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Development of orthogonal and oblique spreading at slow and ultraslow spreading centres: Example from the Mohns Ridge

R. B. PEDERSEN AND B. HELLEVANG

Department of Earth Science, University of Bergen, Allegaten 41, Bergen, N-5007 Norway

The ultraslow spreading Mohns Ridge changed from orthogonal to oblique spreading in the Late Oligocene after a 30º change in the spreading direction. Orthogonal spreading resumed subsequently along the south-westernmost part of the ridge, whereas oblique spreading continued along the rest of the ridge. The Mohns Ridge shows robust magmatic activity with a positive axial relief in southwest, close to Jan Mayen, but grades into a magmatically starved ridge with a deep rift valley northeastwards. The ridge seems therefore to have readjusted to orthogonal spreading only in the region were the magma supply is very robust, and where the crustal accretion is mainly magmatic. The ~ 80 km long orthogonal spreading segment in this region, seems to have developed within the last 10 Ma, and probably as a result of propagation of one or several axial volcanic ridges beyond the boundaries of the rift. Along the magmatically starved parts of the ridge, the obliquely oriented axial volcanic ridges are constrained by well-developed border faults, which seem to prohibit them from propagating beyond the boundaries of the rift floor. The distribution of orthogonal and oblique spreading segments along the Mohns ridge suggest that magma supply has a principal control in stabilizing and destabilizing oblique spreading along ultraslow spreading ridges.

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Source enrichment versus degree of melting beneath the SWIR (9º-25ºE)

J.J. STANDISH[1], H.J.B. DICK[2], S.R. HART [2], R.K. WORKMAN[1] and A.P. LE ROEX[3]

[1] MIT/WHOI Joint Program, Woods Hole, MA (jstandish@whoi.edu)
[2] WHOI, Woods Hole, MA (1st Initial+lastname@whoi.edu)
[3] UCT, Cape Town, SA (aleroex@geology.uct.ac.za)

A 1000 km long section of the very slow-spreading SW Indian ridge (14-16 mm yr^{-1}) between 9º and 25ºE has two super-segments: a 600 km long orthogonally spreading segment, and a 400 km long segment oriented at an oblique angle to the spreading direction. The orthogonal super-segment (16º-25ºE) consists of magmatic segments perpendicular to spreading direction linked by minor non-transform discontinuities. To the west of 16ºE the SWIR bends to the southwest and trends at an oblique angle to the spreading direction. Between 16º and 9ºE the oblique super-segment is formed by a combination of sub-orthogonal magmatic segments (Narrowgate and Joseph Mayes Smt.) connected by a nearly amagmatic accretionary segment, oriented 32º from the spreading direction. Mapping and dredging in 2001 and 2003 along this portion of the SWIR investigated these supersegments to assess the influence of oblique spreading on ridge morphology, basalt geochemistry and mantle thermal structure and upwelling.

Basalts from the orthogonal super-segment are largely thoelitic N-MORB ($(La/Sm)_n<1$, $K/Ti<0.15$), but show a highly systematic enrichment trend from east to west in trace element abundance and ratios, major element indices, and isotopic compositions. The oblique super-segment lava compositions are highly variable. Some of the most depleted and the most enriched (e.g. La/Sm, $^{87/86}Sr$, $^{143/144}Nd$, $^{208/204}Pb$) compositions from either super-segment occur in the amagmatic zone and at Narrowgate, respectively. Differences in heavy isotopes compositions between orthogonal super-segment lavas and lavas from Narrowgate suggests that the MORB mantle source has large-scale heterogeneities within it. However, relatively constant $^{3/4}He$ across both super-segments complicates this interpretation, implying that the bulk mantle is fairly homogeneous. In this case, the sharp contrasts in geochemistry across 16°E longitude also correspond to supersegments with significantly different rates of mantle upwelling due to the ridge geometry. It remains to be seen whether the variability in basalt geochemistry can be explained by source or process, but two possible solutions are; 1) mixing of melts from a two component mantle source (where the components are ambient asthenosphere and an enriched vein assemblage), whose relative contributions vary with F, or 2) reaction of melts during transport through variably depleted mantle columns (mode of cpx varies).