SEG-MJD 2016 Conference

Mineralogical Similarities Between Modern Seafloor Chimneys from Brothers Volcano, Kermadec Arc, and Eastern Pontide (NE Turkey) Paleo-chimney Fragments

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The eastern Pontide belt was formed through magmatism associated with rifting, subduction, and regional extension between the Jurassic and Tertiary periods. Its numerous VMS deposits are associated with the middle stages of volcanism, being hosted by Late Cretaceous, primarily dacitic/rhyolitic volcanic rocks. The preservation of paleochimney fragments within the VMS deposits confirms their formation in a submarine environment. The Kermadec arc was built through subduction of the Pacific plate beneath the Australian plates and includes nearly 30 volcanic centers. Modern hydrothermal chimneys are found at Brothers dacitic volcano, perched on part of the steep caldera walls at the northwest Caldera field. This field strikes for ~600 m between depths of 1,550 and 1,700 m and includes numerous, active, high-temperature (max 302°C) chimneys and even more dead, sulfide-rich spires.

Ore minerals in the Pontide chimneys are dominated by pyrite/marcasite, chalcopyrite, and sphalerite, with lesser galena, other Cu-(Fe) sulfides, pyrrhotite, fahlore (tennantite-tetrahedrite), gold, silver, Hg-rich electrum, wittichenite (Cu_3BiS_3), tellurobismuthite (Bi_2Te_3), hessite (Ag_2Te), kawazulite [$Bi_2(TeSeS)_3$], and Ag sulfosalts. LA-ICP-MS spot analysis across the chimney sections also shows enrichment in Mo, Se, and Sn toward the chimney interiors; conversely, toward the chimney exteriors, there is enrichment in Mn, Co, Ni, Tl, Cd, Pb, Te, Au, Ag, U, and V. Gold concentrations reach 25 ppm. By comparison, chimney samples collected from Brothers are very similar, being dominated by pyrite/marcasite, chalcopyrite, and sphalerite, with lesser galena, other Cu-(Fe) sulfides, pyrrhotite, tennantite, Bi-(Au) tellurides, and kawazulite. In addition, Brothers chimneys also contain Pb-As sulfosalts, realgar, hematite, and goethite. Au concentrations reach 91 ppm. We have undertaken high-resolution trace element mapping of Brothers chimney samples using both sychrotron radiation X-Ray fluorescence microscopy and LA-ICP-MS. In one Cu-rich chimney, visibly laminated chalcopyrite in the interior contains multiple bands (~30 μm) with a magmatic suite of elements, variously including In, Cd, Co, Mo, Ag, Te, Se, Au, Sn, Bi, and Ni. Uranium is also included in many of these bands, suggesting that their deposition was precipitated by an influx of seawater. However, in another Cu chimney, a thick (~2 cm) ring of massive chalcopyrite has no trace banding, but instead includes Se and Hg within the chalcopyrite matrix, suggesting these elements were precipitated through conductive cooling without direct seawater contact. High-resolution element mapping allows us to resolve the distribution of elements in microscopic features of chimneys, such as microbanding, that are easily missed through spot analysis, leading to a better understanding of the physicochemical influences on precipitation of specific elements. Moreover, the determination of a suite of magmatic elements associated with Cu and Au strongly suggests a magmatic infuence in the source of these metals. Comparing mineralogy of modern and paleochimneys may show

which elements have migrated or phases exsolved through time, even when the ancient fragments are well preserved.