

The S cycle of early Earth and implications for mineralisation

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Sulfur is present in all major reservoirs on Earth, including the crust and the mantle, and is interpreted to be abundant in the core. It is present in the oceans, mostly as sulfate, and in the atmosphere as various gaseous species. Because of its multiple valence states (from S^{2-} to S^{6+}), S can participate in a large number of reactions, both abiogenic and biogenic, and is an essential element for extant and ancient life.

S is also an important element in the formation of ore deposits, as it controls the distribution of chalcophile elements in magmas and sediments in its reduced form (sulfide), and can combine with some base and precious elements in fluids (supercritical fluids, liquids and vapours) in hydrothermal environments. In fact, many metal ore deposits are above all S anomalies.

The geochemical cycle of S can be delineated based on the fractionation of its four stable isotopes. On modern Earth, strong fractionation of S isotopes at the planetary scale reflects the redox contrasts between the oxygenated oceans and atmosphere and the mostly reduced mantle and crust. Biogenic reactions also induce strong fractionation of S isotopes, so that S isotopic compositions of various minerals can be used as a tracer of metabolic processes. In contrast, Archaean and early Palaeoproterozoic marine sediments record muted S-isotope fractionation, which is interpreted to reflect lower abundance of sulfate in the ancient oceans.

In this review, I will summarise the present state of knowledge of the geochemical cycle of S in rock successions and ores deposited before ca. 2.4 billion years ago and underline some of the implications for the understanding of the composition of the early atmosphere and oceans. This knowledge can be then applied as a powerful tracer of S during the transport of metals in magmas and fluids and the formation of ore deposits. Well-studied ore deposits will be taken as examples of how modern developments of analytical techniques have changed our understanding of ore-forming processes and the distribution of S between different reservoirs on early Earth.

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