_C1_DOL1 Line 014	1223146_C1_DOL1 Line 015	1223146_C1_DOL1_1	1223146_C1_DOL1_2	1223146_C1_DOL2_1	1223146_C1_DOL2_2	1223146_C1_DOL2_3	1223146_C1_DOL2_4
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
SiO2(Mass%)	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.02	0.00	0.02	0.05	0.00	0.00	0.02	0.00	0.05
Al2O3(Mass%)	0.02	0.00	1.12	0.04	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.00	0.00	0.02	0.01
FeO(Mass%)	7.19	5.96	5.01	4.61	4.45	4.36	4.62	4.83	4.86	4.16	5.75	5.46	5.12	5.33	5.66	5.13
MnO(Mass%)	1.41	1.28	1.07	0.44	0.47	0.39	0.39	0.51	0.66	0.69	0.50	0.44	0.46	0.38	0.43	0.52
MgO(Mass%)	14.79	15.64	15.77	17.33	17.21	16.97	17.14	17.08	17.17	17.30	16.32	16.56	16.57	16.54	16.41	16.38
CaO(Mass%)	27.80	27.83	28.20	28.50	28.77	28.58	28.52	28.42	27.61	28.29	28.34	28.63	28.26	28.50	28.52	28.56
BaO(Mass%)	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.05	0.00	0.00	0.00	0.01	0.00	0.02	0.03
SrO(Mass%)	0.90	0.97	0.26	0.42	0.40	0.35	0.32	0.37	0.55	0.57	0.48	0.54	0.62	0.61	0.42	0.36
La2O3(Mass%)	0.00	0.00	0.00	0.04	0.05	0.00	0.00	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.04	0.04
Ce2O3(Mass%)	0.03	0.05	0.08	0.01	0.06	0.00	0.03	0.00	0.07	0.02	0.03	0.01	0.02	0.06	0.02	0.04
SO3(Mass%)	0.00	0.00	0.00													
F(Mass%)	0.00	0.00	0.00													
TOTAL	52.15	51.73	51.58	51.45	51.40	50.72	51.03	51.36	51.03	51.11	51.54	51.66	51.09	51.44	51.57	51.15
F=O	0.00	0.00	0.00													
TOTAL	52.15	51.73	51.58	51.45	51.40	50.72	51.03	51.36	51.03	51.11	51.54	51.66	51.09	51.44	51.57	51.15
CO2	42.76	42.98	42.54	44.29	44.27	43.79	44.07	44.08	43.65	43.89	43.80	44.12	43.68	43.96	43.95	43.61
sum%	94.91	94.71	94.13	95.74	95.67	94.50	95.10	95.44	94.68	95.00	95.34	95.79	94.77	95.40	95.52	94.76

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1234047_CARB_DOL_15	1234047_CARB_DOL_16	1234047_CARB_DOL_17	1223146_C1_DOL1 Line 001	1223146_C1_DOL1 Line 002	1223146_C1_DOL1 Line 003	1223146_C1_DOL1 Line 004	1223146_C1_DOL1 Line 005	1223146_C1_DOL1 Line 014	1223146_C1_DOL1 Line 015	1223146_C1_DOL1_1	1223146_C1_DOL1_2	1223146_C1_DOL2_1	1223146_C1_DOL2_2	1223146_C1_DOL2_3	1223146_C1_DOL2_4
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.20	0.17	0.14	0.13	0.12	0.12	0.13	0.13	0.14	0.12	0.16	0.15	0.14	0.15	0.16	0.14
Mn	0.04	0.04	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.75	0.79	0.80	0.85	0.85	0.85	0.85	0.84	0.86	0.86	0.81	0.82	0.83	0.82	0.81	0.82
Ca	1.01	1.01	1.02	1.01	1.02	1.02	1.01	1.01	0.99	1.01	1.01	1.02	1.01	1.02	1.02	1.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.03	2.02	2.04	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O																
TOTAL																
CO2(N.O.)	1.99	1.99	1.97	1.99	2.00	2.00	2.00	1.99	1.99	1.99	1.99	2.00	2.00	2.00	2.00	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223146_C1_DOL2_5	1223146_C1_DOL2_6	1223146_C1_DOL2_7	1223146_C1_DOL2_8	223146_C1_DOL3 Line 00	223146_C1_DOL3 Line 00	223146_C1_DOL3 Line 00	1223146_C1_DOL3 Line 00	1223146_C1_DOL3 Line 00	223146_C1_DOL3 Line 00	223146_C1_DOL4 Line 0(	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
SiO2(Mass%)	0.04	0.03	0.02	0.42	0.02	0.00	0.06	0.08	0.00	0.00	0.04	0.03	0.00	0.00	0.00	0.00
Al2O3(Mass%)	0.01	0.04	0.02	0.82	0.00	0.00	0.03	0.00	0.02	0.04	0.00	0.07	0.00	0.00	0.00	0.00
FeO(Mass%)	3.31	2.34	2.28	3.37	6.97	7.79	8.73	8.27	8.37	8.39	8.50	9.04	7.77	8.16	5.00	5.22
MnO(Mass%)	0.44	0.31	0.34	0.33	0.57	0.47	0.51	0.64	0.54	0.55	0.94	0.91	0.81	0.83	0.59	0.48
MgO(Mass%)	17.78	18.68	18.43	17.14	15.78	15.20	14.61	14.87	15.07	14.84	14.41	14.22	15.03	14.78	16.66	16.53
CaO(Mass%)	28.90	28.03	28.41	27.99	28.45	28.43	28.06	28.31	28.34	28.17	28.12	27.98	28.43	28.07	28.57	28.03
BaO(Mass%)	0.01	0.04	0.02	0.00	0.07	0.00	0.03	0.12	0.01	0.05	0.02	0.01	0.04	0.00	0.00	0.00
SrO(Mass%)	0.62	0.61	0.46	0.36	0.27	0.39	0.22	0.48	0.37	0.37	0.64	0.56	0.33	0.31	0.31	0.78
La2O3(Mass%)	0.00	0.00	0.04	0.06	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.06	0.01	0.06	0.05	0.01	0.07	0.02	0.00	0.00	0.05	0.08	0.00	0.04	0.07	0.09	0.00
SO3(Mass%)																
F(Mass%)																
TOTAL	51.18	50.13	50.08	50.58	52.19	52.37	52.32	52.82	52.73	52.50	52.82	52.88	52.56	52.23	51.24	51.09
F=O																
TOTAL	51.18	50.13	50.08	50.58	52.19	52.37	52.32	52.82	52.73	52.50	52.82	52.88	52.56	52.23	51.24	51.09
CO2	44.40	44.09	44.03	42.90	43.97	43.85	43.42	43.75	43.99	43.64	43.30	43.27	43.65	43.31	43.81	43.58
sum%	95.57	94.22	94.10	93.49	96.15	96.22	95.74	96.58	96.72	96.14	96.12	96.15	96.21	95.54	95.05	94.67

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223146_C1_DOL2_5	1223146_C1_DOL2_6	1223146_C1_DOL2_7	1223146_C1_DOL2_8	223146_C1_DOL3 Line 00	223146_C1_DOL3 Line 00	223146_C1_DOL3 Line 00	1223146_C1_DOL3 Line 00	1223146_C1_DOL3 Line 00	223146_C1_DOL3 Line 00	223146_C1_DOL4 Line 0(	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00	223146_C1_DOL4 Line 00
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
Si	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.09	0.06	0.06	0.09	0.19	0.22	0.25	0.23	0.23	0.23	0.24	0.25	0.22	0.23	0.14	0.15
Mn	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.01
Mg	0.87	0.92	0.91	0.86	0.78	0.76	0.73	0.74	0.75	0.74	0.72	0.71	0.75	0.74	0.83	0.83
Ca	1.02	1.00	1.01	1.01	1.01	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.02	1.01	1.02	1.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.03	2.01	2.01	2.01	2.01	2.01	2.01	2.02	2.02	2.02	2.02	2.01	2.01
F=O																
TOTAL																
CO2(N.O.)	1.99	2.00	2.00	1.97	1.99	2.00	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223146_C1_DOL4 Line 007	1223146_C1_DOL4 Line 008	1223146_C1_DOL4 Line 009	1223146_C1_DOL4 Line 010	1223146_C1_DOL4 Line 011	1223146_C1_DOL4 Line 012	1223146_C1_DOL4 Line 013	1223146_C1_DOL4 Line 014	1223146_C1_DOL5_1	1223146_C1_DOL5_2	1223146_C1_DOL5_3	1223146_C1_DOL5_4	1223146_C1_DOL5_5	1223146_C1_DOL5_6	1223146_C1_DOL5_7	1223146_C1_DOL5_8
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
SiO2(Mass%)	0.04	0.00	0.04	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.02	0.00
Al2O3(Mass%)	0.04	0.04	0.00	0.00	0.01	0.02	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.03	0.00
FeO(Mass%)	4.80	5.07	5.09	5.28	8.63	8.09	4.41	6.23	5.18	5.26	5.39	5.56	7.26	7.39	2.82	3.77
MnO(Mass%)	0.41	0.46	0.45	0.45	0.86	0.96	0.61	0.75	0.45	0.53	0.44	0.49	0.49	0.65	0.44	0.50
MgO(Mass%)	16.92	16.69	17.02	16.74	14.88	15.00	17.06	15.81	17.04	16.69	16.80	16.71	15.37	14.90	17.69	17.87
CaO(Mass%)	28.70	28.44	28.23	28.67	28.55	28.13	28.23	28.17	28.86	28.60	27.99	29.04	28.30	28.08	28.07	28.09
BaO(Mass%)	0.04	0.00	0.01	0.02	0.00	0.00	0.03	0.06	0.00	0.04	0.03	0.00	0.01	0.06	0.00	0.01
SrO(Mass%)	0.83	0.73	0.74	0.47	0.25	0.51	0.64	0.76	0.90	0.59	0.62	0.63	0.45	0.16	0.72	0.75
La2O3(Mass%)	0.00	0.00	0.10	0.03	0.03	0.00	0.00	0.00	0.09	0.00	0.02	0.00	0.00	0.00	0.00	0.01
Ce2O3(Mass%)	0.06	0.01	0.00	0.02	0.01	0.00	0.00	0.03	0.03	0.12	0.06	0.12	0.03	0.00	0.05	0.04
SO3(Mass%)																
F(Mass%)																
TOTAL	51.85	51.45	51.71	51.72	53.29	52.72	51.01	51.85	52.59	51.84	51.36	52.58	51.93	51.33	49.88	51.05
F=O																
TOTAL	51.85	51.45	51.71	51.72	53.29	52.72	51.01	51.85	52.59	51.84	51.36	52.58	51.93	51.33	49.88	51.05
CO2	44.31	43.96	44.17	44.23	44.05	43.63	43.77	43.53	44.81	44.17	43.89	44.72	43.64	42.91	43.38	44.20
sum%	96.16	95.41	95.88	95.95	97.34	96.34	94.77	95.39	97.40	96.01	95.25	97.30	95.57	94.25	93.26	95.24

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223146_C1_DOL4 Line 007	1223146_C1_DOL4 Line 008	1223146_C1_DOL4 Line 009	1223146_C1_DOL4 Line 010	1223146_C1_DOL4 Line 011	1223146_C1_DOL4 Line 012	1223146_C1_DOL4 Line 013	1223146_C1_DOL4 Line 014	1223146_C1_DOL5_1	1223146_C1_DOL5_2	1223146_C1_DOL5_3	1223146_C1_DOL5_4	1223146_C1_DOL5_5	1223146_C1_DOL5_6	1223146_C1_DOL5_7	1223146_C1_DOL5_8
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.13	0.14	0.14	0.15	0.24	0.23	0.12	0.17	0.14	0.15	0.15	0.15	0.20	0.21	0.08	0.10
Mn	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Mg	0.83	0.83	0.84	0.82	0.73	0.75	0.85	0.79	0.83	0.82	0.83	0.81	0.77	0.76	0.89	0.88
Ca	1.01	1.01	1.00	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.00	1.02	1.02	1.02	1.01	1.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.02	2.02	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O																
TOTAL																
CO2(N.O.)	1.99	1.99	1.99	2.00	1.99	1.99	1.99	1.99	1.99	1.99	2.00	1.99	2.00	1.99	1.99	2.00

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223146_C1_DOL6_1	1223146_C1_DOL6_2	1223146_C1_DOL6_3	1223146_C4_DOL1 Line 001	1223146_C4_DOL1 Line 002	1223146_C4_DOL1 Line 003	1223146_C4_DOL1 Line 004	1223146_C4_DOL1 Line 005	1223146_C4_DOL1 Line 006	1223146_C4_DOL1 Line 007	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line 0
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
SiO2(Mass%)	0.01	0.00	0.00	0.10	0.05	0.05	0.02	0.02	0.00	0.00	0.00	0.03	0.01	0.08	0.01	0.00
Al2O3(Mass%)	0.00	0.03	0.07	0.01	0.00	0.22	0.00	0.18	0.01	0.00	0.02	0.10	0.00	0.13	0.02	0.03
FeO(Mass%)	5.38	4.97	5.58	7.75	8.47	7.76	7.28	7.74	5.75	5.97	3.93	8.69	8.23	8.10	7.67	8.73
MnO(Mass%)	0.46	0.52	0.51	0.55	0.37	0.82	0.94	0.92	0.79	0.80	0.68	0.84	0.80	0.78	0.60	0.75
MgO(Mass%)	16.83	16.59	16.53	15.05	14.97	15.30	15.12	14.74	16.63	16.10	17.48	14.68	14.76	14.78	15.50	14.87
CaO(Mass%)	28.57	28.09	28.16	28.06	27.81	28.30	28.06	28.03	27.96	28.17	27.98	27.64	28.45	28.14	28.14	28.72
BaO(Mass%)	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.04	0.00	0.00
SrO(Mass%)	0.75	0.69	0.66	0.42	0.32	0.20	0.50	0.42	0.94	0.39	0.72	0.17	0.23	0.23	0.22	0.10
La2O3(Mass%)	0.07	0.00	0.02	0.00	0.03	0.07	0.00	0.00	0.00	0.01	0.04	0.00	0.00	0.00	0.03	0.03
Ce2O3(Mass%)	0.00	0.00	0.08	0.00	0.02	0.07	0.02	0.10	0.09	0.00	0.03	0.00	0.03	0.04	0.02	0.07
SO3(Mass%)																
F(Mass%)																
TOTAL	52.12	51.05	51.66	51.98	52.19	52.79	52.00	52.22	52.23	51.45	50.90	52.30	52.57	52.36	52.26	53.32
F=O																
TOTAL	52.12	51.05	51.66	51.98	52.19	52.79	52.00	52.22	52.23	51.45	50.90	52.30	52.57	52.36	52.26	53.32
CO2	44.41	43.51	43.86	43.37	43.49	43.76	43.20	43.03	44.04	43.51	43.76	43.11	43.59	43.29	43.80	44.18
sum%	96.53	94.55	95.52	95.35	95.68	96.55	95.20	95.25	96.27	94.96	94.66	95.42	96.16	95.65	96.06	97.50

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223146_C1_DOL6_1	1223146_C1_DOL6_2	1223146_C1_DOL6_3	1223146_C4_DOL1 Line 001	1223146_C4_DOL1 Line 002	1223146_C4_DOL1 Line 003	1223146_C4_DOL1 Line 004	1223146_C4_DOL1 Line 005	1223146_C4_DOL1 Line 006	1223146_C4_DOL1 Line 007	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line (	23146_C4_DOL1 Line 0
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Fe	0.15	0.14	0.16	0.22	0.24	0.22	0.21	0.22	0.16	0.17	0.11	0.25	0.23	0.23	0.21	0.24
Mn	0.01	0.01	0.01	0.02	0.01	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Mg	0.83	0.83	0.82	0.75	0.75	0.76	0.76	0.74	0.82	0.80	0.87	0.74	0.74	0.74	0.77	0.73
Ca	1.01	1.01	1.00	1.01	1.00	1.01	1.01	1.02	0.99	1.01	1.00	1.00	1.02	1.01	1.00	1.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.01	2.02	2.02	2.02	2.02	2.02	2.01	2.02	2.02	2.02	2.01	2.01
F=O																
TOTAL																
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223146_C4_DOL1 Line 015	1223146_C4_DOL1 Line 016	1223146_C4_DOL1 Line 017	1223146_C4_DOL1 Line 018	1223146_C4_DOL1 Line 019	1223146_C4_DOL1 Line 020	1223007_C3_DOL1_1	1223007_C3_DOL1_2	1223007_C3_DOL1_3	1223007_C3_DOL1_4	1223007_C3_DOL2_1	1223007_C3_DOL2_2	1223007_C3_DOL2_3	1223007_C3_DOL2_4	1223007_C3_DOL3_1	1223007_C3_DOL3_2
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.08	0.00	0.00	0.02	0.00	0.03	0.00	0.00	0.03	0.00	0.02	0.01	0.00	0.05	0.01	0.04
Al2O3(Mass%)	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.00	0.00
FeO(Mass%)	3.86	5.29	5.15	5.11	5.05	5.17	4.46	4.17	4.47	4.27	5.41	5.23	5.34	5.26	4.69	4.58
MnO(Mass%)	0.27	0.44	0.43	0.51	0.47	0.56	0.55	0.61	0.54	0.59	0.58	0.54	0.61	0.61	0.55	0.50
MgO(Mass%)	17.78	17.18	16.66	16.66	16.90	16.95	16.89	17.03	16.79	16.88	16.83	16.73	16.38	16.60	16.99	17.01
CaO(Mass%)	28.08	28.18	28.36	28.29	28.14	28.47	28.63	28.74	28.90	28.86	28.72	28.16	28.23	28.22	28.68	28.62
BaO(Mass%)	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.01	0.01	0.11	0.02	0.00	0.04	0.03
SrO(Mass%)	0.61	0.56	0.63	0.60	0.63	0.82	0.62	0.73	0.76	0.74	0.89	0.84	0.67	0.84	0.68	0.68
La2O3(Mass%)	0.00	0.04	0.01	0.00	0.00	0.00	0.03	0.02	0.00	0.03	0.00	0.01	0.03	0.04	0.00	0.06
Ce2O3(Mass%)	0.00	0.05	0.01	0.06	0.07	0.00	0.01	0.10	0.02	0.03	0.01	0.06	0.05	0.09	0.02	0.04
SO3(Mass%)																
F(Mass%)																
TOTAL	50.78	51.82	51.33	51.28	51.27	52.05	51.21	51.48	51.55	51.46	52.51	51.76	51.38	51.75	51.78	51.56
F=O																
TOTAL	50.78	51.82	51.33	51.28	51.27	52.05	51.21	51.48	51.55	51.46	52.51	51.76	51.38	51.75	51.78	51.56
CO2	44.09	44.37	43.88	43.79	43.90	44.36	43.90	44.04	44.09	44.02	44.60	43.97	43.61	43.86	44.24	44.13
sum%	94.87	96.18	95.21	95.07	95.18	96.41	95.11	95.52	95.64	95.48	97.11	95.73	94.99	95.62	96.01	95.70

AMOSTRA	1223146_C4_DOL1 Line 015	1223146_C4_DOL1 Line 016	1223146_C4_DOL1 Line 017	1223146_C4_DOL1 Line 018	1223146_C4_DOL1 Line 019	1223146_C4_DOL1 Line 020	1223007_C3_DOL1_1	1223007_C3_DOL1_2	1223007_C3_DOL1_3	1223007_C3_DOL1_4	1223007_C3_DOL2_1	1223007_C3_DOL2_2	1223007_C3_DOL2_3	1223007_C3_DOL2_4	1223007_C3_DOL3_1	1223007_C3_DOL3_2
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.11	0.15	0.14	0.14	0.14	0.14	0.12	0.12	0.12	0.12	0.15	0.15	0.15	0.15	0.13	0.13
Mn	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Mg	0.88	0.84	0.83	0.83	0.84	0.83	0.84	0.84	0.83	0.84	0.82	0.83	0.82	0.82	0.84	0.84
Ca	1.00	0.99	1.01	1.01	1.00	1.00	1.02	1.02	1.03	1.03	1.01	1.00	1.01	1.01	1.01	1.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
F=O																
TOTAL																
CO2(N.O.)	2.00	2.00	2.00	1.99	2.00	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223007_C3_DOL3_3	1223007_C3_DOL4_2	1223007_C3_DOL4_3	1223007_C3_DOL4_4	1223007_C3_DOL1 Line 001	1223007_C3_DOL1 Line 002	1223007_C3_DOL1 Line 003	1223007_C3_DOL1 Line 004	1223007_C3_DOL1 Line 005	1223007_C3_DOL1 Line 006	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.04	0.00	0.02	0.00
Al2O3(Mass%)	0.01	0.00	0.06	0.00	0.03	0.01	0.00	0.02	0.00	0.65	0.00	0.00	0.00	0.02	0.04
FeO(Mass%)	4.62	5.18	4.91	5.56	5.96	6.11	6.47	4.73	4.49	4.29	4.13	4.58	4.54	7.42	7.93
MnO(Mass%)	0.49	0.62	0.65	0.66	0.66	0.60	0.63	0.71	0.74	0.77	0.76	0.60	0.61	1.06	0.98
MgO(Mass%)	16.93	17.05	16.73	16.31	16.02	15.97	16.08	16.74	17.19	16.85	16.51	16.75	16.83	15.08	14.87
CaO(Mass%)	28.65	28.68	28.23	28.17	27.96	28.33	28.18	28.29	28.16	28.32	28.41	28.45	28.66	28.45	28.40
BaO(Mass%)	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.04	0.02	0.00	0.03	0.00	0.00	0.00	0.01
SrO(Mass%)	0.74	0.88	0.67	0.62	0.80	0.74	0.60	0.68	0.72	0.30	0.66	0.98	0.80	0.31	0.23
La2O3(Mass%)	0.07	0.00	0.00	0.00	0.05	0.00	0.02	0.00	0.02	0.05	0.07	0.03	0.10	0.00	0.00
Ce2O3(Mass%)	0.02	0.04	0.04	0.06	0.07	0.05	0.04	0.12	0.06	0.06	0.00	0.02	0.07	0.00	0.05
SO3(Mass%)															
F(Mass%)															
TOTAL	51.54	52.56	51.32	51.44	51.64	51.81	52.02	51.34	51.40	51.37	50.60	51.45	51.66	52.36	52.60
F=O															
TOTAL	51.54	52.56	51.32	51.44	51.64	51.81	52.02	51.34	51.40	51.37	50.60	51.45	51.66	52.36	52.60
CO2	44.12	44.68	43.72	43.60	43.43	43.73	43.90	43.70	43.94	43.39	43.14	43.85	43.99	43.47	43.49
sum%	95.65	97.24	95.04	95.04	95.07	95.55	95.92	95.04	95.34	94.75	93.75	95.30	95.65	95.82	96.09

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223007_C3_DOL3_3	1223007_C3_DOL4_2	1223007_C3_DOL4_3	1223007_C3_DOL4_4	1223007_C3_DOL1 Line 001	1223007_C3_DOL1 Line 002	1223007_C3_DOL1 Line 003	1223007_C3_DOL1 Line 004	1223007_C3_DOL1 Line 005	1223007_C3_DOL1 Line 006	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (	23007_C3_DOL1 Line (
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Fe	0.13	0.14	0.14	0.16	0.17	0.17	0.18	0.13	0.12	0.12	0.12	0.13	0.13	0.21	0.22
Mn	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Mg	0.84	0.83	0.83	0.81	0.80	0.80	0.80	0.83	0.85	0.84	0.83	0.83	0.83	0.75	0.74
Ca	1.02	1.00	1.01	1.01	1.01	1.01	1.00	1.01	1.00	1.01	1.03	1.02	1.02	1.02	1.02
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.03	2.02	2.01	2.01	2.02	2.02
F=O															
TOTAL															
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.98	1.99	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223007_C4_DOL1 Line 003	1223007_C4_DOL1 Line 004	1223007_C4_DOL1 Line 005	1223007_C4_DOL1 Line 006	1223007_C4_DOL1 Line 007	1223007_C4_DOL1 Line 008	1223007_C4_DOL1 Line 009	1223007_C4_DOL1 Line 010	1223007_C4_DOL1 Line 011	1223007_C4_DOL1 Line 012	1223007_C4_DOL1 Line 013	1223007_C4_DOL1 Line 014	1223007_C4_DOL1 Line 015	1223007_C4_DOL1 Line 016	1223007_C4_DOL1 Line 017
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.03	0.00	0.07	0.00	0.03	0.00	0.00	0.00	0.03	0.07	0.03	0.00	0.03	0.07	0.00
Al2O3(Mass%)	0.00	0.00	0.03	0.07	0.02	0.22	0.79	0.06	0.18	0.18	0.03	0.43	0.78	0.16	0.01
FeO(Mass%)	3.91	4.36	4.20	4.17	3.85	3.73	4.49	5.04	6.01	4.53	5.46	4.72	3.62	4.04	4.44
MnO(Mass%)	0.78	0.84	1.06	0.86	1.11	0.98	0.72	0.82	1.11	1.04	0.88	0.88	0.72	0.77	0.77
MgO(Mass%)	17.68	16.74	17.04	17.93	18.13	17.53	17.52	17.01	15.89	15.64	15.85	16.78	17.90	17.85	17.64
CaO(Mass%)	27.90	28.32	28.11	27.35	27.66	27.58	26.87	27.91	28.41	29.21	28.45	28.13	27.34	27.85	28.08
BaO(Mass%)	0.04	0.05	0.00	0.00	0.00	0.00	0.03	0.01	0.01	0.02	0.01	0.02	0.03	0.03	0.09
SrO(Mass%)	0.28	0.27	0.32	0.38	0.30	0.46	0.48	0.26	0.24	0.05	0.23	0.29	0.43	0.52	0.35
La2O3(Mass%)	0.01	0.03	0.00	0.00	0.04	0.00	0.00	0.01	0.05	0.02	0.04	0.03	0.00	0.00	0.00
Ce2O3(Mass%)	0.06	0.07	0.02	0.07	0.02	0.02	0.10	0.01	0.00	0.04	0.05	0.08	0.00	0.04	0.03
SO3(Mass%)															
F(Mass%)															
TOTAL	50.80	50.71	50.93	50.96	51.19	50.74	51.06	51.29	52.08	50.81	51.12	51.48	51.03	51.47	51.50
F=O															
TOTAL	50.80	50.71	50.93	50.96	51.19	50.74	51.06	51.29	52.08	50.81	51.12	51.48	51.03	51.47	51.50
CO2	43.74	43.32	43.38	43.76	43.99	43.27	43.19	43.68	43.43	42.80	43.09	43.43	43.42	44.06	44.20
sum%	94.54	94.02	94.31	94.72	95.18	94.01	94.26	94.97	95.51	93.61	94.21	94.91	94.45	95.52	95.70

PROPORÇÃO ATÔMICA PARA 6 O

AMOSTRA	1223007_C4_DOL1 Line 003	1223007_C4_DOL1 Line 004	1223007_C4_DOL1 Line 005	1223007_C4_DOL1 Line 006	1223007_C4_DOL1 Line 007	1223007_C4_DOL1 Line 008	1223007_C4_DOL1 Line 009	1223007_C4_DOL1 Line 010	1223007_C4_DOL1 Line 011	1223007_C4_DOL1 Line 012	1223007_C4_DOL1 Line 013	1223007_C4_DOL1 Line 014	1223007_C4_DOL1 Line 015	1223007_C4_DOL1 Line 016	1223007_C4_DOL1 Line 017
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.01	0.01	0.00	0.02	0.03	0.01	0.00
Fe	0.11	0.12	0.12	0.12	0.11	0.10	0.13	0.14	0.17	0.13	0.15	0.13	0.10	0.11	0.12
Mn	0.02	0.02	0.03	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02
Mg	0.88	0.84	0.85	0.89	0.89	0.88	0.88	0.85	0.79	0.79	0.80	0.84	0.89	0.88	0.87
Ca	1.00	1.02	1.01	0.98	0.98	0.99	0.97	1.00	1.02	1.06	1.03	1.01	0.98	0.99	0.99
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.02	2.02	2.02	2.02	2.02	2.02	2.03	2.02	2.03	2.02	2.02	2.03	2.03	2.02	2.01
F=O															
TOTAL															
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.99	1.98	1.99	1.99	1.98	1.99	1.98	1.98	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223001_C2_DOL2 _LINE3	1223001_C2_DOL2 _LINE4	1223001_C1_DOL2_ 1	1223001_C1_DOL 2_2	1234042_CARB_ SIDGRANDE Line 024	1234042_CARB_ SIDGRANDE Line 028	1234042_CARB_SI DGRANDE Line 029	1234069_CARB_Z ONBORDA_6	1234069_CARB_Z ONBORDA_7	1234069_CARB_Z ONBORDA_8	1234069_CARB_Z ONBORDA_12	1234069_CARB_Z ONBORDA_13	1223010_CARB_AS SOCQTZCENTRO_7	1223010_CARB_ASSOCQT ZCENTRO_8	1223010_CARB_ASSOCQTZB ORDA_9	1223010_CARB_ASSOCQTZ BORDA_10
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.01	0.02	0.00	0.07	0.00	0.16	0.10	0.00	0.03	0.00	0.07	0.03	0.00	0.04	0.11	0.10
Al2O3(Mass%)	0.03	0.11	0.07	0.09	0.05	0.66	0.08	0.00	0.00	0.00	1.69	0.03	0.01	0.01	1.04	0.00
FeO(Mass%)	6.86	8.00	5.82	7.77	11.73	11.43	9.96	10.16	9.19	9.09	8.70	8.50	8.94	9.49	10.47	10.91
MnO(Mass%)	0.40	0.69	0.40	0.29	0.94	0.75	0.89	1.63	1.46	1.42	1.22	1.30	3.20	2.22	1.41	1.74
MgO(Mass%)	15.74	14.67	16.11	15.52	13.11	12.04	13.88	12.92	13.69	13.88	13.79	14.04	12.56	13.20	12.22	12.26
CaO(Mass%)	28.47	28.02	28.80	28.08	28.39	28.49	28.54	27.96	28.03	28.60	28.00	28.47	27.77	27.84	27.82	27.93
BaO(Mass%)	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.08	0.03	0.01	0.02
SrO(Mass%)	0.19	0.04	0.32	0.04	0.16	0.06	0.04	0.21	0.10	0.00	0.00	0.00	0.30	0.12	0.12	0.19
La2O3(Mass%)	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.00	0.01	0.07	0.07	0.04	0.05	0.05	0.03	0.08	0.04	0.07	0.03	0.05	0.09	0.01	0.05
SO3(Mass%)					0.01	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.81	51.60	51.65	52.01	54.42	53.63	53.54	52.92	52.65	53.06	53.53	52.42	52.90	53.03	53.21	53.19
F=O					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	51.81	51.60	51.65	52.01	54.42	53.63	53.54	52.92	52.65	53.06	53.53	52.42	52.90	53.03	53.21	53.19
CO2	43.81	42.92	43.92	43.78	43.85	42.54	43.68	42.36	42.63	43.18	42.37	42.89	41.14	42.15	41.65	42.08
sum%	95.62	94.53	95.56	95.79	98.27	96.18	97.21	95.28	95.27	96.24	95.90	95.31	94.04	95.18	94.86	95.27

AMOSTRA	1223001_C2_DOL2 _LINE3	1223001_C2_DOL2 _LINE4	1223001_C1_DOL2_ 1	1223001_C1_DOL 2_2	1234042_CARB_ SIDGRANDE Line 024	1234042_CARB_ SIDGRANDE Line 028	1234042_CARB_SI DGRANDE Line 029	1234069_CARB_Z ONBORDA_6	1234069_CARB_Z ONBORDA_7	1234069_CARB_Z ONBORDA_8	1234069_CARB_Z ONBORDA_12	1234069_CARB_Z ONBORDA_13	1223010_CARB_AS SOCQTZCENTRO_7	1223010_CARB_ASSOCQT ZCENTRO_8	1223010_CARB_ASSOCQTZB ORDA_9	1223010_CARB_ASSOCQTZ BORDA_10
CARBONATO	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.04	0.00
Fe	0.19	0.23	0.16	0.22	0.33	0.33	0.28	0.29	0.26	0.26	0.25	0.24	0.26	0.27	0.30	0.31
Mn	0.01	0.02	0.01	0.01	0.03	0.02	0.03	0.05	0.04	0.04	0.03	0.04	0.09	0.06	0.04	0.05
Mg	0.78	0.74	0.80	0.77	0.65	0.61	0.69	0.66	0.70	0.70	0.69	0.71	0.66	0.68	0.63	0.63
Ca	1.02	1.02	1.03	1.00	1.01	1.04	1.02	1.03	1.02	1.03	1.01	1.03	1.04	1.02	1.03	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.02	2.01	2.01	2.02	2.03	2.02	2.03	2.03	2.03	2.06	2.03	2.06	2.04	2.05	2.04
F=O																
TOTAL																
CO2(N.O.)	2.00	1.99	1.99	1.99	1.99	1.98	1.99	1.98	1.98	1.99	1.95	1.99	1.97	1.98	1.96	1.98

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	23010_CARB_ASSOCQTZ	23010_CARB_ASSOCQTZ_	1223010_CARB_DOL_7	1223010_CARB_DOL_8	1223010_CARB_DOL_9	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	0_CARB_DOLPERFIL	l0_CARB_DOLPERFIL	l0_CARB_DOLPERFIL	l0_CARB_DOLPERFIL L	1223010_CARB_DOL_	1223010_CARB_DOL_3
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.02	0.00	0.16	0.02	0.03	0.00	0.01	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.19
Al2O3(Mass%)	0.16	0.00	1.24	0.00	0.14	0.00	0.00	0.00	0.08	0.21	0.01	0.03	0.00	0.00	0.03	0.49
FeO(Mass%)	9.89	9.43	9.08	8.71	10.75	10.07	9.90	9.65	9.82	9.69	9.96	9.01	9.03	10.09	8.90	9.66
MnO(Mass%)	1.82	2.16	2.15	1.85	2.25	2.12	1.62	2.90	2.71	2.00	2.03	1.78	1.87	1.59	2.01	2.05
MgO(Mass%)	12.89	13.32	13.51	13.95	12.56	13.04	13.29	12.66	12.71	12.86	12.56	13.65	13.58	13.25	13.66	12.27
CaO(Mass%)	28.36	28.32	27.65	28.18	27.99	27.71	28.17	27.68	27.69	28.07	28.30	28.05	28.32	28.44	28.25	27.12
BaO(Mass%)	0.00	0.09	0.00	0.04	0.00	0.00	0.00	0.00	0.03	0.00	0.04	0.00	0.00	0.01	0.02	0.00
SrO(Mass%)	0.19	0.13	0.11	0.33	0.07	0.13	0.06	0.17	0.19	0.12	0.23	0.08	0.06	0.00	0.26	0.08
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01
Ce2O3(Mass%)	0.04	0.08	0.03	0.04	0.05	0.06	0.04	0.07	0.04	0.06	0.03	0.04	0.05	0.05	0.04	0.03
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	53.36	53.53	53.93	53.13	53.84	53.13	53.09	53.13	53.27	53.03	53.15	52.64	52.91	53.45	53.17	51.91
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	53.36	53.53	53.93	53.13	53.84	53.13	53.09	53.13	53.27	53.03	53.15	52.64	52.91	53.45	53.17	51.91
CO2	42.47	42.64	42.07	42.85	42.30	42.22	42.72	41.54	41.71	42.07	42.14	42.48	42.61	42.97	42.65	40.64
sum%	95.83	96.17	96.00	95.98	96.13	95.36	95.81	94.66	94.98	95.10	95.29	95.12	95.52	96.42	95.82	92.55

AMOSTRA	23010_CARB_ASSOCQTZ	23010_CARB_ASSOCQTZ_	1223010_CARB_DOL_7	1223010_CARB_DOL_8	1223010_CARB_DOL_9	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	3010_CARB_DOLPERFIL Line	0_CARB_DOLPERFIL	l0_CARB_DOLPERFIL	l0_CARB_DOLPERFIL	l0_CARB_DOLPERFIL L	1223010_CARB_DOL_	1223010_CARB_DOL_3
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Al	0.01	0.00	0.05	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
Fe	0.28	0.27	0.26	0.25	0.31	0.29	0.28	0.28	0.28	0.28	0.29	0.26	0.26	0.29	0.25	0.29
Mn	0.05	0.06	0.06	0.05	0.07	0.06	0.05	0.09	0.08	0.06	0.06	0.05	0.05	0.05	0.06	0.06
Mg	0.66	0.68	0.68	0.70	0.64	0.67	0.67	0.66	0.66	0.66	0.64	0.70	0.69	0.67	0.69	0.65
Ca	1.04	1.03	1.01	1.02	1.03	1.02	1.03	1.03	1.03	1.03	1.04	1.03	1.03	1.03	1.03	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.04	2.04	2.07	2.04	2.05	2.04	2.03	2.06	2.05	2.04	2.04	2.04	2.04	2.03	2.04	2.05
F=O																
TOTAL																
CO2(N.O.)	1.98	1.98	1.95	1.98	1.97	1.98	1.98	1.97	1.97	1.98	1.98	1.98	1.98	1.98	1.98	1.96

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223010_CARB_DOL_4	:3012_CARB_DOL_12 Line	3012_CARB_DOL_12 Line	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	1234047_CARB_DOL_14	23146_C1_DOL1 Line	023146_C1_DOL1 Line	023146_C1_DOL1 Line	023146_C1_DOL1 Line	0:23146_C1_DOL1 Line	0:23146_C1_DOL1 Line	(:3146_C1_DOL1 Line (
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
SiO2(Mass%)	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.05	0.00	0.00	0.00	0.00	0.00
Al2O3(Mass%)	0.19	0.68	0.03	0.02	0.02	0.01	0.00	0.01	0.02	0.01	0.00	0.02	0.06	0.00	0.05	0.00	0.05
FeO(Mass%)	10.54	7.83	3.95	3.81	4.97	4.91	4.69	5.24	4.17	11.87	9.11	9.25	8.70	9.13	8.65	8.62	9.84
MnO(Mass%)	1.70	5.37	6.17	2.64	3.37	4.16	3.32	2.17	5.60	1.07	0.66	0.95	0.85	0.84	0.82	0.83	0.70
MgO(Mass%)	12.28	11.12	12.95	16.40	15.12	14.35	15.54	15.64	13.80	11.85	14.57	14.06	14.21	14.15	14.64	14.35	14.30
CaO(Mass%)	27.98	26.89	27.01	27.03	27.05	27.33	27.47	26.93	26.90	28.24	27.97	28.06	28.05	28.02	27.82	28.10	27.98
BaO(Mass%)	0.02	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.06	0.03	0.00
SrO(Mass%)	0.03	0.29	0.67	1.06	0.66	0.41	0.72	1.18	0.63	0.06	0.59	0.44	0.36	0.20	0.17	0.19	0.45
La2O3(Mass%)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.07	0.00	0.03
Ce2O3(Mass%)	0.03	0.07	0.03	0.02	0.07	0.04	0.03	0.01	0.03	0.02	0.05	0.05	0.06	0.11	0.01	0.05	0.00
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
TOTAL	52.86	52.26	50.81	50.98	51.30	51.20	51.76	51.18	51.16	53.14	52.94	52.96	52.35	52.52	52.30	52.20	53.41
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
TOTAL	52.86	52.26	50.81	50.98	51.30	51.20	51.76	51.18	51.16	53.14	52.94	52.96	52.35	52.52	52.30	52.20	53.41
CO2	41.84	38.17	38.04	41.91	41.08	40.30	41.70	41.92	39.00	42.39	43.69	43.24	43.03	43.13	43.20	43.10	43.79
sum%	94.70	90.43	88.85	92.89	92.38	91.50	93.46	93.10	90.16	95.53	96.63	96.21	95.38	95.64	95.51	95.30	97.20

AMOSTRA	1223010_CARB_DOL_4	:3012_CARB_DOL_12 Line	3012_CARB_DOL_12 Line	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	23012_CARB_DOL_12 Line 0	1234047_CARB_DOL_14	23146_C1_DOL1 Line	023146_C1_DOL1 Line	023146_C1_DOL1 Line	023146_C1_DOL1 Line	0:23146_C1_DOL1 Line	0:23146_C1_DOL1 Line	(:3146_C1_DOL1 Line (
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.31	0.24	0.12	0.11	0.15	0.15	0.14	0.15	0.13	0.34	0.25	0.26	0.25	0.26	0.24	0.24	0.27
Mn	0.05	0.17	0.19	0.08	0.10	0.13	0.10	0.06	0.17	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02
Mg	0.63	0.61	0.72	0.84	0.79	0.76	0.80	0.81	0.75	0.61	0.73	0.71	0.72	0.71	0.74	0.72	0.71
Ca	1.04	1.07	1.08	1.00	1.02	1.04	1.02	1.00	1.05	1.04	1.00	1.01	1.02	1.02	1.01	1.02	1.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.04	2.13	2.13	2.05	2.07	2.08	2.06	2.04	2.12	2.02	2.01	2.02	2.02	2.02	2.02	2.02	2.01
F=O																	
TOTAL																	
CO2(N.O.)	1.98	1.93	1.93	1.97	1.97	1.96	1.97	1.98	1.94	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223146_C1_DOL1 Line 013	1223146_C1_DOL1_3	1223146_C1_DOL1_4	1223146_C1_DOL1_5	1223146_C1_DOL2_9	1223146_C1_DOL3 Line 001	1223146_C1_DOL3 Line 002	1223146_C4_DOL1 Line 009	1223007_C5_DOL1_4	1223007_C5_DOL1_9	1223001_C3_DOL_1 LINE9	1223001_C3_DOL1_ 15	1223001_C2_DOL1_ LINE4	1223001_C2_DOL1_ LINE5	1223001_C2_DOL1_ LINE6	1223001_C2_DOL1_ LINE7
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Al2O3(Mass%)	0.00	0.07	0.01	0.00	0.04	0.00	0.03	0.00	0.04	0.02	0.00	0.00	0.01	0.00	0.17	0.00
FeO(Mass%)	8.86	9.49	9.53	9.88	9.21	9.55	11.17	9.60	9.05	9.32	11.78	13.79	10.68	10.79	10.65	10.43
MnO(Mass%)	0.69	0.89	0.77	0.67	0.90	0.79	0.72	0.91	2.70	2.48	0.81	0.83	0.70	0.68	0.64	0.72
MgO(Mass%)	14.91	13.79	14.38	14.15	14.47	13.90	13.30	13.23	12.82	12.83	12.84	11.16	13.37	13.18	12.93	13.46
CaO(Mass%)	27.86	28.13	27.68	27.84	27.74	28.34	27.62	28.03	28.58	28.60	28.13	27.57	28.27	28.26	28.40	29.00
BaO(Mass%)	0.10	0.00	0.00	0.02	0.05	0.04	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
SrO(Mass%)	0.47	0.41	0.39	0.31	0.22	0.13	0.07	0.23	0.10	0.25	0.02	0.15	0.01	0.06	0.00	0.01
La2O3(Mass%)	0.03	0.00	0.01	0.00	0.05	0.02	0.04	0.00	0.03	0.05	0.04	0.00	0.03	0.00	0.00	0.00
Ce2O3(Mass%)	0.10	0.00	0.06	0.01	0.07	0.08	0.07	0.03	0.05	0.05	0.04	0.02	0.02	0.00	0.04	0.04
SO3(Mass%)																
F(Mass%)																
TOTAL	53.01	52.87	52.87	52.89	52.79	52.87	53.15	52.21	53.50	53.60	53.65	53.52	53.12	53.03	52.82	53.65
F=O																
TOTAL	53.01	52.87	52.87	52.89	52.79	52.87	53.15	52.21	53.50	53.60	53.65	53.52	53.12	53.03	52.82	53.65
CO2	43.81	43.12	43.44	43.48	43.33	43.34	43.09	42.44	42.01	42.27	43.32	42.34	43.33	43.21	42.93	43.85
sum%	96.82	95.98	96.31	96.37	96.12	96.22	96.25	94.65	95.52	95.87	96.97	95.85	96.46	96.24	95.76	97.50

AMOSTRA	1223146_C1_DOL1 Line 013	1223146_C1_DOL1_3	1223146_C1_DOL1_4	1223146_C1_DOL1_5	1223146_C1_DOL2_9	1223146_C1_DOL3 Line 001	1223146_C1_DOL3 Line 002	1223146_C4_DOL1 Line 009	1223007_C5_DOL1_4	1223007_C5_DOL1_9	1223001_C3_DOL_1 LINE9	1223001_C3_DOL1_ 15	1223001_C2_DOL1_ LINE4	1223001_C2_DOL1_ LINE5	1223001_C2_DOL1_ LINE6	1223001_C2_DOL1_ LINE7
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Fe	0.25	0.27	0.27	0.28	0.26	0.27	0.32	0.28	0.26	0.27	0.33	0.40	0.30	0.30	0.30	0.29
Mn	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.08	0.07	0.02	0.02	0.02	0.02	0.02	0.02
Mg	0.74	0.69	0.72	0.71	0.73	0.70	0.67	0.68	0.66	0.65	0.64	0.57	0.67	0.66	0.65	0.67
Ca	0.99	1.02	1.00	1.00	1.00	1.02	1.00	1.03	1.05	1.05	1.01	1.02	1.02	1.02	1.03	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.02	2.01	2.01	2.02	2.02	2.01	2.02	2.05	2.05	2.02	2.02	2.01	2.01	2.02	2.01
F=O																
TOTAL																
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.97	1.98	1.99	1.99	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223146_C1_DOL1 Line 013	1223146_C1_DOL1_3	1223146_C1_DOL1_4	1223146_C1_DOL1_5	1223146_C1_DOL2_9	1223146_C1_DOL3 Line 001	1223146_C1_DOL3 Line 002	1223146_C4_DOL1 Line 009	1223007_C5_DOL1_4	1223007_C5_DOL1_9	23001_C3_DOL_1 LIN	1223001_C3_DOL1_ 15	23001_C2_DOL1_ LIN	23001_C2_DOL1_ LIN	23001_C2_DOL1_ LIN	23001_C2_DOL1_ LINE
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Al2O3(Mass%)	0.00	0.07	0.01	0.00	0.04	0.00	0.03	0.00	0.04	0.02	0.00	0.00	0.01	0.00	0.17	0.00
FeO(Mass%)	8.86	9.49	9.53	9.88	9.21	9.55	11.17	9.60	9.05	9.32	11.78	13.79	10.68	10.79	10.65	10.43
MnO(Mass%)	0.69	0.89	0.77	0.67	0.90	0.79	0.72	0.91	2.70	2.48	0.81	0.83	0.70	0.68	0.64	0.72
MgO(Mass%)	14.91	13.79	14.38	14.15	14.47	13.90	13.30	13.23	12.82	12.83	12.84	11.16	13.37	13.18	12.93	13.46
CaO(Mass%)	27.86	28.13	27.68	27.84	27.74	28.34	27.62	28.03	28.58	28.60	28.13	27.57	28.27	28.26	28.40	29.00
BaO(Mass%)	0.10	0.00	0.00	0.02	0.05	0.04	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
SrO(Mass%)	0.47	0.41	0.39	0.31	0.22	0.13	0.07	0.23	0.10	0.25	0.02	0.15	0.01	0.06	0.00	0.01
La2O3(Mass%)	0.03	0.00	0.01	0.00	0.05	0.02	0.04	0.00	0.03	0.05	0.04	0.00	0.03	0.00	0.00	0.00
Ce2O3(Mass%)	0.10	0.00	0.06	0.01	0.07	0.08	0.07	0.03	0.05	0.05	0.04	0.02	0.02	0.00	0.04	0.04
SO3(Mass%)																
F(Mass%)																
TOTAL	53.01	52.87	52.87	52.89	52.79	52.87	53.15	52.21	53.50	53.60	53.65	53.52	53.12	53.03	52.82	53.65
F=O																
TOTAL	53.01	52.87	52.87	52.89	52.79	52.87	53.15	52.21	53.50	53.60	53.65	53.52	53.12	53.03	52.82	53.65
CO2	43.81	43.12	43.44	43.48	43.33	43.34	43.09	42.44	42.01	42.27	43.32	42.34	43.33	43.21	42.93	43.85
sum%	96.82	95.98	96.31	96.37	96.12	96.22	96.25	94.65	95.52	95.87	96.97	95.85	96.46	96.24	95.76	97.50

AMOSTRA	1223146_C1_DOL1 Line 013	1223146_C1_DOL1_3	1223146_C1_DOL1_4	1223146_C1_DOL1_5	1223146_C1_DOL2_9	1223146_C1_DOL3 Line 001	1223146_C1_DOL3 Line 002	1223146_C4_DOL1 Line 009	1223007_C5_DOL1_4	1223007_C5_DOL1_9	23001_C3_DOL_1 LIN	1223001_C3_DOL1_ 15	23001_C2_DOL1_ LIN	23001_C2_DOL1_ LIN	23001_C2_DOL1_ LIN	23001_C2_DOL1_ LINE
CARBONATO	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe	Fe dolomita > Fe
LITOLOGIA	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Fe CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Fe	0.25	0.27	0.27	0.28	0.26	0.27	0.32	0.28	0.26	0.27	0.33	0.40	0.30	0.30	0.30	0.29
Mn	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.08	0.07	0.02	0.02	0.02	0.02	0.02	0.02
Mg	0.74	0.69	0.72	0.71	0.73	0.70	0.67	0.68	0.66	0.65	0.64	0.57	0.67	0.66	0.65	0.67
Ca	0.99	1.02	1.00	1.00	1.00	1.02	1.00	1.03	1.05	1.05	1.01	1.02	1.02	1.02	1.03	1.03
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.01	2.02	2.01	2.01	2.02	2.02	2.01	2.02	2.05	2.05	2.02	2.02	2.01	2.01	2.02	2.01
F=O																
TOTAL																
CO2(N.O.)	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.97	1.98	1.99	1.99	1.99	1.99	1.99	1.99

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223010_CARB_ASSOCQTZ_20	1223010_CARB_DOLPERFIL Line 002	1223010_CARB_DOLPERFIL Line 019	1223012_CARB_ANK_1	1223012_CARB_ANK_2	1223012_CARB_ANK_3	1223012_CARB_ANK_4	1223012_CARB_ANK_5	1223012_CARB_ANK_6
CARBONATO	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.04	0.03	0.00	0.00	0.03	0.00	0.00	0.03	0.03
Al2O3(Mass%	0.02	0.81	0.00	0.00	0.01	0.10	0.01	0.00	0.01
FeO(Mass%)	12.10	12.51	12.03	15.84	15.65	12.76	15.27	14.34	15.67
MnO(Mass%)	1.93	1.92	2.02	2.91	3.26	2.84	2.76	2.87	3.18
MgO(Mass%)	11.04	10.50	11.28	7.98	8.06	10.24	8.53	9.24	8.58
CaO(Mass%)	27.87	27.44	27.84	27.56	27.43	27.60	27.23	27.36	27.43
BaO(Mass%)	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.02	0.02
SrO(Mass%)	0.28	0.01	0.24	0.00	0.00	0.00	0.00	0.00	0.00
La2O3(Mass%	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%	0.01	0.06	0.03	0.02	0.04	0.00	0.04	0.04	0.04
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	53.30	53.32	53.44	54.32	54.47	53.57	53.85	53.90	54.95
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	53.3034	53.3186	53.4389	54.3223	54.468	53.5655	53.852	53.9023	54.9485
CO2	41.46035179	40.67874698	41.64251746	40.04510139	39.91207023	40.67162116	40.04840639	40.35731015	40.4969466
sum%	94.76375179	93.99734698	95.08141746	94.36740139	94.38007023	94.23712116	93.90040639	94.25961015	95.4454466

AMOSTRA	23010_CARB_ASSOCQTZ_	23010_CARB_DOLPERFIL Line (	23010_CARB_DOLPERFIL Line	223012_CARB_ANK_	223012_CARB_ANK_	223012_CARB_ANK_	223012_CARB_ANK_	223012_CARB_ANK_	223012_CARB_ANK_
CARBONATO	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.001475658	0.001162746	0	0	0.000995638	0.000106407	0	0.00090107	0.001081471
Al	0.001001461	0.033776203	0.00016418	0	0.000599468	0.003971235	0.000582163	0.000130639	0.000599559
Fe	0.35	0.37	0.35	0.48	0.47	0.38	0.46	0.43	0.47
Mn	0.06	0.06	0.06	0.09	0.10	0.09	0.08	0.09	0.10
Mg	0.58	0.55	0.59	0.43	0.43	0.54	0.46	0.49	0.45
Ca	1.04	1.04	1.04	1.06	1.06	1.05	1.05	1.05	1.05
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.04	2.06	2.04	2.06	2.07	2.06	2.06	2.06	2.06
F=O									
TOTAL									
CO2(N.O.)	1.98	1.96	1.98	1.97	1.97	1.97	1.97	1.97	1.97

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

AMOSTRA	1223012_CARB_ANK_7	1223012_CARB_ANK_8	1223012_CARB_ANK_9	1223012_CARB_ANK_10	1223012_CARB_ANK_11	1223012_CARB_SID_15	1223012_CARB_DOL_22	1223012_CARB_DOL_23	1223012_CARB_DOL_24	1223012_CARB_DOL_25
CARBONATO	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.04	0.01	0.01	0.00	0.00	0.09	0.00	0.00	0.00	0.0139
Al2O3(Mass%	0.54	0.01	0.00	0.02	0.00	2.90	0.01	0.02	0.00	0.0602
FeO(Mass%)	15.83	15.75	14.98	15.06	15.09	14.16	15.42	9.13	15.47	15.8668
MnO(Mass%)	3.12	3.21	2.87	2.99	3.21	3.44	2.90	4.35	3.27	3.3474
MgO(Mass%)	8.11	8.07	8.69	8.69	8.72	8.09	8.65	11.43	8.42	7.9295
CaO(Mass%)	27.42	27.40	27.60	27.62	27.60	26.60	27.60	27.39	27.38	27.6538
BaO(Mass%)	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
SrO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0
La2O3(Mass%	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Ce2O3(Mass%	0.01	0.06	0.05	0.06	0.05	0.05	0.07	0.06	0.08	0.0657
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
TOTAL	55.09	54.50	54.20	54.46	54.67	55.34	54.66	52.57	54.62	54.9373
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
TOTAL	55.0898	54.5023	54.1981	54.4593	54.6749	55.337	54.6583	52.5713	54.6159	54.9373
CO2	40.07667547	39.95980028	40.33391737	40.40267648	40.4334342	38.39750445	40.56585384	39.65597476	40.17025513	40.08883467
sum%	95.16647547	94.46210028	94.53201737	94.86197648	95.1083342	93.73450445	95.22415384	92.22727476	94.78615513	95.02613467

AMOSTRA	1223012_CARB_ANK_7	1223012_CARB_ANK_8	1223012_CARB_ANK_9	1223012_CARB_ANK_10	1223012_CARB_ANK_11	1223012_CARB_SID_15	1223012_CARB_DOL_22	1223012_CARB_DOL_23	1223012_CARB_DOL_24	1223012_CARB_DOL_25
CARBONATO	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita	Ankerita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.0014	0.0004	0.0004	0.0001	0.0001	0.0033	0.0000	0.0000	0.0000	0.0005
Al	0.0227	0.0005	0.0000	0.0009	0.0001	0.1238	0.0004	0.0007	0.0000	0.0025
Fe	0.4733	0.4747	0.4482	0.4496	0.4497	0.4293	0.4588	0.2756	0.4640	0.4762
Mn	0.0944	0.0980	0.0870	0.0905	0.0968	0.1055	0.0874	0.1331	0.0993	0.1017
Mg	0.4322	0.4334	0.4637	0.4624	0.4635	0.4374	0.4590	0.6153	0.4503	0.4242
Ca	1.0504	1.0581	1.0584	1.0565	1.0538	1.0334	1.0522	1.0596	1.0518	1.0633
Ba	0.0002	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0042	0.0000	0.0000
La	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ce	0.0001	0.0008	0.0006	0.0008	0.0007	0.0007	0.0009	0.0008	0.0010	0.0009
S	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
F(N.O.)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	2.0748	2.0659	2.0582	2.0610	2.0648	2.1335	2.0586	2.0892	2.0663	2.0694
F=O										
TOTAL										
CO2(N.O.)	1.9562	1.9665	1.9706	1.9690	1.9674	1.9005	1.9704	1.9550	1.9666	1.9642

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

SAMPLE	1223010_CARB_ASSOCQTZ_1	1223010_CARB_ASSOCQTZ_2	1223010_CARB_ASSOCQTZ_11	1223010_CARB_ASSOCQTZ_13	1223010_CARB_ASSOCQTZ_15	1223010_CARB_ASSOCQTZ_16	1223010_CARB_ASSOCQTZ_17	1223010_CARB_SIDER_5	1223010_CARB_SIDER_6	1223010_CARB_DOL_10 Line 003	1223010_CARB_DOL_10 Line 004	1223010_CARB_DOL_10 Line 005
CARBONATO	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.10	0.07	0.01	0.03	2.59	0.10	0.05	0.01	0.01	0.00	0.00	0.13
Al2O3(Mass%)	0.03	0.01	0.00	0.11	0.03	0.01	0.01	0.04	0.02	0.00	0.01	0.96
FeO(Mass%)	40.83	41.13	44.44	40.33	40.29	41.13	41.98	43.88	41.26	40.88	41.67	41.52
MnO(Mass%)	4.95	3.73	4.59	4.22	4.02	4.15	3.93	3.04	4.30	4.17	4.23	3.80
MgO(Mass%)	9.84	10.98	7.05	11.27	10.27	10.62	10.03	9.89	10.64	11.47	10.71	10.17
CaO(Mass%)	0.06	0.05	0.46	0.03	0.04	0.06	0.11	0.03	0.04	0.06	0.03	0.03
BaO(Mass%)	0.02	0.01	0.02	0.00	0.03	0.30	0.06	0.00	0.00	0.03	0.00	0.00
SrO(Mass%)	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.02	0.00
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.05	0.02	0.03	0.04	0.11	0.17	0.07	0.05	0.03	0.05	0.02	0.01
SO3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	55.89	56.01	56.58	56.03	57.38	56.55	56.25	56.94	56.31	56.66	56.69	56.62
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	55.89	56.01	56.58	56.03	57.38	56.55	56.25	56.94	56.31	56.66	56.69	56.62
CO2	35.82	37.23	35.28	37.04	35.95	36.95	36.78	37.71	36.93	37.63	37.26	36.57
sum%	91.71	93.24	91.86	93.07	93.33	93.50	93.02	94.66	93.24	94.29	93.95	93.19

PROPORÇÃO ATÔMICA PARA 6 O

SAMPLE	1223010_CARB_ASSOCQTZ_1	1223010_CARB_ASSOCQTZ_2	1223010_CARB_ASSOCQTZ_11	1223010_CARB_ASSOCQTZ_13	1223010_CARB_ASSOCQTZ_15	1223010_CARB_ASSOCQTZ_16	1223010_CARB_ASSOCQTZ_17	1223010_CARB_SIDER_5	1223010_CARB_SIDER_6	1223010_CARB_DOL_10 Line 003	1223010_CARB_DOL_10 Line 004	1223010_CARB_DOL_10 Line 005
CARBONATO	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Fe	1.36	1.32	1.50	1.30	1.30	1.33	1.37	1.40	1.34	1.30	1.34	1.34
Mn	0.17	0.12	0.16	0.14	0.13	0.14	0.13	0.10	0.14	0.13	0.14	0.12
Mg	0.58	0.63	0.42	0.65	0.59	0.61	0.58	0.56	0.61	0.65	0.61	0.59
Ca	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.11	2.08	2.10	2.09	2.12	2.09	2.09	2.07	2.09	2.09	2.09	2.11
F=O												
TOTAL												
CO2(N.O.)	1.94	1.96	1.95	1.95	1.89	1.95	1.95	1.97	1.95	1.95	1.95	1.93

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

SAMPLE	1223010_CARB_DOL_10 Line 014	1223010_CARB_DOL_10 Line 015	1223146_C1_CARB1_8	1223010_CARB_SID_5	1223010_CARB_SID_6	1223010_CARB_SID_7	1223010_CARB_SID_8	1223012_CARB_SID_13	1223012_CARB_SIDESCURO_20	1223012_CARB_SIDESCURO_21	1234042_CARB_SID_1	1234042_CARB_SID_2	1234042_CARB_SID_3	1234042_CARB_SID_4	1234042_CARB_SID_5	1234042_CARB_SID Line 001	1234042_CARB_SID Line 002	1234042_CARB_SID Line 003	1234042_CARB_SID Line 004	1234042_CARB_SID Line 005
CARBONATO	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.03	0.01	0.13	0.04	0.04	0.02	0.01	0.01	0.01	0.03	0.02	0.00	0.02	0.00	0.00	0.01	0.01	0.03	0.01	0.00
Al2O3(Mass%)	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.00	0.01	0.03	0.04	0.03	0.00	0.04	0.00	0.01	0.00	0.00	0.01
FeO(Mass%)	42.37	41.36	41.38	42.46	41.46	39.79	42.13	41.05	43.12	43.21	52.92	53.22	52.50	52.98	49.37	48.55	48.78	48.84	49.81	52.70
MnO(Mass%)	4.05	4.17	2.15	3.97	3.95	4.62	3.82	0.68	6.27	6.54	2.66	2.57	2.61	2.64	3.54	1.64	1.78	3.18	2.99	2.67
MgO(Mass%)	10.26	10.55	11.27	9.48	10.61	10.87	9.99	10.46	6.90	6.50	2.19	1.89	1.93	1.91	4.15	5.79	5.62	4.90	3.96	2.13
CaO(Mass%)	0.06	0.03	0.22	0.05	0.15	0.15	0.15	2.49	0.12	0.15	0.17	0.15	0.17	0.17	0.04	0.27	0.53	0.37	0.25	0.16
BaO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.01	0.00	0.03	0.02
SrO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
La2O3(Mass%)	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Ce2O3(Mass%)	0.06	0.05	0.05	0.04	0.03	0.02	0.04	0.02	0.04	0.05	0.04	0.04	0.05	0.07	0.08	0.06	0.04	0.07	0.08	0.06
SO3(Mass%)	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00
F(Mass%)	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	56.83	56.18	55.28	56.03	56.25	55.52	56.15	54.75	56.46	56.53	58.03	57.93	57.31	57.82	57.26	56.32	56.79	57.42	57.13	57.75
F=O	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	56.83	56.18	55.28	56.03	56.25	55.52	56.15	54.75	56.46	56.53	58.03	57.93	57.31	57.82	57.26	56.32	56.79	57.42	57.13	57.75
CO2	37.21	36.88	37.83	36.40	37.10	36.38	36.83	38.53	34.05	33.69	34.95	34.79	34.40	34.70	34.83	36.28	36.44	35.57	35.05	34.74
sum%	94.04	93.06	93.11	92.43	93.36	91.90	92.98	93.28	90.51	90.22	92.98	92.72	91.71	92.53	92.09	92.59	93.23	92.99	92.18	92.49

PROPORÇÃO ATÔMICA PARA 6 O

SAMPLE	1223010_CARB_DOL_10 Line 014	1223010_CARB_DOL_10 Line 015	1223146_C1_CARB1_8	1223010_CARB_SID_5	1223010_CARB_SID_6	1223010_CARB_SID_7	1223010_CARB_SID_8	1223012_CARB_SID_13	1223012_CARB_SIDESCURO_20	1223012_CARB_SIDESCURO_21	1234042_CARB_SID_1	1234042_CARB_SID_2	1234042_CARB_SID_3	1234042_CARB_SID_4	1234042_CARB_SID_5	1234042_CARB_SID Line 001	1234042_CARB_SID Line 002	1234042_CARB_SID Line 003	1234042_CARB_SID Line 004	1234042_CARB_SID Line 005
CARBONATO	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	1.36	1.34	1.32	1.40	1.34	1.31	1.37	1.30	1.49	1.51	1.82	1.84	1.84	1.84	1.70	1.62	1.62	1.65	1.71	1.83
Mn	0.13	0.14	0.07	0.13	0.13	0.15	0.13	0.02	0.22	0.23	0.09	0.09	0.09	0.09	0.12	0.06	0.06	0.11	0.10	0.09
Mg	0.59	0.61	0.64	0.56	0.61	0.64	0.58	0.59	0.43	0.40	0.13	0.12	0.12	0.12	0.25	0.35	0.33	0.30	0.24	0.13
Ca	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.02	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.09	2.09	2.05	2.09	2.09	2.10	2.08	2.02	2.15	2.16	2.06	2.06	2.06	2.06	2.08	2.04	2.04	2.07	2.07	2.06
F=O																				
TOTAL																				
CO2(N.O.)	1.95	1.95	1.97	1.95	1.96	1.95	1.96	1.99	1.93	1.92	1.97	1.97	1.97	1.97	1.96	1.98	1.98	1.96	1.96	1.97

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

SAMPLE	1234042_CARB_SID Line 006	1234042_CARB_SID Line 007	1234042_CARB_SID Line 008	1234042_CARB_SID Line 009	1234042_CARB_SID Line 010	1234042_CARB_SID Line 011	1234042_CARB_SID Line 012	1234042_CARB_SID Line 013	1234042_CARB_SID Line 014	1234042_CARB_SID Line 015	1234042_CARB_SID Line 016	1234042_CARB_SID Line 017	1234042_CARB_SIDZON_7	1234042_CARB_SIDZON_8	1234042_CARB_SIDZON_9
CARBONATO	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.02	0.00	0.01	0.00	0.01	0.03	0.01	0.00	0.01	0.03	0.00	0.04	0.00	0.00	0.02
Al2O3(Mass%)	0.01	0.02	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03
FeO(Mass%)	52.95	52.88	52.94	52.36	50.52	52.87	52.95	52.68	53.07	50.23	49.01	48.11	39.25	43.18	48.88
MnO(Mass%)	2.54	2.36	2.50	2.34	2.30	2.48	2.53	2.57	2.61	3.06	3.23	3.93	3.70	1.93	3.11
MgO(Mass%)	1.89	1.99	1.98	2.45	4.11	2.10	1.90	1.93	1.70	3.65	3.93	4.25	1.97	1.03	4.67
CaO(Mass%)	0.14	0.16	0.18	0.21	0.25	0.18	0.19	0.17	0.16	0.20	0.22	0.46	0.12	0.08	0.06
BaO(Mass%)	0.03	0.01	0.02	0.02	0.02	0.00	0.01	0.05	0.01	0.05	0.07	0.10	0.00	0.00	0.01
SrO(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.04	0.01	0.00	0.05
La2O3(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce2O3(Mass%)	0.06	0.08	0.08	0.06	0.10	0.05	0.08	0.05	0.05	0.12	0.07	0.10	0.04	0.03	0.06
SO3(Mass%)	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	57.63	57.50	57.72	57.45	57.30	57.74	57.68	57.46	57.61	57.36	56.52	57.04	45.10	46.25	56.88
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	57.63	57.50	57.72	57.45	57.30	57.74	57.68	57.46	57.61	57.36	56.52	57.04	45.10	46.25	56.88
CO2	34.62	34.71	34.75	34.93	35.65	34.82	34.68	34.53	34.50	34.95	34.51	34.53	26.29	27.64	35.12
sum%	92.25	92.21	92.47	92.38	92.95	92.56	92.35	91.99	92.11	92.32	91.03	91.58	71.39	73.89	92.00

PROPORÇÃO ATÔMICA PARA 6 O

SAMPLE	1234042_CARB_SID Line 006	1234042_CARB_SID Line 007	1234042_CARB_SID Line 008	1234042_CARB_SID Line 009	1234042_CARB_SID Line 010	1234042_CARB_SID Line 011	1234042_CARB_SID Line 012	1234042_CARB_SID Line 013	1234042_CARB_SID Line 014	1234042_CARB_SID Line 015	1234042_CARB_SID Line 016	1234042_CARB_SID Line 017	1234042_CARB_SIDZON_7	1234042_CARB_SIDZON_8	1234042_CARB_SIDZON_9
CARBONATO	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita	Mg siderita
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	1.84	1.84	1.84	1.81	1.71	1.83	1.84	1.84	1.86	1.73	1.71	1.67	1.78	1.89	1.67
Mn	0.09	0.08	0.09	0.08	0.08	0.09	0.09	0.09	0.09	0.11	0.11	0.14	0.17	0.09	0.11
Mg	0.12	0.12	0.12	0.15	0.25	0.13	0.12	0.12	0.11	0.22	0.24	0.26	0.16	0.08	0.28
Ca	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.06	2.06	2.06	2.06	2.05	2.06	2.06	2.06	2.06	2.07	2.08	2.09	2.11	2.06	2.07
F=O															
TOTAL															
CO2(N.O.)	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.96	1.96	1.95	1.94	1.97	1.96

ANEXO B – QUÍMICA MINERAL – WDS – CARBONATOS

SAMPLE	1234042_CARB_SIDZON_2	1234042_CARB_SIDZON_3	1234042_CARB_SIDZON_4	1234042_CARB_SIDZON_5	1234042_CARB_SIDZON_6	1234042_CARB_SIDGRANDE Line 001	1234042_CARB_SIDGRANDE Line 002	1234042_CARB_SIDGRANDE Line 003	1234042_CARB_SIDGRANDE Line 004	1234042_CARB_SIDGRANDE Line 005	1234042_CARB_SIDGRANDE Line 006	1234042_CARB_SIDGRANDE Line 007	1234042_CARB_SIDGRANDE Line 016	1234042_CARB_SIDGRANDE Line 018	1234042_CARB_SIDGRANDE Line 019	1234042_CARB_SIDGRANDE Line 021	1223012_CARB_SID_14	1223012_CARB_SID_16	1223012_CARB_SID_17	1223012_CARB_SIDCLARO_18	1223012_CARB_SIDCLARO_19
CARBONATO	Siderita	Siderita	Siderita	Siderita	Siderita	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
SiO2(Mass%)	0.00	0.00	0.03	0.00	0.01	0.03	0.03	0.03	0.00	0.00	0.00	0.11	2.72	2.01	1.52	0.56	0.00	0.04	0.03	0.01	0.00
Al2O3(Mass%)	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.01	0.22	0.02	0.00	0.82	0.28	0.03	0.00	0.02	0.00	0.00
FeO(Mass%)	43.46	53.01	43.69	43.28	46.92	50.51	51.09	50.32	50.53	50.27	50.10	46.42	55.55	52.68	50.44	47.47	45.72	44.81	47.96	47.91	48.13
MnO(Mass%)	2.02	2.47	2.05	1.97	2.45	2.51	2.50	2.46	2.43	2.47	2.36	2.70	2.34	2.27	2.68	3.71	5.94	5.90	4.85	5.17	4.92
MgO(Mass%)	1.07	2.12	0.88	0.91	0.63	3.88	4.07	4.15	4.22	4.08	4.38	4.41	2.48	3.05	3.72	5.27	4.84	6.17	4.31	4.12	3.94
CaO(Mass%)	0.10	0.15	0.07	0.09	0.08	0.25	0.33	0.37	0.46	0.73	0.55	2.07	0.55	0.42	0.30	0.31	0.25	0.19	0.04	0.08	0.05
BaO(Mass%)	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.05	0.00	0.00	0.03	0.04	0.01	0.00	0.02	0.00	0.00	0.00
SrO(Mass%)	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.02	0.02	0.02	0.00	0.00	0.01	0.00	0.00
La2O3(Mass%)	0.00	0.00	0.01	0.00	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Ce2O3(Mass%)	0.06	0.05	0.01	0.06	0.02	0.05	0.06	0.04	0.04	0.04	0.06	0.05	0.06	0.08	0.04	0.05	0.03	0.04	0.07	0.03	0.00
SO3(Mass%)	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.03	1.29	0.00	0.15	0.08	0.09	0.00	0.00	0.00	0.00	0.00
F(Mass%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	46.71	57.81	46.77	46.32	50.13	57.27	58.12	57.38	57.71	57.60	57.54	57.28	63.77	60.71	59.67	57.78	56.81	57.18	57.30	57.32	57.04
F=O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	46.71	57.81	46.77	46.32	50.13	57.27	58.12	57.38	57.71	57.60	57.54	57.28	63.77	60.71	59.67	57.78	56.81	57.18	57.30	57.32	57.04
CO2	27.88	34.91	27.78	27.59	29.49	35.39	36.01	35.65	35.93	35.83	35.92	34.89	37.20	35.96	35.23	35.09	33.49	34.36	34.13	33.91	33.82
sum%	74.59	92.73	74.55	73.91	79.62	92.66	94.13	93.03	93.64	93.43	93.46	92.17	100.97	96.67	94.90	92.87	90.30	91.54	91.43	91.23	90.86

SAMPLE	1234042_CARB_SIDZON_2	1234042_CARB_SIDZON_3	1234042_CARB_SIDZON_4	1234042_CARB_SIDZON_5	1234042_CARB_SIDZON_6	1234042_CARB_SIDGRANDE Line 001	1234042_CARB_SIDGRANDE Line 002	1234042_CARB_SIDGRANDE Line 003	1234042_CARB_SIDGRANDE Line 004	1234042_CARB_SIDGRANDE Line 005	1234042_CARB_SIDGRANDE Line 006	1234042_CARB_SIDGRANDE Line 007	1234042_CARB_SIDGRANDE Line 016	1234042_CARB_SIDGRANDE Line 018	1234042_CARB_SIDGRANDE Line 019	1234042_CARB_SIDGRANDE Line 021	1223012_CARB_SID_14	1223012_CARB_SID_16	1223012_CARB_SID_17	1223012_CARB_SIDCLARO_18	1223012_CARB_SIDCLARO_19
CARBONATO	Siderita	Siderita	Siderita	Siderita	Siderita	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA	SIDERITA
LITOLOGIA	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio	Fe CBT tardio
Si	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.08	0.06	0.02	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00
Fe	1.88	1.83	1.90	1.89	1.92	1.72	1.71	1.70	1.70	1.69	1.68	1.57	1.74	1.72	1.67	1.60	1.61	1.54	1.67	1.68	1.69
Mn	0.09	0.09	0.09	0.09	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.09	0.07	0.08	0.09	0.13	0.21	0.21	0.17	0.18	0.18
Mg	0.08	0.13	0.07	0.07	0.05	0.24	0.24	0.25	0.25	0.25	0.26	0.27	0.14	0.18	0.22	0.32	0.30	0.38	0.27	0.26	0.25
Ca	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.09	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F(N.O.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	2.06	2.06	2.06	2.06	2.07	2.06	2.06	2.06	2.06	2.06	2.05	2.07	2.08	2.08	2.10	2.10	2.14	2.14	2.12	2.12	2.12
F=O																					
TOTAL																					
CO2(N.O.)	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.92	1.91	1.92	1.91	1.93	1.93	1.93	1.94	1.94	1.94

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_APAT_COLAPS_1	1223001_APAT_COLAPS_2	1223001_APAT_COLAPS_3	1223001_APAT_COLAPS_4	1223001_APAT_COLAPS_5	1223001_APAT_COLAPS_6	1223001_APAT_COLAPS_7	1223001_APAT_COLAPS_8	1223001_APAT_COLAPS_9	1223001_APAT_IMG1_1	1223001_APAT_IMG1_10	1223001_APAT_IMG1_2	1223001_APAT_IMG1_3	1223001_APAT_IMG1_4	1223001_APAT_IMG1_5
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.01	0.02	n.d.	n.d.	0.03	0.01	n.d.	0.02	0.02	0.01	0.05	0.04	n.d.	0.00	n.d.
Al2O3(Mass%	n.d.	0.01	0.00	0.01	0.00	0.01	0.00	0.03	0.01	0.01	0.01	0.02	0.02	0.01	0.01
FeO(Mass%)	0.09	0.13	0.02	0.03	0.21	0.11	0.03	0.04	0.06	0.06	0.05	0.10	0.04	0.06	0.13
MnO(Mass%)	0.03	0.04	0.03	0.01	0.01	0.02	n.d.	0.01	n.d.	0.02	0.06	0.07	0.02	0.02	0.02
MgO(Mass%)	0.07	0.12	n.d.	0.02	0.03	0.06	n.d.	0.05	0.00	0.04	0.17	0.15	0.02	0.08	0.05
CaO(Mass%)	54.31	54.55	54.91	55.23	55.01	54.73	54.84	54.79	55.21	54.37	54.31	54.60	55.07	54.84	54.75
BaO(Mass%)	n.d.	0.01	0.02	n.d.	n.d.	n.d.	n.d.	0.04	0.04	n.d.	n.d.	0.02	n.d.	0.03	0.02
SrO(Mass%)	0.14	0.05	0.30	0.17	0.28	0.13	0.24	0.09	0.20	0.08	0.01	0.08	0.09	0.09	0.15
Na2O(Mass%	0.25	0.29	0.09	0.15	0.18	0.29	0.17	0.17	0.14	0.17	0.32	0.31	0.22	0.21	0.29
P2O5(Mass%)	40.76	40.64	41.16	41.34	40.88	41.05	40.69	40.73	41.14	40.30	40.34	41.06	40.80	40.94	40.79
La2O3(Mass%	0.05	0.04	0.03	0.04	0.01	0.02	0.07	0.04	0.08	0.05	n.d.	0.01	0.03	0.00	0.06
Ce2O3(Mass%	0.18	0.13	0.20	0.17	0.19	0.14	0.21	0.16	0.19	0.18	0.09	0.09	0.13	0.18	0.16
Pr2O3(Mass%	n.d.	n.d.	n.d.	0.04	n.d.	0.01	n.d.	0.02	n.d.	0.08	n.d.	n.d.	0.01	0.04	0.00
Nd2O3(Mass%	0.09	n.d.	0.14	0.07	0.08	0.13	0.10	0.08	0.11	0.09	0.03	0.06	0.07	n.d.	0.07
Sm2O3(Mass%	0.02	0.02	n.d.	n.d.	0.04	n.d.	n.d.	n.d.	0.00	n.d.	0.01	n.d.	0.02	n.d.	n.d.
LREE	0.35	0.19	0.37	0.31	0.33	0.30	0.38	0.31	0.39	0.40	0.12	0.15	0.25	0.22	0.29
Y2O3(Mass%)	0.04	0.00	0.04	0.04	0.01	0.01	0.04	0.04	n.d.	0.01	n.d.	0.01	0.01	0.02	0.00
SO3(Mass%)	0.03	0.01	0.02	0.01	0.04	0.03	n.d.	0.02	0.02	0.05	0.06	0.08	0.04	0.03	n.d.
F(Mass%)	1.41	1.01	1.60	1.41	1.57	0.70	0.92	0.43	1.12	0.96	1.03	0.71	1.22	0.96	0.85
Cl(Mass%)	0.02	0.02	0.01	n.d.	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.01
TOTAL	97.50	97.09	98.56	98.73	98.59	97.47	97.32	96.78	98.36	96.48	96.55	97.41	97.82	97.54	97.36
F=O	-0.59	-0.43	-0.67	-0.59	-0.66	-0.29	-0.39	-0.18	-0.47	-0.40	-0.43	-0.30	-0.51	-0.40	-0.36
Cl=O	0.00	-0.01	0.00	n.d.	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.01	0.00
TOTAL	96.91	96.66	97.88	98.14	97.93	97.17	96.93	96.59	97.89	96.08	96.12	97.10	97.30	97.13	97.00

AMOSTRA	1223001_APAT_COLAPS_1	1223001_APAT_COLAPS_2	1223001_APAT_COLAPS_3	1223001_APAT_COLAPS_4	1223001_APAT_COLAPS_5	1223001_APAT_COLAPS_6	1223001_APAT_COLAPS_7	1223001_APAT_COLAPS_8	1223001_APAT_COLAPS_9	1223001_APAT_IMG1_1	1223001_APAT_IMG1_10	1223001_APAT_IMG1_2	1223001_APAT_IMG1_3	1223001_APAT_IMG1_4	1223001_APAT_IMG1_5
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.001	0.003	n.d.	n.d.	0.005	0.002	n.d.	0.003	0.003	0.002	0.009	0.007	n.d.	0.001	n.d.
Al	n.d.	0.002	0.000	0.003	0.001	0.001	0.000	0.006	0.002	0.003	0.003	0.004	0.005	0.002	0.003
Fe	0.013	0.019	0.003	0.004	0.029	0.016	0.004	0.006	0.009	0.009	0.008	0.014	0.005	0.009	0.018
Mn	0.005	0.006	0.004	0.002	0.002	0.003	n.d.	0.001	n.d.	0.003	0.009	0.010	0.003	0.002	0.003
Mg	0.018	0.030	n.d.	0.005	0.008	0.016	n.d.	0.013	n.d.	0.010	0.043	0.037	0.005	0.020	0.013
Ca	10.014	10.062	10.042	10.050	10.068	10.019	10.107	10.083	10.074	10.096	10.067	9.987	10.107	10.054	10.066
Ba	n.d.	0.001	0.001	n.d.	n.d.	n.d.	n.d.	0.003	0.003	n.d.	n.d.	0.001	n.d.	0.002	0.001
Sr	0.014	0.005	0.030	0.016	0.028	0.013	0.024	0.009	0.020	0.008	0.001	0.008	0.009	0.009	0.015
Na	0.084	0.096	0.031	0.049	0.058	0.096	0.057	0.058	0.047	0.056	0.108	0.103	0.073	0.070	0.095
P	5.939	5.924	5.947	5.944	5.912	5.937	5.925	5.923	5.932	5.913	5.908	5.934	5.917	5.931	5.925
La	0.003	0.002	0.002	0.002	0.001	0.002	0.005	0.003	0.005	0.003	n.d.	0.001	0.002	0.000	0.004
Ce	0.012	0.008	0.013	0.011	0.012	0.009	0.013	0.010	0.012	0.011	0.006	0.006	0.008	0.011	0.010
Pr	n.d.	n.d.	n.d.	0.002	n.d.	0.001	n.d.	0.002	n.d.	0.005	n.d.	n.d.	0.000	0.003	n.d.
Nd	0.006	n.d.	0.008	0.004	0.005	0.008	0.006	0.005	0.007	0.006	0.002	0.004	0.004	n.d.	0.004
Sm	0.001	0.001	n.d.	n.d.	0.003	n.d.	n.d.	n.d.	0.000	n.d.	0.000	n.d.	0.001	n.d.	n.d.
Y	0.003	0.000	0.003	0.004	0.001	0.001	0.003	0.004	n.d.	0.001	n.d.	0.001	0.001	0.002	0.000
S	0.004	0.002	0.002	0.001	0.006	0.005	n.d.	0.002	0.002	0.006	0.007	0.010	0.005	0.004	n.d.
F	0.744	0.539	0.833	0.735	0.818	0.372	0.491	0.231	0.589	0.514	0.550	0.375	0.645	0.508	0.452
Cl	0.005	0.007	0.002	n.d.	0.005	0.004	0.003	0.004	0.003	0.003	0.008	0.008	0.004	0.007	0.001
TOTAL	16.867	16.706	16.921	16.831	16.959	16.502	16.639	16.364	16.707	16.649	16.728	16.508	16.794	16.636	16.612

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_APAT_IMG1_6	1223001_APAT_IMG1_7	1223001_APAT_IMG1_8	1223001_APAT_IMG1_9	1223001_APAT_IMG2_1	1223001_APAT_IMG2_2	1223001_APAT_ZIRC_1	1223001_APAT_ZIRC_2	1223001_APAT_ZIRC_3	1223001_APAT_ZIRC_4	1223001_APAT_ZIRC_5	1223001_APAT_ZIRC_6	1223001_APAT_ZIRC_7	1223001_APAT2GER_IMG5_1	1223001_APAT2GER_IMG5_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.03	n.d.	0.06	0.02	n.d.	n.d.	0.02	0.05	n.d.	0.00	0.01	0.00	n.d.	n.d.	0.00
Al2O3(Mass%)	0.01	n.d.	0.00	0.01	n.d.	0.01	0.00	n.d.	0.02	0.02	0.01	n.d.	0.01	n.d.	n.d.
FeO(Mass%)	0.03	0.04	0.11	0.04	0.06	0.13	0.08	0.08	0.07	0.07	0.03	0.05	0.04	0.07	0.05
MnO(Mass%)	0.01	0.01	0.05	0.01	0.03	0.05	0.01	0.04	0.03	n.d.	0.02	0.01	0.01	0.02	0.03
MgO(Mass%)	0.02	0.01	0.24	0.03	0.01	0.04	0.06	0.16	0.07	n.d.	0.09	n.d.	0.02	0.03	0.02
CaO(Mass%)	55.13	55.00	54.04	54.55	55.17	54.87	55.04	54.79	54.62	54.99	54.75	55.19	54.81	54.98	54.91
BaO(Mass%)	0.01	n.d.	n.d.	0.02	0.02	n.d.	n.d.	0.00	n.d.	n.d.	0.01	0.00	0.00	n.d.	n.d.
SrO(Mass%)	0.07	0.11	0.06	0.11	0.09	0.32	0.14	0.09	0.06	0.14	0.10	0.19	0.10	0.11	0.09
Na2O(Mass%)	0.19	0.16	0.41	0.28	0.17	0.21	0.17	0.31	0.22	0.15	0.23	0.12	0.15	0.19	0.21
P2O5(Mass%)	40.80	41.23	40.02	40.94	41.30	41.03	41.26	40.78	40.96	41.19	40.88	41.11	41.04	40.99	41.39
La2O3(Mass%)	0.03	0.04	0.02	0.06	0.01	0.07	n.d.	0.02	0.02	0.08	0.01	0.07	0.05	0.03	0.10
Ce2O3(Mass%)	0.22	0.16	0.07	0.18	0.14	0.12	0.14	0.12	0.17	0.14	0.14	0.26	0.22	0.15	0.22
Pr2O3(Mass%)	0.01	n.d.	n.d.	n.d.	0.05	0.03	n.d.	0.00	0.04	n.d.	n.d.	0.07	n.d.	0.03	n.d.
Nd2O3(Mass%)	0.02	0.05	n.d.	0.00	n.d.	0.03	0.03	0.01	0.09	0.14	0.09	0.02	0.03	0.06	0.08
Sm2O3(Mass%)	n.d.	n.d.	0.01	0.11	0.02	0.00	0.04	0.01	n.d.	0.02	n.d.	0.09	n.d.	0.07	0.04
LREE	0.27	0.25	0.11	0.35	0.22	0.26	0.22	0.16	0.32	0.37	0.24	0.51	0.30	0.34	0.44
Y2O3(Mass%)	0.03	n.d.	0.00	0.01	0.05	0.00	0.01	0.02	0.02	0.03	0.02	0.01	0.02	0.03	n.d.
SO3(Mass%)	0.02	0.01	0.02	0.03	0.03	n.d.	0.02	0.02	0.02	0.03	0.05	n.d.	0.01	0.01	0.02
F(Mass%)	0.60	0.08	0.45	0.45	0.76	0.49	1.08	0.62	1.07	1.26	1.23	1.13	0.45	1.51	0.80
Cl(Mass%)	0.01	0.01	0.04	0.02	0.01	0.00	0.02	0.03	0.03	0.01	0.02	0.00	0.02	0.02	0.01
TOTAL	97.23	96.90	95.62	96.88	97.93	97.39	98.14	97.17	97.51	98.26	97.68	98.34	96.98	98.29	97.97
F=O	-0.25	-0.03	-0.19	-0.19	-0.32	-0.21	-0.46	-0.26	-0.45	-0.53	-0.52	-0.48	-0.19	-0.63	-0.34
Cl=O	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
TOTAL	96.97	96.87	95.42	96.68	97.61	97.18	97.68	96.90	97.06	97.73	97.16	97.86	96.78	97.65	97.63

AMOSTRA	1223001_APAT_IMG1_6	1223001_APAT_IMG1_7	1223001_APAT_IMG1_8	1223001_APAT_IMG1_9	1223001_APAT_IMG2_1	1223001_APAT_IMG2_2	1223001_APAT_ZIRC_1	1223001_APAT_ZIRC_2	1223001_APAT_ZIRC_3	1223001_APAT_ZIRC_4	1223001_APAT_ZIRC_5	1223001_APAT_ZIRC_6	1223001_APAT_ZIRC_7	1223001_APAT2GER_IMG5_1	1223001_APAT2GER_IMG5_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.005	n.d.	0.011	0.004	n.d.	n.d.	0.004	0.009	n.d.	0.000	0.001	0.000	n.d.	n.d.	0.001
Al	0.003	n.d.	0.001	0.002	n.d.	0.001	n.d.	n.d.	0.005	0.003	0.002	n.d.	0.001	n.d.	n.d.
Fe	0.004	0.005	0.016	0.006	0.008	0.018	0.012	0.012	0.010	0.010	0.004	0.008	0.006	0.010	0.007
Mn	0.002	0.001	0.007	0.002	0.005	0.007	0.002	0.006	0.004	n.d.	0.003	0.002	0.001	0.002	0.005
Mg	0.005	0.003	0.062	0.008	0.003	0.010	0.015	0.041	0.018	n.d.	0.023	n.d.	0.004	0.008	0.006
Ca	10.114	10.054	10.070	10.019	10.049	10.041	10.035	10.054	10.027	10.043	10.056	10.077	10.053	10.075	10.004
Ba	0.001	n.d.	n.d.	0.002	0.001	n.d.	n.d.	0.000	n.d.	n.d.	0.001	n.d.	n.d.	n.d.	n.d.
Sr	0.007	0.011	0.006	0.011	0.009	0.031	0.014	0.009	0.006	0.013	0.010	0.019	0.010	0.011	0.009
Na	0.062	0.053	0.140	0.093	0.056	0.071	0.057	0.104	0.074	0.049	0.078	0.041	0.049	0.062	0.069
P	5.916	5.955	5.893	5.941	5.943	5.934	5.944	5.913	5.942	5.945	5.932	5.932	5.948	5.936	5.958
La	0.002	0.003	0.001	0.004	0.001	0.004	n.d.	0.001	0.001	0.005	0.001	0.004	0.003	0.002	0.006
Ce	0.014	0.010	0.005	0.011	0.009	0.008	0.009	0.008	0.011	0.009	0.009	0.016	0.014	0.009	0.014
Pr	0.001	n.d.	n.d.	n.d.	0.003	0.002	n.d.	n.d.	0.003	n.d.	n.d.	0.004	n.d.	0.002	n.d.
Nd	0.001	0.003	n.d.	0.000	n.d.	0.002	0.002	0.001	0.005	0.008	0.006	0.001	0.002	0.004	0.005
Sm	n.d.	n.d.	0.001	0.006	0.001	0.000	0.003	0.000	n.d.	0.001	n.d.	0.005	n.d.	0.004	0.002
Y	0.003	n.d.	0.000	0.001	0.005	n.d.	0.001	0.002	0.002	0.003	0.002	0.001	0.002	0.003	n.d.
S	0.002	0.002	0.003	0.004	0.004	n.d.	0.003	0.002	0.002	0.004	0.006	n.d.	0.001	0.002	0.002
F	0.322	0.044	0.247	0.242	0.401	0.263	0.570	0.334	0.567	0.662	0.650	0.594	0.243	0.789	0.421
Cl	0.003	0.004	0.010	0.005	0.004	0.001	0.007	0.008	0.009	0.003	0.007	0.001	0.005	0.005	0.003
TOTAL	16.464	16.147	16.472	16.361	16.502	16.393	16.676	16.504	16.686	16.758	16.788	16.706	16.343	16.924	16.510

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_APAT2GER_IMG5_3	1223001_APAT2GER_IMG5_4	1223001_APAT2GER_IMG5_5	1223001_APAT2GER_IMG5_6	1223001_APAT2GER_IMG5_7	1223001_APATFINABOXWORK_IMG4_1	1223001_APATFINABOXWORK_IMG4_2	1223001_APATFINABOXWORK_IMG4_3	1223001_APATFINABOXWORK_IMG4_4	1223001_C1_APAT1B_3	1223001_C1_APAT1B_4	1223001_C1_APAT1C_1	1223001_C1_APAT1C_2	1223001_C1_APAT2B_7	1223001_C1_APAT2B_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.01	0.01	0.13	0.01	0.01	0.01	0.02	0.03	n.d.	0.05	0.02	0.03	0.05	0.01	0.04
Al2O3(Mass%)	0.00	n.d.	0.47	0.02	0.01	0.05	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.02
FeO(Mass%)	0.02	0.05	0.07	0.03	0.01	0.05	0.03	0.03	0.01	0.09	0.12	0.03	0.02	0.11	0.24
MnO(Mass%)	0.01	0.02	0.02	0.01	0.04	0.02	0.02	0.06	0.03	0.04	0.02	0.02	0.01	0.02	0.06
MgO(Mass%)	0.05	0.04	0.07	n.d.	0.01	n.d.	0.00	0.16	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.71	54.58	53.67	54.82	54.48	54.89	54.92	54.67	54.98	54.52	54.00	53.98	54.60	54.25	53.77
BaO(Mass%)	0.02	n.d.	n.d.	0.01	0.05	0.01	0.02	n.d.	0.04	0.01	n.d.	0.02	n.d.	n.d.	0.02
SrO(Mass%)	0.11	0.03	0.06	0.03	0.20	0.21	0.20	0.08	0.18	0.24	0.25	0.20	0.22	0.31	0.22
Na2O(Mass%)	0.16	0.15	0.19	0.14	0.18	0.17	0.11	0.30	0.17	0.23	0.24	0.15	0.15	0.30	0.44
P2O5(Mass%)	40.78	40.90	40.25	40.44	40.84	41.22	41.11	40.96	41.85	40.92	40.51	40.91	40.79	41.01	40.43
La2O3(Mass%)	0.02	0.02	0.03	0.06	0.05	0.07	0.03	n.d.	0.03	0.03	0.02	n.d.	0.02	n.d.	0.04
Ce2O3(Mass%)	0.14	0.17	0.16	0.23	0.12	0.22	0.23	0.09	0.17	0.11	0.09	0.16	0.08	0.10	0.11
Pr2O3(Mass%)	n.d.	0.06	n.d.	0.03	0.02	n.d.	0.13	0.01	0.04	0.02	0.02	0.06	n.d.	n.d.	n.d.
Nd2O3(Mass%)	0.04	0.10	0.08	0.12	0.09	0.06	n.d.	n.d.	0.04	n.d.	n.d.	n.d.	n.d.	0.04	0.04
Sm2O3(Mass%)	n.d.	0.03	0.09	0.01	0.03	0.01	n.d.	0.02	n.d.	n.d.	0.07	0.03	n.d.	n.d.	n.d.
LREE	0.20	0.38	0.36	0.45	0.31	0.36	0.39	0.12	0.28	0.16	0.20	0.26	0.10	0.14	0.19
Y2O3(Mass%)	0.00	0.04	0.02	0.07	0.00	0.03	0.02	0.02	0.04	0.01	n.d.	0.01	n.d.	0.04	n.d.
SO3(Mass%)	0.00	0.09	0.04	0.01	0.01	0.01	0.01	0.05	0.03	n.d.	0.05	0.02	0.04	0.01	0.03
F(Mass%)	0.23	0.84	0.64	0.84	1.10	1.00	1.18	0.85	0.95	0.73	0.52	1.65	1.05	0.90	0.46
Cl(Mass%)	0.02	0.00	0.02	0.02	0.01	n.d.	0.01	0.03	0.01	0.02	n.d.	0.01	0.01	0.01	0.02
TOTAL	96.32	97.13	96.01	96.91	97.27	98.03	98.04	97.37	98.59	97.01	95.92	97.30	97.04	97.14	95.93
F=O	-0.10	-0.36	-0.27	-0.36	-0.46	-0.42	-0.50	-0.36	-0.40	-0.31	-0.22	-0.69	-0.44	-0.38	-0.19
Cl=O	0.00	0.00	0.00	0.00	0.00	n.d.	0.00	-0.01	0.00	0.00	n.d.	0.00	0.00	0.00	0.00
TOTAL	96.22	96.77	95.74	96.55	96.81	97.61	97.55	97.00	98.19	96.69	95.70	96.60	96.60	96.76	95.74

AMOSTRA	1223001_APAT2GER_IMG5_3	1223001_APAT2GER_IMG5_4	1223001_APAT2GER_IMG5_5	1223001_APAT2GER_IMG5_6	1223001_APAT2GER_IMG5_7	1223001_APATFINABOXWORK_IMG4_1	1223001_APATFINABOXWORK_IMG4_2	1223001_APATFINABOXWORK_IMG4_3	1223001_APATFINABOXWORK_IMG4_4	1223001_C1_APAT1B_3	1223001_C1_APAT1B_4	1223001_C1_APAT1C_1	1223001_C1_APAT1C_2	1223001_C1_APAT2B_7	1223001_C1_APAT2B_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.001	0.001	0.023	0.002	0.002	0.001	0.003	0.005	n.d.	0.008	0.004	0.005	0.009	0.003	0.006
Al	0.001	n.d.	0.096	0.005	0.002	0.010	n.d.	n.d.	0.002	n.d.	0.001	n.d.	0.001	0.001	0.004
Fe	0.003	0.007	0.011	0.005	0.001	0.007	0.004	0.004	0.001	0.013	0.017	0.005	0.003	0.016	0.034
Mn	0.001	0.002	0.003	0.002	0.006	0.003	0.003	0.008	0.004	0.006	0.003	0.004	0.001	0.003	0.009
Mg	0.012	0.011	0.017	n.d.	0.003	n.d.	0.000	0.042	0.003	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.080	10.031	9.950	10.133	10.033	10.022	10.051	10.022	9.947	10.044	10.027	9.987	10.075	9.982	9.989
Ba	0.001	n.d.	n.d.	0.000	0.004	0.000	0.001	n.d.	0.002	0.001	n.d.	0.001	n.d.	n.d.	0.001
Sr	0.011	0.003	0.006	0.003	0.020	0.021	0.020	0.008	0.017	0.024	0.025	0.020	0.022	0.031	0.022
Na	0.055	0.052	0.065	0.047	0.060	0.057	0.038	0.099	0.055	0.076	0.079	0.049	0.050	0.099	0.148
P	5.938	5.939	5.897	5.907	5.944	5.946	5.946	5.933	5.984	5.957	5.944	5.980	5.947	5.963	5.935
La	0.001	0.002	0.002	0.004	0.003	0.005	0.002	n.d.	0.002	0.002	0.001	n.d.	0.001	n.d.	0.002
Ce	0.009	0.011	0.010	0.014	0.008	0.014	0.014	0.006	0.011	0.007	0.006	0.010	0.005	0.006	0.007
Pr	n.d.	0.004	n.d.	0.002	0.001	n.d.	0.008	0.001	0.003	0.001	0.002	0.004	n.d.	n.d.	n.d.
Nd	0.002	0.006	0.005	0.008	0.006	0.004	n.d.	n.d.	0.002	n.d.	n.d.	n.d.	0.000	0.003	0.002
Sm	n.d.	0.002	0.005	0.000	0.002	0.000	n.d.	0.001	n.d.	n.d.	0.004	0.002	n.d.	n.d.	n.d.
Y	0.000	0.004	0.002	0.006	0.000	0.003	0.002	0.002	0.004	0.001	n.d.	0.001	n.d.	0.003	0.000
S	0.000	0.012	0.005	0.002	0.002	0.001	0.002	0.007	0.004	0.000	0.006	0.003	0.005	0.001	0.004
F	0.125	0.450	0.345	0.452	0.583	0.529	0.620	0.454	0.499	0.392	0.284	0.868	0.557	0.481	0.251
Cl	0.006	0.001	0.005	0.005	0.002	n.d.	0.003	0.008	0.003	0.005	0.002	0.003	0.003	0.003	0.005
TOTAL	16.247	16.535	16.448	16.597	16.682	16.623	16.716	16.599	16.543	16.535	16.404	16.942	16.679	16.596	16.421

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_C1_APAT 2C_5	1223001_C1_APAT 2C_6	1223001_C1_APAT 3B_3	1223001_C1_APAT 3B_4	1223001_C1_APAT 3C_1	1223001_C1_APAT 3C_2	1223001_C1_APAT 4 Line 001	1223001_C1_APAT 4 Line 002	1223001_C1_APAT 4 Line 003	1223001_C1_APAT 4 Line 004	1223001_C1_APAT 4 Line 005	1223001_C1_APAT 4 Line 006	1223001_C1_APAT 4 Line 007	1223001_C1_APAT 4 Line 008	1223001_C1_APAT 4 Line 009	1223001_C1_APAT 4 Line 010
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.02	0.01	0.07	0.04	0.08	0.09	0.05	0.03	0.03	0.03	0.05	0.03	0.02	0.04	n.d.	0.04
Al2O3(Mass%)	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	0.01
FeO(Mass%)	0.05	0.02	0.05	0.05	0.07	0.06	0.12	0.09	0.05	0.08	0.05	0.05	0.04	0.05	0.08	0.06
MnO(Mass%)	0.02	0.03	0.03	0.03	0.04	0.07	0.03	0.05	0.03	0.04	0.02	0.03	0.03	0.02	0.03	0.03
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	0.11	0.05	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.91	54.81	54.51	54.35	53.73	54.27	54.64	54.62	54.57	54.42	54.44	54.42	54.64	54.34	54.58	54.43
BaO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SrO(Mass%)	0.23	0.24	0.23	0.21	0.18	0.21	0.31	0.45	0.31	0.24	0.25	0.27	0.25	0.20	0.23	0.24
Na2O(Mass%)	0.23	0.14	0.20	0.20	0.35	0.33	0.19	0.16	0.15	0.23	0.24	0.26	0.22	0.27	0.23	0.13
P2O5(Mass%)	41.11	41.70	40.69	41.25	40.37	40.33	41.30	41.25	41.28	40.95	41.20	40.73	40.88	41.42	41.12	41.02
La2O3(Mass%)	0.05	0.03	0.02	0.07	0.06	0.01	0.02	0.08	0.03	0.04	0.04	0.05	0.01	0.06	n.d.	0.05
Ce2O3(Mass%)	0.16	0.21	0.16	0.14	0.10	0.10	0.18	0.19	0.14	0.10	0.08	0.14	0.14	0.13	0.14	0.17
Pr2O3(Mass%)	0.06	0.06	n.d.	0.03	n.d.	n.d.	0.03	n.d.	0.06	n.d.	0.06	n.d.	0.02	0.01	0.02	0.02
Nd2O3(Mass%)	0.03	0.01	0.07	0.02	0.06	n.d.	0.15	0.05	0.13	0.04	0.13	0.12	0.08	0.08	0.04	0.06
Sm2O3(Mass%)	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	0.07	0.11	n.d.	0.01	0.03	0.11	n.d.
LREE	0.30	0.32	0.26	0.26	0.22	0.11	0.38	0.32	0.40	0.25	0.41	0.30	0.27	0.32	0.30	0.30
Y2O3(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.05	0.02	0.04	n.d.	n.d.	0.01	0.03	n.d.	0.02	0.01
SO3(Mass%)	n.d.	n.d.	0.02	n.d.	0.05	0.04	0.03	n.d.	0.01	0.05	0.02	0.02	0.02	0.02	0.04	0.03
F(Mass%)	0.22	1.19	1.02	1.01	0.25	0.78	1.20	2.06	1.31	1.52	1.08	1.05	1.07	0.79	1.31	1.36
Cl(Mass%)	0.01	n.d.	0.02	0.02	0.04	0.04	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	0.01	0.02	0.01	n.d.
TOTAL	97.12	98.46	97.10	97.45	95.49	96.38	98.30	99.04	98.16	97.84	97.76	97.17	97.46	97.50	98.00	97.66
F=O	-0.09	-0.50	-0.43	-0.43	-0.10	-0.33	-0.51	-0.87	-0.55	-0.64	-0.46	-0.44	-0.45	-0.33	-0.55	-0.57
Cl=O	0.00	n.d.	0.00	0.00	-0.01	-0.01	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	0.00	0.00	0.00	n.d.
TOTAL	97.03	97.96	96.66	97.02	95.38	96.05	97.79	98.17	97.61	97.19	97.30	96.73	97.01	97.16	97.44	97.08

AMOSTRA	1223001_C1_APAT 2C_5	1223001_C1_APAT 2C_6	1223001_C1_APAT 3B_3	1223001_C1_APAT 3B_4	1223001_C1_APAT 3C_1	1223001_C1_APAT 3C_2	1223001_C1_APAT 4 Line 001	1223001_C1_APAT 4 Line 002	1223001_C1_APAT 4 Line 003	1223001_C1_APAT 4 Line 004	1223001_C1_APAT 4 Line 005	1223001_C1_APAT 4 Line 006	1223001_C1_APAT 4 Line 007	1223001_C1_APAT 4 Line 008	1223001_C1_APAT 4 Line 009	1223001_C1_APAT 4 Line 010
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.003	0.002	0.011	0.007	0.013	0.016	0.009	0.006	0.005	0.006	0.009	0.005	0.003	0.007	0.001	0.007
Al	n.d.	n.d.	0.004	0.000	n.d.	n.d.	0.002	0.001	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	0.006	0.003
Fe	0.008	0.004	0.007	0.007	0.010	0.008	0.018	0.013	0.007	0.012	0.007	0.008	0.005	0.007	0.012	0.008
Mn	0.004	0.004	0.004	0.005	0.006	0.011	0.004	0.007	0.004	0.005	0.004	0.004	0.004	0.004	0.005	0.004
Mg	n.d.	n.d.	n.d.	n.d.	0.030	0.014	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.059	9.980	10.069	9.977	9.994	10.065	9.976	9.991	9.986	10.008	9.974	10.047	10.051	9.940	10.002	10.019
Ba	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	0.000	0.000	n.d.	n.d.	0.000	n.d.	n.d.	0.001	n.d.
Sr	0.023	0.024	0.023	0.021	0.018	0.021	0.030	0.044	0.031	0.024	0.024	0.027	0.025	0.020	0.022	0.024
Na	0.076	0.046	0.068	0.067	0.118	0.111	0.061	0.054	0.050	0.076	0.078	0.086	0.073	0.090	0.077	0.042
P	5.952	6.000	5.939	5.984	5.933	5.911	5.958	5.962	5.969	5.951	5.965	5.941	5.942	5.988	5.954	5.967
La	0.003	0.002	0.002	0.005	0.004	0.001	0.002	0.005	0.002	0.003	0.002	0.003	0.001	0.004	n.d.	0.003
Ce	0.010	0.013	0.010	0.009	0.006	0.006	0.011	0.012	0.009	0.006	0.005	0.009	0.009	0.008	0.009	0.011
Pr	0.004	0.004	n.d.	0.002	n.d.	n.d.	0.002	n.d.	0.004	n.d.	0.004	n.d.	0.001	0.001	0.001	0.001
Nd	0.002	0.001	0.005	0.001	0.004	n.d.	0.009	0.003	0.008	0.003	0.008	0.007	0.005	0.005	0.003	0.004
Sm	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.002	0.004	0.006	n.d.	0.001	0.002	0.006	n.d.
Y	n.d.	n.d.	0.000	n.d.	n.d.	n.d.	0.005	0.002	0.004	0.001	0.001	0.001	0.003	n.d.	0.002	0.001
S	0.001	0.001	0.002	n.d.	0.007	0.006	0.004	0.001	0.001	0.006	0.003	0.003	0.003	0.003	0.006	0.003
F	0.116	0.622	0.542	0.537	0.136	0.422	0.631	1.065	0.687	0.798	0.573	0.561	0.566	0.422	0.691	0.720
Cl	0.003	n.d.	0.005	0.005	0.011	0.011	0.001	0.002	0.000	0.004	0.000	0.002	0.003	0.005	0.004	n.d.
TOTAL	16.263	16.703	16.690	16.627	16.289	16.601	16.722	17.169	16.769	16.908	16.662	16.703	16.694	16.505	16.800	16.817

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_C1_APAT 5 Line 001	1223001_C1_APAT 5 Line 002	1223001_C1_APAT 5 Line 003	1223001_C1_APAT 5 Line 004	1223001_C1_APAT 5 Line 005	1223001_C1_APAT 5 Line 006	1223001_C1_APAT 5 Line 007	1223001_C1_APAT 5 Line 008	1223001_C1_APAT 5 Line 009	1223001_C1_APAT 5 Line 010	1223001_C2_APAT 1 Line 12	1223001_C2_APAT 1 Line 13	1223001_C2_APAT 1 Line 14	1223001_C2_APAT 1 Line 15	1223001_C2_APAT 1 Line 16	1223001_C2_APAT 1 Line 17
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.03	0.03	0.02	0.04	0.02	0.05	0.02	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.02	0.02
Al2O3(Mass%)	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	0.02	0.02	n.d.	0.01	n.d.	n.d.
FeO(Mass%)	0.07	0.06	0.06	0.01	0.04	0.06	0.06	0.06	0.06	0.10	0.04	0.01	0.09	0.05	0.06	0.03
MnO(Mass%)	0.04	0.03	0.02	0.06	n.d.	0.01	0.03	0.02	0.02	0.03	0.04	0.02	0.03	0.04	0.01	0.05
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.43	54.73	54.69	54.40	54.52	54.67	54.48	54.34	54.51	54.77	54.23	54.63	54.73	54.22	55.01	54.66
BaO(Mass%)	n.d.	0.01	0.02	n.d.	n.d.	n.d.	n.d.	0.02	0.02	0.02	n.d.	n.d.	0.02	n.d.	0.03	n.d.
SrO(Mass%)	0.28	0.23	0.22	0.36	0.37	0.37	0.32	0.42	0.24	0.26	0.34	0.41	0.26	0.26	0.21	0.20
Na2O(Mass%)	0.20	0.18	0.22	0.17	0.18	0.15	0.11	0.18	0.22	0.16	0.17	0.17	0.29	0.33	0.18	0.19
P2O5(Mass%)	41.10	41.05	41.25	40.88	41.07	41.13	40.84	41.41	41.14	40.94	41.37	41.01	40.79	40.63	40.79	41.26
La2O3(Mass%)	0.03	0.02	n.d.	0.07	0.10	0.05	0.04	0.05	0.03	0.04	0.05	0.07	0.02	n.d.	0.07	0.05
Ce2O3(Mass%)	0.12	0.18	0.20	0.20	0.22	0.20	0.18	0.23	0.15	0.18	0.18	0.22	0.12	0.06	0.16	0.16
Pr2O3(Mass%)	0.02	n.d.	0.04	0.04	0.07	n.d.	0.07	0.04	0.04	0.03	0.05	0.02	0.02	n.d.	n.d.	n.d.
Nd2O3(Mass%)	0.05	0.10	0.02	0.13	0.21	0.05	0.12	0.13	0.18	0.13	0.08	0.05	0.05	n.d.	0.07	n.d.
Sm2O3(Mass%)	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	0.03	0.03	0.09	0.05	0.04	0.07	n.d.	0.03	0.05	0.03
LREE	0.22	0.30	0.26	0.44	0.63	0.30	0.44	0.48	0.50	0.42	0.40	0.43	0.21	0.09	0.35	0.24
Y2O3(Mass%)	0.03	0.02	n.d.	0.01	0.04	0.02	0.03	n.d.	n.d.	0.02	n.d.	0.01	0.03	0.03	0.03	n.d.
SO3(Mass%)	0.01	0.01	n.d.	0.03	n.d.	0.02	0.02	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	0.04
F(Mass%)	1.67	1.26	1.11	0.77	1.18	0.86	1.29	1.30	1.15	1.85	1.61	1.85	0.96	0.51	0.57	1.24
Cl(Mass%)	n.d.	0.02	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.01	n.d.	0.01	0.01	0.01	0.03	0.01
TOTAL	98.13	97.94	97.88	97.18	98.05	97.65	97.65	98.27	97.89	98.65	98.28	98.62	97.45	96.24	97.27	97.94
F=O	-0.70	-0.53	-0.47	-0.32	-0.50	-0.36	-0.54	-0.55	-0.48	-0.78	-0.68	-0.78	-0.40	-0.21	-0.24	-0.52
Cl=O	n.d.	0.00	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	0.00	n.d.	0.00	0.00	0.00	-0.01	0.00
TOTAL	97.42	97.40	97.41	96.85	97.55	97.28	97.11	97.72	97.40	97.87	97.61	97.84	97.04	96.02	97.03	97.42

AMOSTRA	1223001_C1_APAT 5 Line 001	1223001_C1_APAT 5 Line 002	1223001_C1_APAT 5 Line 003	1223001_C1_APAT 5 Line 004	1223001_C1_APAT 5 Line 005	1223001_C1_APAT 5 Line 006	1223001_C1_APAT 5 Line 007	1223001_C1_APAT 5 Line 008	1223001_C1_APAT 5 Line 009	1223001_C1_APAT 5 Line 010	1223001_C2_APAT 1 Line 12	1223001_C2_APAT 1 Line 13	1223001_C2_APAT 1 Line 14	1223001_C2_APAT 1 Line 15	1223001_C2_APAT 1 Line 16	1223001_C2_APAT 1 Line 17
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.006	0.005	0.004	0.007	0.003	0.009	0.004	0.008	0.008	0.008	0.008	0.007	0.006	0.006	0.003	0.004
Al	0.002	n.d.	0.002	n.d.	0.000	n.d.	0.002	n.d.	0.002	0.006	0.003	0.004	n.d.	0.002	n.d.	n.d.
Fe	0.011	0.008	0.008	0.002	0.006	0.008	0.008	0.008	0.008	0.014	0.006	0.002	0.012	0.007	0.008	0.004
Mn	0.006	0.004	0.003	0.009	0.001	0.001	0.004	0.003	0.002	0.005	0.006	0.004	0.004	0.007	0.002	0.008
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	9.995	10.043	10.007	10.018	10.004	10.016	10.038	9.938	9.992	10.052	9.932	10.030	10.069	10.032	10.112	10.005
Ba	n.d.	0.001	0.001	n.d.	n.d.	0.000	n.d.	0.001	0.001	0.001	n.d.	n.d.	0.001	n.d.	0.002	n.d.
Sr	0.027	0.023	0.022	0.036	0.036	0.037	0.032	0.042	0.024	0.026	0.034	0.041	0.026	0.026	0.021	0.020
Na	0.066	0.061	0.073	0.056	0.061	0.049	0.038	0.061	0.072	0.054	0.056	0.057	0.097	0.109	0.059	0.062
P	5.965	5.952	5.965	5.949	5.954	5.955	5.947	5.984	5.959	5.938	5.987	5.948	5.929	5.940	5.924	5.968
La	0.002	0.001	n.d.	0.005	0.006	0.003	0.003	0.003	0.002	0.002	0.003	0.005	0.001	n.d.	0.005	0.003
Ce	0.008	0.011	0.013	0.013	0.014	0.013	0.011	0.015	0.010	0.011	0.011	0.014	0.008	0.004	0.010	0.010
Pr	0.002	n.d.	0.002	0.002	0.004	0.001	0.004	0.003	0.002	0.002	0.003	0.002	0.001	n.d.	n.d.	n.d.
Nd	0.003	0.006	0.001	0.008	0.013	0.003	0.008	0.008	0.011	0.008	0.005	0.003	0.003	0.001	0.004	n.d.
Sm	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	0.002	0.002	0.006	0.003	0.002	0.004	n.d.	0.002	0.003	0.002
Y	0.002	0.001	0.000	0.001	0.004	0.002	0.003	0.000	n.d.	0.002	0.000	0.001	0.003	0.003	0.002	n.d.
S	0.002	0.002	0.000	0.003	n.d.	0.002	0.003	n.d.	0.001	n.d.	0.003	0.001	0.001	0.000	0.001	0.005
F	0.872	0.667	0.583	0.410	0.623	0.457	0.681	0.681	0.606	0.965	0.839	0.962	0.511	0.275	0.305	0.654
Cl	0.001	0.005	0.003	0.002	0.001	n.d.	n.d.	0.001	0.003	0.004	0.000	0.003	0.003	0.003	0.008	0.003
TOTAL	16.970	16.790	16.688	16.521	16.732	16.556	16.788	16.756	16.708	17.098	16.898	17.086	16.675	16.417	16.467	16.746

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_C2_APAT 1 Line 18	1223001_C3_APAT 1 LINE 1	1223001_C3_APAT 1 LINE 2	1223001_C3_APAT 1 LINE 3	1223001_C3_APAT 1 LINE 4	1223001_C3_APAT 2_1	1223001_C3_APAT 2_2	1223001_C3_APAT 4_1	1223001_C3_APAT 4_2	1223001_C3_APAT 5_1	1223001_C3_APAT 5_2	1223001_C3_APAT 7_1	1223001_C3_APAT 7_2	1223001_C4_APAT 1_1	1223001_C4_APAT 1_2	1223001_C4_APAT 1_3	1223001_C4_APAT 1_4
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.04	0.04	0.02	0.04	0.05	0.05	0.04	0.03	0.03	0.17	0.10	0.06	0.04	0.04	0.01	0.01	0.07
Al2O3(Mass%)	n.d.	n.d.	0.01	0.10	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	0.01	0.01	n.d.	n.d.	n.d.
FeO(Mass%)	0.01	0.04	0.05	0.04	0.02	0.03	0.03	0.13	0.06	0.04	0.07	0.09	0.07	0.06	0.04	0.01	0.03
MnO(Mass%)	n.d.	0.02	0.02	0.03	n.d.	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.03
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.43	54.57	54.65	54.18	54.44	54.79	54.49	54.27	54.52	54.00	53.92	53.49	53.58	54.15	54.94	54.33	54.70
BaO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.02	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.
SrO(Mass%)	0.21	0.23	0.25	0.24	0.36	0.35	0.36	0.36	0.33	0.37	0.33	0.24	0.23	0.41	0.33	0.40	0.38
Na2O(Mass%)	0.18	0.25	0.24	0.23	0.11	0.18	0.15	0.25	0.14	0.18	0.18	0.28	0.28	0.27	0.18	0.16	0.12
P2O5(Mass%)	41.14	40.86	40.42	41.02	41.24	40.91	41.43	41.11	40.91	40.62	40.69	40.33	40.56	41.36	41.60	41.29	41.11
La2O3(Mass%)	0.07	n.d.	0.05	0.04	0.04	0.02	0.07	0.02	n.d.	0.04	0.02	0.02	0.04	0.04	0.03	0.07	0.02
Ce2O3(Mass%)	0.19	0.11	0.14	0.18	0.15	0.16	0.19	0.11	0.17	0.21	0.14	0.18	0.15	0.13	0.18	0.15	0.13
Pr2O3(Mass%)	n.d.	0.07	0.01	0.05	n.d.	0.04	n.d.	n.d.	n.d.	0.01	0.02	n.d.	n.d.	0.11	n.d.	n.d.	n.d.
Nd2O3(Mass%)	n.d.	0.04	0.03	0.15	0.05	0.10	0.04	0.08	0.04	0.11	0.09	n.d.	n.d.	0.02	0.11	0.05	0.03
Sm2O3(Mass%)	0.09	0.02	0.03	n.d.	0.04	0.05	0.03	0.03	n.d.	n.d.	0.07	n.d.	n.d.	0.05	0.06	0.03	n.d.
LREE	0.35	0.24	0.26	0.43	0.28	0.37	0.32	0.25	0.21	0.36	0.33	0.20	0.19	0.36	0.37	0.30	0.18
Y2O3(Mass%)	n.d.	0.02	0.02	0.01	n.d.	n.d.	0.04	n.d.	0.03	n.d.	n.d.	0.03	0.05	n.d.	n.d.	n.d.	n.d.
SO3(Mass%)	n.d.	0.02	0.17	0.01	0.01	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	0.05	n.d.	n.d.
F(Mass%)	1.19	0.82	1.18	1.04	0.97	0.72	1.62	0.66	1.39	0.79	1.43	1.17	0.58	1.32	1.32	1.38	1.55
Cl(Mass%)	0.01	n.d.	n.d.	0.02	0.01	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	0.02	0.02	0.01	n.d.	n.d.	n.d.
TOTAL	97.56	97.12	97.32	97.39	97.50	97.41	98.53	97.12	97.69	96.56	97.08	95.98	95.63	98.04	98.90	97.91	98.18
F=O	-0.50	-0.35	-0.50	-0.44	-0.41	-0.30	-0.68	-0.28	-0.59	-0.33	-0.60	-0.49	-0.24	-0.55	-0.56	-0.58	-0.65
Cl=O	0.00	n.d.	n.d.	0.00	0.00	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	0.00	0.00	0.00	n.d.	n.d.	n.d.
TOTAL	97.06	96.77	96.82	96.95	97.08	97.11	97.85	96.84	97.10	96.23	96.47	95.48	95.38	97.48	98.34	97.33	97.53

AMOSTRA	1223001_C2_APAT 1 Line 18	1223001_C3_APAT 1 LINE 1	1223001_C3_APAT 1 LINE 2	1223001_C3_APAT 1 LINE 3	1223001_C3_APAT 1 LINE 4	1223001_C3_APAT 2_1	1223001_C3_APAT 2_2	1223001_C3_APAT 4_1	1223001_C3_APAT 4_2	1223001_C3_APAT 5_1	1223001_C3_APAT 5_2	1223001_C3_APAT 7_1	1223001_C3_APAT 7_2	1223001_C4_APAT 1_1	1223001_C4_APAT 1_2	1223001_C4_APAT 1_3	1223001_C4_APAT 1_4
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.008	0.007	0.004	0.008	0.008	0.008	0.007	0.006	0.005	0.029	0.017	0.011	0.007	0.007	0.002	0.002	0.012
Al	0.001	n.d.	0.002	0.020	0.000	n.d.	n.d.	n.d.	0.004	n.d.	0.002	n.d.	0.003	0.003	n.d.	n.d.	n.d.
Fe	0.002	0.006	0.007	0.006	0.004	0.005	0.005	0.018	0.008	0.005	0.010	0.012	0.010	0.009	0.006	0.001	0.005
Mn	0.000	0.004	0.003	0.004	0.001	0.002	0.003	0.004	0.005	0.005	0.004	0.006	0.004	0.005	0.005	0.006	0.004
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	9.999	10.050	10.097	9.961	9.991	10.071	9.960	9.972	10.047	10.004	9.990	9.993	9.974	9.926	9.989	10.000	10.056
Ba	n.d.	n.d.	n.d.	n.d.	n.d.	0.000	0.001	0.001	0.000	n.d.	n.d.	0.001	n.d.	0.001	0.000	n.d.	n.d.
Sr	0.021	0.023	0.025	0.024	0.036	0.035	0.036	0.035	0.033	0.037	0.033	0.024	0.023	0.041	0.033	0.040	0.038
Na	0.059	0.084	0.080	0.076	0.036	0.060	0.050	0.084	0.048	0.059	0.062	0.094	0.093	0.090	0.061	0.052	0.041
P	5.973	5.946	5.902	5.961	5.980	5.942	5.983	5.968	5.957	5.946	5.958	5.953	5.965	5.991	5.977	6.005	5.972
La	0.004	n.d.	0.003	0.002	0.003	0.001	0.005	0.001	n.d.	0.002	0.001	0.001	0.002	0.003	0.002	0.005	0.001
Ce	0.012	0.007	0.009	0.012	0.010	0.010	0.012	0.007	0.011	0.013	0.009	0.012	0.010	0.008	0.011	0.009	0.009
Pr	n.d.	0.005	0.001	0.003	n.d.	0.003	n.d.	n.d.	n.d.	0.001	0.001	0.000	n.d.	0.007	n.d.	n.d.	n.d.
Nd	n.d.	0.003	0.002	0.010	0.003	0.006	0.002	0.005	0.002	0.007	0.006	0.000	n.d.	0.001	0.007	0.003	0.002
Sm	0.005	0.001	0.002	n.d.	0.002	0.003	0.002	0.002	n.d.	n.d.	0.004	n.d.	n.d.	0.003	0.003	0.002	n.d.
Y	n.d.	0.001	0.001	0.001	0.000	0.001	0.004	n.d.	0.003	0.001	0.001	0.003	0.004	n.d.	n.d.	n.d.	n.d.
S	0.000	0.002	0.022	0.002	0.002	0.001	n.d.	0.002	n.d.	n.d.	0.001	0.002	0.001	n.d.	0.006	n.d.	n.d.
F	0.629	0.440	0.629	0.552	0.517	0.383	0.843	0.352	0.735	0.422	0.759	0.629	0.313	0.693	0.689	0.730	0.816
Cl	0.003	0.002	0.000	0.006	0.003	0.002	0.003	0.003	n.d.	n.d.	n.d.	0.004	0.006	0.004	0.002	0.002	0.000
TOTAL	16.716	16.579	16.789	16.647	16.594	16.533	16.914	16.460	16.858	16.531	16.856	16.746	16.415	16.792	16.792	16.856	16.956

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_C4_APAT 1_5	1223001_C4_APAT 3_1	1223001_C4_APAT 3_2	1223001_C4_APAT 4B_1	1223001_C4_APAT 4B_4	1223001_C4_APAT 4C_2	1223001_C4_APAT 4C_3	1223001_C5_APAT 1_1	1223001_C5_APAT 1_10	1223001_C5_APAT 1_2	1223001_C5_APAT 1_3	1223001_C5_APAT 1_8	1223001_C5_APAT 1_9	1223001_C5_APAT 2_1	1223001_C5_APAT 2_2	1223001_C5_APAT 2_3	1223001_C5_APAT 2_4	1223001_APAT2GER_IMG5_10
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.02	0.04	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.04	0.06	0.03	0.05	0.05	0.07	0.02	0.06
Al2O3(Mass%)	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	0.04
FeO(Mass%)	0.06	0.12	0.10	0.07	0.06	0.05	0.04	0.12	0.12	0.06	0.05	0.15	0.24	0.06	0.06	0.10	0.14	1.65
MnO(Mass%)	0.03	0.07	0.03	0.02	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.02
MgO(Mass%)	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.31
CaO(Mass%)	54.83	53.66	54.44	54.95	54.89	54.64	54.91	54.30	54.63	54.40	54.72	54.21	54.08	54.78	54.78	54.44	54.49	53.00
BaO(Mass%)	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	0.03	n.d.	n.d.	0.02	0.01	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.
SrO(Mass%)	0.36	0.37	0.34	0.36	0.40	0.36	0.37	0.36	0.38	0.34	0.25	0.22	0.35	0.38	0.38	0.27	0.25	0.59
Na2O(Mass%)	0.17	0.44	0.18	0.17	0.16	0.17	0.16	0.26	0.10	0.27	0.14	0.19	0.24	0.12	0.15	0.26	0.28	0.04
P2O5(Mass%)	41.21	40.72	41.42	41.29	40.91	41.02	41.13	40.79	41.01	40.64	41.52	40.70	40.36	40.97	41.15	40.89	40.70	39.22
La2O3(Mass%)	n.d.	n.d.	0.06	0.02	0.04	0.02	0.03	0.04	0.05	0.01	0.05	0.06	0.03	0.03	0.02	n.d.	0.05	0.02
Ce2O3(Mass%)	0.20	0.17	0.19	0.17	0.16	0.17	0.13	0.15	0.17	0.11	0.20	0.14	0.14	0.15	0.15	0.11	0.09	0.08
Pr2O3(Mass%)	n.d.	0.09	0.03	n.d.	n.d.	0.03	n.d.	0.04	0.08	0.08	n.d.	0.04	n.d.	n.d.	0.06	0.09	n.d.	n.d.
Nd2O3(Mass%)	0.14	0.06	0.07	0.14	0.04	0.03	0.12	0.14	0.03	0.07	0.06	0.04	0.02	0.04	0.01	0.12	0.11	n.d.
Sm2O3(Mass%)	n.d.	n.d.	0.07	0.04	n.d.	0.04	0.01	n.d.	0.03	n.d.	0.05	0.09	0.05	0.07	0.04	n.d.	n.d.	n.d.
LREE	0.34	0.32	0.42	0.37	0.23	0.29	0.29	0.37	0.35	0.28	0.35	0.37	0.23	0.29	0.29	0.31	0.25	0.10
Y2O3(Mass%)	n.d.	0.01	n.d.	0.03	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	0.03	n.d.	0.03	0.02	0.02	n.d.	0.03
SO3(Mass%)	0.01	n.d.	0.02	n.d.	0.02	0.01	n.d.	0.05	0.03	0.04	n.d.	0.03	n.d.	0.04	n.d.	n.d.	n.d.	0.01
F(Mass%)	1.21	1.44	1.05	1.36	1.31	1.60	1.27	1.33	1.61	1.01	0.66	1.41	1.14	1.05	1.17	0.77	1.25	3.32
Cl(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	0.01	0.01	0.01	0.01	n.d.	n.d.	0.02	0.01	n.d.
TOTAL	98.23	97.20	98.06	98.65	98.05	98.21	98.25	97.65	98.27	97.10	97.76	97.39	96.74	97.80	98.06	97.19	97.39	98.39
F=O	-0.51	-0.61	-0.44	-0.57	-0.55	-0.68	-0.53	-0.56	-0.68	-0.43	-0.28	-0.59	-0.48	-0.44	-0.49	-0.32	-0.52	-1.40
Cl=O	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	0.00	0.00	0.00	0.00	n.d.	n.d.	0.00	0.00	n.d.
TOTAL	97.72	96.59	97.62	98.07	97.50	97.53	97.72	97.08	97.59	96.67	97.48	96.79	96.26	97.35	97.57	96.86	96.87	96.99

AMOSTRA	1223001_C4_APAT 1_5	1223001_C4_APAT 3_1	1223001_C4_APAT 3_2	1223001_C4_APAT 4B_1	1223001_C4_APAT 4B_4	1223001_C4_APAT 4C_2	1223001_C4_APAT 4C_3	1223001_C5_APAT 1_1	1223001_C5_APAT 1_10	1223001_C5_APAT 1_2	1223001_C5_APAT 1_3	1223001_C5_APAT 1_8	1223001_C5_APAT 1_9	1223001_C5_APAT 2_1	1223001_C5_APAT 2_2	1223001_C5_APAT 2_3	1223001_C5_APAT 2_4	1223001_APAT2GER_IMG5_10
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.003	0.006	0.008	0.007	0.005	0.004	0.004	0.003	0.003	0.004	0.006	0.010	0.006	0.008	0.008	0.012	0.003	0.010
Al	0.001	0.002	n.d.	n.d.	0.004	0.002	n.d.	0.002	0.000	n.d.	n.d.	n.d.	0.001	n.d.	0.001	0.003	0.001	0.008
Fe	0.009	0.017	0.015	0.010	0.008	0.008	0.006	0.017	0.017	0.009	0.007	0.021	0.035	0.009	0.008	0.015	0.020	0.243
Mn	0.005	0.011	0.004	0.003	0.004	0.005	0.003	0.005	0.003	0.004	0.003	0.004	0.004	0.005	0.004	0.003	0.003	0.003
Mg	n.d.	0.003	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.082
Ca	10.048	9.929	9.947	10.026	10.077	10.034	10.052	10.014	10.036	10.063	9.990	10.016	10.057	10.057	10.038	10.016	10.057	9.977
Ba	n.d.	n.d.	0.001	n.d.	n.d.	n.d.	0.002	n.d.	n.d.	0.001	0.001	n.d.	0.001	n.d.	0.001	n.d.	n.d.	n.d.
Sr	0.036	0.037	0.033	0.035	0.040	0.036	0.036	0.036	0.038	0.034	0.025	0.022	0.035	0.037	0.038	0.027	0.025	0.060
Na	0.056	0.146	0.061	0.055	0.052	0.057	0.053	0.088	0.034	0.089	0.047	0.065	0.080	0.040	0.049	0.087	0.092	0.014
P	5.967	5.954	5.980	5.953	5.934	5.952	5.949	5.944	5.954	5.939	5.989	5.942	5.929	5.944	5.958	5.946	5.935	5.834
La	n.d.	0.000	0.004	0.001	0.003	0.001	0.002	0.002	0.003	0.001	0.003	0.004	0.002	0.002	0.001	0.001	0.003	0.001
Ce	0.013	0.011	0.012	0.011	0.010	0.011	0.008	0.009	0.010	0.007	0.012	0.009	0.009	0.010	0.010	0.007	0.006	0.005
Pr	n.d.	0.006	0.002	n.d.	n.d.	0.002	n.d.	0.003	0.005	0.005	n.d.	0.002	0.000	n.d.	0.004	0.005	n.d.	n.d.
Nd	0.008	0.004	0.004	0.009	0.002	0.002	0.007	0.009	0.002	0.005	0.004	0.002	0.001	0.003	0.001	0.007	0.007	n.d.
Sm	n.d.	n.d.	0.004	0.002	n.d.	0.002	0.001	n.d.	0.002	n.d.	0.003	0.005	0.003	0.004	0.003	n.d.	n.d.	n.d.
Y	n.d.	0.001	n.d.	0.003	0.001	n.d.	0.002	n.d.	n.d.	n.d.	n.d.	0.002	n.d.	0.002	0.002	0.002	n.d.	0.003
S	0.001	0.001	0.003	n.d.	0.003	0.002	n.d.	0.007	0.003	0.005	n.d.	0.004	n.d.	0.005	n.d.	n.d.	n.d.	0.001
F	0.638	0.765	0.556	0.713	0.691	0.840	0.666	0.702	0.843	0.539	0.350	0.744	0.610	0.556	0.615	0.412	0.660	1.719
Cl	0.001	0.001	0.001	0.002	n.d.	0.000	0.001	0.003	n.d.	0.003	0.003	0.004	0.003	0.001	0.000	0.005	0.003	n.d.
TOTAL	16.784	16.893	16.635	16.829	16.832	16.957	16.790	16.842	16.952	16.707	16.443	16.856	16.776	16.682	16.739	16.547	16.815	17.961

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_APAT2GER_IMG5_11	1223001_APAT2GER_IMG5_12	1223001_APAT2GER_IMG5_13	1223001_APAT2GER_IMG5_8	1223001_APAT2GER_IMG5_9	1223001_APATBANDALT_IMG3_1	1223001_APATBANDALT_IMG3_2	1223001_APATBANDALT_IMG3_3	1223001_APATBANDALT_IMG3_4	1223001_APATBANDALT_IMG3_5	1223001_APATBANDALT_IMG3_6	1223001_APATFINABOXWORK_IMG4_10	1223001_APATFINABOXWORK_IMG4_5	1223001_APATFINABOXWORK_IMG4_6	1223001_APATFINABOXWORK_IMG4_7	1223001_APATFINABOXWORK_IMG4_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.01	n.d.	n.d.	n.d.	0.16	n.d.	0.00	n.d.	0.00	0.01	0.08	n.d.	n.d.	n.d.	n.d.	n.d.
Al2O3(Mass%)	0.25	0.03	n.d.	0.04	0.09	0.07	0.34	n.d.	0.11	0.01	0.05	0.02	0.17	0.46	0.04	0.03
FeO(Mass%)	0.04	0.04	0.07	n.d.	0.16	0.09	0.11	0.15	0.16	0.10	1.58	0.02	0.04	0.03	0.02	0.04
MnO(Mass%)	0.00	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	0.01	0.02	0.01	n.d.	0.00
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	0.01	n.d.	n.d.	0.01	0.00	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.82	54.18	54.41	54.23	53.28	54.37	54.21	54.43	53.92	54.62	53.53	54.00	54.10	53.35	55.12	54.57
BaO(Mass%)	n.d.	0.03	0.01	0.01	0.01	n.d.	n.d.	n.d.	0.02	0.01	0.02	0.01	0.01	0.04	n.d.	n.d.
SrO(Mass%)	0.44	1.47	1.61	1.11	0.94	0.81	0.64	0.82	1.18	0.81	1.03	1.78	1.53	1.97	0.70	0.59
Na2O(Mass%)	0.04	0.04	0.07	0.03	0.07	0.19	0.30	0.20	0.18	0.20	0.14	0.07	0.10	0.07	0.05	0.11
P2O5(Mass%)	40.96	40.31	40.13	40.41	39.86	40.27	39.92	40.31	39.92	40.18	39.54	40.14	40.30	39.60	41.06	40.68
La2O3(Mass%)	n.d.	0.01	n.d.	0.02	0.02	0.01	0.01	0.03	0.02	n.d.	0.00	n.d.	0.03	0.03	0.01	0.03
Ce2O3(Mass%)	0.06	0.07	0.06	0.03	0.05	0.09	0.10	0.08	0.13	0.09	0.06	0.10	0.09	0.14	0.10	0.13
Pr2O3(Mass%)	n.d.	n.d.	0.04	n.d.	0.00	n.d.	n.d.	n.d.	0.05	0.00	n.d.	n.d.	n.d.	n.d.	0.04	n.d.
Nd2O3(Mass%)	0.01	n.d.	n.d.	n.d.	n.d.	0.08	0.07	n.d.	0.03	n.d.	n.d.	0.07	0.02	0.03	0.08	0.07
Sm2O3(Mass%)	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	0.08	0.05	0.04
LREE	0.07	0.10	0.10	0.05	0.07	0.18	0.17	0.10	0.24	0.10	0.07	0.18	0.13	0.28	0.27	0.27
Y2O3(Mass%)	0.01	0.00	n.d.	0.02	0.00	0.06	0.08	0.08	0.05	0.09	0.10	n.d.	0.05	0.05	0.07	0.03
SO3(Mass%)	0.02	0.00	0.03	0.04	0.04	0.02	0.05	0.05	0.03	0.02	0.06	0.03	n.d.	0.03	0.03	0.03
F(Mass%)	3.31	4.13	3.57	4.14	3.30	3.82	3.33	3.01	3.11	3.18	3.49	3.82	3.79	4.10	3.68	3.49
Cl(Mass%)	0.00	n.d.	0.00	0.00	n.d.	n.d.	n.d.	0.00	n.d.	0.00	0.01	n.d.	n.d.	0.00	0.00	0.01
TOTAL	99.97	100.34	100.00	100.09	98.01	99.87	99.18	99.15	98.92	99.35	99.67	100.09	100.24	99.97	101.04	99.83
F=O	-1.39	-1.74	-1.50	-1.74	-1.39	-1.61	-1.40	-1.27	-1.31	-1.34	-1.47	-1.61	-1.59	-1.73	-1.55	-1.47
Cl=O	0.00	n.d.	0.00	0.00	n.d.	n.d.	n.d.	0.00	n.d.	0.00	0.00	n.d.	n.d.	0.00	0.00	0.00
TOTAL	98.58	98.60	98.50	98.34	96.62	98.26	97.77	97.89	97.60	98.02	98.20	98.49	98.64	98.25	99.49	98.36

AMOSTRA	1223001_APAT2GER_IMG5_11	1223001_APAT2GER_IMG5_12	1223001_APAT2GER_IMG5_13	1223001_APAT2GER_IMG5_8	1223001_APAT2GER_IMG5_9	1223001_APATBANDALT_IMG3_1	1223001_APATBANDALT_IMG3_2	1223001_APATBANDALT_IMG3_3	1223001_APATBANDALT_IMG3_4	1223001_APATBANDALT_IMG3_5	1223001_APATBANDALT_IMG3_6	1223001_APATFINABOXWORK_IMG4_10	1223001_APATFINABOXWORK_IMG4_5	1223001_APATFINABOXWORK_IMG4_6	1223001_APATFINABOXWORK_IMG4_7	1223001_APATFINABOXWORK_IMG4_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.002	n.d.	n.d.	n.d.	0.029	n.d.	0.001	n.d.	0.001	0.002	0.014	n.d.	n.d.	n.d.	n.d.	n.d.
Al	0.050	0.006	n.d.	0.009	0.019	0.014	0.069	n.d.	0.022	0.003	0.009	0.004	0.035	0.094	0.008	0.006
Fe	0.006	0.006	0.010	n.d.	0.023	0.013	0.016	0.022	0.023	0.014	0.230	0.003	0.006	0.004	0.003	0.005
Mn	0.000	n.d.	n.d.	n.d.	0.002	n.d.	n.d.	0.002	n.d.	n.d.	n.d.	0.002	0.003	0.001	n.d.	n.d.
Mg	n.d.	n.d.	n.d.	n.d.	0.002	n.d.	0.002	n.d.	n.d.	0.003	0.001	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.041	10.057	10.107	10.058	9.994	10.085	10.072	10.086	10.053	10.127	9.991	10.040	10.025	9.977	10.067	10.062
Ba	n.d.	0.002	0.001	0.001	0.001	n.d.	n.d.	n.d.	0.001	0.001	0.001	0.001	0.001	0.003	n.d.	n.d.
Sr	0.043	0.148	0.162	0.112	0.095	0.081	0.065	0.082	0.119	0.082	0.104	0.180	0.154	0.199	0.070	0.059
Na	0.012	0.015	0.024	0.010	0.022	0.065	0.101	0.068	0.061	0.068	0.046	0.022	0.035	0.024	0.018	0.036
P	5.929	5.913	5.891	5.922	5.908	5.902	5.861	5.903	5.881	5.887	5.831	5.898	5.901	5.852	5.926	5.927
La	n.d.	0.001	n.d.	0.001	0.001	0.000	0.001	0.002	0.002	n.d.	0.000	n.d.	0.002	0.002	0.001	0.002
Ce	0.004	0.004	0.004	0.002	0.003	0.006	0.006	0.005	0.008	0.006	0.004	0.006	0.006	0.009	0.006	0.008
Pr	n.d.	n.d.	0.003	n.d.	n.d.	n.d.	n.d.	n.d.	0.003	0.000	n.d.	n.d.	n.d.	n.d.	0.002	n.d.
Nd	0.001	n.d.	n.d.	n.d.	n.d.	0.005	0.004	n.d.	0.002	n.d.	n.d.	0.004	0.001	0.002	0.005	0.004
Sm	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	0.005	0.003	0.002
Y	0.001	0.000	n.d.	0.002	0.000	0.006	0.008	0.007	0.004	0.008	0.009	n.d.	0.005	0.005	0.007	0.003
S	0.003	0.000	0.005	0.005	0.006	0.002	0.007	0.006	0.005	0.003	0.008	0.005	n.d.	0.004	0.004	0.003
F	1.670	2.073	1.814	2.080	1.704	1.930	1.701	1.544	1.604	1.625	1.783	1.932	1.913	2.075	1.838	1.766
Cl	0.001	n.d.	0.001	0.001	n.d.	n.d.	n.d.	0.001	n.d.	0.000	0.002	n.d.	n.d.	0.000	0.001	0.002
TOTAL	17.762	18.226	18.019	18.202	17.808	18.109	17.913	17.727	17.789	17.829	18.033	18.098	18.084	18.254	17.956	17.885

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_APATFIN ABOXWORK_IMG4 _9	1223001_C2_APAT 1 Line 1	1223001_C2_APAT 1 Line 10	1223001_C2_APAT 1 Line 11	1223001_C2_APAT 1 Line 2	1223001_C2_APAT 1 Line 3	1223001_C2_APAT 1 Line 4	1223001_C2_APAT 1 Line 5	1223001_C2_APAT 1 Line 6	1223001_C2_APAT 1 Line 7	1223001_C2_APAT 1 Line 8	1223001_C2_APAT 1 Line 9	1223001_C2_APAT 2_1	1223001_C2_APAT 2_2	1223001_C2_APAT 2_3	1223001_C2_APAT 2_4	1223001_C2_APAT 2_5
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	n.d.	0.05	0.06	0.06	0.03	0.04	0.05	0.25	0.05	0.08	0.05	0.05	0.04	0.04	0.04	0.05	0.05
Al2O3(Mass%)	0.01	n.d.	1.03	1.43	0.04	0.20	0.03	1.17	0.05	0.32	n.d.	0.02	0.04	n.d.	n.d.	0.03	0.07
FeO(Mass%)	0.05	0.13	0.08	0.03	0.11	0.04	0.09	1.65	0.02	0.10	0.05	0.08	0.23	0.24	0.21	0.21	0.19
MnO(Mass%)	0.00	0.02	0.01	0.05	0.02	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	0.01	0.03	0.02	n.d.	0.04
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.27	54.34	53.05	53.23	53.48	53.73	53.73	52.40	53.89	53.23	53.99	53.59	53.89	54.08	54.15	53.81	54.15
BaO(Mass%)	n.d.	0.03	0.01	n.d.	n.d.	0.04	n.d.	n.d.	0.04	0.02	0.01	n.d.	n.d.	0.04	0.05	0.03	n.d.
SrO(Mass%)	1.98	1.25	1.55	1.38	1.53	1.27	1.19	0.94	1.72	1.76	1.54	1.62	0.71	0.80	0.85	0.79	0.70
Na2O(Mass%)	0.05	0.08	0.11	0.08	0.08	0.07	0.10	0.08	0.04	0.08	0.06	n.d.	0.23	0.34	0.34	0.28	0.26
P2O5(Mass%)	39.94	40.57	39.20	39.43	39.69	40.55	40.04	38.85	39.60	39.51	39.58	40.18	40.31	39.94	40.20	40.06	40.07
La2O3(Mass%)	n.d.	0.03	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	0.04	0.01	n.d.	n.d.	0.03	0.02	0.04	0.03
Ce2O3(Mass%)	0.07	0.08	0.12	0.11	0.04	0.11	0.05	0.10	0.06	0.07	0.07	0.09	0.13	0.10	0.14	0.08	0.11
Pr2O3(Mass%)	0.01	0.07	0.05	n.d.	0.03	0.04	0.04	n.d.	0.03	n.d.	n.d.	0.06	n.d.	n.d.	0.04	0.02	n.d.
Nd2O3(Mass%)	n.d.	0.03	0.06	0.14	n.d.	n.d.	0.05	0.01	0.02	0.06	n.d.	n.d.	0.03	n.d.	n.d.	n.d.	0.03
Sm2O3(Mass%)	n.d.	0.01	0.10	0.01	0.05	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	0.02	0.02	0.06	n.d.	n.d.
LREE	0.08	0.21	0.36	0.26	0.13	0.16	0.14	0.11	0.14	0.18	0.09	0.24	0.18	0.14	0.25	0.13	0.16
Y2O3(Mass%)	0.02	0.02	0.08	0.05	0.08	0.02	0.08	0.04	0.05	0.04	0.06	0.02	0.02	n.d.	0.03	0.05	n.d.
SO3(Mass%)	0.06	0.02	0.04	0.06	0.06	0.04	0.04	0.05	0.05	0.06	0.04	0.04	0.02	0.04	0.06	0.08	0.03
F(Mass%)	4.31	4.48	4.03	3.09	4.45	4.74	4.49	3.41	4.73	4.09	4.38	3.81	4.78	3.35	3.30	4.14	3.80
Cl(Mass%)	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
TOTAL	100.78	101.22	99.60	99.15	99.70	100.91	99.98	98.97	100.37	99.47	99.87	99.64	100.48	99.06	99.52	99.66	99.54
F=O	-1.81	-1.89	-1.70	-1.30	-1.88	-2.00	-1.89	-1.44	-1.99	-1.72	-1.84	-1.60	-2.01	-1.41	-1.39	-1.74	-1.60
Cl=O	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
TOTAL	98.96	99.33	97.90	97.85	97.82	98.91	98.09	97.53	98.38	97.75	98.03	98.04	98.46	97.65	98.13	97.92	97.94

AMOSTRA	1223001_APATFIN ABOXWORK_IMG4 _9	1223001_C2_APAT 1 Line 1	1223001_C2_APAT 1 Line 10	1223001_C2_APAT 1 Line 11	1223001_C2_APAT 1 Line 2	1223001_C2_APAT 1 Line 3	1223001_C2_APAT 1 Line 4	1223001_C2_APAT 1 Line 5	1223001_C2_APAT 1 Line 6	1223001_C2_APAT 1 Line 7	1223001_C2_APAT 1 Line 8	1223001_C2_APAT 1 Line 9	1223001_C2_APAT 2_1	1223001_C2_APAT 2_2	1223001_C2_APAT 2_3	1223001_C2_APAT 2_4	1223001_C2_APAT 2_5
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	n.d.	0.008	0.010	0.011	0.005	0.007	0.008	0.044	0.009	0.014	0.008	0.008	0.007	0.007	0.008	0.009	0.008
Al	0.002	n.d.	0.211	0.292	0.008	0.041	0.006	0.242	0.009	0.067	n.d.	0.005	0.008	n.d.	0.001	0.006	0.014
Fe	0.007	0.018	0.011	0.004	0.016	0.005	0.013	0.241	0.003	0.015	0.007	0.011	0.034	0.035	0.030	0.030	0.028
Mn	0.000	0.003	0.001	0.008	0.003	n.d.	n.d.	0.002	0.001	0.000	0.000	0.001	0.002	0.004	0.002	n.d.	0.006
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.094	10.030	9.940	9.891	10.050	9.950	10.040	9.817	10.108	10.000	10.139	9.999	10.027	10.091	10.052	10.040	10.080
Ba	n.d.	0.002	0.001	0.000	n.d.	0.003	n.d.	0.000	0.002	0.002	0.001	0.000	0.001	0.003	0.003	0.002	n.d.
Sr	0.200	0.125	0.157	0.139	0.155	0.128	0.121	0.096	0.175	0.179	0.156	0.163	0.072	0.081	0.086	0.080	0.070
Na	0.016	0.028	0.037	0.026	0.029	0.022	0.034	0.027	0.013	0.028	0.022	n.d.	0.078	0.115	0.114	0.095	0.088
P	5.870	5.916	5.803	5.790	5.895	5.933	5.912	5.750	5.868	5.865	5.873	5.924	5.926	5.890	5.897	5.907	5.894
La	n.d.	0.002	0.002	n.d.	n.d.	n.d.	n.d.	0.000	0.003	0.003	0.001	n.d.	n.d.	0.002	0.001	0.003	0.002
Ce	0.004	0.005	0.007	0.007	0.003	0.007	0.003	0.007	0.004	0.005	0.005	0.006	0.008	0.006	0.009	0.005	0.007
Pr	0.001	0.004	0.003	n.d.	0.002	0.002	0.003	n.d.	0.002	n.d.	n.d.	0.004	n.d.	0.000	0.002	0.001	0.000
Nd	n.d.	0.002	0.004	0.009	n.d.	n.d.	0.003	0.001	0.001	0.004	n.d.	n.d.	0.002	0.000	n.d.	n.d.	0.002
Sm	n.d.	0.001	0.006	0.001	0.003	0.001	n.d.	0.000	n.d.	0.000	n.d.	0.005	0.001	0.001	0.004	n.d.	n.d.
Y	0.002	0.002	0.007	0.005	0.007	0.002	0.007	0.004	0.005	0.004	0.006	0.002	0.002	n.d.	0.003	0.004	0.001
S	0.008	0.003	0.005	0.007	0.008	0.006	0.005	0.007	0.006	0.008	0.005	0.005	0.003	0.006	0.008	0.011	0.004
F	2.161	2.223	2.045	1.586	2.248	2.349	2.255	1.755	2.368	2.081	2.213	1.934	2.376	1.718	1.688	2.088	1.929
Cl	n.d.	0.003	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	0.002	n.d.	0.000	n.d.	n.d.	0.000	0.002	n.d.	n.d.
TOTAL	18.365	18.375	18.251	17.776	18.432	18.455	18.412	17.990	18.580	18.273	18.437	18.068	18.547	17.961	17.911	18.282	18.132

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_C2_APAT 2_6	1223001_C2_APAT 2_7	1223001_C2_APAT 2_8	1223001_C3_APAT 1 LINE 5	1223001_C3_APAT 1 LINE 6	1223001_C3_APAT 1 LINE 7	1223001_C3_APAT 1 LINE 8	1223001_C3_APAT 3_1	1223001_C3_APAT 3_2	1223001_C3_APAT 3_3	1223001_C3_APAT 3_4	1223001_C3_APAT 5_1	1223001_C3_APAT 5_2	1223001_C3_APAT 5_3	1223001_C3_APAT 5_4	1223001_C4_APAT 2_1	1223001_C4_APAT 2_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.05	0.04	0.02	0.05	0.03	0.08	0.08	0.03	0.06	0.09	0.09	0.04	0.03	0.01	0.06	0.02	0.04
Al2O3(Mass%)	0.02	n.d.	n.d.	0.01	n.d.	0.05	0.09	0.03	n.d.	n.d.	0.09	n.d.	0.02	n.d.	1.22	0.11	0.13
FeO(Mass%)	0.11	0.20	0.14	0.05	0.03	0.09	0.03	0.04	0.16	0.15	0.04	0.23	0.31	0.15	0.20	0.18	0.19
MnO(Mass%)	0.03	0.04	n.d.	0.01	0.01	n.d.	n.d.	n.d.	0.03	n.d.	n.d.	0.02	0.01	n.d.	n.d.	0.03	0.03
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.48	54.05	53.90	54.59	54.04	53.92	54.80	54.82	54.41	53.97	54.59	53.66	53.15	53.90	53.65	53.67	53.73
BaO(Mass%)	n.d.	0.02	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.02	n.d.	0.03	0.02	0.01	n.d.	n.d.	0.03
SrO(Mass%)	0.99	1.26	1.86	0.51	0.68	0.83	0.57	0.66	0.66	0.75	0.61	1.07	1.08	0.80	0.89	0.97	0.86
Na2O(Mass%)	0.04	0.10	0.07	0.14	0.16	0.18	0.14	0.08	0.11	0.06	0.10	0.29	0.48	0.16	0.10	0.51	0.51
P2O5(Mass%)	40.05	39.57	39.55	40.76	40.54	40.24	40.26	40.88	40.60	40.45	40.88	39.61	39.79	40.44	39.86	38.95	39.01
La2O3(Mass%)	n.d.	0.02	n.d.	0.05	0.04	0.01	n.d.	0.03	0.08	0.02	0.06	0.03	n.d.	n.d.	n.d.	n.d.	n.d.
Ce2O3(Mass%)	0.10	0.14	0.06	0.23	0.12	0.13	0.12	0.11	0.12	0.15	0.09	0.14	0.13	0.10	0.09	0.08	0.10
Pr2O3(Mass%)	0.04	0.02	0.03	0.02	0.08	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	0.02	0.05	n.d.	0.01	n.d.	0.03
Nd2O3(Mass%)	0.07	0.02	n.d.	0.09	0.13	n.d.	0.02	0.07	n.d.	0.08	n.d.	0.05	n.d.	0.25	0.07	n.d.	n.d.
Sm2O3(Mass%)	n.d.	n.d.	0.06	n.d.	0.11	0.07	n.d.	n.d.	0.04	0.05	0.01	0.04	n.d.	0.03	n.d.	0.01	0.06
LREE	0.22	0.20	0.14	0.39	0.48	0.22	0.16	0.21	0.23	0.31	0.16	0.28	0.18	0.38	0.17	0.09	0.19
Y2O3(Mass%)	n.d.	0.04	n.d.	0.03	0.06	0.07	0.04	0.08	0.04	0.06	0.03	0.07	0.04	0.06	0.08	n.d.	0.06
SO3(Mass%)	0.06	0.02	0.05	0.03	0.06	0.03	0.08	0.04	0.03	0.02	0.05	0.08	0.11	0.03	0.02	0.02	0.05
F(Mass%)	4.40	4.68	4.46	2.18	3.76	3.52	4.53	4.44	3.73	4.38	4.36	3.84	2.18	2.94	3.47	4.68	4.39
Cl(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.02
TOTAL	100.47	100.23	100.22	98.76	99.87	99.24	100.80	101.31	100.08	100.26	101.00	99.23	97.40	98.91	99.73	99.22	99.23
F=O	-1.85	-1.97	-1.88	-0.92	-1.58	-1.48	-1.91	-1.87	-1.57	-1.85	-1.84	-1.62	-0.92	-1.24	-1.46	-1.97	-1.85
Cl=O	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	0.00
TOTAL	98.62	98.26	98.35	97.84	98.28	97.76	98.89	99.44	98.51	98.41	99.17	97.61	96.48	97.68	98.27	97.25	97.38

AMOSTRA	1223001_C2_APAT 2_6	1223001_C2_APAT 2_7	1223001_C2_APAT 2_8	1223001_C3_APAT 1 LINE 5	1223001_C3_APAT 1 LINE 6	1223001_C3_APAT 1 LINE 7	1223001_C3_APAT 1 LINE 8	1223001_C3_APAT 3_1	1223001_C3_APAT 3_2	1223001_C3_APAT 3_3	1223001_C3_APAT 3_4	1223001_C3_APAT 5_1	1223001_C3_APAT 5_2	1223001_C3_APAT 5_3	1223001_C3_APAT 5_4	1223001_C4_APAT 2_1	1223001_C4_APAT 2_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.009	0.006	0.004	0.009	0.006	0.013	0.014	0.006	0.010	0.015	0.016	0.007	0.006	0.003	0.011	0.003	0.007
Al	0.005	0.000	0.000	0.002	n.d.	0.009	0.019	0.005	0.001	0.000	0.018	0.001	0.003	0.001	0.249	0.022	0.027
Fe	0.016	0.030	0.021	0.007	0.005	0.014	0.005	0.005	0.023	0.022	0.006	0.034	0.045	0.022	0.028	0.026	0.029
Mn	0.004	0.006	n.d.	0.001	0.002	n.d.	n.d.	n.d.	0.004	n.d.	n.d.	0.003	0.001	n.d.	0.000	0.005	0.004
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.129	10.145	10.118	10.053	10.013	10.038	10.141	10.067	10.051	10.021	10.027	10.073	9.968	10.011	9.918	10.177	10.151
Ba	n.d.	0.002	0.002	n.d.	n.d.	0.000	n.d.	n.d.	0.001	0.001	n.d.	0.002	0.002	0.001	n.d.	0.000	0.002
Sr	0.100	0.128	0.189	0.051	0.068	0.084	0.058	0.065	0.066	0.076	0.061	0.109	0.110	0.081	0.090	0.100	0.088
Na	0.014	0.035	0.023	0.048	0.054	0.062	0.049	0.028	0.038	0.020	0.033	0.097	0.164	0.052	0.032	0.173	0.175
P	5.884	5.868	5.867	5.932	5.936	5.920	5.888	5.933	5.925	5.936	5.933	5.874	5.897	5.935	5.822	5.836	5.824
La	0.000	0.001	n.d.	0.003	0.003	0.001	n.d.	0.002	0.005	0.001	0.004	0.002	0.001	n.d.	n.d.	0.000	n.d.
Ce	0.007	0.009	0.004	0.014	0.008	0.008	0.008	0.007	0.008	0.010	0.006	0.009	0.008	0.006	0.006	0.005	0.006
Pr	0.003	0.002	0.002	0.001	0.005	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	0.001	0.003	0.000	0.001	n.d.	0.002
Nd	0.005	0.002	n.d.	0.006	0.008	n.d.	0.002	0.004	n.d.	0.005	0.000	0.003	n.d.	0.015	0.004	0.001	n.d.
Sm	n.d.	n.d.	0.003	0.000	0.006	0.005	n.d.	n.d.	0.002	0.003	0.001	0.002	n.d.	0.002	n.d.	0.001	0.004
Y	0.000	0.004	n.d.	0.003	0.006	0.006	0.004	0.008	0.003	0.006	0.002	0.007	0.003	0.005	0.007	n.d.	0.005
S	0.008	0.003	0.006	0.004	0.008	0.004	0.010	0.005	0.004	0.002	0.006	0.010	0.015	0.004	0.003	0.003	0.007
F	2.200	2.349	2.249	1.133	1.900	1.797	2.252	2.195	1.881	2.192	2.160	1.963	1.153	1.514	1.761	2.369	2.227
Cl	n.d.	n.d.	n.d.	0.001	0.001	n.d.	n.d.	n.d.	0.002	n.d.	0.002	0.000	n.d.	0.001	0.001	0.002	0.005
TOTAL	18.385	18.588	18.487	17.269	18.028	17.961	18.449	18.330	18.024	18.309	18.275	18.197	17.378	17.655	17.933	18.722	18.563

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223001_C4_APAT2_3	1223001_C4_APAT2_4	1223001_C4_APAT2_5	1223001_C4_APAT2_6	1223001_C4_APAT2_7	1223001_C5_APAT1_4	1223001_C5_APAT1_5	1223001_C5_APAT1_6	1223001_C5_APAT1_7	1223007_C2_APAT_1	1223007_C2_APAT_2	1223007_C2_APAT_3	1223007_C2_APAT_4	1223007_C2_APAT_5	1223007_C2_APAT_6	1223007_C2_APAT_7	1223007_C2_APAT_8	1223007_C3_APAT_1	1223007_C3_APAT_10	1223007_C3_APAT_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.05	0.01	0.03	n.d.	0.05	0.04	0.04	0.10	0.08	0.03	0.11	0.03	0.02	0.05	0.06	0.05	0.04	0.01	0.02	0.05
Al2O3(Mass%)	0.05	n.d.	n.d.	n.d.	0.12	0.17	0.11	0.09	0.02	0.07	0.36	0.12	0.01	0.16	0.02	0.03	0.10	0.01	0.05	0.03
FeO(Mass%)	0.23	0.08	0.07	0.09	0.10	0.22	0.39	0.19	0.33	0.64	0.79	0.37	0.40	0.29	0.44	0.40	0.47	0.42	0.37	0.62
MnO(Mass%)	0.04	n.d.	0.03	0.01	0.03	n.d.	0.03	n.d.	0.01	0.07	0.08	0.07	0.09	0.06	0.09	0.10	0.11	0.08	0.08	0.08
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	53.45	54.49	54.24	53.72	53.61	53.50	53.35	54.17	53.57	50.50	50.73	50.91	50.74	51.49	50.70	51.20	50.93	51.62	51.76	51.69
BaO(Mass%)	n.d.	0.02	0.05	n.d.	0.03	n.d.	n.d.	0.04	n.d.	0.02	n.d.	0.04	n.d.	0.03	0.04	0.06	0.02	0.04	0.04	0.01
SrO(Mass%)	0.92	1.16	1.95	1.70	2.14	0.99	0.97	0.99	1.10	1.05	1.15	0.87	1.07	0.92	1.11	1.12	1.09	0.81	0.86	0.84
Na2O(Mass%)	0.49	0.06	0.06	0.05	0.05	0.18	0.49	0.13	0.39	1.03	1.30	0.97	1.19	0.89	1.27	1.12	1.20	1.01	0.96	1.00
P2O5(Mass%)	38.47	40.46	39.38	40.13	39.49	40.15	39.23	40.23	39.81	37.67	37.81	38.26	37.99	38.21	37.42	37.88	37.96	38.40	38.20	38.12
La2O3(Mass%)	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	0.05	n.d.	0.05	0.06	0.18	0.15	0.12	0.12	0.12	0.09	0.17	0.11	0.13
Ce2O3(Mass%)	0.05	0.07	0.08	0.08	0.06	0.08	0.09	0.08	0.02	0.31	0.28	0.41	0.38	0.41	0.32	0.37	0.24	0.50	0.34	0.45
Pr2O3(Mass%)	0.06	0.02	n.d.	0.04	0.01	n.d.	n.d.	0.01	0.06	n.d.	0.05	n.d.	0.04	n.d.	n.d.	0.01	0.03	0.06	n.d.	0.14
Nd2O3(Mass%)	0.02	n.d.	0.04	n.d.	0.02	0.04	n.d.	n.d.	n.d.	0.16	0.15	0.07	0.17	0.18	0.14	0.13	0.26	0.20	0.11	0.19
Sm2O3(Mass%)	n.d.	n.d.	0.03	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	0.04	0.04	0.08	0.03	0.06	0.02	0.07	n.d.	0.02	0.06	0.14
LREE	0.12	0.09	0.15	0.12	0.09	0.12	0.10	0.14	0.08	0.56	0.57	0.73	0.77	0.76	0.59	0.70	0.62	0.95	0.63	1.05
Y2O3(Mass%)	n.d.	0.03	0.01	0.02	0.03	0.05	0.05	0.04	0.02	0.06	0.04	0.04	0.02	0.06	0.04	0.05	0.04	0.04	0.02	0.03
SO3(Mass%)	0.06	0.03	0.02	0.03	0.04	0.07	0.28	0.07	0.07	0.07	0.03	0.07	0.05	0.05	0.05	0.05	0.05	0.08	0.06	0.03
F(Mass%)	4.76	4.90	4.25	5.03	4.84	5.15	4.45	5.59	4.20	1.95	0.83	2.11	2.01	2.14	1.28	1.53	1.04	2.51	2.46	2.50
Cl(Mass%)	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.
TOTAL	98.66	101.33	100.26	100.92	100.62	100.64	99.50	101.79	99.70	93.71	93.81	94.59	94.37	95.11	93.11	94.28	93.70	96.00	95.50	96.04
F=O	-2.00	-2.06	-1.79	-2.12	-2.04	-2.17	-1.87	-2.35	-1.77	-0.82	-0.35	-0.89	-0.85	-0.90	-0.54	-0.64	-0.44	-1.06	-1.03	-1.05
Cl=O	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.
TOTAL	96.65	99.27	98.47	98.80	98.58	98.47	97.62	99.44	97.93	92.89	93.46	93.70	93.52	94.21	92.57	93.63	93.26	94.94	94.46	94.98

AMOSTRA	1223001_C4_APAT2_3	1223001_C4_APAT2_4	1223001_C4_APAT2_5	1223001_C4_APAT2_6	1223001_C4_APAT2_7	1223001_C5_APAT1_4	1223001_C5_APAT1_5	1223001_C5_APAT1_6	1223001_C5_APAT1_7	1223007_C2_APAT_1	1223007_C2_APAT_2	1223007_C2_APAT_3	1223007_C2_APAT_4	1223007_C2_APAT_5	1223007_C2_APAT_6	1223007_C2_APAT_7	1223007_C2_APAT_8	1223007_C3_APAT_1	1223007_C3_APAT_10	1223007_C3_APAT_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.009	0.003	0.005	0.001	0.009	0.007	0.007	0.017	0.014	0.005	0.019	0.006	0.004	0.009	0.011	0.010	0.007	0.002	0.003	0.009
Al	0.011	0.001	n.d.	n.d.	0.025	0.036	0.023	0.018	0.004	0.015	0.076	0.025	0.002	0.033	0.005	0.006	0.022	0.003	0.010	0.007
Fe	0.035	0.012	0.011	0.013	0.015	0.032	0.057	0.027	0.048	0.098	0.120	0.057	0.061	0.044	0.067	0.061	0.071	0.063	0.056	0.093
Mn	0.006	n.d.	0.004	0.002	0.005	n.d.	0.005	0.001	0.002	0.011	0.013	0.011	0.013	0.009	0.014	0.015	0.017	0.013	0.012	0.012
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.220	10.086	10.178	10.030	10.063	9.978	10.042	10.045	10.028	9.907	9.839	9.880	9.894	9.960	9.969	9.964	9.904	9.942	10.008	9.982
Ba	n.d.	0.001	0.004	0.001	0.002	n.d.	0.000	0.003	0.000	0.002	n.d.	0.003	0.001	0.002	0.003	0.004	0.002	0.003	0.003	0.001
Sr	0.095	0.116	0.198	0.172	0.218	0.100	0.099	0.100	0.112	0.111	0.121	0.091	0.113	0.096	0.118	0.118	0.115	0.085	0.090	0.088
Na	0.169	0.019	0.020	0.018	0.018	0.061	0.167	0.045	0.131	0.365	0.455	0.341	0.420	0.311	0.450	0.395	0.423	0.351	0.335	0.351
P	5.812	5.917	5.840	5.921	5.857	5.916	5.835	5.895	5.888	5.840	5.795	5.868	5.853	5.841	5.814	5.826	5.834	5.845	5.836	5.817
La	n.d.	n.d.	n.d.	0.001	0.000	n.d.	n.d.	0.004	n.d.	0.003	0.004	0.012	0.010	0.008	0.008	0.008	0.006	0.011	0.007	0.008
Ce	0.003	0.004	0.005	0.005	0.004	0.005	0.006	0.005	0.001	0.021	0.018	0.027	0.025	0.027	0.021	0.025	0.016	0.033	0.023	0.030
Pr	0.004	0.001	n.d.	0.002	0.001	n.d.	n.d.	0.001	0.004	n.d.	0.003	n.d.	0.003	n.d.	n.d.	0.001	0.002	0.004	0.000	0.009
Nd	0.001	n.d.	0.003	n.d.	0.001	0.003	n.d.	n.d.	n.d.	0.011	0.010	0.005	0.011	0.012	0.009	0.008	0.017	0.013	0.007	0.012
Sm	n.d.	n.d.	0.002	n.d.	n.d.	n.d.	0.001	n.d.	n.d.	0.003	0.002	0.005	0.002	0.004	0.001	0.005	n.d.	0.002	0.004	0.009
Y	n.d.	0.003	0.001	0.002	0.003	0.005	0.004	0.004	0.002	0.005	0.004	0.004	0.002	0.006	0.004	0.005	0.004	0.004	0.002	0.003
S	0.008	0.004	0.002	0.004	0.005	0.009	0.037	0.009	0.009	0.010	0.004	0.009	0.007	0.007	0.007	0.006	0.007	0.011	0.008	0.004
F	2.425	2.417	2.152	2.495	2.422	2.544	2.250	2.727	2.124	1.080	0.465	1.155	1.107	1.165	0.724	0.846	0.584	1.352	1.328	1.347
Cl	0.005	n.d.	n.d.	0.001	0.001	n.d.	0.000	0.001	n.d.	0.002	0.004	n.d.	0.002	0.001	n.d.	0.002	0.003	n.d.	0.001	0.001
TOTAL	18.801	18.583	18.425	18.666	18.649	18.696	18.534	18.900	18.366	17.488	16.951	17.496	17.531	17.534	17.225	17.304	17.034	17.736	17.733	17.781

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223007_C3_APAT_3	1223007_C3_APAT_4	1223007_C3_APAT_5	1223007_C3_APAT_6	1223007_C3_APAT_7	1223007_C3_APAT_8	1223007_C3_APAT_9	1223007_C4_APAT_1	1223007_C4_APAT_10	1223007_C4_APAT_11	1223007_C4_APAT_12	1223007_C4_APAT_14	1223007_C4_APAT_15	1223007_C4_APAT_16	1223007_C4_APAT_2	1223007_C4_APAT_3	1223007_C4_APAT_4	1223007_C4_APAT_5	1223007_C4_APAT_6
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.03	0.04	0.05	0.01	n.d.	0.02	0.04	0.05	0.01	0.03	0.09	0.01	n.d.	0.06	0.02	0.02	0.07	0.05	0.03
Al2O3(Mass%)	n.d.	0.04	0.43	0.03	0.02	0.02	0.02	n.d.	0.02	0.03	1.89	n.d.	0.08	0.07	n.d.	0.01	0.05	n.d.	0.04
FeO(Mass%)	0.32	0.36	0.29	0.30	0.39	0.41	0.33	0.33	0.34	0.48	0.31	0.23	0.24	0.34	0.42	0.35	0.34	0.31	0.50
MnO(Mass%)	0.06	0.08	0.07	0.10	0.10	0.09	0.08	0.09	0.08	0.12	0.08	0.06	0.08	0.08	0.12	0.10	0.09	0.07	0.12
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	51.97	51.17	51.96	51.76	51.62	51.73	51.35	51.86	52.33	51.39	50.88	52.49	52.64	52.14	51.37	51.82	52.38	51.95	51.27
BaO(Mass%)	0.03	0.05	0.03	n.d.	0.03	0.05	0.04	0.03	0.03	0.02	0.01	n.d.	0.04	0.06	0.05	0.01	0.02	0.04	n.d.
SrO(Mass%)	0.83	0.83	0.84	0.94	0.86	0.84	0.96	0.93	0.86	1.03	0.84	0.89	0.83	0.88	1.17	1.16	0.84	0.95	1.29
Na2O(Mass%)	0.98	1.01	0.87	0.98	0.96	0.96	1.11	1.09	0.92	1.26	0.89	0.80	0.83	0.86	1.20	0.96	0.86	0.88	1.18
P2O5(Mass%)	38.37	38.39	38.50	38.22	38.57	37.93	38.16	38.10	38.62	37.57	37.48	38.77	38.90	38.36	37.82	38.32	38.66	38.42	38.14
La2O3(Mass%)	0.14	0.13	0.12	0.17	0.19	0.12	0.08	0.10	0.05	0.08	0.11	0.05	0.02	0.04	0.06	0.02	0.05	0.15	0.03
Ce2O3(Mass%)	0.40	0.29	0.40	0.48	0.45	0.42	0.41	0.30	0.16	0.21	0.30	0.22	0.22	0.13	0.17	0.19	0.17	0.33	0.15
Pr2O3(Mass%)	0.06	0.03	0.06	n.d.	0.07	0.07	0.02	0.05	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	0.03	0.07	0.04
Nd2O3(Mass%)	0.18	0.23	0.24	0.26	0.17	0.13	0.22	0.06	0.15	0.20	0.07	0.13	0.09	0.04	n.d.	0.14	0.08	0.16	0.07
Sm2O3(Mass%)	n.d.	0.04	0.01	n.d.	n.d.	0.03	n.d.	0.03	n.d.	n.d.	n.d.	0.06	0.02	0.04	0.02	n.d.	0.04	0.03	0.08
LREE	0.79	0.71	0.82	0.90	0.89	0.78	0.72	0.54	0.37	0.49	0.48	0.45	0.35	0.26	0.25	0.39	0.37	0.75	0.36
Y2O3(Mass%)	0.04	0.03	0.05	0.05	0.02	0.04	n.d.	0.05	0.03	n.d.	0.02	0.05	n.d.	0.01	n.d.	0.05	0.04	0.03	n.d.
SO3(Mass%)	0.08	0.06	0.05	0.05	0.05	0.03	0.07	0.08	0.06	0.10	0.06	0.06	0.06	0.08	0.07	0.04	0.08	0.06	0.07
F(Mass%)	1.90	2.29	3.43	2.84	1.91	3.06	1.81	2.35	3.08	1.91	2.25	2.97	3.14	3.58	2.41	1.55	3.06	2.77	1.81
Cl(Mass%)	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.
TOTAL	95.42	95.08	97.37	96.19	95.42	95.98	94.69	95.53	96.77	94.43	95.28	96.78	97.19	96.76	94.91	94.77	96.85	96.29	94.82
F=O	-0.80	-0.96	-1.44	-1.19	-0.81	-1.29	-0.76	-0.99	-1.30	-0.80	-0.95	-1.25	-1.32	-1.51	-1.01	-0.65	-1.29	-1.17	-0.76
Cl=O	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.
TOTAL	94.62	94.11	95.93	94.99	94.62	94.69	93.92	94.54	95.47	93.63	94.33	95.53	95.86	95.25	93.89	94.12	95.56	95.12	94.06

AMOSTRA	1223007_C3_APAT_3	1223007_C3_APAT_4	1223007_C3_APAT_5	1223007_C3_APAT_6	1223007_C3_APAT_7	1223007_C3_APAT_8	1223007_C3_APAT_9	1223007_C4_APAT_1	1223007_C4_APAT_10	1223007_C4_APAT_11	1223007_C4_APAT_12	1223007_C4_APAT_14	1223007_C4_APAT_15	1223007_C4_APAT_16	1223007_C4_APAT_2	1223007_C4_APAT_3	1223007_C4_APAT_4	1223007_C4_APAT_5	1223007_C4_APAT_6
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.006	0.007	0.009	0.003	n.d.	0.004	0.007	0.009	0.002	0.006	0.016	0.002	0.001	0.011	0.003	0.004	0.013	0.009	0.006
Al	0.001	0.010	0.090	0.007	0.005	0.004	0.004	n.d.	0.004	0.006	0.399	0.001	0.017	0.014	0.000	0.002	0.010	n.d.	0.008
Fe	0.048	0.055	0.043	0.045	0.059	0.062	0.049	0.050	0.052	0.073	0.047	0.035	0.036	0.050	0.065	0.052	0.051	0.047	0.075
Mn	0.009	0.012	0.010	0.015	0.015	0.013	0.012	0.014	0.012	0.019	0.012	0.010	0.012	0.012	0.018	0.015	0.013	0.010	0.019
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.002	9.904	9.937	9.993	9.930	10.044	9.955	10.025	10.030	10.029	9.786	10.037	10.038	10.037	10.020	10.000	10.015	9.997	9.919
Ba	0.002	0.004	0.002	n.d.	0.002	0.003	0.003	0.002	0.002	0.002	0.001	0.000	0.003	0.004	0.003	0.001	0.001	0.003	0.001
Sr	0.087	0.087	0.087	0.099	0.089	0.088	0.101	0.098	0.090	0.109	0.087	0.092	0.086	0.091	0.124	0.121	0.087	0.099	0.135
Na	0.341	0.352	0.301	0.344	0.333	0.338	0.389	0.382	0.319	0.445	0.309	0.275	0.286	0.299	0.424	0.334	0.297	0.308	0.415
P	5.835	5.871	5.819	5.831	5.863	5.820	5.846	5.819	5.849	5.794	5.696	5.859	5.863	5.836	5.829	5.844	5.841	5.843	5.831
La	0.010	0.009	0.008	0.011	0.013	0.008	0.005	0.006	0.003	0.005	0.007	0.003	0.001	0.003	0.004	0.002	0.003	0.010	0.002
Ce	0.026	0.019	0.026	0.032	0.030	0.028	0.027	0.020	0.010	0.014	0.020	0.014	0.014	0.009	0.011	0.012	0.011	0.022	0.010
Pr	0.004	0.002	0.004	0.001	0.005	0.005	0.001	0.004	0.001	0.000	n.d.	n.d.	0.000	n.d.	n.d.	0.003	0.002	0.005	0.003
Nd	0.012	0.015	0.015	0.017	0.011	0.009	0.014	0.004	0.010	0.013	0.004	0.008	0.006	0.003	0.000	0.009	0.005	0.011	0.004
Sm	n.d.	0.002	0.001	0.000	n.d.	0.002	n.d.	0.002	n.d.	n.d.	0.000	0.004	0.001	0.002	0.001	n.d.	0.002	0.002	0.005
Y	0.004	0.003	0.004	0.005	0.002	0.004	n.d.	0.005	0.003	n.d.	0.002	0.005	n.d.	0.001	n.d.	0.005	0.004	0.003	0.000
S	0.011	0.008	0.007	0.006	0.006	0.005	0.009	0.010	0.008	0.014	0.008	0.009	0.008	0.011	0.010	0.005	0.010	0.008	0.010
F	1.037	1.243	1.795	1.518	1.041	1.641	0.997	1.270	1.631	1.052	1.213	1.570	1.650	1.880	1.313	0.855	1.614	1.481	0.991
Cl	0.000	0.003	n.d.	0.000	n.d.	0.001	0.001	0.001	0.003	0.002	0.001	0.002	0.001	n.d.	0.000	n.d.	0.000	0.004	0.002
TOTAL	17.435	17.605	18.158	17.926	17.404	18.079	17.421	17.722	18.027	17.582	17.609	17.924	18.023	18.264	17.827	17.263	17.980	17.860	17.434

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223007_C4_APAT _7	1223007_C4_APAT _8	1223007_C4_APAT _9	1223007_C6_APAT 1_1	1223007_C6_APAT 1_10	1223007_C6_APAT 1_3	1223007_C6_APAT 1_4	1223007_C6_APAT 1_5	1223007_C6_APAT 1_6	1223007_C6_APAT 1_7	1223007_C6_APAT 1_8	1223007_C6_APAT 1_9	12231142_C2_APA T5 LINE 1	12231142_C2_APA T5 LINE 10	12231142_C2_APA T5 LINE 11	12231142_C2_APA T5 LINE 12	12231142_C2_APA T5 LINE 13	12231142_C2_APA T5 LINE 14	12231142_C2_APA T5 LINE 15	12231142_C2_APA T5 LINE 16	12231142_C2_APA T5 LINE 17
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.05	n.d.	0.03	0.06	0.01	0.09	0.17	0.05	0.03	n.d.	0.06	0.02	0.04	0.03	0.08	0.05	0.08	0.03	0.15	0.14	0.04
Al2O3(Mass%)	0.03	0.01	0.02	0.01	0.02	2.13	0.14	0.06	n.d.	0.03	0.03	0.01	0.05	0.03	0.03	0.03	0.05	0.04	1.24	0.04	0.14
FeO(Mass%)	0.24	0.41	0.46	0.86	0.42	0.95	1.04	0.54	0.46	0.79	0.99	0.55	1.79	0.24	1.37	1.87	1.02	0.50	1.92	1.92	0.17
MnO(Mass%)	0.06	0.11	0.15	0.07	0.05	0.06	0.07	0.09	0.06	0.04	0.03	0.05	n.d.	n.d.	n.d.	n.d.	0.01	0.02	0.01	0.03	0.02
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	51.84	51.63	51.36	52.48	51.59	49.57	52.70	52.25	51.93	53.07	52.19	51.70	52.28	52.70	52.18	52.25	52.84	52.92	51.50	52.18	53.14
BaO(Mass%)	0.05	0.03	0.07	0.02	0.04	0.08	n.d.	n.d.	0.03	0.02	n.d.	0.07	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	0.01
SrO(Mass%)	0.96	0.96	1.27	0.65	0.91	0.75	0.69	0.85	0.77	0.81	0.82	0.68	0.84	0.83	0.86	0.84	1.02	1.09	0.82	0.73	1.01
Na2O(Mass%)	0.86	1.22	1.11	1.06	0.97	0.88	0.94	1.18	1.08	0.78	0.97	1.10	0.17	0.27	0.24	0.17	0.15	0.13	0.20	0.22	0.17
P2O5(Mass%)	38.67	37.61	38.18	38.37	36.88	36.93	38.63	35.40	37.58	38.65	36.57	36.59	39.13	39.19	39.40	38.83	39.51	39.73	38.36	39.44	40.03
La2O3(Mass%)	0.08	0.04	0.01	0.09	0.10	0.04	0.04	0.08	0.08	0.02	0.12	0.07	n.d.	n.d.	0.01	n.d.	n.d.	0.02	n.d.	0.01	n.d.
Ce2O3(Mass%)	0.26	0.29	0.15	0.30	0.23	0.23	0.20	0.21	0.27	0.22	0.33	0.29	0.07	0.05	0.02	0.01	0.05	0.03	0.08	0.06	0.03
Pr2O3(Mass%)	0.05	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.05	0.05	n.d.	0.03	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	0.02	n.d.
Nd2O3(Mass%)	0.11	n.d.	0.21	0.17	0.08	0.09	0.09	0.10	0.08	0.05	0.13	0.14	0.02	n.d.	0.06	n.d.	n.d.	n.d.	0.05	n.d.	0.01
Sm2O3(Mass%)	0.05	n.d.	n.d.	0.05	0.06	0.10	0.04	n.d.	n.d.	0.06	n.d.	0.08	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	0.05	0.10
LREE	0.55	0.33	0.37	0.61	0.48	0.47	0.36	0.44	0.49	0.35	0.62	0.61	0.09	0.05	0.09	0.01	0.05	0.06	0.17	0.14	0.14
Y2O3(Mass%)	0.06	n.d.	n.d.	n.d.	0.02	0.04	0.04	0.03	0.05	0.05	0.04	n.d.	n.d.	0.01	n.d.	0.03	0.01	n.d.	n.d.	n.d.	n.d.
SO3(Mass%)	0.04	0.09	0.03	0.07	0.10	0.06	0.04	0.07	0.05	0.08	0.04	0.05	0.04	0.04	0.07	0.05	0.07	0.04	0.07	0.07	0.01
F(Mass%)	2.01	2.18	2.08	3.70	3.18	2.65	2.79	2.62	2.53	3.51	2.90	3.51	3.28	4.55	3.80	3.73	3.63	3.97	2.93	3.30	3.90
Cl(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.01	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	0.01	n.d.	n.d.
TOTAL	95.42	94.60	95.15	97.99	94.70	94.64	97.60	93.59	95.06	98.19	95.27	94.96	97.72	97.93	98.11	97.89	98.48	98.54	97.39	98.22	98.81
F=O	-0.85	-0.92	-0.88	-1.56	-1.34	-1.12	-1.17	-1.10	-1.06	-1.48	-1.22	-1.48	-1.38	-1.92	-1.60	-1.57	-1.53	-1.67	-1.23	-1.39	-1.64
Cl=O	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	0.00	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	0.00	n.d.	n.d.
TOTAL	94.58	93.68	94.27	96.43	93.36	93.53	96.43	92.48	94.00	96.71	94.05	93.48	96.34	96.02	96.52	96.32	96.95	96.86	96.16	96.83	97.17

AMOSTRA	1223007_C4_APAT _7	1223007_C4_APAT _8	1223007_C4_APAT _9	1223007_C6_APAT 1_1	1223007_C6_APAT 1_10	1223007_C6_APAT 1_3	1223007_C6_APAT 1_4	1223007_C6_APAT 1_5	1223007_C6_APAT 1_6	1223007_C6_APAT 1_7	1223007_C6_APAT 1_8	1223007_C6_APAT 1_9	12231142_C2_APA T5 LINE 1	12231142_C2_APA T5 LINE 10	12231142_C2_APA T5 LINE 11	12231142_C2_APA T5 LINE 12	12231142_C2_APA T5 LINE 13	12231142_C2_APA T5 LINE 14	12231142_C2_APA T5 LINE 15	12231142_C2_APA T5 LINE 16	12231142_C2_APA T5 LINE 17
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.009	0.002	0.006	0.010	0.003	0.016	0.029	0.008	0.006	n.d.	0.011	0.003	0.008	0.006	0.014	0.009	0.014	0.006	0.027	0.025	0.008
Al	0.006	0.002	0.003	0.003	0.005	0.455	0.030	0.014	n.d.	0.007	0.007	0.003	0.010	0.005	0.005	0.006	0.010	0.007	0.259	0.008	0.028
Fe	0.036	0.063	0.069	0.129	0.065	0.144	0.154	0.084	0.071	0.117	0.152	0.086	0.265	0.035	0.203	0.278	0.151	0.074	0.285	0.282	0.025
Mn	0.009	0.016	0.023	0.010	0.008	0.010	0.010	0.015	0.010	0.006	0.005	0.008	n.d.	0.001	n.d.	0.001	0.002	0.003	0.002	0.004	0.003
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	9.956	10.112	9.963	10.038	10.195	9.638	9.999	10.485	10.122	10.096	10.275	10.248	9.922	10.058	9.889	9.970	9.965	9.985	9.768	9.840	9.968
Ba	0.003	0.002	0.005	0.002	0.003	0.006	0.001	n.d.	0.002	0.001	n.d.	0.005	0.000	0.000	n.d.	n.d.	0.001	0.000	0.001	n.d.	0.001
Sr	0.100	0.102	0.133	0.068	0.098	0.079	0.070	0.092	0.081	0.083	0.087	0.073	0.087	0.086	0.089	0.087	0.104	0.112	0.085	0.075	0.102
Na	0.300	0.434	0.390	0.368	0.347	0.308	0.324	0.428	0.381	0.267	0.346	0.394	0.058	0.094	0.082	0.059	0.053	0.045	0.070	0.076	0.058
P	5.869	5.821	5.851	5.799	5.759	5.674	5.792	5.613	5.788	5.810	5.690	5.731	5.869	5.910	5.901	5.855	5.889	5.923	5.749	5.878	5.933
La	0.006	0.003	0.001	0.006	0.007	0.003	0.002	0.006	0.005	0.002	0.008	0.005	n.d.	n.d.	0.001	n.d.	n.d.	0.001	n.d.	0.001	n.d.
Ce	0.017	0.020	0.010	0.020	0.015	0.015	0.013	0.014	0.018	0.014	0.022	0.020	0.005	0.003	0.001	0.001	0.003	0.002	0.005	0.004	0.002
Pr	0.003	n.d.	n.d.	n.d.	n.d.	n.d.	0.000	0.004	0.004	n.d.	0.002	0.002	n.d.	0.000	n.d.	n.d.	n.d.	n.d.	0.003	0.001	n.d.
Nd	0.007	n.d.	0.014	0.011	0.006	0.006	0.005	0.007	0.005	0.003	0.009	0.009	0.002	n.d.	0.004	n.d.	n.d.	n.d.	0.003	0.000	0.001
Sm	0.003	n.d.	n.d.	0.003	0.004	0.006	0.002	n.d.	n.d.	0.004	n.d.	0.005	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	0.003	0.006
Y	0.005	n.d.	n.d.	0.000	0.002	0.004	0.004	0.003	0.005	0.005	0.004	n.d.	n.d.	0.001	n.d.	0.003	0.001	n.d.	n.d.	0.001	0.001
S	0.006	0.012	0.004	0.009	0.014	0.008	0.005	0.010	0.007	0.010	0.005	0.007	0.005	0.005	0.009	0.007	0.009	0.005	0.009	0.010	0.001
F	1.089	1.198	1.138	1.930	1.724	1.433	1.468	1.460	1.374	1.826	1.578	1.897	1.711	2.327	1.957	1.936	1.871	2.031	1.537	1.712	1.988
Cl	n.d.	n.d.	0.001	0.001	0.001	0.001	0.003	0.003	0.001	0.002	0.002	0.003	0.002	0.001	0.002	0.003	0.001	0.002	0.003	n.d.	0.001
TOTAL	17.425	17.787	17.613	18.405	18.256	17.806	17.912	18.247	17.880	18.253	18.203	18.499	17.943	18.533	18.157	18.215	18.073	18.197	17.804	17.919	18.125

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	12231142_C2_APA T5 LINE 18	12231142_C2_APA T5 LINE 19	12231142_C2_APA T5 LINE 2	12231142_C2_APA T5 LINE 20	12231142_C2_APA T5 LINE 21	12231142_C2_APA T5 LINE 3	12231142_C2_APA T5 LINE 4	12231142_C2_APA T5 LINE 5	12231142_C2_APA T5 LINE 6	12231142_C2_APA T5 LINE 7	12231142_C2_APA T5 LINE 8	12231142_C2_APA T5 LINE 9	12231142_C1_APAT 1_1	12231142_C1_APAT 1_10	12231142_C1_APAT 1_11	12231142_C1_APAT 1_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.05	0.05	0.04	0.11	0.05	0.02	0.07	0.06	0.03	0.05	0.05	0.08	0.04	0.05	0.04	0.03
Al2O3(Mass%)	n.d.	0.01	0.09	0.03	0.10	0.02	0.48	0.03	n.d.	0.02	0.01	0.04	n.d.	n.d.	n.d.	n.d.
FeO(Mass%)	1.25	0.12	0.77	2.00	0.58	0.56	0.40	0.21	0.38	0.12	0.15	0.26	0.05	0.10	0.03	0.01
MnO(Mass%)	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	0.02	0.01	0.06	n.d.	n.d.	0.02	0.01	0.06	n.d.	0.03
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.
CaO(Mass%)	52.61	53.56	54.33	52.56	53.97	53.96	53.61	54.02	53.99	53.46	53.67	52.87	53.87	54.15	54.60	54.05
BaO(Mass%)	0.03	n.d.	0.03	0.03	n.d.	0.01	n.d.	0.02	0.02	0.01	n.d.	n.d.	0.03	0.03	n.d.	n.d.
SrO(Mass%)	1.13	1.28	0.90	0.96	0.90	0.91	0.91	1.30	0.69	1.35	1.29	1.01	0.26	0.26	0.24	0.26
Na2O(Mass%)	0.17	0.12	0.19	0.18	0.17	0.17	0.19	0.10	0.34	n.d.	0.09	0.27	0.16	0.28	0.08	0.14
P2O5(Mass%)	39.54	40.28	40.26	39.54	40.28	40.16	40.16	40.82	39.88	40.30	40.13	39.77	40.72	40.84	41.18	40.51
La2O3(Mass%)	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.01	n.d.	n.d.	n.d.	0.03	0.01	n.d.	0.05	0.05
Ce2O3(Mass%)	0.06	0.05	0.04	0.05	0.05	0.05	0.07	0.06	0.06	0.05	0.07	0.06	0.15	0.10	0.16	0.07
Pr2O3(Mass%)	n.d.	n.d.	n.d.	0.06	n.d.	0.01	n.d.	0.05	0.05	0.06	0.04	n.d.	n.d.	0.02	0.03	n.d.
Nd2O3(Mass%)	n.d.	0.14	n.d.	n.d.	0.10	n.d.	n.d.	n.d.	0.03	n.d.	0.03	0.03	0.03	n.d.	n.d.	n.d.
Sm2O3(Mass%)	0.04	n.d.	n.d.	n.d.	0.04	n.d.	0.04	0.10	n.d.	0.09	n.d.	n.d.	0.05	n.d.	n.d.	n.d.
LREE	0.11	0.19	0.04	0.11	0.19	0.06	0.12	0.22	0.14	0.20	0.14	0.11	0.24	0.13	0.23	0.12
Y2O3(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	0.01	0.02	0.04	0.02	0.03	0.01	n.d.	n.d.	n.d.
SO3(Mass%)	0.01	n.d.	0.06	0.07	0.06	0.03	0.04	0.03	0.08	0.03	n.d.	0.03	0.03	n.d.	n.d.	0.01
F(Mass%)	4.27	4.00	3.48	3.38	3.26	4.18	2.94	3.19	3.60	4.48	4.44	4.11	1.08	1.60	1.44	1.22
Cl(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	0.02	n.d.	0.02
TOTAL	99.17	99.65	100.21	98.98	99.56	100.09	98.98	100.05	99.25	100.08	100.01	98.61	96.51	97.51	97.84	96.38
F=O	-1.80	-1.69	-1.46	-1.42	-1.37	-1.76	-1.24	-1.34	-1.52	-1.89	-1.87	-1.73	-0.45	-0.67	-0.60	-0.51
Cl=O	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	0.00	n.d.	0.00
TOTAL	97.37	97.96	98.75	97.55	98.18	98.33	97.74	98.71	97.73	98.19	98.14	96.87	96.06	96.84	97.24	95.87

AMOSTRA	12231142_C2_APA T5 LINE 18	12231142_C2_APA T5 LINE 19	12231142_C2_APA T5 LINE 2	12231142_C2_APA T5 LINE 20	12231142_C2_APA T5 LINE 21	12231142_C2_APA T5 LINE 3	12231142_C2_APA T5 LINE 4	12231142_C2_APA T5 LINE 5	12231142_C2_APA T5 LINE 6	12231142_C2_APA T5 LINE 7	12231142_C2_APA T5 LINE 8	12231142_C2_APA T5 LINE 9	12231142_C1_APAT 1_1	12231142_C1_APAT 1_10	12231142_C1_APAT 1_11	12231142_C1_APAT 1_2
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.009	0.008	0.007	0.020	0.008	0.004	0.013	0.010	0.006	0.009	0.010	0.014	0.007	0.009	0.007	0.005
Al	0.001	0.003	0.019	0.006	0.021	0.005	0.098	0.007	n.d.	0.004	0.003	0.008	0.001	0.002	0.000	n.d.
Fe	0.185	0.018	0.112	0.293	0.084	0.081	0.059	0.030	0.056	0.017	0.023	0.038	0.008	0.014	0.005	0.002
Mn	0.001	n.d.	0.002	0.001	0.001	0.001	0.003	0.002	0.008	0.001	0.001	0.004	0.002	0.009	0.000	0.004
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.004	n.d.	n.d.
Ca	9.935	9.998	10.040	9.865	10.000	10.049	9.947	9.950	10.077	9.973	10.029	9.969	9.992	9.992	10.023	10.065
Ba	0.002	0.000	0.002	0.002	0.000	0.001	n.d.	0.001	0.001	0.001	n.d.	n.d.	0.002	0.002	0.000	n.d.
Sr	0.116	0.130	0.090	0.098	0.090	0.092	0.091	0.130	0.070	0.137	0.130	0.103	0.027	0.026	0.024	0.026
Na	0.057	0.039	0.064	0.060	0.058	0.058	0.063	0.034	0.116	0.002	0.031	0.091	0.054	0.094	0.028	0.048
P	5.900	5.942	5.879	5.864	5.897	5.910	5.888	5.940	5.882	5.941	5.926	5.926	5.968	5.955	5.974	5.960
La	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	0.001	n.d.	n.d.	n.d.	0.002	0.001	0.000	0.003	0.003
Ce	0.004	0.003	0.002	0.003	0.003	0.003	0.005	0.004	0.004	0.004	0.005	0.004	0.009	0.007	0.010	0.004
Pr	n.d.	n.d.	0.000	0.004	n.d.	0.001	n.d.	0.003	0.003	0.004	0.003	n.d.	n.d.	0.001	0.002	n.d.
Nd	n.d.	0.009	n.d.	0.000	0.006	n.d.	n.d.	n.d.	0.002	n.d.	0.002	0.002	0.002	n.d.	n.d.	n.d.
Sm	0.002	n.d.	n.d.	n.d.	0.002	n.d.	0.002	0.006	n.d.	0.006	n.d.	0.000	0.003	n.d.	0.000	n.d.
Y	0.000	n.d.	n.d.	n.d.	0.001	0.000	0.002	0.001	0.002	0.004	0.002	0.003	0.001	n.d.	0.000	0.000
S	0.002	n.d.	0.008	0.009	0.008	0.004	0.005	0.004	0.011	0.005	0.000	0.005	0.004	n.d.	n.d.	0.001
F	2.175	2.027	1.762	1.743	1.666	2.103	1.512	1.621	1.837	2.245	2.232	2.097	0.577	0.844	0.755	0.650
Cl	n.d.	0.000	n.d.	0.001	0.002	0.002	0.002	n.d.	n.d.	0.003	0.001	n.d.	n.d.	0.004	n.d.	0.004
TOTAL	18.389	18.177	17.988	17.970	17.847	18.313	17.690	17.744	18.076	18.354	18.397	18.263	16.657	16.960	16.831	16.774

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	12231142_C1_APAT1_3	12231142_C1_APAT1_4	12231142_C1_APAT1_5	12231142_C1_APAT1_6	12231142_C1_APAT1_7	12231142_C1_APAT1_8	12231142_C1_APAT1_9	12231142_C2_APAT1_1	12231142_C2_APAT1_2	12231142_C2_APAT1_3	12231142_C2_APAT2_1	12231142_C2_APAT2_2	12231142_C2_APAT3_1	12231142_C2_APAT3_2	12231142_C2_APAT3_3	12231142_C2_APAT3_4	12231142_C2_APAT3_5	12231142_C2_APAT3_6	12231142_C2_APAT3_7	12231142_C2_APAT3_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.02	0.03	0.04	0.03	0.07	0.08	0.07	0.05	0.05	0.03	0.03	0.05	0.08	0.03	0.06	0.03	0.04	n.d.	0.06	0.02
Al2O3(Mass%)	n.d.	0.02	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	0.01	n.d.	n.d.	0.01	n.d.	0.02	n.d.
FeO(Mass%)	0.07	0.08	0.07	0.10	0.11	0.05	0.06	0.10	0.05	0.09	0.12	0.12	0.07	0.08	0.07	n.d.	0.02	0.02	0.02	0.10
MnO(Mass%)	0.01	0.03	0.04	0.05	0.05	0.03	n.d.	0.05	0.01	0.02	0.04	0.03	0.05	n.d.	0.03	0.03	n.d.	0.01	0.02	0.04
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.07	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	53.60	53.83	54.30	53.69	54.02	54.45	54.38	53.96	53.88	54.60	54.09	54.67	54.20	54.48	54.61	54.64	54.39	54.41	54.77	54.30
BaO(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	0.03	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SrO(Mass%)	0.23	0.24	0.22	0.24	0.23	0.25	0.23	0.20	0.22	0.19	0.26	0.24	0.25	0.27	0.18	0.29	0.22	0.22	0.19	0.20
Na2O(Mass%)	0.21	0.17	0.14	0.26	0.22	0.14	0.19	0.30	0.25	0.11	0.30	0.17	0.17	0.28	0.12	0.13	0.09	0.15	0.09	0.24
P2O5(Mass%)	40.33	40.59	40.99	40.65	40.53	41.15	40.85	40.06	40.78	40.97	41.01	40.99	40.45	40.46	40.77	41.35	40.99	41.00	41.29	40.57
La2O3(Mass%)	0.01	0.04	0.01	n.d.	0.01	0.01	n.d.	n.d.	0.04	n.d.	n.d.	n.d.	0.04	0.02	0.03	0.02	0.01	n.d.	0.01	0.01
Ce2O3(Mass%)	0.08	0.14	0.13	0.08	0.12	0.10	0.12	0.11	0.07	0.15	0.15	0.09	0.15	0.12	0.16	0.18	0.17	0.17	0.17	0.09
Pr2O3(Mass%)	n.d.	n.d.	n.d.	0.08	0.07	0.03	n.d.	0.04	n.d.	0.01	0.01	n.d.	0.04	n.d.	n.d.	0.04	0.05	0.04	0.05	n.d.
Nd2O3(Mass%)	0.16	0.07	0.07	0.04	n.d.	n.d.	0.02	0.03	0.02	0.14	n.d.	0.10	0.05	0.02	0.06	0.05	0.08	n.d.	0.12	0.07
Sm2O3(Mass%)	n.d.	n.d.	n.d.	0.07	n.d.	n.d.	n.d.	0.05	0.01	0.02	n.d.	0.03	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	0.02
LREE	0.25	0.24	0.22	0.27	0.20	0.14	0.13	0.22	0.15	0.31	0.16	0.21	0.29	0.16	0.25	0.28	0.30	0.21	0.39	0.20
Y2O3(Mass%)	n.d.	0.03	n.d.	0.01	n.d.	0.01	0.04	0.02	0.02	0.03	0.04	0.01	n.d.	0.03	0.03	0.01	0.02	0.01	0.02	n.d.
SO3(Mass%)	0.07	0.03	0.03	0.05	0.03	0.01	0.05	0.04	0.07	0.02	0.01	n.d.	0.08	0.08	0.02	n.d.	n.d.	0.01	0.02	0.04
F(Mass%)	0.43	1.53	0.64	1.00	1.39	0.98	0.70	0.91	0.76	1.24	0.76	1.12	1.39	1.13	1.63	1.12	0.60	1.35	0.52	1.01
Cl(Mass%)	0.01	n.d.	n.d.	0.01	0.02	n.d.	n.d.	0.03	0.02	n.d.	0.02	n.d.	0.01	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.
TOTAL	95.23	96.83	96.69	96.35	96.87	97.33	96.72	96.03	96.26	97.63	96.85	97.64	97.05	97.02	97.77	97.87	96.68	97.39	97.42	96.74
F=O	-0.18	-0.64	-0.27	-0.42	-0.59	-0.41	-0.30	-0.38	-0.32	-0.52	-0.32	-0.47	-0.59	-0.47	-0.69	-0.47	-0.25	-0.57	-0.22	-0.43
Cl=O	0.00	n.d.	n.d.	0.00	0.00	n.d.	n.d.	-0.01	0.00	n.d.	0.00	n.d.	0.00	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.
TOTAL	95.05	96.19	96.42	95.92	96.28	96.92	96.43	95.65	95.94	97.11	96.52	97.17	96.46	96.54	97.08	97.40	96.43	96.83	97.20	96.31

AMOSTRA	12231142_C1_APAT1_3	12231142_C1_APAT1_4	12231142_C1_APAT1_5	12231142_C1_APAT1_6	12231142_C1_APAT1_7	12231142_C1_APAT1_8	12231142_C1_APAT1_9	12231142_C2_APAT1_1	12231142_C2_APAT1_2	12231142_C2_APAT1_3	12231142_C2_APAT2_1	12231142_C2_APAT2_2	12231142_C2_APAT3_1	12231142_C2_APAT3_2	12231142_C2_APAT3_3	12231142_C2_APAT3_4	12231142_C2_APAT3_5	12231142_C2_APAT3_6	12231142_C2_APAT3_7	12231142_C2_APAT3_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.004	0.006	0.008	0.005	0.012	0.013	0.013	0.009	0.009	0.005	0.006	0.008	0.013	0.005	0.011	0.004	0.006	n.d.	0.011	0.003
Al	0.001	0.004	n.d.	n.d.	0.001	0.004	0.002	0.001	0.001	n.d.	n.d.	0.003	0.001	0.002	n.d.	n.d.	0.002	n.d.	0.003	n.d.
Fe	0.010	0.012	0.010	0.014	0.016	0.007	0.009	0.014	0.007	0.013	0.017	0.018	0.010	0.011	0.010	0.001	0.003	0.003	0.004	0.014
Mn	0.002	0.004	0.006	0.007	0.007	0.004	0.000	0.007	0.002	0.003	0.005	0.004	0.007	0.001	0.004	0.004	0.001	0.002	0.002	0.005
Mg	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.017	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.014	10.004	10.012	9.968	10.028	9.995	10.025	10.066	9.966	10.046	9.959	10.041	10.046	10.081	10.068	10.001	10.026	10.030	10.010	10.059
Ba	n.d.	n.d.	n.d.	n.d.	0.000	0.001	n.d.	0.002	n.d.	n.d.	0.000	0.001	0.001	n.d.	n.d.	0.000	n.d.	0.000	n.d.	n.d.
Sr	0.024	0.025	0.022	0.024	0.023	0.025	0.023	0.020	0.022	0.019	0.026	0.024	0.025	0.027	0.018	0.029	0.022	0.022	0.019	0.020
Na	0.071	0.057	0.048	0.087	0.075	0.046	0.065	0.101	0.085	0.036	0.099	0.055	0.058	0.093	0.040	0.045	0.030	0.050	0.031	0.079
P	5.954	5.962	5.973	5.963	5.945	5.968	5.950	5.905	5.961	5.957	5.967	5.949	5.925	5.916	5.940	5.980	5.970	5.972	5.963	5.938
La	0.001	0.002	0.001	0.000	0.001	0.001	0.000	0.000	0.003	n.d.	n.d.	n.d.	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001
Ce	0.005	0.009	0.008	0.005	0.007	0.007	0.008	0.007	0.005	0.009	0.009	0.005	0.009	0.008	0.010	0.011	0.011	0.011	0.011	0.006
Pr	n.d.	0.000	n.d.	0.005	0.005	0.002	n.d.	0.002	n.d.	0.001	0.001	n.d.	0.003	n.d.	n.d.	0.002	0.003	0.003	0.003	n.d.
Nd	0.010	0.004	0.004	0.003	n.d.	n.d.	0.001	0.002	0.001	0.008	0.000	0.006	0.003	0.001	0.004	0.003	0.005	n.d.	0.008	0.004
Sm	n.d.	n.d.	n.d.	0.004	0.000	n.d.	n.d.	0.003	0.001	0.001	n.d.	0.002	0.001	n.d.	n.d.	n.d.	n.d.	0.000	0.002	0.002
Y	n.d.	0.003	n.d.	0.001	n.d.	0.001	0.004	0.002	0.002	0.003	0.003	0.001	0.001	0.003	0.002	0.001	0.001	0.001	0.002	0.001
S	0.009	0.004	0.004	0.007	0.004	0.001	0.007	0.005	0.009	0.003	0.001	0.001	0.010	0.010	0.002	0.001	0.001	0.002	0.002	0.005
F	0.233	0.812	0.346	0.537	0.740	0.520	0.376	0.490	0.410	0.654	0.408	0.592	0.739	0.600	0.858	0.590	0.323	0.712	0.277	0.542
Cl	0.003	0.001	n.d.	0.004	0.006	0.002	0.002	0.008	0.006	0.000	0.005	0.001	0.003	0.001	0.004	n.d.	n.d.	0.001	0.000	0.002
TOTAL	16.340	16.909	16.441	16.633	16.869	16.596	16.483	16.662	16.489	16.759	16.507	16.710	16.857	16.761	16.972	16.673	16.405	16.809	16.349	16.682

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223142_APAT_ASSOCMAG_1	1223142_APAT_ASSOCMAG_2	1223142_APAT_ASSOCMAG_4	1223142_APAT_ASSOCMAG_6	1223142_APAT_DENTROMAG_1	1223142_APAT_DENTROMAG_2	1223142_APAT_FENO_1	1223142_APAT_FENO_2	1223142_APAT_FENO_3	1223142_APAT_FENO_4	1223142_APAT_FENO_5	1223142_APAT_FENO_6	1223142_APAT_FENO_7	1223142_APAT_FENO_8	1223142_APAT_MASSA_10	1223142_APAT_MASSACENTRO_1	1223142_APAT_MASSACENTRO_2	1223142_APAT_MASSACENTRO_3
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.12	n.d.	0.00	0.05	0.01	0.00	0.02	n.d.	n.d.	n.d.	0.02	0.01	0.00	0.01	0.28	n.d.	n.d.	n.d.
Al2O3(Mass%)	0.50	0.02	n.d.	0.00	0.09	n.d.	0.13	n.d.	0.00	n.d.	n.d.	n.d.	0.01	0.01	0.02	0.01	n.d.	0.00
FeO(Mass%)	0.52	0.03	0.28	0.23	0.94	0.93	0.09	0.23	0.15	0.06	0.06	0.02	0.05	0.01	0.18	0.02	0.09	0.09
MnO(Mass%)	0.02	0.04	0.03	0.07	n.d.	0.02	0.04	0.04	0.04	0.03	0.01	0.00	0.03	0.02	0.00	0.02	0.03	0.01
MgO(Mass%)	0.09	0.04	0.07	0.19	0.08	0.02	n.d.	0.11	0.07	0.04	0.04	n.d.	0.06	n.d.	0.09	0.01	0.05	0.08
CaO(Mass%)	53.86	54.82	54.57	54.06	54.74	54.54	54.57	54.30	54.96	54.61	54.86	55.12	54.83	54.05	54.75	54.90	54.83	54.54
BaO(Mass%)	0.00	n.d.	0.02	0.01	n.d.	n.d.	0.03	0.03	0.00	n.d.	0.01	n.d.	n.d.	n.d.	0.02	n.d.	0.03	n.d.
SrO(Mass%)	0.13	0.11	0.15	0.11	0.06	0.07	0.13	0.09	0.10	0.14	0.15	0.11	0.10	0.21	0.15	0.08	0.08	0.17
Na2O(Mass%)	0.16	0.15	0.24	0.39	0.18	0.13	0.08	0.19	0.25	0.14	0.16	0.08	0.23	0.19	0.12	0.10	0.17	0.22
P2O5(Mass%)	38.91	40.79	40.91	40.43	40.61	40.97	40.67	40.80	40.94	40.54	40.77	41.02	40.57	40.88	40.41	41.12	40.91	40.60
La2O3(Mass%)	0.03	n.d.	0.00	0.05	0.04	0.07	0.05	0.01	0.03	0.05	0.02	0.01	0.03	0.08	0.01	0.03	0.02	0.01
Ce2O3(Mass%)	0.13	0.12	0.16	0.09	0.12	0.15	0.14	0.11	0.17	0.15	0.10	0.16	0.13	0.18	0.16	0.20	0.15	0.11
Pr2O3(Mass%)	0.04	0.02	0.07	n.d.	0.08	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	n.d.	n.d.	n.d.	0.10
Nd2O3(Mass%)	0.14	0.05	n.d.	n.d.	0.05	0.01	0.10	0.00	0.07	0.02	0.09	0.07	0.15	0.10	0.01	0.06	0.06	0.04
Sm2O3(Mass%)	0.06	0.05	n.d.	n.d.	0.02	0.03	n.d.	0.05	n.d.	n.d.	n.d.	n.d.	0.07	n.d.	0.03	0.07	0.02	n.d.
LREE	0.40	0.24	0.24	0.14	0.31	0.26	0.29	0.17	0.27	0.22	0.22	0.23	0.39	0.38	0.21	0.35	0.24	0.25
Y2O3(Mass%)	n.d.	n.d.	0.02	0.05	n.d.	0.01	0.05	n.d.	0.04	0.05	0.04	0.00	n.d.	0.00	0.06	0.06	0.01	0.01
SO3(Mass%)	0.02	n.d.	0.05	0.04	0.00	0.03	0.04	0.03	0.04	0.02	0.04	0.02	0.04	0.04	0.02	0.00	0.01	0.04
F(Mass%)	0.56	0.64	0.58	0.12	0.86	0.43	0.75	0.69	0.62	0.73	0.76	0.77	0.86	1.45	0.58	1.30	0.85	1.02
Cl(Mass%)	0.01	0.01	0.01	0.03	0.02	0.01	0.00	0.01	0.01	0.00	0.01	n.d.	0.01	0.01	0.00	0.00	0.01	0.01
TOTAL	95.32	96.87	97.16	95.93	97.87	97.43	96.89	96.68	97.49	96.58	97.15	97.39	97.18	97.25	96.88	97.98	97.32	97.05
F=O	-0.24	-0.27	-0.24	-0.05	-0.36	-0.18	-0.31	-0.29	-0.26	-0.31	-0.32	-0.32	-0.36	-0.61	-0.25	-0.55	-0.36	-0.43
Cl=O	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n.d.	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	95.08	96.60	96.91	95.88	97.51	97.25	96.58	96.39	97.22	96.27	96.83	97.06	96.81	96.64	96.64	97.43	96.96	96.62

AMOSTRA	1223142_APAT_ASSOCMAG_1	1223142_APAT_ASSOCMAG_2	1223142_APAT_ASSOCMAG_4	1223142_APAT_ASSOCMAG_6	1223142_APAT_DENTROMAG_1	1223142_APAT_DENTROMAG_2	1223142_APAT_FENO_1	1223142_APAT_FENO_2	1223142_APAT_FENO_3	1223142_APAT_FENO_4	1223142_APAT_FENO_5	1223142_APAT_FENO_6	1223142_APAT_FENO_7	1223142_APAT_FENO_8	1223142_APAT_MASSA_10	1223142_APAT_MASSACENTRO_1	1223142_APAT_MASSACENTRO_2	1223142_APAT_MASSACENTRO_3
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.021	n.d.	0.001	0.009	0.002	0.001	0.003	n.d.	n.d.	n.d.	0.004	0.001	0.000	0.001	0.049	n.d.	n.d.	n.d.
Al	0.104	0.003	n.d.	0.000	0.018	n.d.	0.027	n.d.	0.000	n.d.	n.d.	n.d.	0.002	0.001	0.004	0.003	n.d.	0.000
Fe	0.077	0.004	0.041	0.034	0.135	0.133	0.013	0.034	0.022	0.008	0.008	0.003	0.008	0.001	0.025	0.003	0.012	0.013
Mn	0.004	0.006	0.004	0.010	n.d.	0.004	0.005	0.006	0.006	0.004	0.002	0.001	0.004	0.003	0.001	0.003	0.004	0.001
Mg	0.023	0.009	0.018	0.050	0.020	0.005	n.d.	0.028	0.018	0.011	0.009	n.d.	0.015	n.d.	0.024	0.002	0.013	0.020
Ca	10.139	10.091	10.013	10.005	10.041	9.984	10.060	10.012	10.068	10.104	10.087	10.105	10.103	9.983	10.083	10.057	10.070	10.072
Ba	0.000	n.d.	0.001	0.000	n.d.	n.d.	0.002	0.002	0.000	n.d.	0.001	n.d.	n.d.	n.d.	0.001	n.d.	0.002	n.d.
Sr	0.013	0.011	0.015	0.011	0.006	0.007	0.013	0.009	0.010	0.014	0.015	0.011	0.010	0.021	0.015	0.008	0.008	0.017
Na	0.055	0.050	0.079	0.132	0.059	0.043	0.026	0.063	0.082	0.047	0.055	0.028	0.076	0.064	0.039	0.033	0.055	0.074
P	5.788	5.933	5.932	5.912	5.886	5.927	5.923	5.944	5.927	5.926	5.925	5.941	5.908	5.966	5.880	5.952	5.937	5.924
La	0.002	n.d.	0.000	0.003	0.003	0.004	0.003	0.001	0.002	0.003	0.002	0.001	0.002	0.005	0.000	0.002	0.001	0.001
Ce	0.008	0.008	0.010	0.006	0.007	0.010	0.009	0.007	0.011	0.009	0.007	0.010	0.008	0.011	0.010	0.012	0.009	0.007
Pr	0.003	0.001	0.004	n.d.	0.005	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.002	n.d.	n.d.	n.d.	0.006
Nd	0.009	0.003	n.d.	n.d.	0.003	0.001	0.006	0.000	0.004	0.001	0.006	0.004	0.009	0.006	0.000	0.003	0.004	0.002
Sm	0.004	0.003	n.d.	n.d.	0.001	0.002	n.d.	0.003	n.d.	n.d.	n.d.	n.d.	0.004	n.d.	0.002	0.004	0.001	n.d.
Y	n.d.	n.d.	0.002	0.004	n.d.	0.001	0.005	n.d.	0.004	0.004	0.004	0.000	n.d.	0.000	0.005	0.005	0.001	0.001
S	0.003	n.d.	0.007	0.006	0.000	0.004	0.006	0.003	0.005	0.003	0.005	0.003	0.006	0.006	0.002	0.000	0.001	0.006
F	0.308	0.341	0.310	0.063	0.456	0.228	0.400	0.370	0.331	0.393	0.406	0.410	0.459	0.764	0.314	0.684	0.455	0.544
Cl	0.003	0.002	0.003	0.009	0.004	0.003	0.001	0.002	0.003	0.001	0.002	n.d.	0.003	0.003	0.001	0.001	0.002	0.003
TOTAL	16.564	16.465	16.440	16.254	16.645	16.354	16.502	16.484	16.492	16.529	16.535	16.517	16.616	16.836	16.456	16.773	16.577	16.690

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223142_APAT_MASSACENTRO_4	1223142_APAT_MASSACENTRO_5	1223142_APAT_MASSACENTRO_6	1223142_APAT_MASSACENTRO_7	1223142_APAT_MASSACENTRO_8	1223142_APAT_MASSASSOCCARB_1	1223142_APAT_MASSASSOCCARB_2	1223142_APAT_MASSASSOCCARB_4	12231142_C2_APAT4_1	12231142_C2_APAT4_2	12231142_C2_APAT4_3	12231142_C2_APAT4_4	12231142_C2_APAT4_5	12231142_C2_APAT4_6	12231142_C2_APAT4_7	1223142_APAT_ASSOCMAG_3	1223142_APAT_ASSOCMAG_5	1223142_APAT_CASCA_1	1223142_APAT_CASCA_2	1223142_APAT_CASCA_3
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.02	0.01	0.00	0.00	0.02	0.02	0.02	0.07	0.04	0.02	0.06	0.02	0.05	0.01	0.06	n.d.	0.00	n.d.	n.d.	0.01
Al2O3(Mass%)	0.02	0.00	n.d.	0.01	0.00	0.01	0.05	1.92	0.06	0.03	0.61	0.03	0.05	0.03	0.03	0.06	0.09	0.03	0.01	0.09
FeO(Mass%)	0.09	0.07	0.04	0.03	0.03	0.04	0.06	0.10	0.11	0.24	0.14	0.17	0.18	0.30	0.26	0.17	0.41	1.01	0.16	2.53
MnO(Mass%)	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.02	n.d.	0.01	0.02	n.d.	0.03	0.00	n.d.	0.02	0.03	n.d.
MgO(Mass%)	0.08	0.01	n.d.	0.02	n.d.	0.06	0.05	0.13	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	54.78	54.73	54.97	54.93	54.77	54.48	54.43	53.03	53.81	53.88	53.61	53.80	53.82	53.86	53.94	54.35	54.16	53.28	54.55	52.65
BaO(Mass%)	0.04	0.02	0.01	n.d.	n.d.	0.01	n.d.	n.d.	0.01	0.04	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SrO(Mass%)	0.14	0.13	0.13	0.12	0.13	0.12	0.10	0.31	1.34	1.24	1.11	1.23	1.27	1.05	1.10	1.22	1.31	0.86	0.92	1.06
Na2O(Mass%)	0.21	0.09	0.11	0.10	0.11	0.23	0.18	0.12	0.10	0.24	0.07	0.14	0.07	0.17	0.12	0.03	0.07	0.18	0.22	0.06
P2O5(Mass%)	40.74	40.96	40.89	41.06	41.32	40.64	40.50	39.42	40.23	40.06	39.98	40.37	40.65	39.89	40.10	39.80	40.11	38.99	40.01	38.84
La2O3(Mass%)	0.03	0.07	0.00	0.03	0.05	0.04	n.d.	0.00	n.d.	0.01	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	0.02	n.d.	0.03	n.d.
Ce2O3(Mass%)	0.10	0.14	0.17	0.16	0.16	0.14	0.14	0.12	0.06	0.04	0.05	0.08	0.02	0.08	0.08	0.10	0.12	0.09	0.06	0.05
Pr2O3(Mass%)	n.d.	n.d.	n.d.	0.05	0.02	0.02	0.02	n.d.	0.03	n.d.	0.03	n.d.	n.d.	0.05	n.d.	n.d.	0.04	n.d.	n.d.	n.d.
Nd2O3(Mass%)	n.d.	0.04	0.01	n.d.	0.01	n.d.	0.10	0.06	0.01	0.02	0.02	0.02	n.d.	0.02	0.03	n.d.	n.d.	0.09	0.01	n.d.
Sm2O3(Mass%)	n.d.	0.08	n.d.	0.13	n.d.	0.02	0.06	0.10	n.d.	n.d.	n.d.	n.d.	0.08	0.05	n.d.	n.d.	0.00	n.d.	0.00	n.d.
LREE	0.13	0.33	0.19	0.38	0.24	0.22	0.32	0.29	0.11	0.07	0.11	0.10	0.10	0.21	0.10	0.10	0.18	0.18	0.10	0.05
Y2O3(Mass%)	n.d.	0.01	0.02	0.04	0.01	0.05	0.02	0.01	n.d.	n.d.	n.d.	0.02	0.03	0.02	n.d.	n.d.	0.00	n.d.	0.00	0.03
SO3(Mass%)	0.05	0.04	0.02	0.00	0.02	0.03	0.04	0.06	0.02	0.03	0.03	n.d.	n.d.	0.05	0.01	0.01	0.02	0.02	0.02	0.01
F(Mass%)	1.14	0.73	0.50	0.52	1.16	0.81	0.44	1.11	4.21	3.73	4.10	3.50	3.36	4.16	3.81	4.05	2.46	2.23	2.91	3.19
Cl(Mass%)	0.01	0.00	0.01	0.00	n.d.	0.01	0.01	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	0.03	0.00
TOTAL	97.46	97.16	96.91	97.24	97.83	96.77	96.25	96.62	100.07	99.60	99.84	99.38	99.63	99.76	99.57	99.79	98.81	96.81	98.95	98.53
F=O	-0.48	-0.31	-0.21	-0.22	-0.49	-0.34	-0.19	-0.47	-1.77	-1.57	-1.73	-1.47	-1.41	-1.75	-1.61	-1.70	-1.04	-0.94	-1.22	-1.34
Cl=O	0.00	0.00	0.00	0.00	n.d.	0.00	0.00	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	-0.01	0.00
TOTAL	96.98	96.85	96.70	97.02	97.34	96.42	96.06	96.16	98.30	98.03	98.11	97.91	98.21	98.01	97.97	98.08	97.77	95.87	97.72	97.18

AMOSTRA	1223142_APAT_MASSACENTRO_4	1223142_APAT_MASSACENTRO_5	1223142_APAT_MASSACENTRO_6	1223142_APAT_MASSACENTRO_7	1223142_APAT_MASSACENTRO_8	1223142_APAT_MASSASSOCCARB_1	1223142_APAT_MASSASSOCCARB_2	1223142_APAT_MASSASSOCCARB_4	12231142_C2_APAT4_1	12231142_C2_APAT4_2	12231142_C2_APAT4_3	12231142_C2_APAT4_4	12231142_C2_APAT4_5	12231142_C2_APAT4_6	12231142_C2_APAT4_7	1223142_APAT_ASSOCMAG_3	1223142_APAT_ASSOCMAG_5	1223142_APAT_CASCA_1	1223142_APAT_CASCA_2	1223142_APAT_CASCA_3
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.003	0.001	0.001	0.001	0.003	0.003	0.003	0.012	0.008	0.003	0.010	0.004	0.008	0.002	0.011	n.d.	0.001	n.d.	n.d.	0.002
Al	0.003	0.000	n.d.	0.002	0.001	0.002	0.009	0.391	0.013	0.006	0.124	0.005	0.011	0.006	0.007	0.013	0.018	0.007	0.002	0.019
Fe	0.014	0.010	0.006	0.005	0.004	0.006	0.008	0.015	0.016	0.035	0.021	0.024	0.026	0.044	0.038	0.025	0.059	0.150	0.024	0.374
Mn	0.003	0.004	0.004	0.004	0.002	0.005	0.005	0.004	0.003	0.003	n.d.	0.002	0.004	0.001	0.004	0.000	n.d.	0.003	0.004	n.d.
Mg	0.021	0.002	n.d.	0.004	n.d.	0.016	0.014	0.033	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	10.079	10.050	10.100	10.061	10.009	10.056	10.067	9.819	10.020	10.045	9.973	10.008	9.968	10.074	10.062	10.158	10.051	10.104	10.143	9.961
Ba	0.003	0.001	0.001	n.d.	n.d.	0.000	n.d.	n.d.	0.001	0.003	0.002	n.d.	0.001	0.000	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sr	0.014	0.013	0.013	0.012	0.012	0.012	0.010	0.032	0.135	0.125	0.111	0.124	0.128	0.107	0.111	0.124	0.131	0.088	0.092	0.109
Na	0.071	0.030	0.035	0.033	0.037	0.076	0.061	0.041	0.034	0.082	0.024	0.049	0.024	0.057	0.042	0.012	0.023	0.062	0.075	0.022
P	5.923	5.944	5.936	5.943	5.967	5.927	5.919	5.767	5.920	5.902	5.877	5.933	5.948	5.895	5.910	5.878	5.883	5.843	5.878	5.806
La	0.002	0.004	0.000	0.002	0.003	0.003	n.d.	0.000	0.000	0.001	n.d.	0.000	n.d.	0.001	n.d.	n.d.	0.001	n.d.	0.002	n.d.
Ce	0.006	0.009	0.011	0.010	0.010	0.009	0.009	0.008	0.004	0.003	0.003	0.005	0.001	0.005	0.005	0.006	0.008	0.006	0.004	0.004
Pr	n.d.	n.d.	n.d.	0.003	0.001	0.001	0.001	n.d.	0.002	0.000	0.002	n.d.	n.d.	0.003	n.d.	n.d.	0.002	n.d.	n.d.	n.d.
Nd	n.d.	0.003	0.001	n.d.	0.001	n.d.	0.006	0.004	0.001	0.001	0.002	0.001	0.000	0.002	0.002	n.d.	n.d.	0.006	0.000	n.d.
Sm	n.d.	0.005	n.d.	0.008	n.d.	0.001	0.004	0.006	0.001	0.000	n.d.	n.d.	0.005	0.003	n.d.	n.d.	n.d.	n.d.	0.000	n.d.
Y	n.d.	0.001	0.002	0.004	0.001	0.005	0.002	0.001	0.000	n.d.	0.001	0.001	0.002	0.002	0.000	n.d.	0.000	n.d.	0.000	0.003
S	0.006	0.005	0.002	0.001	0.003	0.005	0.006	0.008	0.003	0.004	0.004	0.001	n.d.	0.006	0.002	0.001	0.003	0.003	0.002	0.001
F	0.602	0.392	0.267	0.277	0.608	0.432	0.238	0.591	2.120	1.896	2.065	1.783	1.710	2.101	1.937	2.051	1.279	1.189	1.500	1.664
Cl	0.003	0.001	0.001	0.000	n.d.	0.004	0.003	0.004	0.001	n.d.	0.002	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	0.000	0.008	0.001
TOTAL	16.752	16.475	16.381	16.369	16.663	16.563	16.364	16.736	18.280	18.107	18.220	17.940	17.836	18.309	18.131	18.266	17.459	17.460	17.734	17.964

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223142_APAT_CASCA_4	1223142_APAT_CASCA_5	1223142_APAT_CASCA_6	1223142_APAT_CASCA_7	1223142_APAT_CASCA_8	1223142_APAT_MASSA_2	1223142_APAT_MASSA_3	1223142_APAT_MASSA_4	1223142_APAT_MASSA_5	1223142_APAT_MASSA_6	1223142_APAT_MASSA_7	1223142_APAT_MASSA_8	1223142_APAT_MASSABORDAPOROS_10	1223142_APAT_MASSABORDAPOROS_11	1223142_APAT_MASSABORDAPOROS_15
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	n.d.	0.01	0.01	n.d.	n.d.	0.02	0.43	0.03	0.28	0.00	0.05	0.04	0.07	0.87	n.d.
Al2O3(Mass%)	0.01	0.09	0.30	0.01	0.10	0.20	4.92	0.56	1.45	0.43	1.53	1.07	0.04	0.09	0.09
FeO(Mass%)	0.11	2.40	0.45	0.02	0.11	0.25	0.28	0.20	0.75	0.15	0.23	0.22	3.69	0.32	0.15
MnO(Mass%)	0.02	n.d.	0.00	n.d.	n.d.	0.04	0.01	0.04	0.03	0.03	0.01	0.03	0.02	0.04	0.00
MgO(Mass%)	0.27	n.d.	0.00	0.00	n.d.	0.07	0.06	0.03	0.02	n.d.	0.05	n.d.	0.01	n.d.	n.d.
CaO(Mass%)	53.58	52.71	53.76	54.16	54.76	53.54	51.05	53.57	52.60	53.75	51.36	53.32	51.95	52.49	54.45
BaO(Mass%)	n.d.	0.01	n.d.	0.04	0.00	n.d.	n.d.	0.01	0.00	n.d.	0.02	0.01	0.01	0.00	0.04
SrO(Mass%)	1.30	0.79	0.66	1.33	1.35	0.41	0.65	0.83	0.67	0.44	0.72	0.59	1.13	1.06	0.72
Na2O(Mass%)	0.07	0.13	0.19	0.02	0.02	0.34	0.25	0.16	0.18	0.21	0.28	0.18	0.08	0.13	0.18
P2O5(Mass%)	39.54	38.73	39.61	40.28	40.43	39.31	37.26	39.27	38.59	39.68	37.89	39.22	37.95	39.07	40.25
La2O3(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	0.02	n.d.	n.d.	n.d.
Ce2O3(Mass%)	0.08	0.06	0.06	0.05	0.06	0.08	0.03	0.04	0.08	0.09	0.08	0.07	0.09	0.08	0.03
Pr2O3(Mass%)	n.d.	n.d.	0.02	n.d.	0.04	n.d.	0.03	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	n.d.
Nd2O3(Mass%)	n.d.	n.d.	0.02	n.d.	0.02	0.01	0.03	n.d.	0.00	0.07	n.d.	0.04	n.d.	0.07	n.d.
Sm2O3(Mass%)	n.d.	n.d.	0.12	0.07	0.03	n.d.	0.00	n.d.	0.02	0.04	n.d.	n.d.	0.02	0.07	0.01
LREE	0.08	0.06	0.22	0.12	0.15	0.09	0.10	0.04	0.12	0.20	0.08	0.13	0.11	0.30	0.04
Y2O3(Mass%)	n.d.	0.03	0.00	0.01	0.01	0.01	0.05	0.00	0.00	0.02	0.01	n.d.	0.01	n.d.	n.d.
SO3(Mass%)	0.02	0.01	0.03	n.d.	n.d.	0.10	0.04	0.03	0.05	0.06	0.14	0.05	0.00	0.03	0.02
F(Mass%)	3.13	2.34	2.57	3.73	3.62	3.03	2.17	3.02	2.08	2.76	2.62	2.88	2.34	2.52	3.23
Cl(Mass%)	n.d.	0.01	n.d.	0.01	n.d.	0.01	0.01	0.01	0.01	0.01	0.08	n.d.	0.01	0.01	n.d.
TOTAL	98.13	97.32	97.81	99.73	100.56	97.44	97.27	97.81	96.84	97.77	95.06	97.74	97.42	96.94	99.17
F=O	-1.32	-0.98	-1.08	-1.57	-1.52	-1.27	-0.91	-1.27	-0.88	-1.16	-1.10	-1.21	-0.99	-1.06	-1.36
Cl=O	n.d.	0.00	n.d.	0.00	n.d.	0.00	0.00	0.00	0.00	0.00	-0.02	n.d.	0.00	0.00	n.d.
TOTAL	96.81	96.34	96.72	98.15	99.04	96.16	96.35	96.54	95.96	96.60	93.94	96.53	96.43	95.87	97.81

AMOSTRA	1223142_APAT_CASCA_4	1223142_APAT_CASCA_5	1223142_APAT_CASCA_6	1223142_APAT_CASCA_7	1223142_APAT_CASCA_8	1223142_APAT_MASSA_2	1223142_APAT_MASSA_3	1223142_APAT_MASSA_4	1223142_APAT_MASSA_5	1223142_APAT_MASSA_6	1223142_APAT_MASSA_7	1223142_APAT_MASSA_8	1223142_APAT_MASSABORDAPOROS_10	1223142_APAT_MASSABORDAPOROS_11	1223142_APAT_MASSABORDAPOROS_15
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	n.d.	0.001	0.002	n.d.	n.d.	0.004	0.074	0.005	0.049	0.001	0.008	0.007	0.013	0.152	n.d.
Al	0.003	0.019	0.063	0.001	0.021	0.042	1.004	0.115	0.299	0.089	0.324	0.220	0.009	0.018	0.018
Fe	0.017	0.355	0.065	0.003	0.016	0.037	0.041	0.030	0.110	0.022	0.035	0.032	0.550	0.047	0.022
Mn	0.003	n.d.	0.001	n.d.	n.d.	0.007	0.001	0.005	0.004	0.005	0.001	0.005	0.003	0.006	n.d.
Mg	0.071	n.d.	0.000	0.000	n.d.	0.020	0.016	0.009	0.006	n.d.	0.014	n.d.	0.003	n.d.	n.d.
Ca	10.084	9.996	10.063	10.075	10.094	10.089	9.481	10.070	9.883	10.055	9.877	9.993	9.933	9.895	10.105
Ba	n.d.	0.001	n.d.	0.003	0.000	n.d.	n.d.	0.001	n.d.	n.d.	0.001	0.001	0.001	0.000	0.003
Sr	0.132	0.081	0.066	0.133	0.134	0.042	0.065	0.085	0.068	0.045	0.075	0.060	0.117	0.108	0.072
Na	0.022	0.044	0.065	0.006	0.008	0.116	0.084	0.055	0.063	0.072	0.097	0.060	0.027	0.045	0.060
P	5.881	5.803	5.858	5.921	5.888	5.854	5.469	5.833	5.729	5.866	5.758	5.809	5.734	5.821	5.903
La	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	n.d.	0.001	n.d.	n.d.	n.d.
Ce	0.005	0.004	0.004	0.003	0.004	0.005	0.002	0.003	0.005	0.006	0.005	0.005	0.006	0.005	0.002
Pr	n.d.	n.d.	0.001	n.d.	0.002	n.d.	0.002	0.000	n.d.	n.d.	n.d.	n.d.	n.d.	0.005	n.d.
Nd	n.d.	n.d.	0.002	n.d.	0.002	0.000	0.002	n.d.	0.000	0.004	n.d.	0.003	n.d.	0.005	n.d.
Sm	n.d.	n.d.	0.007	0.004	0.002	n.d.	0.000	n.d.	0.001	0.003	n.d.	n.d.	0.001	0.004	0.000
Y	n.d.	0.003	0.000	0.001	0.001	0.001	0.005	0.000	0.000	0.002	0.001	n.d.	0.001	n.d.	n.d.
S	0.003	0.002	0.004	n.d.	n.d.	0.013	0.005	0.004	0.007	0.008	0.019	0.006	0.000	0.005	0.002
F	1.626	1.243	1.345	1.892	1.825	1.576	1.136	1.570	1.104	1.438	1.400	1.498	1.256	1.328	1.652
Cl	n.d.	0.001	n.d.	0.002	n.d.	0.003	0.002	0.002	0.002	0.002	0.023	n.d.	0.002	0.003	n.d.
TOTAL	17.846	17.555	17.546	18.045	17.997	17.810	17.389	17.787	17.333	17.617	17.638	17.699	17.656	17.447	17.839

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1223142_APAT_MASSABORDAPOROS_16	1223142_APAT_MASSABORDAPOROS_17	1223142_APAT_MASSABORDAPOROS_18	1234061_APAT_CAVIDADE_1	1234061_APAT_CAVIDADE_2	1234061_APAT_CAVIDADE_3	1234061_APAT_CAVIDADE_4	1234061_APAT_CAVIDADE_5	1234061_APAT_CAVIDADE_6	1234061_APAT_CAVIDADE_7	1234061_APAT_CAVIDADE_8	1234061_APAT_COLOF_1	1234061_APAT_COLOF_10	1234061_APAT_COLOF_11	1234061_APAT_COLOF_12	1234061_APAT_COLOF_13	1234061_APAT_COLOF_14	1234061_APAT_COLOF_15	1234061_APAT_COLOF_16	1234061_APAT_COLOF_17
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.00	0.01	0.02	0.03	0.08	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.01	n.d.	n.d.
Al2O3(Mass%)	0.43	0.33	0.15	1.64	4.91	1.11	0.62	0.04	0.04	0.13	0.04	0.35	0.02	0.20	0.03	0.20	1.85	3.67	1.02	0.00
FeO(Mass%)	0.48	0.20	0.08	0.45	0.39	0.39	0.42	1.34	0.12	0.42	0.14	0.40	0.17	0.64	0.12	0.41	0.45	0.31	0.15	0.47
MnO(Mass%)	0.01	0.02	0.02	0.16	0.13	0.09	0.16	0.11	0.13	0.13	0.14	0.10	0.10	0.12	0.14	0.15	0.21	0.09	0.08	0.15
MgO(Mass%)	0.00	0.01	0.00	0.02	0.02	0.00	0.04	0.01	0.05	0.00	0.04	n.d.	0.01	n.d.	0.05	0.03	0.10	0.05	n.d.	0.05
CaO(Mass%)	53.37	54.23	54.31	50.63	49.13	51.44	50.53	50.92	50.37	50.54	50.59	51.36	51.15	51.35	51.03	50.98	50.35	50.60	51.04	51.69
BaO(Mass%)	0.01	n.d.	n.d.	0.05	n.d.	n.d.	n.d.	0.01	0.04	0.04	0.03	0.00	0.06	0.05	0.05	0.02	0.05	0.06	n.d.	n.d.
SrO(Mass%)	0.74	0.66	0.82	1.56	1.60	1.57	1.73	1.57	1.76	1.68	1.74	1.62	1.72	1.72	1.66	1.64	1.56	1.56	1.69	1.60
Na2O(Mass%)	0.20	0.21	0.12	0.73	0.80	0.75	0.93	0.86	0.94	0.97	0.97	0.99	0.95	0.83	0.90	0.86	0.84	0.76	0.87	0.84
P2O5(Mass%)	39.48	39.39	40.04	37.91	36.71	38.29	37.87	37.82	37.92	37.41	38.04	38.42	38.09	38.53	38.13	38.23	37.71	37.35	37.98	38.25
La2O3(Mass%)	n.d.	0.01	0.03	0.10	0.07	0.10	0.16	0.17	0.18	0.23	0.16	0.10	0.06	0.09	0.09	0.12	0.04	0.05	0.13	0.12
Ce2O3(Mass%)	0.05	0.08	0.08	0.30	0.29	0.31	0.45	0.38	0.51	0.60	0.43	0.34	0.31	0.26	0.34	0.29	0.24	0.18	0.27	0.31
Pr2O3(Mass%)	0.02	0.04	0.01	n.d.	n.d.	n.d.	n.d.	0.10	0.00	0.01	n.d.	n.d.	n.d.	n.d.	0.04	n.d.	n.d.	n.d.	0.00	0.01
Nd2O3(Mass%)	n.d.	0.01	n.d.	0.05	0.06	0.13	0.28	0.15	0.41	0.26	0.18	0.06	0.03	0.08	0.07	0.16	0.06	0.06	0.04	0.09
Sm2O3(Mass%)	n.d.	0.09	n.d.	n.d.	0.02	n.d.	0.10	0.01	0.07	0.05	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	0.02	0.08	n.d.	0.06
LREE	0.08	0.23	0.13	0.45	0.43	0.54	0.99	0.81	1.17	1.15	0.77	0.49	0.40	0.43	0.54	0.58	0.35	0.38	0.44	0.59
Y2O3(Mass%)	0.01	0.03	n.d.	0.03	0.02	0.06	0.04	0.05	0.02	0.03	0.04	0.03	0.02	0.04	0.02	0.04	n.d.	0.02	0.06	0.06
SO3(Mass%)	0.05	0.07	0.03	0.03	0.04	0.07	0.06	0.03	0.06	0.06	0.04	0.09	0.07	0.05	0.03	0.07	0.05	0.13	0.09	0.07
F(Mass%)	2.68	3.55	3.37	1.47	1.36	1.90	1.32	1.67	1.54	1.05	2.22	1.34	1.64	1.26	1.70	1.91	2.06	1.19	1.70	1.98
Cl(Mass%)	0.00	n.d.	0.00	n.d.	n.d.	n.d.	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00
TOTAL	97.54	98.93	99.08	95.18	95.64	96.22	94.73	95.24	94.17	93.63	94.81	95.20	94.43	95.21	94.40	95.14	95.60	96.17	95.12	95.76
F=O	-1.13	-1.49	-1.42	-0.62	-0.57	-0.80	-0.56	-0.70	-0.65	-0.44	-0.94	-0.56	-0.69	-0.53	-0.71	-0.81	-0.87	-0.50	-0.72	-0.83
Cl=O	0.00	n.d.	0.00	n.d.	n.d.	n.d.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	96.41	97.44	97.66	94.56	95.06	95.42	94.17	94.53	93.52	93.18	93.87	94.63	93.73	94.69	93.68	94.33	94.72	95.67	94.40	94.93

AMOSTRA	1223142_APAT_MASSABORDAPOROS_16	1223142_APAT_MASSABORDAPOROS_17	1223142_APAT_MASSABORDAPOROS_18	1234061_APAT_CAVIDADE_1	1234061_APAT_CAVIDADE_2	1234061_APAT_CAVIDADE_3	1234061_APAT_CAVIDADE_4	1234061_APAT_CAVIDADE_5	1234061_APAT_CAVIDADE_6	1234061_APAT_CAVIDADE_7	1234061_APAT_CAVIDADE_8	1234061_APAT_COLOF_1	1234061_APAT_COLOF_10	1234061_APAT_COLOF_11	1234061_APAT_COLOF_12	1234061_APAT_COLOF_13	1234061_APAT_COLOF_14	1234061_APAT_COLOF_15	1234061_APAT_COLOF_16	1234061_APAT_COLOF_17
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.000	0.002	0.003	0.006	0.015	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	0.002	n.d.	n.d.
Al	0.088	0.069	0.030	0.346	1.021	0.234	0.133	0.008	0.009	0.029	0.008	0.074	0.005	0.042	0.007	0.044	0.389	0.759	0.215	0.001
Fe	0.070	0.029	0.012	0.068	0.057	0.058	0.064	0.202	0.018	0.064	0.021	0.060	0.026	0.096	0.018	0.062	0.068	0.045	0.023	0.071
Mn	0.002	0.003	0.002	0.025	0.020	0.014	0.024	0.017	0.020	0.020	0.022	0.015	0.016	0.019	0.021	0.023	0.032	0.013	0.012	0.023
Mg	0.000	0.002	0.000	0.006	0.006	n.d.	0.012	0.002	0.013	0.001	0.011	n.d.	0.002	n.d.	0.015	0.008	0.025	0.012	n.d.	0.012
Ca	10.021	10.146	10.110	9.690	9.288	9.803	9.776	9.872	9.829	9.905	9.858	9.845	9.932	9.847	9.911	9.857	9.650	9.524	9.814	9.949
Ba	0.000	n.d.	n.d.	0.003	n.d.	n.d.	n.d.	0.001	0.003	0.003	0.002	0.000	0.004	0.004	0.004	0.002	0.004	0.004	n.d.	n.d.
Sr	0.075	0.067	0.082	0.162	0.164	0.162	0.181	0.165	0.186	0.178	0.184	0.169	0.181	0.179	0.175	0.172	0.162	0.159	0.176	0.167
Na	0.069	0.070	0.040	0.252	0.275	0.260	0.325	0.302	0.331	0.343	0.341	0.342	0.332	0.288	0.315	0.302	0.292	0.258	0.303	0.294
P	5.858	5.823	5.889	5.733	5.484	5.766	5.790	5.794	5.848	5.793	5.858	5.820	5.843	5.839	5.852	5.840	5.711	5.556	5.771	5.818
La	n.d.	0.001	0.002	0.006	0.004	0.007	0.011	0.011	0.012	0.015	0.011	0.006	0.004	0.006	0.006	0.008	0.003	0.004	0.009	0.008
Ce	0.004	0.005	0.005	0.020	0.019	0.020	0.030	0.025	0.034	0.040	0.029	0.022	0.020	0.017	0.023	0.019	0.015	0.012	0.017	0.020
Pr	0.002	0.002	0.001	n.d.	n.d.	n.d.	n.d.	0.007	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	0.003	n.d.	n.d.	n.d.	0.000	0.000
Nd	n.d.	0.001	n.d.	0.004	0.004	0.008	0.018	0.010	0.027	0.017	0.012	0.004	0.002	0.005	0.005	0.011	0.004	0.004	0.003	0.006
Sm	n.d.	0.006	n.d.	n.d.	0.001	n.d.	0.006	0.001	0.004	0.003	n.d.	n.d.	n.d.	0.000	n.d.	n.d.	0.001	0.005	n.d.	0.004
Y	0.001	0.003	n.d.	0.003	0.002	0.005	0.004	0.005	0.002	0.003	0.004	0.003	0.002	0.004	0.002	0.004	n.d.	0.002	0.006	0.006
S	0.006	0.010	0.004	0.004	0.005	0.010	0.008	0.004	0.009	0.008	0.006	0.013	0.010	0.007	0.004	0.010	0.007	0.018	0.012	0.010
F	1.402	1.816	1.725	0.805	0.739	1.023	0.734	0.920	0.854	0.595	1.216	0.734	0.907	0.691	0.936	1.046	1.116	0.644	0.931	1.076
Cl	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	0.002	0.001	0.003	0.004	0.002	0.001	0.003	0.001	0.001	0.003	0.003	0.002	0.001	n.d.
TOTAL	17.599	18.054	17.905	17.132	17.102	17.369	17.117	17.345	17.203	17.021	17.583	17.106	17.291	17.043	17.296	17.409	17.483	17.023	17.291	17.465

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1234061_APAT_COLOF_18	1234061_APAT_COLOF_19	1234061_APAT_COLOF_2	1234061_APAT_COLOF_20	1234061_APAT_COLOF_21	1234061_APAT_COLOF_22	1234061_APAT_COLOF_23	1234061_APAT_COLOF_24	1234061_APAT_COLOF_25	1234061_APAT_COLOF_26	1234061_APAT_COLOF_27	1234061_APAT_COLOF_28	1234061_APAT_COLOF_29	1234061_APAT_COLOF_3	1234061_APAT_COLOF_30	1234061_APAT_COLOF_31	1234061_APAT_COLOF_32	1234061_APAT_COLOF_33	1234061_APAT_COLOF_34	1234061_APAT_COLOF_4
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	n.d.	0.05	0.11	n.d.	0.05	n.d.	0.06	0.01	0.00	0.04	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	0.01	n.d.	n.d.	n.d.
Al2O3(Mass%)	0.74	2.50	5.97	0.03	4.99	n.d.	0.06	0.03	0.09	0.04	0.23	0.01	0.68	0.17	0.04	0.03	0.03	0.03	0.04	0.27
FeO(Mass%)	0.85	0.62	0.43	0.17	0.59	0.15	0.19	0.06	0.53	0.72	0.18	0.36	0.04	0.48	0.18	0.08	0.32	0.28	0.23	0.33
MnO(Mass%)	0.17	0.19	0.11	0.13	0.11	0.06	0.09	0.09	0.07	0.09	0.10	0.24	0.11	0.12	0.15	0.08	0.08	0.08	0.06	0.10
MgO(Mass%)	0.04	0.08	0.27	0.02	0.05	0.02	0.05	n.d.	0.00	n.d.	0.01	0.13	0.01	0.03	0.02	0.02	n.d.	0.02	n.d.	0.01
CaO(Mass%)	50.21	49.68	48.14	51.66	48.41	52.78	52.20	52.05	52.52	52.23	51.93	51.46	52.28	50.77	51.91	52.49	52.37	52.01	52.12	51.13
BaO(Mass%)	0.04	0.09	0.03	0.03	0.02	0.06	0.12	0.06	0.05	0.05	n.d.	0.08	0.03	0.00	0.05	0.03	0.05	0.10	0.09	0.04
SrO(Mass%)	1.68	1.87	1.61	1.55	1.38	1.35	1.37	1.36	1.38	1.25	1.71	1.97	1.90	1.70	1.80	1.45	1.40	1.48	1.53	1.79
Na2O(Mass%)	1.02	0.87	0.68	0.83	0.83	0.39	0.50	0.51	0.44	0.43	0.50	0.73	0.43	0.71	0.66	0.57	0.46	0.51	0.55	0.80
P2O5(Mass%)	37.69	37.60	36.04	38.38	36.34	38.92	38.77	39.01	39.08	38.57	39.14	38.90	38.60	38.08	38.84	38.77	38.88	38.41	38.40	38.27
La2O3(Mass%)	0.15	0.07	0.06	0.06	0.06	n.d.	n.d.	n.d.	0.00	n.d.	0.01	0.03	0.02	0.05	0.01	0.02	n.d.	0.02	0.01	0.07
Ce2O3(Mass%)	0.39	0.31	0.29	0.25	0.19	0.06	0.09	0.12	0.12	0.09	0.11	0.17	0.20	0.19	0.09	0.09	0.13	0.12	0.11	0.24
Pr2O3(Mass%)	0.07	n.d.	0.02	n.d.	n.d.	0.01	n.d.	0.00	n.d.	n.d.	0.04	0.01	n.d.	0.01	0.02	0.03	n.d.	n.d.	0.03	n.d.
Nd2O3(Mass%)	0.26	0.06	0.11	0.01	0.04	0.03	0.01	0.06	n.d.	0.01	0.15	0.04	0.18	0.22	0.04	0.10	0.10	0.06	0.08	0.08
Sm2O3(Mass%)	0.05	0.02	0.05	n.d.	0.02	0.04	0.02	0.03	n.d.	0.01	n.d.	n.d.	0.01	n.d.	0.04	n.d.	0.04	n.d.	0.09	0.07
LREE	0.91	0.46	0.53	0.31	0.32	0.14	0.12	0.21	0.12	0.11	0.32	0.26	0.40	0.47	0.19	0.24	0.27	0.20	0.31	0.47
Y2O3(Mass%)	0.01	0.03	0.02	0.04	0.02	0.01	0.03	0.04	0.02	n.d.	0.01	0.06	0.05	0.02	0.04	0.04	0.00	0.03	0.03	0.04
SO3(Mass%)	0.06	0.04	0.04	0.03	0.04	0.10	0.15	0.07	0.15	0.09	0.08	0.02	0.06	0.07	0.11	0.11	0.08	0.14	0.10	0.07
F(Mass%)	2.21	1.70	1.62	2.56	2.03	1.43	2.13	1.64	0.58	1.21	0.55	1.94	1.21	1.84	0.64	1.33	1.22	1.23	1.44	1.18
Cl(Mass%)	0.01	0.00	n.d.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00	n.d.	0.01	n.d.	0.01	0.00	n.d.
TOTAL	95.65	95.79	95.58	95.76	95.19	95.40	95.85	95.14	95.04	94.83	94.78	96.16	95.81	94.47	94.64	95.30	95.18	94.54	94.89	94.50
F=O	-0.93	-0.72	-0.68	-1.08	-0.86	-0.60	-0.90	-0.69	-0.24	-0.51	-0.23	-0.82	-0.51	-0.77	-0.27	-0.56	-0.51	-0.52	-0.61	-0.49
Cl=O	0.00	0.00	n.d.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n.d.	0.00	n.d.	0.00	0.00	n.d.
TOTAL	94.71	95.07	94.90	94.68	94.34	94.80	94.95	94.45	94.80	94.32	94.55	95.34	95.30	93.69	94.37	94.74	94.66	94.02	94.28	94.01

AMOSTRA	1234061_APAT_COLOF_18	1234061_APAT_COLOF_19	1234061_APAT_COLOF_2	1234061_APAT_COLOF_20	1234061_APAT_COLOF_21	1234061_APAT_COLOF_22	1234061_APAT_COLOF_23	1234061_APAT_COLOF_24	1234061_APAT_COLOF_25	1234061_APAT_COLOF_26	1234061_APAT_COLOF_27	1234061_APAT_COLOF_28	1234061_APAT_COLOF_29	1234061_APAT_COLOF_3	1234061_APAT_COLOF_30	1234061_APAT_COLOF_31	1234061_APAT_COLOF_32	1234061_APAT_COLOF_33	1234061_APAT_COLOF_34	1234061_APAT_COLOF_4
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	n.d.	0.009	0.019	n.d.	0.009	n.d.	0.010	0.001	0.001	0.007	n.d.	n.d.	n.d.	n.d.	n.d.	0.008	0.002	n.d.	n.d.	n.d.
Al	0.157	0.525	1.242	0.006	1.049	n.d.	0.013	0.006	0.018	0.009	0.049	0.002	0.141	0.037	0.009	0.006	0.006	0.007	0.008	0.057
Fe	0.128	0.092	0.064	0.025	0.088	0.022	0.028	0.009	0.078	0.108	0.027	0.054	0.006	0.073	0.027	0.012	0.048	0.042	0.035	0.050
Mn	0.026	0.029	0.016	0.020	0.017	0.009	0.014	0.014	0.011	0.013	0.016	0.036	0.017	0.018	0.023	0.012	0.013	0.012	0.010	0.015
Mg	0.011	0.022	0.071	0.006	0.014	0.004	0.013	n.d.	0.001	n.d.	0.003	0.034	0.003	0.007	0.006	0.006	n.d.	0.005	n.d.	0.004
Ca	9.717	9.476	9.115	9.970	9.244	10.056	9.968	9.950	9.963	10.008	9.874	9.833	9.941	9.860	9.918	10.015	9.993	10.011	10.027	9.864
Ba	0.003	0.006	0.002	0.002	0.001	0.004	0.009	0.004	0.004	0.003	n.d.	0.006	0.002	0.000	0.004	0.002	0.003	0.007	0.006	0.003
Sr	0.176	0.193	0.165	0.162	0.143	0.139	0.142	0.141	0.141	0.130	0.176	0.203	0.195	0.179	0.187	0.150	0.145	0.154	0.159	0.187
Na	0.359	0.300	0.232	0.291	0.287	0.133	0.171	0.176	0.151	0.149	0.173	0.254	0.147	0.250	0.230	0.196	0.159	0.177	0.190	0.279
P	5.764	5.667	5.391	5.854	5.484	5.860	5.852	5.892	5.858	5.840	5.881	5.874	5.799	5.844	5.864	5.845	5.863	5.843	5.836	5.835
La	0.010	0.005	0.004	0.004	0.004	n.d.	n.d.	n.d.	0.000	n.d.	0.001	0.002	0.001	0.003	0.001	0.001	n.d.	0.001	0.001	0.005
Ce	0.026	0.020	0.019	0.016	0.013	0.004	0.006	0.008	0.008	0.006	0.007	0.011	0.013	0.013	0.006	0.006	0.009	0.008	0.007	0.016
Pr	0.004	n.d.	0.002	n.d.	n.d.	0.001	n.d.	0.000	n.d.	n.d.	0.003	0.001	n.d.	0.001	0.001	0.002	n.d.	n.d.	0.002	n.d.
Nd	0.017	0.004	0.007	0.001	0.003	0.002	0.000	0.004	n.d.	0.000	0.010	0.003	0.011	0.014	0.003	0.007	0.006	0.004	0.005	0.005
Sm	0.003	0.001	0.003	n.d.	0.001	0.002	0.001	0.002	n.d.	0.001	n.d.	n.d.	0.001	n.d.	0.002	n.d.	0.002	n.d.	0.006	0.005
Y	0.001	0.003	0.002	0.004	0.002	0.001	0.003	0.003	0.002	n.d.	0.001	0.005	0.005	0.002	0.004	0.004	n.d.	0.003	0.003	0.004
S	0.008	0.005	0.006	0.005	0.006	0.013	0.021	0.009	0.020	0.012	0.010	0.003	0.009	0.010	0.015	0.015	0.011	0.019	0.014	0.010
F	1.200	0.923	0.872	1.379	1.095	0.779	1.144	0.894	0.321	0.665	0.306	1.048	0.661	1.010	0.353	0.727	0.669	0.682	0.793	0.652
Cl	0.004	0.001	n.d.	0.002	0.002	0.004	0.004	0.003	0.002	0.003	0.001	0.002	0.002	0.001	n.d.	0.002	n.d.	0.002	0.000	n.d.
TOTAL	17.614	17.281	17.231	17.744	17.461	17.033	17.399	17.116	16.578	16.954	16.537	17.369	16.955	17.321	16.650	17.015	16.928	16.977	17.100	16.988

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1234061_APAT_COLOF_5	1234061_APAT_COLOF_7	1234061_APAT_COLOF_8	1234061_APAT_COLOF_9	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C2_APAT1_1	1234061_C2_APAT1_2	1234061_C2_APAT1_3	1234061_C2_APAT1_4	1234061_C2_APAT1_5
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.07	n.d.	0.25	0.01	0.02	0.04	0.07	0.04	0.06	0.02	0.07	0.03	5.15	0.03	0.04	0.04	0.03	0.04	0.09	0.04
Al2O3(Mass%)	0.35	0.08	2.29	1.40	0.02	0.02	0.76	0.11	0.02	0.03	0.07	0.10	0.02	0.02	0.06	n.d.	n.d.	0.03	1.88	0.19
FeO(Mass%)	0.37	0.28	0.42	0.45	0.56	0.36	0.50	0.11	0.11	0.51	0.18	0.10	0.39	0.15	0.34	0.46	0.47	0.68	0.59	1.49
MnO(Mass%)	0.12	0.08	0.12	0.10	0.13	0.15	0.16	0.13	0.13	0.15	0.09	0.10	0.09	0.08	0.11	0.15	0.23	0.34	0.12	0.07
MgO(Mass%)	0.04	0.03	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO(Mass%)	51.03	51.51	50.27	50.72	50.92	50.34	51.02	52.36	52.08	51.37	52.51	51.98	49.73	52.33	51.93	50.59	52.04	50.76	49.28	50.89
BaO(Mass%)	0.01	0.04	0.03	0.04	n.d.	0.02	0.04	0.01	n.d.	n.d.	0.05	0.03	0.06	n.d.	0.02	n.d.	0.02	0.13	0.05	0.05
SrO(Mass%)	1.78	1.55	1.64	1.71	1.46	1.87	1.81	1.98	1.64	1.81	1.65	1.60	1.55	1.51	1.78	1.72	1.51	1.58	1.73	1.73
Na2O(Mass%)	0.75	0.74	0.88	0.93	1.21	0.68	0.58	0.52	0.56	0.79	0.49	0.49	0.45	0.48	0.67	0.99	0.79	0.74	0.92	0.92
P2O5(Mass%)	37.95	38.05	37.78	37.99	37.68	37.79	38.40	39.25	38.90	38.87	39.50	39.52	37.50	39.18	38.99	38.41	38.73	38.52	37.37	38.32
La2O3(Mass%)	0.06	0.10	0.07	0.08	n.d.	0.03	0.08	0.01	0.01	0.05	0.01	0.03	0.03	0.02	n.d.	0.10	0.07	0.08	0.10	0.11
Ce2O3(Mass%)	0.28	0.34	0.25	0.27	0.09	0.12	0.23	0.14	0.12	0.21	0.07	0.13	0.09	0.06	0.13	0.32	0.27	0.43	0.43	0.33
Pr2O3(Mass%)	0.08	n.d.	n.d.	n.d.	n.d.	0.01	0.03	n.d.	n.d.	0.07	n.d.	n.d.	n.d.	0.09	n.d.	0.05	n.d.	0.09	n.d.	0.02
Nd2O3(Mass%)	0.14	0.07	0.09	0.10	0.03	n.d.	0.06	0.10	0.02	0.01	0.04	n.d.	n.d.	n.d.	0.05	0.10	0.12	0.22	0.15	0.21
Sm2O3(Mass%)	0.06	n.d.	0.06	0.03	n.d.	0.04	n.d.	0.02	n.d.	0.07	0.02	0.02	n.d.	0.07	n.d.	0.01	n.d.	0.02	0.09	n.d.
LREE	0.62	0.51	0.47	0.48	0.12	0.20	0.39	0.27	0.15	0.41	0.14	0.18	0.12	0.24	0.18	0.59	0.46	0.83	0.76	0.67
Y2O3(Mass%)	0.03	0.03	0.02	0.04	n.d.	0.03	0.02	0.03	n.d.	0.04	0.04	0.03	0.02	0.01	0.07	0.05	0.06	0.04	0.05	0.06
SO3(Mass%)	0.05	0.06	0.04	0.07	0.03	0.03	0.09	0.03	0.06	0.05	0.13	0.08	0.07	0.05	0.07	0.09	0.05	0.07	0.06	0.05
F(Mass%)	2.21	0.72	1.95	2.14	1.75	0.37	0.97	1.33	0.12	1.72	0.52	0.67	1.29	0.31	2.02	1.88	2.47	1.38	2.60	3.05
Cl(Mass%)	0.01	0.01	0.00	0.01	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.01	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	0.01
TOTAL	95.40	93.70	96.18	96.08	93.93	91.88	94.80	96.18	93.82	95.78	95.45	94.93	96.47	94.41	96.30	94.97	96.84	95.18	95.55	97.55
F=O	-0.93	-0.30	-0.82	-0.90	-0.74	-0.15	-0.41	-0.56	-0.05	-0.72	-0.22	-0.28	-0.54	-0.13	-0.85	-0.79	-1.04	-0.58	-1.09	-1.29
Cl=O	0.00	0.00	0.00	0.00	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	0.00	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	-0.01	0.00
TOTAL	94.46	93.40	95.35	95.18	93.18	91.73	94.39	95.62	93.77	95.06	95.23	94.65	95.92	94.28	95.45	94.18	95.80	94.60	94.45	96.26

AMOSTRA	1234061_APAT_COLOF_5	1234061_APAT_COLOF_7	1234061_APAT_COLOF_8	1234061_APAT_COLOF_9	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C1_APAT1	1234061_C2_APAT1_1	1234061_C2_APAT1_2	1234061_C2_APAT1_3	1234061_C2_APAT1_4	1234061_C2_APAT1_5
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.013	n.d.	0.044	0.002	0.003	0.007	0.012	0.007	0.011	0.003	0.012	0.005	0.890	0.006	0.007	0.008	0.005	0.008	0.016	0.008
Al	0.074	0.018	0.478	0.296	0.005	0.004	0.160	0.023	0.004	0.006	0.015	0.021	0.003	0.004	0.012	n.d.	n.d.	0.007	0.401	0.040
Fe	0.056	0.043	0.062	0.067	0.085	0.056	0.074	0.016	0.016	0.076	0.027	0.015	0.056	0.023	0.051	0.070	0.069	0.102	0.088	0.223
Mn	0.019	0.012	0.018	0.015	0.021	0.023	0.024	0.019	0.020	0.023	0.013	0.015	0.013	0.013	0.017	0.022	0.034	0.052	0.018	0.011
Mg	0.012	0.009	0.004	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ca	9.870	9.984	9.549	9.703	9.963	9.897	9.769	9.927	9.967	9.834	9.905	9.856	9.202	9.966	9.896	9.785	9.934	9.765	9.539	9.767
Ba	0.001	0.003	0.002	0.003	0.001	0.001	0.003	0.001	0.000	0.000	0.003	0.002	0.004	0.001	0.001	n.d.	0.001	0.009	0.004	0.003
Sr	0.187	0.162	0.169	0.177	0.154	0.199	0.187	0.204	0.169	0.187	0.169	0.164	0.156	0.156	0.184	0.180	0.156	0.165	0.182	0.180
Na	0.261	0.259	0.303	0.321	0.430	0.241	0.200	0.177	0.194	0.273	0.168	0.168	0.151	0.166	0.230	0.347	0.273	0.259	0.322	0.320
P	5.802	5.828	5.671	5.743	5.825	5.871	5.811	5.879	5.882	5.879	5.887	5.921	5.483	5.896	5.872	5.871	5.843	5.855	5.717	5.811
La	0.004	0.007	0.005	0.006	n.d.	0.002	0.005	0.001	0.001	0.004	0.001	0.002	0.002	0.001	n.d.	0.007	0.005	0.005	0.006	0.007
Ce	0.018	0.022	0.016	0.018	0.006	0.008	0.015	0.009	0.008	0.013	0.004	0.009	0.006	0.004	0.009	0.021	0.018	0.029	0.028	0.022
Pr	0.005	n.d.	n.d.	n.d.	0.000	0.001	0.002	0.001	n.d.	0.005	n.d.	0.001	n.d.	0.006	0.000	0.003	0.000	0.006	n.d.	0.001
Nd	0.009	0.005	0.006	0.006	0.002	n.d.	0.004	0.006	0.001	0.001	0.002	n.d.	n.d.	n.d.	0.003	0.007	0.007	0.014	0.010	0.014
Sm	0.004	n.d.	0.004	0.002	n.d.	0.002	0.000	0.001	n.d.	0.004	0.001	0.001	n.d.	0.004	n.d.	0.001	n.d.	0.001	0.006	n.d.
Y	0.003	0.003	0.002	0.004	0.001	0.003	0.002	0.003	n.d.	0.004	0.004	0.003	0.002	0.001	0.006	0.005	0.006	0.004	0.005	0.005
S	0.007	0.009	0.005	0.009	0.004	0.004	0.012	0.004	0.008	0.006	0.017	0.010	0.009	0.006	0.009	0.012	0.006	0.009	0.008	0.007
F	1.199	0.406	1.049	1.153	0.974	0.211	0.538	0.724	0.068	0.934	0.286	0.369	0.687	0.174	1.089	1.030	1.320	0.759	1.401	1.617
Cl	0.004	0.002	0.001	0.002	0.003	0.003	0.002	0.002	0.002	n.d.	0.004	0.004	0.004	0.001	0.002	0.002	n.d.	0.000	0.009	0.003
TOTAL	17.547	16.771	17.387	17.526	17.476	16.532	16.819	17.003	16.352	17.252	16.517	16.564	16.667	16.427	17.388	17.370	17.678	17.050	17.760	18.038

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1234061_C2_APAT 1_6	1234061_C2_APAT 1_7	1234061_C2_APAT 1_8	1234063_APAT_COLOFBORDA Line 004	1234063_APAT_COLOFBORDA Line 005	1234063_APAT_COLOFBORDA Line 007	1234063_APAT_COLOFBORDA Line 008	1234063_APAT_COLOFBORDA Line 009	1234063_APAT_COLOFBORDA Line 010	1234063_APAT_COLOFBORDA Line 011	1234063_APAT_COLOFBORDA Line 012	1234063_APAT_COLOFBORDA Line 013	1234063_APAT_COLOFBORDA Line 014	1234063_APAT_COLOFBORDA Line 015	1234063_APAT_COLOFBORDA Line 016	1234063_APAT_COLOFBORDA Line 017	1234063_APAT_COLOFBORDA Line 018	1234063_APAT_COLOFBORDA Line 019	1234063_APAT_COLOFBORDA Line 020
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	0.10	0.22	0.02	0.39	0.27	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	0.03	0.15
Al2O3(Mass%)	0.12	0.15	0.11	0.01	0.17	0.25	0.06	0.06	0.46	0.12	0.14	0.10	0.76	1.08	0.01	0.13	0.29	0.28	0.81
FeO(Mass%)	0.47	0.39	0.82	0.11	0.10	0.19	0.13	0.06	0.11	0.24	0.23	1.76	0.07	0.25	0.08	0.13	0.21	1.32	0.19
MnO(Mass%)	0.11	0.11	0.13	0.02	0.04	0.04	0.05	0.03	0.06	0.06	0.09	0.06	0.04	0.08	0.07	0.04	0.06	0.03	0.05
MgO(Mass%)	n.d.	n.d.	n.d.	n.d.	0.03	0.04	0.02	0.02	0.01	0.01	0.00	0.03	0.03	0.05	0.01	0.01	0.02	0.01	0.10
CaO(Mass%)	50.35	50.85	50.94	51.31	50.37	52.57	52.27	52.49	52.57	52.04	52.27	51.15	51.65	50.68	51.78	52.43	52.14	52.02	52.18
BaO(Mass%)	0.02	0.06	0.04	0.03	0.01	0.00	0.04	n.d.	0.02	0.01	0.05	0.00	0.04	n.d.	0.03	0.03	0.05	0.04	n.d.
SrO(Mass%)	1.86	1.66	1.65	2.19	2.50	1.93	2.12	2.24	2.39	2.37	1.97	2.59	2.66	3.05	2.80	2.26	2.43	2.15	2.60
Na2O(Mass%)	0.95	0.84	1.01	0.33	0.24	0.49	0.35	0.28	0.19	0.31	0.45	0.38	0.28	0.45	0.37	0.25	0.33	0.26	0.13
P2O5(Mass%)	37.99	38.74	38.77	38.15	37.46	38.30	38.34	38.55	38.43	38.36	38.66	38.23	38.48	38.32	38.86	39.17	38.71	37.98	38.71
La2O3(Mass%)	0.18	0.06	0.14	0.08	0.09	0.06	0.05	0.01	0.02	0.05	n.d.	n.d.	0.05	n.d.	0.02	0.04	0.03	n.d.	0.00
Ce2O3(Mass%)	0.47	0.31	0.39	0.30	0.34	0.24	0.14	0.11	0.11	0.16	0.06	0.08	0.13	0.13	0.13	0.16	0.21	0.13	0.12
Pr2O3(Mass%)	0.06	0.03	0.01	n.d.	0.05	0.08	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	0.05	n.d.	n.d.	n.d.	n.d.
Nd2O3(Mass%)	0.15	0.07	0.19	0.15	0.24	0.08	n.d.	0.07	0.01	0.09	n.d.	0.05	0.05	0.09	n.d.	0.04	0.08	0.09	0.01
Sm2O3(Mass%)	n.d.	0.05	0.02	0.13	0.02	n.d.	n.d.	n.d.	0.01	n.d.	0.07	n.d.	0.01	0.02	n.d.	0.02	0.02	0.05	0.04
LREE	0.85	0.52	0.75	0.66	0.75	0.46	0.19	0.22	0.15	0.30	0.12	0.13	0.23	0.27	0.20	0.26	0.34	0.27	0.18
Y2O3(Mass%)	0.03	0.06	0.04	0.05	0.00	n.d.	n.d.	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	0.03	n.d.	n.d.
SO3(Mass%)	0.03	0.06	0.05	0.01	0.06	0.01	0.02	0.06	0.06	0.06	0.04	0.04	0.03	0.02	0.02	0.04	0.03	0.03	0.02
F(Mass%)	2.74	3.19	3.15	2.62	2.74	2.48	2.65	3.04	3.31	2.16	1.40	1.43	1.71	0.30	0.92	2.39	2.34	2.36	3.37
Cl(Mass%)	n.d.	0.01	0.01	0.00	0.02	0.01	0.00	n.d.	0.01	0.00	0.00	0.02	0.02	0.00	0.01	0.00	0.00	0.01	0.00
TOTAL	95.66	96.87	97.49	95.89	94.77	96.77	96.25	97.09	97.76	96.03	95.45	95.91	96.00	94.57	95.16	97.16	97.00	96.77	98.49
F=O	-1.16	-1.35	-1.33	-1.10	-1.15	-1.04	-1.12	-1.28	-1.39	-0.91	-0.59	-0.60	-0.72	-0.13	-0.39	-1.01	-0.99	-0.99	-1.42
Cl=O	n.d.	0.00	0.00	0.00	0.00	0.00	0.00	n.d.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	94.50	95.53	96.16	94.79	93.61	95.73	95.13	95.80	96.37	95.13	94.86	95.30	95.28	94.44	94.77	96.15	96.01	95.78	97.07

AMOSTRA	1234061_C2_APAT 1_6	1234061_C2_APAT 1_7	1234061_C2_APAT 1_8	1234063_APAT_COLOFBORDA Line 004	1234063_APAT_COLOFBORDA Line 005	1234063_APAT_COLOFBORDA Line 007	1234063_APAT_COLOFBORDA Line 008	1234063_APAT_COLOFBORDA Line 009	1234063_APAT_COLOFBORDA Line 010	1234063_APAT_COLOFBORDA Line 011	1234063_APAT_COLOFBORDA Line 012	1234063_APAT_COLOFBORDA Line 013	1234063_APAT_COLOFBORDA Line 014	1234063_APAT_COLOFBORDA Line 015	1234063_APAT_COLOFBORDA Line 016	1234063_APAT_COLOFBORDA Line 017	1234063_APAT_COLOFBORDA Line 018	1234063_APAT_COLOFBORDA Line 019	1234063_APAT_COLOFBORDA Line 020
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	0.017	0.039	0.004	0.071	0.050	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.002	n.d.	n.d.	n.d.	0.005	0.026
Al	0.025	0.032	0.022	0.002	0.036	0.053	0.012	0.014	0.096	0.026	0.030	0.021	0.159	0.227	0.002	0.027	0.062	0.058	0.168
Fe	0.072	0.058	0.122	0.017	0.015	0.028	0.019	0.009	0.016	0.036	0.035	0.264	0.011	0.038	0.012	0.019	0.032	0.198	0.029
Mn	0.017	0.016	0.019	0.003	0.007	0.006	0.008	0.004	0.009	0.009	0.013	0.008	0.006	0.012	0.010	0.006	0.009	0.005	0.008
Mg	n.d.	n.d.	n.d.	n.d.	0.008	0.011	0.006	0.005	0.003	0.003	0.001	0.009	0.009	0.012	0.003	0.002	0.006	0.002	0.026
Ca	9.796	9.752	9.750	9.913	9.884	10.064	10.073	10.056	10.032	10.006	9.999	9.836	9.870	9.693	9.917	9.950	9.936	9.991	9.867
Ba	0.002	0.005	0.003	0.002	0.001	0.000	0.003	n.d.	0.002	0.001	0.004	0.000	0.003	n.d.	0.002	0.002	0.004	0.003	n.d.
Sr	0.196	0.173	0.171	0.229	0.266	0.201	0.222	0.233	0.246	0.246	0.204	0.270	0.275	0.316	0.291	0.232	0.251	0.223	0.266
Na	0.336	0.292	0.350	0.116	0.086	0.169	0.122	0.098	0.066	0.106	0.157	0.131	0.098	0.157	0.127	0.086	0.115	0.090	0.043
P	5.841	5.871	5.863	5.824	5.808	5.795	5.838	5.836	5.795	5.828	5.845	5.809	5.810	5.792	5.881	5.874	5.830	5.764	5.783
La	0.012	0.004	0.009	0.005	0.006	0.004	0.003	0.001	0.001	0.004	n.d.	n.d.	0.003	n.d.	0.001	0.003	0.002	n.d.	0.000
Ce	0.031	0.020	0.026	0.020	0.023	0.016	0.009	0.008	0.007	0.010	0.004	0.005	0.008	0.009	0.009	0.010	0.014	0.009	0.008
Pr	0.004	0.002	0.001	n.d.	0.003	0.005	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	0.002	0.003	n.d.	n.d.	n.d.	n.d.
Nd	0.010	0.004	0.012	0.010	0.016	0.005	n.d.	0.005	0.001	0.006	n.d.	0.003	0.003	0.006	n.d.	0.002	0.005	0.006	0.001
Sm	n.d.	0.003	0.001	0.008	0.001	n.d.	n.d.	n.d.	0.001	n.d.	0.004	n.d.	0.001	0.001	n.d.	0.001	0.001	0.003	0.003
Y	0.003	0.005	0.004	0.004	0.000	n.d.	n.d.	0.003	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.002	0.003	n.d.	n.d.
S	0.004	0.008	0.006	0.001	0.009	0.001	0.003	0.009	0.008	0.008	0.006	0.006	0.004	0.003	0.003	0.005	0.004	0.004	0.003
F	1.482	1.686	1.663	1.410	1.492	1.324	1.423	1.610	1.736	1.167	0.767	0.785	0.926	0.170	0.510	1.272	1.253	1.268	1.752
Cl	0.001	0.003	0.003	0.001	0.005	0.002	0.001	n.d.	0.002	0.000	0.001	0.005	0.005	0.001	0.002	0.000	0.001	0.002	0.001
TOTAL	17.849	17.974	18.029	17.637	17.717	17.684	17.741	17.890	18.020	17.457	17.070	17.152	17.189	16.440	16.771	17.495	17.525	17.629	17.982

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1234069_APAT_COLOFBORDA_10	1234069_APAT_COLOFBORDA_12	1234069_APAT_COLOFBORDA_2	1234069_APAT_COLOFBORDA_4	1234069_APAT_COLOFBORDA_5	1234069_APAT_COLOFBORDA_6	1234069_APAT_COLOFBORDA_7	1234069_APAT_COLOFBORDA_8	1234069_APAT_COLOFBORDA_9	1234069_APAT_COLOFQTZ_1	1234069_APAT_COLOFQTZ_10	1234069_APAT_COLOFQTZ_11	1234069_APAT_COLOFQTZ_12	1234069_APAT_COLOFQTZ_13	1234069_APAT_COLOFQTZ_14	1234069_APAT_COLOFQTZ_15	1234069_APAT_COLOFQTZ_16	1234069_APAT_COLOFQTZ_17	1234069_APAT_COLOFQTZ_18
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.07	0.03	n.d.	n.d.	0.04	n.d.	n.d.	0.14	n.d.	n.d.	n.d.	n.d.
Al2O3(Mass%)	0.13	0.04	0.03	n.d.	0.11	0.07	0.01	0.33	0.48	0.05	0.25	0.14	0.01	0.04	2.47	0.00	0.02	0.03	0.02
FeO(Mass%)	0.04	0.08	0.05	0.16	0.16	0.11	0.18	0.13	0.01	0.02	0.05	0.04	0.45	0.02	0.02	0.03	0.01	0.03	0.02
MnO(Mass%)	0.04	0.03	0.04	0.07	0.03	0.05	0.04	0.05	n.d.	0.00	n.d.	0.12	0.03	0.05	0.03	0.07	0.04	0.06	0.01
MgO(Mass%)	n.d.	n.d.	0.02	n.d.	0.03	0.02	0.01	0.04	0.02	n.d.	n.d.	0.02	0.00	n.d.	0.03	0.01	n.d.	0.01	n.d.
CaO(Mass%)	52.18	52.27	52.23	52.35	51.61	51.79	51.72	51.98	52.59	52.67	52.33	52.86	52.68	53.13	50.94	52.72	52.07	52.41	53.08
BaO(Mass%)	0.03	0.04	0.00	n.d.	0.01	n.d.	n.d.	0.03	0.01	0.03	n.d.	0.03	0.03	0.01	n.d.	0.06	0.00	0.06	n.d.
SrO(Mass%)	2.62	2.28	2.93	2.30	3.35	3.47	2.68	1.98	2.58	2.44	2.63	2.58	1.77	3.11	2.99	2.97	3.76	2.57	2.75
Na2O(Mass%)	0.20	0.19	0.25	0.45	0.26	0.21	0.38	0.30	0.09	0.16	0.15	0.08	0.15	0.09	0.15	0.04	0.05	0.32	0.11
P2O5(Mass%)	38.61	38.60	39.23	38.50	38.50	38.30	38.55	38.07	38.43	38.77	38.72	38.92	37.70	39.13	38.28	38.86	39.13	38.96	38.92
La2O3(Mass%)	0.01	0.05	0.02	n.d.	0.01	n.d.	0.04	0.01	0.04	0.14	0.06	0.04	0.01	n.d.	0.00	0.01	0.02	0.00	n.d.
Ce2O3(Mass%)	0.05	0.22	0.10	0.08	0.10	0.09	0.11	0.14	0.15	0.24	0.20	0.13	0.08	0.01	0.07	0.08	0.05	0.10	0.09
Pr2O3(Mass%)	n.d.	n.d.	0.03	n.d.	n.d.	0.10	n.d.	0.01	0.01	n.d.	n.d.	0.01	0.01	0.03	n.d.	0.02	n.d.	0.03	n.d.
Nd2O3(Mass%)	n.d.	0.10	0.08	0.03	0.05	0.02	n.d.	0.10	n.d.	0.10	0.19	0.06	0.03	n.d.	n.d.	0.01	n.d.	0.07	n.d.
Sm2O3(Mass%)	0.03	0.01	0.08	n.d.	n.d.	n.d.	0.07	n.d.	0.06	0.05	n.d.	n.d.	n.d.	0.01	0.03	n.d.	n.d.	0.07	n.d.
LREE	0.08	0.37	0.31	0.12	0.15	0.21	0.23	0.25	0.25	0.54	0.45	0.24	0.14	0.05	0.11	0.12	0.07	0.27	0.09
Y2O3(Mass%)	n.d.	0.03	n.d.	n.d.	0.01	n.d.	0.00	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	0.00	n.d.
SO3(Mass%)	0.03	0.02	0.00	n.d.	n.d.	0.08	0.03	0.03	0.04	0.01	0.06	0.01	0.05	0.01	0.04	0.03	0.05	n.d.	0.02
F(Mass%)	3.25	2.99	2.01	1.07	2.56	2.88	1.42	3.03	3.76	3.69	3.43	3.26	3.19	3.14	3.55	3.97	4.30	1.62	4.24
Cl(Mass%)	0.00	0.00	0.00	0.00	0.01	0.00	n.d.	0.01	0.01	0.00	0.00	0.01	0.00	n.d.	0.01	n.d.	0.00	0.00	0.00
TOTAL	97.22	96.96	97.12	95.03	96.80	97.20	95.25	96.30	98.30	98.40	98.07	98.35	96.20	98.79	98.73	98.89	99.50	96.34	99.26
F=O	-1.37	-1.26	-0.85	-0.45	-1.08	-1.21	-0.60	-1.27	-1.58	-1.55	-1.44	-1.37	-1.34	-1.32	-1.49	-1.67	-1.81	-0.68	-1.78
Cl=O	0.00	0.00	0.00	0.00	0.00	0.00	n.d.	0.00	0.00	0.00	0.00	0.00	0.00	n.d.	0.00	n.d.	0.00	0.00	0.00
TOTAL	95.85	95.70	96.27	94.58	95.72	95.99	94.65	95.02	96.72	96.84	96.63	96.98	94.86	97.47	97.24	97.21	97.69	95.66	97.47

AMOSTRA	1234069_APAT_COLOFBORDA_10	1234069_APAT_COLOFBORDA_12	1234069_APAT_COLOFBORDA_2	1234069_APAT_COLOFBORDA_4	1234069_APAT_COLOFBORDA_5	1234069_APAT_COLOFBORDA_6	1234069_APAT_COLOFBORDA_7	1234069_APAT_COLOFBORDA_8	1234069_APAT_COLOFBORDA_9	1234069_APAT_COLOFQTZ_1	1234069_APAT_COLOFQTZ_10	1234069_APAT_COLOFQTZ_11	1234069_APAT_COLOFQTZ_12	1234069_APAT_COLOFQTZ_13	1234069_APAT_COLOFQTZ_14	1234069_APAT_COLOFQTZ_15	1234069_APAT_COLOFQTZ_16	1234069_APAT_COLOFQTZ_17	1234069_APAT_COLOFQTZ_18
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.013	0.005	n.d.	n.d.	0.007	n.d.	n.d.	0.024	n.d.	n.d.	n.d.	n.d.
Al	0.028	0.008	0.007	n.d.	0.024	0.014	0.001	0.070	0.102	0.010	0.053	0.030	0.003	0.008	0.511	0.001	0.004	0.006	0.004
Fe	0.006	0.012	0.007	0.025	0.024	0.016	0.027	0.020	0.001	0.003	0.008	0.005	0.069	0.003	0.003	0.005	0.002	0.005	0.004
Mn	0.007	0.005	0.007	0.010	0.005	0.008	0.007	0.007	n.d.	0.001	n.d.	0.017	0.005	0.008	0.005	0.011	0.005	0.010	0.002
Mg	n.d.	n.d.	0.007	n.d.	0.008	0.006	0.003	0.011	0.005	n.d.	n.d.	0.006	0.000	n.d.	0.007	0.002	n.d.	0.002	n.d.
Ca	10.008	10.033	9.912	10.065	9.933	9.968	9.958	10.030	10.032	10.050	9.987	10.027	10.227	10.048	9.588	10.041	9.904	9.986	10.096
Ba	0.002	0.003	0.000	n.d.	0.001	n.d.	n.d.	0.002	0.001	0.002	n.d.	0.002	0.002	0.001	n.d.	0.004	0.000	0.004	n.d.
Sr	0.272	0.237	0.301	0.240	0.349	0.361	0.280	0.207	0.266	0.252	0.271	0.265	0.186	0.318	0.304	0.306	0.387	0.265	0.283
Na	0.070	0.067	0.087	0.156	0.092	0.074	0.134	0.103	0.030	0.056	0.052	0.027	0.054	0.032	0.050	0.015	0.017	0.112	0.036
P	5.852	5.855	5.884	5.849	5.856	5.824	5.865	5.804	5.793	5.845	5.838	5.834	5.783	5.848	5.693	5.847	5.882	5.866	5.849
La	0.000	0.003	0.001	n.d.	0.000	n.d.	0.003	0.001	0.002	0.009	0.004	0.003	0.001	n.d.	0.000	0.001	0.001	0.000	n.d.
Ce	0.003	0.014	0.007	0.006	0.007	0.006	0.008	0.009	0.010	0.016	0.013	0.008	0.006	0.001	0.005	0.005	0.004	0.007	0.006
Pr	n.d.	n.d.	0.002	n.d.	n.d.	0.007	n.d.	0.001	0.001	n.d.	n.d.	0.001	0.001	0.002	n.d.	0.001	n.d.	0.002	n.d.
Nd	n.d.	0.006	0.005	0.002	0.003	0.001	n.d.	0.006	n.d.	0.006	0.012	0.004	0.002	n.d.	n.d.	0.001	n.d.	0.005	n.d.
Sm	0.002	0.000	0.005	n.d.	n.d.	n.d.	0.005	n.d.	0.004	0.003	n.d.	n.d.	n.d.	0.001	0.002	n.d.	n.d.	0.004	n.d.
Y	n.d.	0.003	n.d.	n.d.	0.001	n.d.	0.000	n.d.	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	n.d.	0.000	n.d.
S	0.004	0.003	0.000	n.d.	n.d.	0.011	0.003	0.004	0.006	0.001	0.008	0.001	0.006	0.002	0.006	0.004	0.006	n.d.	0.003
F	1.715	1.585	1.079	0.592	1.374	1.537	0.780	1.613	1.953	1.918	1.794	1.700	1.703	1.640	1.827	2.049	2.203	0.877	2.172
Cl	0.001	0.001	0.001	0.001	0.003	0.001	n.d.	0.002	0.003	0.001	0.001	0.003	0.000	n.d.	0.002	n.d.	0.001	0.001	0.001
TOTAL	17.969	17.836	17.309	16.946	17.679	17.836	17.073	17.903	18.212	18.174	18.041	17.941	18.048	17.912	18.025	18.292	18.415	17.149	18.455

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1234069_APAT_COLOFQTZ_19	1234069_APAT_COLOFQTZ_2	1234069_APAT_COLOFQTZ_20	1234069_APAT_COLOFQTZ_21	1234069_APAT_COLOFQTZ_22	1234069_APAT_COLOFQTZ_23	1234069_APAT_COLOFQTZ_24	1234069_APAT_COLOFQTZ_25	1234069_APAT_COLOFQTZ_26	1234069_APAT_COLOFQTZ_27	1234069_APAT_COLOFQTZ_29	1234069_APAT_COLOFQTZ_3	1234069_APAT_COLOFQTZ_30	1234069_APAT_COLOFQTZ_4	1234069_APAT_COLOFQTZ_5	1234069_APAT_COLOFQTZ_6	1234069_APAT_COLOFQTZ_7	1234069_APAT_COLOFQTZ_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	n.d.	0.06	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.17	0.02	0.05	n.d.	n.d.	n.d.
Al2O3(Mass%)	0.10	0.03	0.60	0.00	0.01	n.d.	0.00	0.01	0.02	0.03	0.06	n.d.	3.83	0.46	0.30	0.05	0.02	n.d.
FeO(Mass%)	0.01	0.04	0.02	0.02	0.06	0.01	0.05	0.06	0.09	0.02	0.05	0.02	0.03	0.01	0.01	0.03	0.08	0.01
MnO(Mass%)	n.d.	0.03	0.01	0.02	0.04	0.02	0.01	0.02	0.03	0.02	0.01	0.03	0.02	0.05	0.01	0.02	0.03	0.00
MgO(Mass%)	n.d.	0.03	0.02	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	0.04	0.00	0.06	0.00	0.02	n.d.
CaO(Mass%)	52.50	52.64	52.70	51.94	52.06	52.17	53.04	52.96	52.31	52.58	52.63	53.26	50.41	51.49	52.45	53.18	52.20	51.94
BaO(Mass%)	n.d.	0.03	n.d.	n.d.	0.03	0.02	0.00	n.d.	n.d.	0.05	0.02	0.02	0.02	n.d.	0.04	0.03	0.03	n.d.
SrO(Mass%)	2.40	2.58	2.24	4.17	3.98	3.46	2.43	2.55	3.62	2.09	2.32	2.41	2.28	3.77	1.98	2.22	3.48	4.06
Na2O(Mass%)	0.20	0.16	0.16	0.12	0.11	0.09	0.13	0.16	0.11	0.17	0.19	0.14	0.10	0.09	0.13	0.13	0.10	0.09
P2O5(Mass%)	38.37	38.61	38.65	39.31	39.64	38.93	38.98	38.97	39.74	38.17	38.57	39.05	36.94	38.75	38.60	38.85	38.64	39.21
La2O3(Mass%)	0.08	0.04	0.06	n.d.	n.d.	0.02	0.06	0.02	0.01	0.09	0.08	0.02	n.d.	n.d.	0.12	0.03	0.03	n.d.
Ce2O3(Mass%)	0.19	0.14	0.14	0.05	0.06	0.10	0.12	0.07	0.07	0.21	0.30	0.04	0.20	0.09	0.33	0.24	0.10	0.10
Pr2O3(Mass%)	0.07	n.d.	0.08	n.d.	0.01	0.02	n.d.	n.d.	0.03	0.05	n.d.	n.d.	0.01	0.05	n.d.	n.d.	0.01	0.03
Nd2O3(Mass%)	0.11	0.06	0.02	0.08	0.02	n.d.	0.00	0.07	0.03	0.18	0.13	0.02	0.01	0.06	n.d.	n.d.	n.d.	n.d.
Sm2O3(Mass%)	n.d.	n.d.	0.02	0.03	0.03	0.00	n.d.	0.09	n.d.	n.d.	0.04	0.01	n.d.	n.d.	0.09	0.05	0.04	n.d.
LREE	0.45	0.23	0.32	0.15	0.13	0.14	0.18	0.24	0.13	0.52	0.54	0.10	0.23	0.21	0.53	0.32	0.18	0.13
Y2O3(Mass%)	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.
SO3(Mass%)	0.01	0.04	n.d.	0.04	0.08	n.d.	0.01	0.01	0.05	0.01	0.01	n.d.	0.04	0.04	0.01	0.02	0.00	0.06
F(Mass%)	3.19	3.09	2.65	3.15	3.37	3.91	3.65	3.61	3.23	3.09	3.19	2.89	3.46	3.61	2.97	2.89	3.82	3.83
Cl(Mass%)	0.00	0.01	n.d.	n.d.	0.00	n.d.	0.01	n.d.	n.d.	0.00	0.00	0.01	0.00	0.00	0.00	0.01	n.d.	n.d.
TOTAL	97.23	97.58	97.38	98.92	99.49	98.76	98.50	98.58	99.33	96.77	97.58	97.94	97.58	98.49	97.14	97.73	98.60	99.33
F=O	-1.34	-1.30	-1.12	-1.33	-1.42	-1.65	-1.54	-1.52	-1.36	-1.30	-1.34	-1.22	-1.46	-1.52	-1.25	-1.21	-1.61	-1.61
Cl=O	0.00	0.00	n.d.	n.d.	0.00	n.d.	0.00	n.d.	n.d.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n.d.	n.d.
TOTAL	95.89	96.27	96.27	97.59	98.07	97.11	96.96	97.06	97.97	95.47	96.24	96.72	96.12	96.98	95.89	96.51	97.00	97.71

AMOSTRA	1234069_APAT_COLOFQTZ_19	1234069_APAT_COLOFQTZ_2	1234069_APAT_COLOFQTZ_20	1234069_APAT_COLOFQTZ_21	1234069_APAT_COLOFQTZ_22	1234069_APAT_COLOFQTZ_23	1234069_APAT_COLOFQTZ_24	1234069_APAT_COLOFQTZ_25	1234069_APAT_COLOFQTZ_26	1234069_APAT_COLOFQTZ_27	1234069_APAT_COLOFQTZ_29	1234069_APAT_COLOFQTZ_3	1234069_APAT_COLOFQTZ_30	1234069_APAT_COLOFQTZ_4	1234069_APAT_COLOFQTZ_5	1234069_APAT_COLOFQTZ_6	1234069_APAT_COLOFQTZ_7	1234069_APAT_COLOFQTZ_8
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	n.d.	0.012	0.002	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.031	0.004	0.008	n.d.	n.d.	n.d.
Al	0.021	0.007	0.125	0.001	0.001	n.d.	0.001	0.002	0.003	0.007	0.012	n.d.	0.799	0.097	0.062	0.010	0.004	n.d.
Fe	0.002	0.006	0.004	0.003	0.008	0.002	0.007	0.008	0.013	0.003	0.007	0.002	0.004	0.001	0.002	0.004	0.012	0.001
Mn	n.d.	0.005	0.002	0.003	0.006	0.003	0.002	0.002	0.004	0.003	0.001	0.004	0.003	0.008	0.001	0.003	0.005	0.001
Mg	n.d.	0.007	0.005	n.d.	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	0.004	0.011	0.001	0.015	0.001	0.005	n.d.
Ca	10.095	10.054	10.011	9.845	9.805	9.959	10.090	10.072	9.838	10.150	10.074	10.097	9.575	9.814	10.021	10.116	9.992	9.866
Ba	n.d.	0.002	n.d.	n.d.	0.002	0.001	0.000	n.d.	n.d.	0.003	0.002	0.002	0.002	n.d.	0.003	0.002	0.002	n.d.
Sr	0.249	0.266	0.231	0.428	0.405	0.358	0.250	0.263	0.368	0.218	0.240	0.247	0.235	0.389	0.205	0.228	0.361	0.417
Na	0.069	0.055	0.056	0.042	0.036	0.033	0.046	0.055	0.036	0.061	0.066	0.047	0.035	0.030	0.045	0.044	0.036	0.030
P	5.830	5.827	5.801	5.887	5.899	5.872	5.859	5.856	5.906	5.823	5.833	5.849	5.543	5.836	5.828	5.840	5.844	5.884
La	0.006	0.003	0.004	n.d.	n.d.	0.001	0.004	0.001	0.001	0.006	0.005	0.002	n.d.	n.d.	0.008	0.002	0.002	n.d.
Ce	0.013	0.009	0.009	0.003	0.004	0.006	0.008	0.005	0.004	0.014	0.020	0.003	0.013	0.006	0.021	0.016	0.007	0.007
Pr	0.004	n.d.	0.005	n.d.	0.001	0.001	n.d.	n.d.	0.002	0.003	n.d.	n.d.	0.001	0.003	n.d.	n.d.	0.001	0.002
Nd	0.007	0.004	0.001	0.005	0.001	n.d.	0.000	0.004	0.002	0.011	0.008	0.002	0.001	0.004	n.d.	n.d.	n.d.	n.d.
Sm	n.d.	n.d.	0.002	0.002	0.002	0.000	n.d.	0.005	n.d.	n.d.	0.002	0.001	n.d.	n.d.	0.005	0.003	0.002	n.d.
Y	n.d.	n.d.	n.d.	n.d.	n.d.	0.000	n.d.	n.d.	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	n.d.
S	0.001	0.005	n.d.	0.005	0.010	n.d.	0.002	0.001	0.006	0.001	0.002	n.d.	0.005	0.005	0.002	0.002	0.000	0.008
F	1.690	1.629	1.404	1.648	1.743	2.024	1.895	1.874	1.675	1.643	1.682	1.521	1.801	1.876	1.568	1.521	1.988	1.979
Cl	0.001	0.003	n.d.	n.d.	0.001	n.d.	0.002	n.d.	n.d.	0.001	0.001	0.002	0.001	0.000	0.000	0.001	n.d.	n.d.
TOTAL	17.988	17.893	17.659	17.870	17.925	18.261	18.165	18.147	17.859	17.950	17.954	17.781	18.060	18.074	17.795	17.794	18.260	18.193

ANEXO C – QUÍMICA MINERAL – WDS – APATITA

PROPORÇÃO ATÔMICA PARA 25 O

AMOSTRA	1234069_APAT_COLOFQTZ_9	1234069_APAT_GRAOSBORDA_1	1234069_APAT_GRAOSBORDA_10	1234069_APAT_GRAOSBORDA_11	1234069_APAT_GRAOSBORDA_12	1234069_APAT_GRAOSBORDA_2	1234069_APAT_GRAOSBORDA_3	1234069_APAT_GRAOSBORDA_4	1234069_APAT_GRAOSBORDA_5	1234069_APAT_GRAOSBORDA_6	1234069_APAT_GRAOSBORDA_7	1234069_APAT_GRAOSBORDA_8	1234069_APAT_GRAOSBORDA_9	1234069_APAT_GRAOSQTZ_1	1234069_APAT_GRAOSQTZ_10	1234069_APAT_GRAOSQTZ_14	1234069_APAT_GRAOSQTZ_2	1234069_APAT_GRAOSQTZ_3	1234069_APAT_GRAOSQTZ_4	1234069_APAT_GRAOSQTZ_6	1234069_APAT_GRAOSQTZ_7	1234069_APAT_GRAOSQTZ_8	1234069_APAT_GRAOSQTZ_9
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
SiO2(Mass%)	n.d.	0.05	n.d.	0.39	n.d.	0.01	n.d.	0.06	0.13	n.d.	0.03	0.02	n.d.	n.d.	0.27	n.d.	0.92	n.d.	n.d.	0.27	n.d.	0.11	n.d.
Al2O3(Mass%)	0.12	1.03	0.23	0.06	0.21	1.29	0.22	0.22	0.71	n.d.	0.39	1.92	0.21	0.03	0.45	n.d.	1.47	0.00	0.01	0.39	0.22	0.07	0.30
FeO(Mass%)	0.02	0.13	0.18	0.29	0.09	0.18	0.24	0.14	0.03	0.15	0.12	0.09	0.18	0.10	0.08	0.09	0.23	0.02	0.11	0.16	0.04	0.04	0.04
MnO(Mass%)	0.03	0.07	0.06	0.06	0.04	0.08	0.08	0.06	0.03	0.01	0.08	0.03	0.06	0.01	0.08	0.07	0.08	0.02	0.04	0.73	0.04	0.07	0.06
MgO(Mass%)	n.d.	0.03	0.07	0.00	0.02	0.05	0.03	0.06	0.03	0.03	0.04	0.09	0.03	0.02	0.16	0.04	0.07	0.04	0.03	0.12	0.02	0.03	0.01
CaO(Mass%)	52.91	51.37	50.45	51.48	51.63	49.68	51.65	51.23	51.01	49.70	51.44	48.47	52.18	51.63	49.57	51.29	49.65	50.67	51.23	49.39	51.41	51.30	51.59
BaO(Mass%)	n.d.	0.04	0.07	0.07	n.d.	0.01	n.d.	n.d.	0.00	n.d.	0.06	n.d.	0.01	0.01	0.05	0.03	0.03	0.01	n.d.	0.10	n.d.	0.02	0.04
SrO(Mass%)	2.29	3.39	4.08	3.02	3.24	4.65	3.75	2.96	3.08	5.64	3.21	6.44	3.40	4.39	4.14	4.36	3.92	5.08	4.29	3.78	4.10	4.37	4.09
Na2O(Mass%)	0.21	0.15	0.14	0.20	0.21	0.11	0.13	0.12	0.13	0.11	0.11	0.11	0.02	0.07	0.14	0.03	0.05	0.03	0.08	0.38	0.06	0.03	0.03
P2O5(Mass%)	38.52	37.88	37.40	38.46	38.71	36.47	38.39	37.42	38.39	38.12	37.59	36.89	37.78	38.20	37.06	38.01	36.40	37.93	38.00	37.55	38.27	38.27	38.82
La2O3(Mass%)	0.10	0.08	0.10	0.25	0.20	n.d.	0.03	0.04	0.02	n.d.	0.02	0.00	0.03	0.01	n.d.	0.01	0.01	n.d.	n.d.	0.01	n.d.	n.d.	0.05
Ce2O3(Mass%)	0.19	0.31	0.24	0.61	0.48	0.09	0.14	0.19	0.18	0.13	0.13	0.10	0.15	0.05	0.09	0.07	0.07	0.06	0.06	0.08	0.06	0.11	0.03
Pr2O3(Mass%)	n.d.	n.d.	n.d.	0.04	n.d.	0.02	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	0.06	0.00	n.d.	n.d.	n.d.	n.d.	0.06	n.d.
Nd2O3(Mass%)	0.15	0.01	0.03	0.29	0.25	0.01	0.00	n.d.	n.d.	0.00	n.d.	0.03	0.08	0.05	0.04	n.d.	0.03	n.d.	0.01	n.d.	n.d.	n.d.	n.d.
Sm2O3(Mass%)	n.d.	n.d.	0.05	n.d.	0.05	0.02	0.02	0.05	0.04	0.07	0.06	0.01	0.05	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	n.d.	0.02	n.d.	0.01
LREE	0.43	0.39	0.43	1.19	0.99	0.14	0.19	0.28	0.25	0.22	0.21	0.14	0.31	0.11	0.13	0.14	0.11	0.06	0.11	0.09	0.08	0.17	0.10
Y2O3(Mass%)	n.d.	n.d.	n.d.	n.d.	0.00	0.02	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	0.01	0.00	0.01	n.d.	n.d.
SO3(Mass%)	n.d.	0.04	0.06	0.04	0.05	0.08	0.06	0.06	0.07	0.14	0.11	0.11	0.06	0.05	0.07	0.04	0.02	0.02	0.01	0.03	0.03	0.06	0.03
F(Mass%)	3.05	2.92	3.89	3.02	2.53	3.77	3.35	3.14	3.58	2.76	3.77	3.93	3.95	4.19	3.93	3.58	2.63	3.20	3.06	2.87	3.40	4.08	3.66
Cl(Mass%)	n.d.	0.00	n.d.	0.00	0.01	n.d.	n.d.	0.00	0.01	n.d.	0.00	0.00	0.00	n.d.	0.01	0.00	n.d.	n.d.	0.01	0.01	n.d.	n.d.	0.01
TOTAL	97.58	97.49	97.05	98.31	97.73	96.54	98.09	95.77	97.44	96.89	97.17	98.24	98.18	98.82	96.14	97.68	95.59	97.09	97.00	95.87	97.68	98.62	98.77
F=O	-1.28	-1.23	-1.64	-1.27	-1.07	-1.59	-1.41	-1.32	-1.51	-1.16	-1.59	-1.65	-1.66	-1.76	-1.65	-1.51	-1.11	-1.35	-1.29	-1.21	-1.43	-1.72	-1.54
Cl=O	n.d.	0.00	n.d.	0.00	0.00	n.d.	n.d.	0.00	0.00	n.d.	0.00	0.00	0.00	n.d.	0.00	0.00	n.d.	n.d.	0.00	0.00	n.d.	n.d.	0.00
TOTAL	96.30	96.26	95.41	97.04	96.66	94.95	96.68	94.44	95.94	95.73	95.59	96.58	96.52	97.05	94.49	96.17	94.48	95.75	95.71	94.66	96.25	96.90	97.23

AMOSTRA	1234069_APAT_COLOFQTZ_9	1234069_APAT_GRAOSBORDA_1	1234069_APAT_GRAOSBORDA_10	1234069_APAT_GRAOSBORDA_11	1234069_APAT_GRAOSBORDA_12	1234069_APAT_GRAOSBORDA_2	1234069_APAT_GRAOSBORDA_3	1234069_APAT_GRAOSBORDA_4	1234069_APAT_GRAOSBORDA_5	1234069_APAT_GRAOSBORDA_6	1234069_APAT_GRAOSBORDA_7	1234069_APAT_GRAOSBORDA_8	1234069_APAT_GRAOSBORDA_9	1234069_APAT_GRAOSQTZ_1	1234069_APAT_GRAOSQTZ_10	1234069_APAT_GRAOSQTZ_14	1234069_APAT_GRAOSQTZ_2	1234069_APAT_GRAOSQTZ_3	1234069_APAT_GRAOSQTZ_4	1234069_APAT_GRAOSQTZ_6	1234069_APAT_GRAOSQTZ_7	1234069_APAT_GRAOSQTZ_8	1234069_APAT_GRAOSQTZ_9
LITOLOGIA	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT	Apatita Mg CBT
Si	n.d.	0.009	n.d.	0.070	n.d.	0.001	n.d.	0.011	0.023	n.d.	0.006	0.004	n.d.	n.d.	0.051	n.d.	0.167	n.d.	n.d.	0.050	n.d.	0.020	n.d.
Al	0.026	0.218	0.050	0.013	0.045	0.279	0.046	0.048	0.150	n.d.	0.084	0.411	0.044	0.007	0.097	n.d.	0.315	0.001	0.003	0.084	0.046	0.015	0.063
Fe	0.003	0.019	0.028	0.043	0.014	0.028	0.037	0.022	0.005	0.022	0.018	0.013	0.027	0.015	0.013	0.014	0.035	0.004	0.017	0.025	0.007	0.006	0.006
Mn	0.005	0.011	0.010	0.009	0.006	0.012	0.012	0.009	0.004	0.001	0.012	0.005	0.009	0.002	0.013	0.010	0.013	0.003	0.006	0.113	0.006	0.010	0.010
Mg	n.d.	0.007	0.019	n.d.	0.006	0.015	0.007	0.015	0.009	0.009	0.012	0.024	0.007	0.007	0.044	0.011	0.019	0.011	0.008	0.032	0.006	0.009	0.003
Ca	10.120	9.850	9.884	9.817	9.853	9.779	9.902	10.021	9.779	9.656	9.987	9.424	10.087	9.952	9.766	9.942	9.676	9.872	9.935	9.641	9.910	9.874	9.837
Ba	n.d.	0.003	0.005	0.005	n.d.	0.001	n.d.	n.d.	0.000	n.d.	0.004	n.d.	0.000	0.001	0.004	0.002	0.002	0.001	n.d.	0.007	n.d.	0.001	0.003
Sr	0.237	0.351	0.432	0.312	0.334	0.496	0.389	0.313	0.320	0.593	0.337	0.677	0.356	0.458	0.441	0.458	0.414	0.536	0.451	0.400	0.428	0.455	0.422
Na	0.074	0.051	0.050	0.071	0.074	0.039	0.046	0.042	0.043	0.040	0.040	0.038	0.008	0.024	0.049	0.011	0.019	0.012	0.029	0.134	0.022	0.012	0.011
P	5.822	5.740	5.789	5.796	5.837	5.673	5.815	5.783	5.816	5.853	5.766	5.667	5.771	5.818	5.768	5.823	5.606	5.839	5.823	5.793	5.829	5.821	5.848
La	0.007	0.005	0.007	0.016	0.013	n.d.	0.002	0.003	0.002	n.d.	0.002	0.000	0.002	0.001	n.d.	0.001	0.001	n.d.	n.d.	0.001	n.d.	n.d.	0.004
Ce	0.012	0.020	0.016	0.040	0.031	0.006	0.010	0.013	0.012	0.009	0.009	0.007	0.010	0.004	0.006	0.005	0.005	0.004	0.004	0.006	0.004	0.008	0.002
Pr	n.d.	n.d.	n.d.	0.003	n.d.	0.002	n.d.	n.d.	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	n.d.	0.004	0.000	n.d.	n.d.	n.d.	n.d.	0.004	n.d.
Nd	0.009	0.001	0.002	0.019	0.016	0.000	0.000	n.d.	n.d.	0.000	n.d.	0.002	0.005	0.004	0.002	n.d.	0.002	n.d.	0.001	n.d.	n.d.	n.d.	n.d.
Sm	n.d.	n.d.	0.003	n.d.	0.003	0.001	0.001	0.003	0.003	0.004	0.004	0.001	0.003	n.d.	n.d.	n.d.	n.d.	n.d.	0.002	n.d.	0.001	n.d.	0.001
Y	n.d.	n.d.	n.d.	n.d.	0.000	0.002	n.d.	0.000	n.d.	n.d.	n.d.	n.d.	n.d.	0.001	n.d.	n.d.	n.d.	n.d.	0.001	0.000	0.001	n.d.	n.d.
S	n.d.	0.005	0.008	0.005	0.006	0.011	0.009	0.009	0.010	0.019	0.016	0.015	0.009	0.007	0.010	0.005	0.003	0.003	0.002	0.004	0.003	0.008	0.003
F	1.610	1.549	2.062	1.592	1.348	2.013	1.762	1.692	1.873	1.487	1.990	2.068	2.069	2.175	2.092	1.893	1.426	1.716	1.636	1.549	1.795	2.122	1.901
Cl	n.d.	n.d.	n.d.	0.000	0.003	n.d.	n.d.	0.001	0.002	n.d.	0.001	0.001	0.001	n.d.	0.004	n.d.	n.d.	n.d.	0.004	0.002	n.d.	n.d.	0.002
TOTAL	17.925	17.839	18.364	17.811	17.590	18.356	18.037	17.985	18.050	17.694	18.286	18.355	18.406	18.473	18.359	18.178	17.702	18.002	17.921	17.840	18.058	18.362	18.115