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The source of sulfur in the Mesoarchaeoan gold deposits of the Barberton Greenstone Belt, southern Africa

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The source of metal-bearing fluids in structurally-controlled ore deposits is controversial, as both metamorphic and igneous sources have been proposed [1]. In gold deposits of Neoproterozoic terranes in Western Australia and Canada, felsic magmatism coeval with mineralisation has been interpreted as the source of gold [2]. The Palaeoproterozoic Barberton Greenstone Belt of southern Africa contains some of the oldest gold deposits known. In these deposits, Au is hosted by late extensional faults that truncate the main compressional structures in the greenstone belt [3]. The ore, which is hosted in meta-volcanic and meta-sedimentary rocks, is dominated by pyrite and arsenopyrite, and gold either occurs finely disseminated in sulfide minerals (“invisible gold” present in solid solution or nano-inclusions), or is present as free gold grains in quartz-carbonate veins. The ore fluids were H₂O-CO₂-rich, and S may have been an important complexing agent for the transport of Au. The estimated age of mineralisation (3.0 – 3.1 Ga) broadly overlaps with felsic magmatism in the area [4, 3]. We used multiple S isotopes (³²S, ³³S and ³⁴S) to track the possible sources of S in sulfides from Barberton gold deposits.

Sulfur in sulfide and sulfate minerals from Proterozoic terrains has $\delta^{33}\text{S}$ and $\delta^{34}\text{S}$ values that characteristically deviate from mass-dependent fractionation. This is interpreted as a consequence of UV radiation-induced photolytic reactions of S gases in a low-oxygen atmosphere [5]. MIF-S can be used to distinguish “atmospheric” S sources from endogenous (volcanic, crustal etc.) sources. Analyses of S isotopes in pyrite hosted in meta-mafic and meta-sedimentary rocks from two deposits of the Barberton Greenstone Belt indicate $\Delta^{33}\text{S} = -0.6$ to $+1.0$ ‰, and $\delta^{34}\text{S} = 0$ to $+8$ ‰. These values overlap with available analyses of pyrite and, to a lesser extent, barite from several sedimentary units in the greenstone belt, and clearly indicate derivation of S from the surrounding rocks. These analyses do not allow to constrain the origin of the major components of the ore fluids (H₂O and CO₂), which may have been derived from sources external to the greenstone belt (e.g. magmas). However, the fact that S – possibly the main complexing agent for Au – was derived from the supracrustal succession places constraints on the ultimate source of Au.

References

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