Paleomagnetism of the Marble Bar Chert Member, Pilbara craton, Western Australia

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Paleomagnetic study is conducted on the early Archean rocks in Pilbara craton, northwestern Australia, to establish a first continuous apparent polar wander path during early Archean time. The Pilbara craton is composed of 3.6~2.7 Ga volcanic and sedimentary rocks, which is one of the best exposures showing complete record of early Earth's history. In the Marble Bar Greenstone Belt, the Tower Formation occurs in the dominantly volcanic Warrawoona Group and is composed of mainly Apex basalt with intercalaeted Marble Bar Chert, targeted on this paleomagnetic study. The radiometric ages of upper Panorama Formation and lower Duffer Formation constrain the age of the Towers Formation as 3454~3471 Ma.In summer 2003, the Archean Biosphere Drilling Project drilled a continuous 270 m long oriented core from the Towers Formation. Lithology of the drilled core is divided into volcanics zone and chert zone, which correspond to the Marble Bar Chert Member. The Marble Bar Chert Member is subdivided into three lithofacies zones which are white banded chert, unstratified black chert, and red-black banded chert.

A suit of rock magnetic experiments for selected specimens reveals an existence of large amounts of Multi-domain (MD)-sized magnetite associated with minor amount of hematite in the red-black banded chert. Thin section observations under microscope and scanning electron microscope reveal that the red-black banded chert exhibits layering and its grading of fine grained particles, and contains automorphic particles of magnetite and hematite. This suggests that the red-black colored chert preserves the primary structure of sedimentation.

Based on results of these experiments, 506 discrete specimens were extracted from the red-black banded chert from the drilled core. Stepwise Alternating Field Demagnetization (AFD) reveals that the MD sized magnetite is easily demagnetized until the 10 mT step and remains is gradually demagnetized through following AFD steps. The second gradual decrease of magnetization attributes finer grained magnetite, which should be main carrier of remanent magnetization. Through stepwise thermal demagnetization (ThD), remanent magnetization apparently defines two components (1) low temperature (300-450C: LT) component and (2) middle temperature (450- 575C: MT) component. The LT component shows clustering paleomagnetic direction. The MT component shows a gradual shift of the paleomagnetic directions along the core depth. The both components are apparently far from the present Earth's magnetic field and drilling hole's directions. The positive result of the intra-formation conglomerate test implies that the MT component was recorded before intrusion of the quartz vein until 3.2 Ga.

The gradual shift of paleomagnetic direction of MT component allows us to calculate three of paleomagnetic pole. Based on these paleomagnetic poles and other known paleomagnetic pole obtained from upper Apex basalt and the Duffer Formation, the simplest Apparent Polar Wander Path (APWP) from early to late Archean time is reconstructed. This APWP shows that the paleomagnetic poles of MT component located between Duffer formation and Apex basalt with smooth curve. This result indicates that the MT component of the Marble Bar Chert Member preserves highly reliable primary magnetization.

The APWP also shows that the paleomagnetic pole of LT component located on the APWP between 3.4 to 2.8 Ga. This result indicates that the remagnetization of the LT component is probably relating with the metamorphic event with intrusion of granitoid batholith before 3.2 Ga.