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Relation of magnetite composition to magnetic susceptibility in Mauritian basalts

Thakurdin, Y[1] and Ashwal, L.D.[1]

[1]School of Geosciences, University of the Witwatersrand, WITS 2050, South Africa.

Magnetic susceptibility in basalts is controlled by the presence of magnetic minerals within the rock body. These magnetic minerals are typically Fe-Ti oxides such as magnetite-ulvöspinel and ilmenite-hematite solid solutions. The magnetic susceptibility of Fe-Ti oxide minerals is strongly related to their detailed chemical compositions and to their grain sizes [1].

The island of Mauritius lies approximately 1000 km east of Madagascar, off the east coast of Africa. Simpson [2] conducted early research into Mauritian Island volcanism and concluded that three separate phases of volcanic activity occurred. These phases were categorized as the Older Series (9 - 4.7 Ma), Intermediate Series (3.6 - 1.6 Ma) and Younger Series (1 - 0 Ma) lavas. The Older Series lavas are largely made up of olivine basalts and are commonly associated with trachytic intrusives. The Younger Series lavas show a trend towards more alkali-rich basalts [3]. This study investigated the relationship between modal abundance, grain size, magnetic mineral (titanomagnetite) composition and magnetic susceptibility within a suite of basaltic rocks from Mauritius, representing the Older, Intermediate and Younger Series.

Electron microprobe data on titanomagnetites reveal varying abundances of Fe, Ti, Al, Mn, Mg, Ni, Zn and V. The components that displayed the greatest control on magnetic susceptibility are $Fe^{2+/3+}$ and Ti^{4+}. Magnetic susceptibility increases with total Fe (Fe^{2+} and Fe^{3+}) abundance in titanomagnetite and decreases with increasing Ti^{4+} abundance. These observations are expected due to the general paramagnetism of Fe and diamagnetism of Ti components in magnetites, respectively. From the observed data, Ti^{4+} abundance in titanomagnetite (TiO_2 = 3.25 – 26.17 wt. %) is likely the strongest controlling chemical element on magnetic susceptibility. Like Ti, concentrations of Mg and V are strongly negatively correlated with magnetic susceptibility, although their abundances are much lower (V_2O_3 = 0.18 – 1.73 wt. %; MgO = 0.05 – 3.59 wt. %). Other magnetic minerals like sulphides (chalcopyrite and pyrite) are sporadically present in Mauritian basalts, but are modally very minor.

Smaller magnetite grains should display greater magnetic susceptibilities due to the relative arrangement of magnetic moments within the grain [4]. From grain size analysis on our samples, the trends produced were not compelling enough to show any strong correlation between grain size of titanomagnetite and magnetic susceptibility within this suite of rocks.

It is a general first order assumption that greater abundances of magnetite within a sample results in higher magnetic susceptibilities. The abundance of magnetite in our samples shows an unexpectedly weak correlation to magnetic susceptibility; increasing amounts of magnetite resulted in only slightly higher magnetic susceptibilities.

References:

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