Comparison of the Petrology of Samples from Two Amphibolite Facies Localities from the Andrelândia Group, Brazil

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Abstract

This is a study of the possible melting of a biotite schist unit in the Andrelândia Group, Minas Gerais, Brazil, through the use of petrology and apatite chemistry. The Andrelândia Group comprises a system of nappes metamorphosed at greenschist to high pressure granulite facies. Within this group, the Andrelândia Nappe comprises an amphibolite facies metapelitic unit, consisting primarily of a biotite schist. The study involves samples from this nappe from two quarries near Cambuquira, Minas Gerais. In the INCOPE quarry (Figure 2), melt may have been generated during metamorphism, as reflected by the presence of extensive feldspar-bearing leucosome in biotite-garnet gneiss. At the abandoned quarry (Figure 3), monomineralic quartz veins in a biotite-garnet schist indicate melting did not occur, because the melting temperature of monomineralic quartz is too high. Previous studies by Kapustin have suggested that the composition of apatite may reflect metamorphic grade. Apatite from samples in both quarries were analyzed for F, Cl, and OH in order to understand the effect of increasing metamorphic grade on apatite chemistry. There is no significant difference between apatite composition at the two localities, which may suggest that melting has not occurred.

Introduction

In metamorphic rocks, apatite composition can yield information about the geologic history of the rock (Spear and Pyle, 2002). The chemical composition of apatite within the samples may reflect changes that occur relating to metamorphism and melting, and whether water was involved with any possible partial melting. Kapustin (1987) studied the chemistry of apatite across a large metamorphic gradient, and suggests that there is a regular change in chemistry with changing pressure and temperature conditions. Kapustin (1987) suggested that F, Cl and OH change systematically with increasing metamorphic grade. In the study, Kapustin looked at apatite in a wide variety of rock types (e.g. pelites, carbonates), and found the F concentration of apatite to increase from the greenschist to granulite facies (Figure 1).

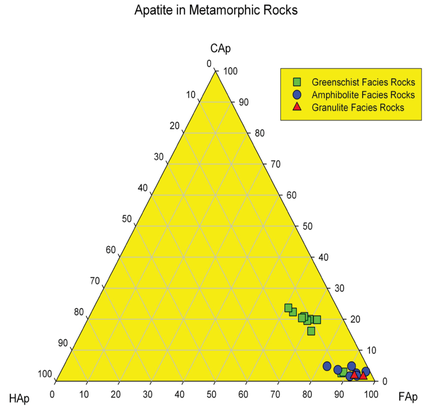


Figure 1: Proportions of chlorapatite, hydroxylapatite, and flourapatite based upon metamorphic grade (modified from Kapustin, 1987).

Field Area

The field area of study consists of two quarries, 15 km apart, in between which is the town of Cambuquira (Figure 4). The quarry south of Cambuquira is abandoned, whereas the quarry north of Cambuquira is the INCOPE Ltda. working quarry. The two quarries are part of the same litho-tectonic unit.

Geologic History

During the Neoproterozoic, the Brazilides Ocean closure resulted in nappe formation. The nappes decrease in peak metamorphic temperature to the base of the group (Garcia et al., 2003b). The Andrelândia nappe (Figure 4) was subjected to amphibolite facies metamorphism at ca. 640 Ma (Reno, Pers. Comm.).

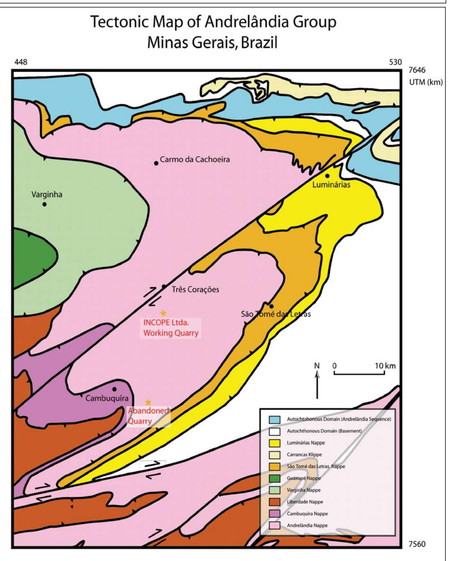


Figure 4: Tectonic map (After Trouw et al., 2003)

Figure 2: INCOPE quarry outcrop

Figure 3: Abandoned quarry outcrop

Figure 5: INCOPE quarry outcrop closeup, extensive leucosomes, gneissic texture

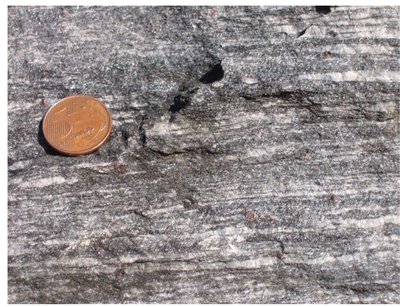


Figure 6: Abandoned quarry outcrop closeup, quartz veins, schistose texture

Figure 7: 04-5-2 thin section scan (INCOPE)

I---------I 4.25 cm

Figure 8: 04-5-5 thin section scan (Abandoned)

Statement of Problem

The INCOPE quarry biotite gneiss potentially experienced partial melting during metamorphism suggested by plagioclase and quartz bearing leucosomes. Plagioclase - quartz bearing leucosomes imply the leucosome could have crystallized from a granitic liquid. Monomineralic quartz is not likely to have been a melt because the melting temperature for monomineralic quartz is too high. The biotite schist at the abandoned quarry most likely did not experience melting as it only contains quartz veins without plagioclase. Determining whether partial melting occurred in the rocks from either quarry will be a focus of the study. This project explores whether apatite chemistry relates to the melting history of a rock.

Hypothesis

The rocks from the INCOPE quarry experienced partial melting whereas the rocks from the abandoned quarry locality did not experience partial melting. Apatite chemistry will reflect the occurrence of partial melting, and will reflect the metamorphic grade.

Methods

The mineralogy, relationship between minerals, their distribution, grain size, shape, and any replacement minerals for each of the samples were recorded, and differences in each of these categories between samples were noted. On the EPMA, WDS was used to determine the concentrations in apatite of F, Ca, Cl, P, Fe, Mn, Sr, Mg, La, Ce, Si, and S for each point.

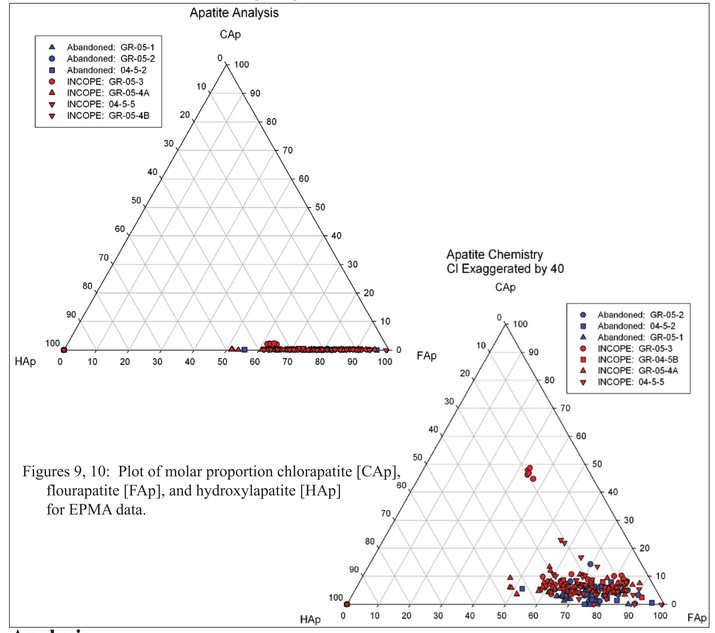
Results: Mineral Chemistry

Table 1 shows the mineral chemistry of each of the apatite grains measured in this study. A ternary diagram (Figure 9) reveals a low Cl concentration in each of the apatite grains. The average apatite composition from the two quarries are not significantly different (Table 1). The Cl concentrations in apatite do not appear to have a correlation with which quarry the apatite is located (Figure 10).

CaO wt %	P2O5 wt %	Cl wt %	F wt %	FeO wt %	MnO wt %	total wt %	
							Abandoned
54.24	42.05	0.007	2.92	0.12	0.04	99.05	
0.87	0.43	0.005	0.29	0.18	0.03	1.03	
							INCOPE
54.64	41.79	0.012	3.02	0.17	0.03	98.84	
0.58	0.45	0.009	0.34	0.21	0.03	1.24	

Table 1: EPMA results for apatite analysis points, average for each quarry

Outliers in Figure 10, data points with exceptionally high CAp components, represent apatite inclusions in the core of garnet. There is a wide range of F concentrations in apatite, and it appears to be zoned, as a greater F concentration is found on the rim of the apatite grains than in the core.



Figures 9, 10: Plot of molar proportion chlorapatite [CAp], flourapatite [FAp], and hydroxylapatite [HAp] for EPMA data.

Analysis

The compositions of the samples are compared with other studies involving the behavior of apatite within metamorphic rocks, such as the results from studies by Kapustin (1987). Comparing Figures 1 and 10, the apatite compositions with this project have a similar range to the amphibolite apatite compositions in the Kapustin study, but there are some differences. The apatite in this study has a greater range of FAp values, and a more restricted range of CAp values. Since the rocks from this study are expected to have undergone similar metamorphism, and are part of the same metamorphic unit, this could cast doubts on the Kapustin data, as the average range of FAp values from this study is not represented on Kapustin's plot.

Zoning in the apatite grain could be a result of growth zoning while the melt was being crystallized. In the garnet, a slow diffusivity leads to the outer core having a different composition than the reaction rim (Spear and Pyle, 2002).

Conclusion

The hypothesis was that the INCOPE quarry rocks experienced partial melting. While the petrology of the rocks from INCOPE is consistent with melting and the petrology of the rocks from the abandoned quarry is consistent with melting not having occurred, the results remain inconclusive. Rocks from INCOPE are gneiss, have larger garnets, and a leucosome mineralogy consistent with melting. Rocks from the abandoned quarry are schist, have smaller grains, and veins that do not likely represent melt composition. The apatite composition is not significantly different, either in bordering different phases or in different rocks or in different quarries, suggesting that apatite composition is not indicative of a partial melt, or that melting did not occur. No demonstrative evidence of melting was found.