B8

Connecting Proterozoic Carbonate-Hosted Zn-Pb-Cu-Ag Mineral Systems Between Two Continents Using Whole-Rock Pb Isotope Geochemistry

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In carbonate-hosted mineral deposit systems, a link can be made between the Pb isotope compositions of ore minerals (galena, sphalerite, pyrite), host rocks (limestones, dolostones), and underlying continental crust that sedimentary basins were deposited upon (e.g., Tosdal et al., 1999). Previous workers have suggested that ore sulfide minerals in the Proterozoic carbonate-hosted Vazante district, on the southwestern margin of the São Francisco Craton (SFC) in Brazil, and in Proterozoic basins on the margins of the Congo Craton in Africa (Kipushi, DRC; Kabwe, Zambia; Tsumeb, Namibia) could have formed during a common metallogenetic event or events, related to the Neoproterozoic Brasiliano/Pan-African orogeny (800–550 Ma). Although a physical connection between the SFC and the Congo Craton is relatively well-established, little work has been done to directly compare the continental crust between these geographically-disparate regions of the world. In this work, we integrate recent studies of the provenance, geochemistry, and metallogenetic evolution of the sedimentary rocks in the Vazante Zn-Pb-Cu-Ag mineral system (Fernandes et al., 2019a, b) with whole-rock Pb isotope geochemistry of the meta-siliciclastic sequence underlying the Vazante ore-hosting carbonate rocks (Fernandes et al., unpub. data) to further test the Afro-Brazilian intercontinental connection.

The meta-siliciclastic sequence underlying the Vazante carbonate rocks was mostly derived from Paleoproterozoic material and lithogeochemistry of these meta-siliciclastic rocks is supportive of a juvenile, intermediate to felsic continental arc origin for sedimentary detritus (Fernandes et al., 2019b). This meta-siliciclastic sequence has also locally undergone a hydrothermal metal enrichment event that predates the orogenic events associated with carbonate-hosted mineralization (Fernandes et al., 2019a). Present-day whole-rock Pb isotope ratios ($^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$) of the meta-siliciclastic sequence (Fernandes et al., unpub. data) show a remarkable overlap with present-day Pb isotope ratios of African Paleoproterozoic volcanic arc rocks rimming the Congo Craton, such as the Orange River Group (ORG; Figure 1; Reid et al., 1987). The ORG was one of the major sources of siliciclastic material and metals in Pan-African carbonate-hosted mineral systems (Frimmel et al., 2004).

The already-recognized, similar deposit-scale characteristics between the mineral deposits of the Vazante District in Brazil and various carbonate-hosted Pan-African districts, along with our new insights into the origin, composition, and whole-rock Pb isotope ratios of the continental crust underneath both of these systems, lead us to suggest that these 1^{st}-order Proterozoic metal-endowed sedimentary basins were indeed floored and connected by continental arc material of similar origin and Paleoproterozoic continental arcs dominated the margins of a composite São Francisco-Congo continent during its evolution. This study highlights the power of whole-rock Pb isotope geochemistry to be used in mineral exploration and in connecting mineral systems across the cratonic to intercratonic scale.

Figure 1: Comparison of Serra do Garrote Formation whole-rock Pb isotope compositions with those of galena from carbonate-hosted zinc deposits in the Vazante District, Brazil, galena from Pan-African carbonate-hosted deposits, and whole-rock Pb isotope ratios of Paleoproterozoic Orange River volcanic Arc, Africa (a) $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$ and (b) $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$.