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West African orogenic gold deposits: do they fit the global paradigm?

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The current orogenic gold paradigm is that such deposits are dominantly sourced from metamorphic fluids. In this model, metals are leached during metamorphism and transported in low salinity, CO_2-rich alkaline fluids largely as S complexes. This is in complete contrast to epithermal gold deposits. Evidence for the metamorphic model is largely built around S isotope signatures and the nature of the low salinity, CO_2-rich fluids. Various authors have, however, stressed the probable importance of magmatic fluids in the evolution of some orogenic gold deposits. We attempt to address this key issue using new data from the Birimian-aged orogenic gold deposits of West Africa.

The Loulo mining camp of West Mali hosts gold mines with a combined resource of over 17 Moz, making this one of West Africa's most important Au regions. Here, both the Gara and Gounkoto deposits feature two distinct hydrothermal fluids: 1) A high temperature, hypersaline, Na-Fe-Cl-B-bearing fluid of uncertain origin and 2) a lower temperature, low salinity, CO_2-N_2-H_2S rich metamorphic fluid. The chemistry of the former fluid is consistent with a magmatic origin [1], as is widespread regional albite alteration that is associated with early stages of mineralization and a strong boron anomaly that extends along the strike of the Senegal-Mali Shear Zone [1, 2]. Tourmaline is a key component of the Loulo deposits. New boron isotope data suggest that the tourmalines have a sedimentary, rather than magmatic source, which indicates that the hypersaline fluids likely also have a metamorphic source. This would be consistent with the $\delta^{34}S$ isotope data of >10 per mil.

However, other orogenic gold deposits from the region are less clearly sourced from metamorphic fluids. For deposits both at Massawa [3] in eastern Senegal and Morila [4] in south Mali (interpreted as a reduced intrusion-related gold system), mineralization can be demonstrated to be synchronous with felsic magmatism. Both deposits have $\delta^{34}S$ signatures close to 0 per mil, which would be consistent with a magmatic fluid. The same goes for the Tongon orebody in northern Cote d'Ivoire where new field data show gold mineralization to be linked to exo-skarn assemblages.

Mineral paragenetic data, together with fluid inclusion and stable isotope chemistries, suggest that the role of magmatic fluids in the development of world-class orogenic gold deposits in the Birimian of West Africa, and elsewhere, may have been underestimated.

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