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Paramagnetism of Rock-Forming Dolerite Minerals of Intraformational Trap Intrusions in West Yakutia as the Basis for Dolerite Correlation

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Abstract—This paper shows that the mineral composition of dolerites affects their specific paramagnetic susceptibility. Two methods for calculating the specific paramagnetic susceptibility were proposed: one used the thermomagnetic analysis (TMA) curve and the other the $M_i(B)$ curve. There was no significant difference between the results obtained with these two approaches. Application of the proposed methods to dolerite core samples showed that specific paramagnetic susceptibility can be used as the basis for correlation of sills. The composition of titanomagnetites in dolerites can be used as an accessory parameter.

Keywords: dolerites, specific paramagnetic susceptibility, titanomagnetites, sill, thermomagnetic curves

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INTRODUCTION

A sill is a sheet intrusion that forms between layers of sedimentary rocks. Sills consist of dolerite and gabbro. Dolerite is 50% plagioclase, 35–40% clinopyroxene and max 12% olivine (Kutolin, 1972).

Plagioclase is a solid solution with albite and anorthite endmembers. Olivine is a solid solution with forsterite and fayalite endmembers. Monoclinic pyroxenes (clinopyroxenes) are most often represented by diopside–hedenbergite and augite–aegirine series.

Upper and lower near-contact zones (UCS and LCZ) are clearly distinguished in the structure of dolerite sills. Usually, they consist of micro- and fine-grained dolerite and a layered series (LS) composing the bulk of the intrusion (Feoktistov et al., 1975) showed that upper and lower near-contact zones mostly consist of plagioclase, while the central part contains olivine and pyroxene.

The structure of intrusive bodies is determined by the differentiation process of magma and reflects redistribution of the melt's components while the melt is hardening and changing its composition (Frenkel et al., 1988; Ariskin and Barmina, 2000). Therefore, the main factor determining the structure of a sill is the temperature distribution within the intrusive body. And this will be mainly determined by the thickness of the intrusive body. In other words, the structure of small intrusive bodies will differ from the structure of large ones not only by the ratio of UCS and LCS to LS, but also by the structure and mineral composition of LS. The most important feature in the structure of LS is the compositional changes from high-temperature series in the lower part to low-temperature series in the upper part. The lower part usually consists of olivine-pyroxene dolerite with a small amount of plagioclase, while the upper part contains more plagioclase than olivine and pyroxene (Frenkel et al., 1988; Ariskin and Barmina, 2000). Several magnetic properties of dolerite are also governed by the cooling process of magma (Metelkin et al., 2019).

The distribution of sills in Western Yakutia is as follows: ~68% of sills are about 50 meters thick; 21% of sills have thickness of 50–150; 11% of sills have thickness of 150–300 meters (Sharapov, 2001).

Experimental studies were conducted into the stability of magnetite and titanomagnetite in silicate melts. (Snyder et al., 1993) indicated that the crystallization point of titanomagnetite does not exceed 1130°C and strongly depends on redox conditions. The release of magnetite from the melt leads to a sharp iron depletion and SiO_2 enrichment (Thy and Lofgren, 1994) showed that magnetite forms at 1105°C regardless of the melt composition. (Toplis and Carrol, 1995) explained high temperature crystallization corresponds to high degree of iron oxidation in the melt.