



Study on the magnetic minerals in the mudstone of Liuchungchi Formation in Southwestern Taiwan by using magnetic force microscopy

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Study of the magnetic minerals in rocks reveals the thermoremanent magnetizations and direction of the Earth's magnetic field at the time of rock formation. Macro-magnetic methods are generally used to analyze the magnetism of rock samples and to obtain information of the mineral phases and remanent magnetization. However, nonmagnetic minerals may contribute to magnetism, which may dilute the magnetization. Therefore, magnetization and magnetic field strength may be inaccurately estimated with macro-magnetic measurements. In this study, magnetic force microscopy (MFM) was used to visualize the magnetic structures of the magnetic minerals in the mudstone of Liuchungchi Formation in Southwestern Taiwan. Furthermore, the possible correlations between the magnetic field directions and magnetic domain structures were analyzed. The XRD pattern revealed the complex mineral phases in this rock sample and it contained quartz, plagioclase, muscovite, chlorite, amphibole, greigite, pyrite, and pyrrhotite. The main magnetic carriers in this sample were greigite and pyrrhotite and the macro-magnetic measurements showed that these existed as pseudo-single-domain (PSD) grains. Additionally, micro-magnetic measurements based on the MFM technique showed that the multi-domain (MD) pyrrhotites (10 μm in length and 5 nm in thickness) were embedded in the matrix and the single-domain (SD) greigites (particle size of 1 μm with granular shapes) with a horizontal dipole (in a southwestern magnetic direction) distributed in the cleavage of clay minerals. The result of MFM measurements corresponded to that of macro-magnetic measurements (The PSD is in a mixture of MD and SD magnetic structures). It demonstrates that the MFM technique can identify micro-scale magnetic structures in individual magnetic minerals and indicate the magnetic field direction. This suggests that the MFM technique has potential applications in Earth sciences.