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M. Goldhaber: SULFUR DIAGENESIS IN MARINE SEDIMENTS

Bacterial sulfate reduction occurs in all marine sediments that contain organic matter. Aqueous sulfide (HS^- , H_2S), one of the initial products of bacterial sulfide reduction, is extremely reactive with iron-bearing minerals: sulfur is fixed into sediments as iron sulfide (first FeS and then Fe_2S_2). The sequence of biological and chemical alterations that occur in sediment once the sulfur has been deposited is called sulfur diagenesis. Diagenesis involves variable and complex reactions at different rates. The rate of the first step, sulfate reduction, varies in different environments by a factor of as much as 10^6 . Such variation is due to the kind and amount of organic matter utilizable by sulfate-reducing bacteria. Sediment accumulation rate dramatically influences the kind of organic matter buried and brought to the zone of sulfate reduction by controlling the exposure of organic matter to degradative oxic conditions near the sediment/water interface.

Aqueous sulfide reacts during sulfur diagenesis with hydrated iron oxide (goethite), which is the major form of reactive iron in most sediments. At the pH of marine pore waters the product of this reaction is mackinawite (tetragonal Fe_3S_4). Subsequently mackinawite transforms to greigite (cubic Fe_3S_4) and finally to pyrite (cubic FeS_2). I believe there occurs in the sediments an addition of elemental sulfur to mackinawite and greigite but the source of this sulfur and its transformations remains obscure.

The quantity of sulfur in pyrite which accumulates in marine sediments is frequently much greater than the sum of the quantities trapped in the pore fluid as sulfate ions plus that entering the sediment as detrital organic sulfur. The excess sulfur is supplied by interchange of pore fluids with overlying sea water caused by the bioturbational activities of the animals and the diffusion of sea water sulfate into sediments. These sources of sulfate are abundant enough to insure that pyrite formation is not limited by sea water sulfate availability. Since the amount of pyrite measured in marine sediments is directly proportional to that of organic carbon, I suggest that the quantity and quality of organic matter controls pyrite formation.

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SULFUR COMPOUNDS IN NATURE

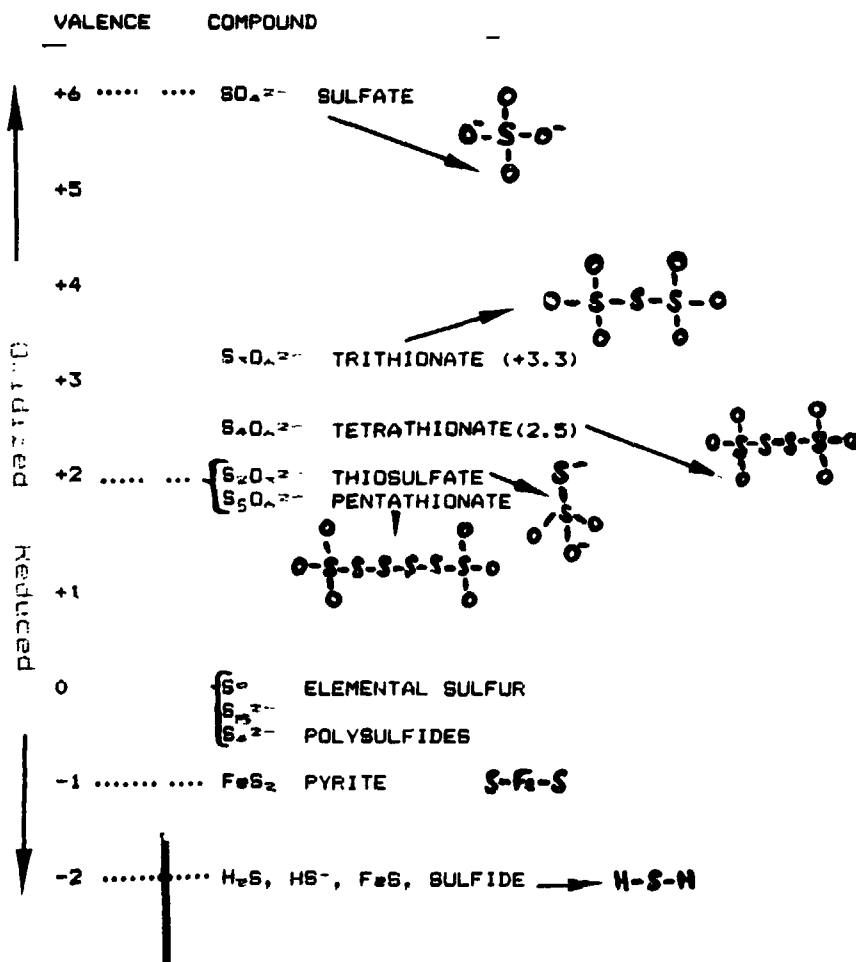


Figure I-12. Sulfur is easily oxidized and reduced: its valence in nature varies from -2 to +6. Sulfates, elemental sulfur and sulfides are the most common forms of the element.