Formation of reactive oxygen species and (iron)silicate (nano)particles in the mixing zone above hydrothermal vent orifices

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The dynamic mixing zone within the first two meters of hydrothermal vent orifices leads to myriad reactions. Here we demonstrate the formation of reactive oxygen species (ROS) as dissolved Fe(II) and FeS nanoparticles from vent rich waters react with O_2 from cold ambient waters, and the formation of silicate phases containing Mg and/or Fe at vents from 9^0 50′ North East Pacific Rise. Plume waters were drawn into syringes preloaded with horseradish peroxidase enzyme and Amplex Red to immediately convert ambient hydrogen peroxide, H_2O_2, to the stable fluorophore, resorufin. Hydrogen peroxide at levels as high as 6.2 micromolar were found in plume and seep waters, and correlated with initial O_2 concentration anticipated during mixing. Data indicate that an Fe-O_2-Mn-H_2S catalytic cycle developed with formation of S_8. Formation of H_2O_2 in the presence of dissolved Fe(II) leads to hydroxyl radicals that can react with refractory materials including organic compounds. Similarly, Mg, which is depleted in vent waters, reacts with silica emanating from vents to from silicates. Selected area electron diffraction patterns of (nano)particles show that Mg- and Fe-bearing silicate phases form in the mixing zone. The mineral phases include kaolinite, Fe-rich micas, and talc/lizardite; their formation in the plume is an example of reverse weathering. These particles are ubiquitous in sampled fluids and are a previously undocumented source of Fe to the global ocean.