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Hydrothermal activity at slow-spreading ridges: variability and importance of magmatic controls

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Hydrothermal activity along mid-ocean ridge axes is ubiquitous, associated with mass, chemical, and heat exchanges between the deep lithosphere and the overlying envelopes, and sustaining chemiosynthetic ecosystems at the seafloor. Compared with hydrothermal fields at fast-spreading ridges, those at slow spreading ones show a large variability as their location and nature is controlled or influenced by several parameters that are inter-related: a) tectonic setting, ranging from 'volcanic systems' (along the rift valley floor, volcanic ridges, seamounts), to 'tectonic' ones (rift-bounding faults, oceanic detachment faults); b) the nature of the host rock, owing to compositional heterogeneity of slow-spreading lithosphere (basalt, gabbro, peridotite); c) the type of heat source (magmatic bodies at depth, hot lithosphere, serpentinization reactions); d) and the associated temperature of outflow fluids (high- vs.- low temperature venting and their relative proportion).

A systematic review of the distribution and characteristics of hydrothermal fields along the slow-spreading Mid-Atlantic Ridge suggests that long-lived hydrothermal activity is concentrated either at oceanic detachment faults, or along volcanic segments with evidence of robust magma supply to the axis. A detailed study of the magmatically robust Lucky Strike segment suggests that all present and past hydrothermal activity is found at the center of the segment. The association of these fields to central volcanos, and the absence of indicators of hydrothermal activity along the remaining of the ridge segment, suggests that long-lived hydrothermal activity in these volcanic systems is maintained by the enhanced melt supply and the associated magma chamber(s) required to build these volcanic edifices. In this setting, hydrothermal outflow zones at the seafloor are systematically controlled by faults, indicating that hydrothermal fluids in the shallow crust exploit permeable fault zones to circulate. While less studied, similar hydrothermal systems are found elsewhere associated to other central volcanoes along the ridge axis (e.g., Menez Gwenn at the Mid-Atlantic Ridge and Soria Mornia or Troll Wall at the Arctic Ridges).

Long-lived hydrothermal activity plays an important role in controlling the thermal structure of the lithosphere and its accretion at and near-axis, and also determining the distribution and biogeography of vent communities. Along slow-spreading segments, long-lived hydrothermal activity can be provided both by volcanic systems (e.g., Lucky Strike) and tectonic systems (oceanic detachment faults). While magmatic and hydrothermal activity is relatively well understood now in volcanic systems (e.g., Lucky Strike), tectonic systems (oceanic detachment faults) require further integrated studies to constrain the links between long-lived localization of deformation along oceanic detachment faults, hydrothermal activity, and origin and nature of off-axis heat sources animating hydrothermal circulation.