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Modelling the Lost City Hydrothermal System

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A preliminary 2-D model of hydrothermal circulation in the Atlantis Massif, mid-Atlantic Ridge, 30 °N has been made using COMSOL Multiphysics®. Our model differs from previous work by including seafloor topography, which strongly controls circulation due to the elevated isotherms within the Massif.
Initial models use a uniform permeability and isotherms corresponding to a vertical thermal gradient of 100 °C/km, which is the approximate gradient seen in IODP Hole U1309D, 10 km to the north of the Lost City hydrothermal field. The basal boundary condition is a constant heat flux corresponding to the thermal gradient. A N-S profile through the massif passing through both Lost City and IODP Site 1309 has been used. For typical permeability values a vigorous hydrothermal circulation is rapidly established, with fluid entering the model at the base of the transform valley, and exiting through the crest of the massif. However, temperatures of venting are generally much higher than at Lost City unless permeability is suppressed in the lower part of the model, and typically the hydrothermal system is short-lived, removing most of the heat from the Massif in less than 3000 years, at which point circulation ceases and a low thermal gradient exists everywhere.
Our work suggests that a particular permeability structure will be required to achieve the combination of prolonged venting at < 100 °C, and a thermal gradient of around 100 °C /km only 10 km to the north. Work is continuing on variable permeability and including heat of serpentinisation in the model. We will also incorporate new data on the thermal structure of IODP Hole U1309D to be collected on IODP Expedition 340T early in 2012. Eventually we hope to predict the isotherm structure as a function of time throughout the Massif, and hence the time-dependent location of temperature conditions suitable for both serpentinisation and microbial life.