KCC - J-DESC

Repository Core Re-Discovery Program (ReCoRD)

Proposal Form

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Basic Information

Title:	Decoding paleomagnetic field intensity variations of the Cretaceous Normal Superchron from the Kerguelen Large Igneous Province
Keywords: (5 or less)	Geodynamo, Paleomagnetic field intensity variation, Cretaceous Normal Superchron, Kerguelen plateau, Key tie-point of magnetic anomaly during Cretaceous Normal Superchron
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☒ Granted. ☐ Not Granted.

Scientific Objectives (250 words or less)

The absence of geomagnetic polarity reversals for ~37 million years during mid-Cretaceous period, known as the Cretaceous Normal Superchron (CNS), is a notable phenomenon (Yoshimura, 2022). This extended period can occur by two core-mantle boundary (CMB) heat conditions based on geodynamo simulations: (a) small CMB heat flux (Driscoll & Olson, 2011). (b) recurrent pattern of large and small CMB heat flux is symmetric around equator (Glatzmaier et al., 1999). They yield different geomagnetic field intensity variations. Therefore, paleomagnetic field intensity (paleointensity) of CNS gives us clues to understand the CMB heat condition during CNS. However, two conflict hypotheses of paleointensity variations: (1) strong and stable (Tarduno et al., 2001, 2002), (2) highly variable (Tauxe & Staudigel, 2004; Granot et al., 2007).

To reveal the paleointensity during CNS, it is essential to recover 25 or more reliable paleointensity (Tauxe & Staudigel, 2004). Therefore, we plan to use volcanic rocks erupted during CNS such as Kerguelen Plateau and Broken Ridge (KP/BR), known as longest-lived Large Igneous Province (LIP) (Jiang et al., 2021). They were drilled by ODP Legs 119, 120 and 183. It is necessary to analyze paleointensity and rock-magnetic properties combined with lava stratigraphy, geochronology, and geophysical sensing.

We aim to reconstruct paleointensity variations during CNS using rock samples of KP/BR through following three works.

1) Paleointensity experiments and rock-magnetism analyses using whole rock and single silicate crystals from Kerguelen LIP.
2) Evaluate lava structure, eruption timing, and the effect of weathering/alteration.
3) Discuss paleointensity variations during CNS with magnetic anomaly.

Proposed Target Cores

Leg/Exp.	Site-Hole	Cores
Leg 119	Site 738-Hole C	32R-36R
Leg 120	Site 747-Hole B	11R-16R
Leg 120	Site 748-Hole C	79R-87R
Leg 120	Site 749-Hole A	11R-16R
Leg 120	Site 750-Hole B	14R-17R
Leg 183	Site 1136-Hole A	15R-19R
Leg 183	Site 1137-Hole A	24R,31R-32R,37R-41R,45R-46R
Leg 183	Site 1138-Hole A	74R-89R
Leg 183	Site 1141-Hole A	13R-24R
Leg 183	Site 1142-Hole A	2R-10R

Add lines as needed
[Note: Only cores in KCC are available.]

Proposed analysis prior to sampling

Split core images (AH and WH) are required as part of a process to pre-select samples. X-ray CT scans and MSCL of the cores (AH and WH) at the Kochi Core Center are required prior to the sampling. X-ray CT scans of the cores will be used to evaluate the relationship between the continuous density distribution and alteration of the cores. MSCL (natural gamma ray, gamma ray density, elastic wave velocity, and resistivity) scans of the cores are used for obtaining more precise density estimation. Natural gamma rays are especially essential for contrasting the litho-stratigraphy of the all drilling cores.

[Note: Please describe above any analysis needed prior to sampling. Standard set is X-ray CT, split core image (WH and/or AH), microscopic imaging of smear slide and/or thin section.]

Summary of previous studies of the target cores

The Kerguelen Plateau and Broken Ridge are together known as the Kerguelen Large Igneous Province (LIP). The two were originally jointed but were split by seafloor spreading along the Southeastern Indian Ridge. The area is approximately 1.9 M km^2 and the volume is 19.7 M km^3 (Coffin et al., 2002). In previous Ocean Drilling Programs (Leg 119, Leg 120, Leg 183), many of the igneous basement (33-233 m depth) recovered from 10 drilling sites on the LIP have been found to have erupted during the Cretaceous Normal Superchron (Coffin et al., 2002; Duncan, 2002, Jiang et al. 2021).

The LIP formed after the Gondwana break-up, and $^{40}Ar/^{39}Ar$ dating studies have shown that eruptions continued from ~127 Ma in the South Kerguelen Plateau to ~90 Ma in the Central Kerguelen Plateau and Broken ridge. In addition, volcanism has also been found to have occurred around ~30 Ma in the North Kerguelen Plateau and ~10-0 Ma in the Central Kerguelen Plateau. These results indicate significantly longer than the period of mantle plume head eruption, which typically erupt over a few million years. This extended duration is inferred to be the result of the ridge-plume

interaction (Jiang et al., 2021). The influence of its long-lasting eruptions on marine anoxic events has also been discussed (Jiang et al., 2022; Matsumoto et al., 2022).

The uppermost igneous basement mainly consists of tholeiitic basalt. The physical characteristics of the lava flows, indicating subaerial eruptions, and the overlying terrestrial-derived sediments, including terrestrial vegetation, suggest that most of the LIP was above sea level during periods of high magma eruption (Frey et al., 2003).

The geochemical characteristics of the basalts forming the LIP differ from those of the mid-ocean ridge basalt (MORB). However, there are also geochemical differences among the tholeiitic basalts erupted at each site. These differences have been attributed to regionally different proportions of geochemical component derived from the Kerguelen plume, depleted MORB-related asthenosphere, and continental lithosphere (Frey et al., 2003).

Regarding previously reported rock magnetic results, it has been found that magnetic minerals (titanomagnetite) tend to be titanium-poor in subaerial erupted lavas and titanium-rich or low-temperature oxidized in submarine erupted lavas (Zhao et al., 2002). However, no further detailed paleomagnetic or rock magnetic analysis has been carried out.

Proponent List

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[Note: For proponents who do not have J-DESC memberships, please put an asterisk (*) AFTER his/her name.]