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Mantle flow and melting at oblique segments of the Southwest Indian Ridge

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Segment obliquity has a marked effect on accreted crustal thickness at ultraslow spreading ridges. This relation is particularly well documented at the Southwest Indian Ridge. Dredges from the orthogonal supersegment at $9-16^{\circ}$ E return almost no basalt while robust magmatism is documented at the neighboring orthogonal supersegment and short intervening orthogonal segments. This relation is corroborated by gravity and magnetic data both at that location and further to the East. The relation between obliquity and crustal thickness can also be observed at the $54-57^{\circ}$ E area, where two ≈ 50 km long oblique segments result in regions of reduced melting that extend at least 100 km off axis.

We derived an analytical model of passive flow at an infinitely long spreading segment. This simple model reveals that crustal thickness is controlled by the effective spreading rate, as suggested earlier by Dick et al., [2003]. Therefore, a 60° obliquity angle has the same effect as halving the spreading rate. At ultraslow spreading rates, this is sufficient to shut down melting or make it so deep that melt extraction may become inefficient. To confirm this theory, we developed 3D finite element models of passive mantle flow and resulting thermal state using the plate boundary geometries of the $9-16^{\circ}$ E and $54-57^{\circ}$ E areas. Not only is melting strongly reduced at the oblique segments but we show that the short orthogonal segments at Narrowgate and Joseph Mayes seamounts, where robust magmatism is observed, have enough of an effect on the thermal structure to allow melting and possibly tap nearby melt.