

運用顯微組構與礦物特徵解決古地磁問題

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摘要

一般常見的磁性礦物包含磁鐵礦、磁赤鐵礦、鈦磁鐵礦、鈦磁赤鐵礦及鈦赤鐵礦等，磁性礦物在溫度降至其居禮溫度以下時，會記錄當時地球磁場性質並保存原始殘磁至今，故這些磁性礦物可稱為古地磁的記錄員！磁性礦物之成分改變，結晶顆粒之變化，乃至於岩石中磁性礦物含量的改變，都會左右礦物顆粒間的磁矩交互作用，進而影響岩石的磁學性質及其古地磁紀錄的可靠性。由於自然岩樣中的磁性礦物通常不是單一純相，但很多磁學性質的理論基礎大都建立在單一磁性礦物且均勻成份的情況下，因此自然岩樣所量測到的磁學特性可能跟理論估算有所差距。故除了巨觀的磁學量測外，針對個別磁性礦物進行微觀的分析也非常重要。本次演講首先會以臺灣澎湖的玄武岩為例，藉由自然殘磁和磁感率的量測發現—臺灣澎湖的矽質玄武岩其殘磁方向和磁化強度是穩定的，但臺灣澎湖的鹼性玄武岩沒有穩定的殘磁方向、但有著相當高的磁感率！細究其原因為：矽質玄武岩的氧化程度較鹼性玄武岩高，且在鈦磁鐵礦中偏析出鈦鐵礦（兩種磁性礦物）；再者，矽質玄武岩含有較多次微米級的鈦磁鐵礦，其所含的單磁區顆粒比例高，這些單磁區磁性礦物之殘磁方向具有較高的一致性。反之鹼性玄武岩雖然只含有鈦磁鐵礦，不過其多磁區的礦物比例較高，且單磁區的殘磁方向分布較不一致，因此導致鹼性玄武岩在巨觀上呈現不穩定的磁學特性。另一例子則為紐西蘭 HariHari 的假玄武玻璃標本，此岩樣也同時證實礦物相、化學組成、顆粒大小與其內部顯微組構都會影響著古地磁的磁特性。

Solving paleomagnetic problems by the microstructural and mineralogical characteristics

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Abstract

Common magnetic minerals include magnetite, maghemite, titanomagnetite, titanomaghemite and titanohematite, etc. Magnetic minerals have generally been regarded as reliable recorders of past geomagnetic signatures because they are believed to carry stable thermal remanent magnetization during the magma cooling process (below the Curie temperature). The magnetic properties of rocks, such as the stability of remanent magnetization, magnetic coercivity, and magnetic susceptibility, are controlled by the properties of the rock's constituent magnetic minerals (including the mineral phase, chemical composition, grain size, and the ratio of magnetic mineral concentration and so on). Since the magnetic minerals in natural rock samples are usually not a single pure phase, many assumptions of magnetic properties are based on a single magnetic mineral with the homogeneous chemical composition. Therefore, the magnetic properties measured by natural rock samples may have differences with those from the theoretical calculation. In addition to the macroscopic magnetic measurement, it is also very important for the mineralogical and microscopic analyses.

In this talk, the basalt samples from Penghu islands (Taiwan) and pseudotachylyte sample from HariHari (New Zealand) are two examples to show how the microstructural and mineral characteristics affect the magnetic properties. The basalts of Penghu islands in Taiwan can be divided into two types—the tholeiitic basalt and alkali basalt. Alkali basalt has relatively high magnetic susceptibility but a rather unstable remanent magnetization compared to tholeiitic basalt. Our results indicate that there are two types of magnetic minerals (titanomagnetite and ilmenite) in tholeiitic basalt and it has a higher degree of oxidation. A high ratio of a single-domain magnetic structure produces a stable natural remanent magnetism (NRM) in tholeiitic basalt, while the results of magnetic force microscopy (MFM) also correspond with the results of thermal demagnetization. Although there is only one type of magnetic mineral (titanomagnetite) in the alkali basalt, a high ratio of multi-domain structure leads to an unstable NRM. The pseudotachylyte sample from HariHari (New Zealand) also proves that the mineral phase, chemical composition, particle size and microstructure all influence the magnetic properties.