Venting history and accumulation rates of hydrothermal sulfide, Endeavour Segment, Juan de Fuca Ridge

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Active hydrothermal systems on the ocean floor provide modern analogues for the formation of ancient VMS deposits. Seafloor hydrothermal processes are also an important mechanism for the transfer of heat and chemicals between the underlying crust and oceans. However, the rates at which these processes occur remain poorly constrained.

Here, we present radioisotope ages and volume estimates of hydrothermal sulfides from the Endeavour Segment, an intermediate rate ocean spreading center along the Juan de Fuca Ridge that hosts 5 active high-temperature vent fields. The ridge is currently undergoing a period of tectonic extension and volcanic quiessence. A suite of 43 sulfide samples, collected by manned submersible from the active fields and extinct/inactive sites, have been dated using ^{226}Ra/Ba ratios from hydrothermal barite that precipitates along with sulfide minerals. Radium-226 has a half-life of 1,600 years, making it an ideal chronometer for samples younger than ~20, 000 years. Results indicate that venting within the current axial valley of the Endeavour segment was initiated at least 2, 500 years ago. Venting within the Main Endeavour Field, the largest field by area, has been continuous for this period of time.

Using a GIS-based volume calculator developed at MBARI, the total volume of hydrothermal sulfide (including active and inactive/extinct structures) is determined from high-resolution bathymetry of the entire ridge segment. By combining volume data with the age of venting at Endeavour, the mass accumulation rates of sulfide can be determined at the segment scale. These results can be used to calibrate the efficiency of sulfide deposition from hydrothermal vents, and provide a time-integrated history of heat, fluid and chemical fluxes at the ridge-segment scale. The comparison of time-integrated rates with real-time estimates, based on fluid and chemical fluxes, as well as heat flow measurements, allow for an estimate of the episodicity of venting at Endeavour.

Porosity evolution, fracturing and Liesegang-banding during spheroidal weathering

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A 10-meter thick andesitic sill intrusion from the Neuquen Basin, Argentina, shows spectacular examples of spheroidal weathering and Liesegang banding. The Liesegang patterns demonstrate how andesite blocks, initially cut out by a pre-weathering joint set, are subdivided by fractures forming during the spheroidal weathering process. The stresses causing fracturing originate from the growth of ferrihydrite and calcite in the pore space of the andesite, partly at the expense of original ilmenite, amphibole, and plagioclase. Fresh andesite has a porosity of ca. 8%. The porosity evolution and fracture formation during progressive weathering has been characterized in 3D by X-ray computed tomography (CT). The extent of pore filling increases with pore-size. Pores > 10^6 μm^3 are almost completely filled, whereas pores < 10^3 μm^3 are < 50% filled. More than 85% of the pore volume is comprised of pores < 10^3 μm^3, and thus the overall porosity is only slightly reduced during weathering. The fracturing associated with spheroidal weathering is caused by growth in pores comprising the largest 10% of the total porosity. We suggest that variation in growth rate with pores size is controlled by more effective transport of externally derived components to the larger pores. Models for diffusive transport in a porous rock with a pore size distribution similar to the observed will be presented, along with a fracturing model where stresses are generated by growth in pores.