Fluctuations in the Rotational Motion of the Antarctic Plate as Derived from Shipboard Three Component Magnetometers

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Since the Shipboard Three Component Magnetometer (STCM) measures the earth's three-component vector magnetic field, magnetic boundary strikes (MBSs) are obtained by measurement along only one survey line. The relative motion between two plates is a rotational motion referred to the Euler pole, and the location of the current Euler pole can be calculated from the NUVEL-1 model etc.

Euler pole should be on the extension of the MBS at each station. If the MBS obtained from magnetic surveys by STCM and the Euler pole orientation at a certain station do not match, the Euler pole when the seafloor was formed at that station should be different from the current one, and it can be considered that the relative motion of rotation between the two plates took place. From this point of view, the authors tried to identify the Euler pole orientation at the time of seafloor formation from the MBSs using the existing STCM observation data for some parts of the Antarctic plate, and found the difference in the current Euler pole orientation. Furthermore, in order to clarify what factors were involved in the fluctuation of plate motion from the viewpoint of the Euler pole orientation, the authors also compared the results with the seafloor spreading rates, spreading asymmetry, and depth anomaly and other geophysical factors.

The MBSs observed by STCM when R/V MIRAI passed during the MR16-09 Leg-1 Cruise through the Antarctic plate along the E-W survey line near the boundary with the Nazca plate tended to shift clockwise towards the east. Such systematic changes are caused by the relative rotational motion of the plates around the Euler pole. Although some irregular fluctuations of the MBSs were observed along the track, the difference between the two orientations is almost zero as a whole. It seems that Euler pole has not changed for 30 million years at this site.

The same method was applied to the area on the Antarctic plate south of the South East Indian Ridge. STCM data were available from MR03-04 Cruise Leg6 by R/V MIRAI, and JARE 51-58 marine geophysical survey by Icebreaker SHIRASE on the way to SYOWA Station. The MBSs orientation is almost the same as the Euler pole orientation around the spreading centre of the South East Indian Ridge (boundary between the Indo-Australian Plate and the Antarctic Plate). However, the MBA turned counterclockwise by about 30° at 85-95°E, 50-56°S corresponding to the age of 30-50Ma of the seafloor. This shows that a clockwise rotation by about 30° took place during this period of 20 million years. The area at 55-60°S along 110°E (almost the same age of the seafloor as the previous case) shows about 70° clockwise rotation during this period to reach the current spreading direction (Fig.1).

On the other hand, on the seafloor of almost the same age near 85°E east, the difference in orientation is smaller than that of the former two cases. However, since differences in these two orientations were observed even around the spreading centre where spreading might be almost uniform, these fluctuation could also be derived from unstable spreading of the plates from time to time.

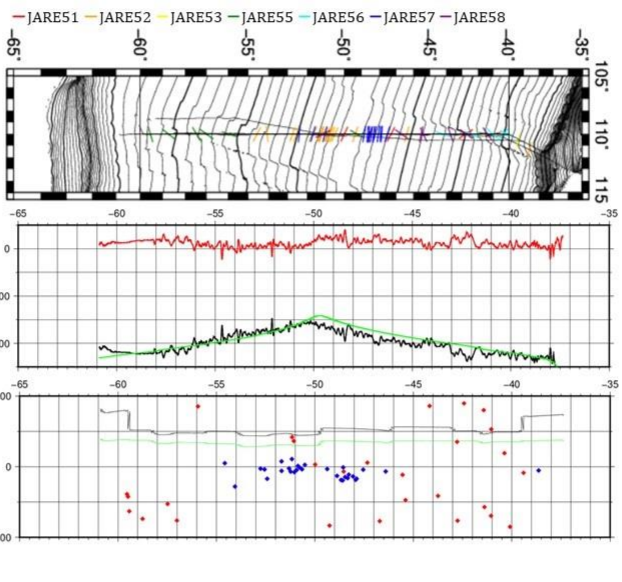

Figure 1: (Top) JARE51-JARE58 cruise tracks with MBS on isochrons (Muller et al., 2016, contour interval 2Ma). (Middle) depth anomaly (red), age-depth model (green) and measured depth (black) at JARE53. (Bottom) spreading asymmetry (black, unit in %), half spreading rate (green, unit in mm/yr), and scatter plot of difference between MBS and Euler pole orientation (red: JARE51-58, blue: JARE52 and JARE58, unit in degree).