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Quantitative mineral proxies of fluid chemistry and geothermal gradients in the Kumano Transect, Nankai Trough, Japan

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The Nankai Trough subduction margin is capable of generating tsunamigenic earthquakes with M>8. The physical properties of materials involved in faulting and the magnitude of fluid overpressures exert important controls on the nature of seismicity. We present data from diagenetic carbonates constraining the temperature and chemistry of fluids passing through the accretionary system during deformation. Reference drill sites C0011 and C0012 sampled the sedimentary section and part of basaltic crust. Both sites comprise hemipelagic mud, silty and sandy turbidites with significant ash and volcaniclastic sediment. Carbonates are dominantly calcite or ankerite with varying substitutions of primarily Mn and Fe for Ca. The minimum δ18O values of carbonate samples show a steady trend of decreasing values with depth, and although multiple factors contribute to isotope signatures, at a first order the isotopes are consistent with recent carbonate formation at temperatures following along a geotherm. Temperatures of carbonate formation determined from carbon clumped geothermometry at both sites confirm formation in equilibrium with the modern geothermal gradients, although showing some scatter, consistent with recent and active cementation.

Cuttings and cores from Site C0002 in the Kumano Basin, from depths up to $\sim$3 km, suggest increased faulting and carbonate formation with depth. Sample below 2100 mbsf include numerous carbonate slickenfibers. Carbonates are dominantly calcite or low-Mn calcite, with minor Fe substitution. Veined samples show a steady of trend of decreasing δ18O values with depth that could be attributed to vein formation at increasing burial temperatures. No temperature measurements are available from this interval and temperatures have to be estimated by extrapolation of measurements from the shallow Kumano Basin, and using thermal conductivity measurements of well cuttings. The preliminary clumped isotope temperature estimates, mainly from a cored fault interval at 2105 mbsf, fall mostly below the gradient, even though the trend in oxygen isotope values from several cements and veins suggests formation along a geotherm. The carbonates could have formed at shallower depths, and the apparent trend along a geotherm is fortuitious. Another possibility is that the geothermal gradient decreases more rapidly at depth than has been modeled, and that the carbonates are a record of recent temperatures. If the latter is correct, then there is a clear temperature spike of $\sim$20°C from the 2105 fault that records flow of exotic fluid from depth. Additional carbonate clumped analyses are underway on samples from beneath the Kumano Basin.

In accretionary margins it is common to observe carbonate formation in the upper 10s to 100s of meters, above the sulfate-methane transition zone, but our results show at greater depths processes continue to favor dissolution and reprecipitation of carbonate, especially in faults, thus contributing to sediment lithification before and during deformation. The relationship of veins with faults supports faults as prevalent conduits. In some cases it is clear that carbonates can provide quantitative estimates of thermal gradients where other temperature data are not available. Such information is essential for understanding other processes that can change physical properties.