Remanent Hysteresis Study of Dolerite Dykes

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Abstract—Saturation remanent hysteresis studies were carried out on numerous dolerite dyke samples from the peninsular India. These studies result in four types of remanent hysteresis curves which indicate that the magnetic material is magnetite or titanomagnetite with variable grain-size having remanent coercive forces ($H_{cr}$) of 8 to 30 mT, requiring saturating fields ($H_s$) up to 250 mT. Two extreme types of samples with (1) low coercive forces requiring high saturating fields and (2) high coercive forces requiring low saturating fields are noticed along with the generally observed ones. The Granulometric and Lowrie-Fuller Tests on these samples indicated that the magnetic material i.e., magnetite or titanomagnetite in these rocks is in the form of Multi-Domain (MD), Cation Deficient (CD) and a mixture of these two forms (MD + CD) within.

Key words: Coercive force, grain size, magnetics, hysteresis, granulometry, domain wall, relaxation time.

1. Introduction

The stability of Natural Remanent Magnetism (NRM) is a main concern to palaeomagnetists in understanding the primary magnetization of the rocks acquired at the time of their formation. Magnetic grains containing high coercive force resist the destructive forces during its long geological period and faithfully keep the memory of its original magnetizations to serve as a record of ancient geomagnetic field. Rocks with low coercive force grains, therefore, are not suitable for palaeomagnetic interpretations. In an assembly of non-interacting uniaxial single domain grains, the stability of magnetization is linked up with its coercive force (NEEL, 1955; NAGATA, 1961). PARRY (1965) studied the dependence of coercive force with grain size for dispersed magnetite grains and found that the coercive force increases with decreasing grain sizes in assemblages of grains. Therefore, a study of the coercive force spectrum of magnetic grains in rocks will be a very important factor in distinguishing rocks with stable and unstable magnetizations within. Ranges of coercive force have been suggested for various minerals and grain sizes. Coercive force of a particular mineral is dependent on its size, shape, composition, state of

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oxidation, contamination, etc. In the present study we have investigated many dolerite dykes from different swarms in peninsular India for their remanent saturation studies and observed some interesting features that are described in this paper.

2. Geology of the Dykes

The peninsular Archaean complex is traversed by a network of basic dykes transecting their foliation planes. They are found to be developed very intensely in the area surrounding the Cuddapah basin. At places they form into thick clusters in a single direction, known as swarms (Karunakaran, 1971; Drury, 1984). The dyke material of the present study was selected from a number of swarms in different directions surrounding the Cuddapah basin, on which intensive palaeomagnetic studies were also carried out. The dyke rocks are compositionally different from the Cuddapah traps, suggesting their difference of source.

The dykes are very long, sometimes running for a few tens of kilometers. The width of these dykes is variable, from a few meters to as high as 150 m, but on average they are of 20–25 m, with a general elevation above the surrounding area. The dyke rocks exhibit ophitic to subophitic texture and range from coarse to fine grained, in general. The predominant minerals are plagioclase, pyroxenes and opaques, with quartz, biotite, apatite as accessories. These minerals with typical ophitic texture classify the rocks as doleritic. One dyke exhibited a myrmekite-like outgrowth of plagioclase and vermicular inclusion of magnetite rimmed against labradorite indicating late stages of crystallization of the magma. Magnetite and ilmenite are the major opaques. Magnetite is subhedral to anhedral in shape and skeletal at times. Ilmenite is found as lamellae also in the planes of host magnetite. Though the dykes are exceedingly old (early–mid Proterozoic) all are very fresh, without any traces of metamorphic effects.

3. Saturation Remanent Hysteresis Curves

An electromagnet which can generate DC magnetic fields reaching 1.5 Tesla was used for magnetizing the rocks and an astatic magnetometer was employed to measure the acquired magnetizations following the method of Carmichael (1961). At least one cylindrical specimen of 2.5 cm in diameter and 2.2 cm in length from each dolerite dyke representing several swarms was studied for its saturation remanent hysteresis properties. The specimens were magnetized in increasing DC magnetic fields in steps of 10 mT up to 100 mT and 50 or 100 mT up to 500 mT until saturation. The intensity of Induced Remanent Magnetization