Quartz precipitation and fluid-inclusion characteristics in submarine hydrothermal systems

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Numerical modeling of quartz dissolution and precipitation in a sub-seafloor hydrothermal system was used to predict where in the system quartz could deposit and trap fluid inclusions. The spatial distribution of zones of quartz dissolution and precipitation is complex, owing to the many inter-related factors controlling quartz solubility, including temperature, fluid salinity and fluid immiscibility, and quartz may exhibit either prograde or retrograde solubility, depending on the *PTX* conditions [1]. Using the *PVTX* properties of H_2O-NaCl, the petrographic and microthermometric properties of fluid inclusions trapped at various locations within the hydrothermal system are predicted. Vapor-rich inclusions are trapped as a result of the retrograde temperature-dependence of quartz solubility as deep convecting fluid is heated in the vicinity of the magmatic heat source. Coexisting liquid-rich and vapor-rich inclusions are also trapped in this deep region when quartz precipitates as the convecting fluid enters the region of fluid immiscibility. Vapor generated as a result of fluid immiscibility migrates upward, entraining variable amounts of brine and/or heated seawater. During ascent, vapor condenses and mixes with seawater entrained in the upwelling plume. Fluid inclusions trapped along the upflow path in the shallower subsurface near the seafloor vents and in the underlying stockwork are liquid-rich and homogenize at 200-400 °C. Salinities of these inclusions are similar (but generally not equal) to that of seawater. Volcanogenic massive sulfide (VMS) deposits represent fossil submarine hydrothermal systems, in which mineralization commonly forms a stockwork zone beneath seafloor vents. Because the spatial variation of fluid-inclusion properties in this portion of the submarine hydrothermal system can be predicted, relationships between fluid-inclusion properties and location within the hydrothermal system can be inferred. Fluid inclusion properties can thus be used as an exploration tool for VMS deposits. Importantly, fluid inclusions can define vectors to infer the direction towards potential massive sulfide ore within fossil submarine hydrothermal systems, and can be used to determine the "up" direction within a deformed or tilted volcanic pile.

[1] Akinfiev, Diamond (2009) *Geochim. Cosmochim. Acta* **73**, 1597-1608.

Climate forcing of ice sheet dynamics in West Antarctica

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Recent West Antarctic Climate and Ice Sheet Change

Ice shelves and glaciers along the margin of the Antarctic ice sheet are thinning rapidly. The greatest thinning rates are in West Antarctica, where warm Circumpolar Deep Water (CDW) floods the continental shelf and melts the ice shelves from below. This region has also experienced significant climate changes in the last 30 years or more, including rising temperatures over most of continental West Antarctica and the Antarctic Peninsula, and declines in sea ice in the Amundsen-Bellingshausen Seas [1].

Climate and glaciological changes in West Antarctica are linked by changes in the regional atmospheric circulation which have caused increased poleward warm-air advection, sea ice convergence, and wind-driven inflow of CDW onto the shelf. These changes in regional atmospheric circulation are largely a response to forcing from the tropical Pacific (Figure 1). Particularly in the 1990s, strong sea surface temperature anomalies and anomalous deep convection in the central tropical Pacific caused enhanced Rossby wave activity, resulting in anomalous westerlies along the Amundsen Sea coast of West Antarctica [2].

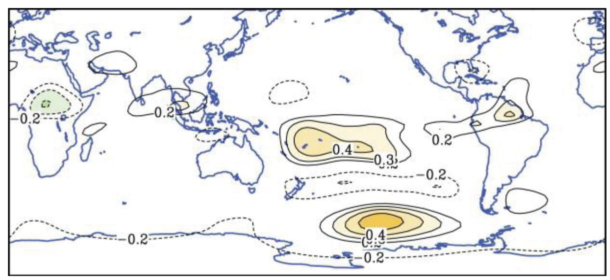

Figure 1: Correlation between the global 200 hPa stream function and the westerly wind stress over the West Antarctic shelf edge [2].

Attribution

These results imply that recent glaciological changes in West Antarctica can be attributed to anthropogenic forcing only to the extent that recent changes in the tropical Pacific can be so attributed. Paleoclimate record from corals shows that the anomalous conditions in the tropics in the last ~30 years are very likely exceptional in the last millennium. Similarly, the ice core record from West Antarctica shows that the 1990s are the most anomalous decade in at least the last 300 years. Nevertheless, attribution of tropical Pacific climate changes to anthropogenic forcing remains equivocal, largely because there is significant uncertainty in the response of the El Niño-Southern Oscillation. Uncertainty in projections of the future behavior of the West Antarctic ice sheet is further complicated by uncertainty in projections of tropical climate.

[1] Ding *et al*. (2011), *Nature Geosci.* **4,** 398-403.
[2] Steig *et al.* (2012) *Annal. Glaciol.* **62**, in press.