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Thermal evolution of Site U1414 by stable isotopes δ13C and δ18O, 87Sr/86Sr and fluid inclusion analyses, IODP Expedition 344

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IODP Expedition 344 is the second expedition in course of the Costa Rica Seismogenesis Project (Program A), that was designed to reveal processes that effect nucleation and seismic rupture of large earthquakes at erosional subduction zones. Site 344-U1414, located 1 km seaward of the deformation front offshore Costa Rica, serves to evaluate fluid-rock interaction and geochemical processes linked with the tectonic evolution of the incoming Cocos Plate from the Early Miocene up to recent times. Combined isotope analyses and microthermometric analyses of fluid inclusions of hydrothermal veins within lithified sediments and the igneous basement (Cocos Ridge basalt), was used to reveal the thermal history of Site 344-U1414. Veins in the sedimentary rocks are mainly filled by coarse-grained calcite and subordinately by quartz. Veins within the basalt show polymineralic filling of clay minerals, calcite, aragonite and quartz. Blocky veins with embedded wall rock fragments, appearing in the sediments and in the basalt, indicate hydraulic fracturing. The carbon isotopic composition of the vein calcite suggest the influence of a CO_2 -rich fluid mixed with seawater (-3.0 to -0.4‰ V-PDB) and the δ18O values can be differentiated in two groups, depending on the formation temperature (-13.6 to -9.3‰ and -10.8 to -4.7‰ V-PDB). 87Sr/86Sr ratios from the veins confirm the results of the stable isotope analyses, with a higher 87Sr/86Sr ratio close to seawater composition and lower ratios indicating the influence of basalt alteration.

The hydrothermal veins contain different types of fluid inclusions with high and low entrapment temperatures and low saline fluids. The occurrence of decrepitated fluid inclusions, formed by increased internal overpressure, is related to isobaric heating. Elongated fluid inclusion planes, arc-like fluid inclusions and low homogenization temperatures suggest subsequent isobaric cooling. The stable isotopic content, strontium isotopic composition and the results of fluid inclusion analyses indicate that the source of fluids is a mixture of mobilized pore water and invaded seawater that communicated with high temperature CO_2-rich fluids. We propose that lithification of the sediments was accompanied with a first stage of vein development in the Middle Miocene and was a result of the Galapagos hotspot activity. Heat advection led to subsequent vein modification related to isobaric heating. The latest mineralization occurred during crustal cooling up to recent times.