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Large Igneous Provinces, Their Giant Mafic Dyke Swarms, and Links to Metallogeny

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Giant mafic dyke swarms are a key component of the feeder system of Large Igneous Provinces (LIPs), large volume (>0.1 Mkm³; frequently above >1 M km³), mainly mafic (-ultramafic) magmatic events of intraplate affinity. These events occur in both continental and oceanic settings, and are typically of short duration (<5 m.y.) or consist of multiple short pulses of magmatism over a maximum of a few 10s of m.y. (Ernst, 2014 and references therein). They comprise volcanic packages (flood basalts), and a plumbing system of sills, layered intrusions, and most dramatically, giant mafic dyke swarms. The latter can have an overall radiating pattern whose focus locates the center of the mantle plume responsible for the LIP event. LIPs can also be associated with silicic magmatism, carbonatites and kimberlites. LIP events are linked with continental breakup, global climate change including extinction events, and represent significant reservoirs of energy and metals that can either drive or contribute to a variety of metallogenic systems. The relationships between LIPs, their giant dyke swarms and differing metallogenic systems can be condensed into five distinct although partially overlapping classifications (Ernst and Jowitt, 2013; Ernst, 2014):

(1) LIP magmas that directly generate mineral deposits such as the orthomagmatic Ni-Cu-PGE sulfides (e.g. those within the circum-Superior, Matachewan, or Mackenzie LIPs; Jowitt and Ernst, 2013) or Nb-Ta-REE and diamonds for often LIP-related carbonatites and kimberlites, respectively (e.g. Ernst and Bell, 2010).

(2) LIP magmas that provide energy, fluids, and/or metals for ore types such as hydrothermal volcanogenic

massive sulfide (VMS) and iron oxide-copper-gold (IOCG) deposits such as those of the Gawler Craton in Australia (e.g. Ernst and Jowitt, 2013), with the latter also including the silicic components of LIPs or SLIPs. LIP magmas also could have acted as heat sources that drove hydrocarbon source rocks to maturation or over-maturation.

(3) LIP rocks (particularly sills and dykes) as barriers to fluid flow and/or as reaction zones that control mineralizing events (e.g. during the formation of some Au deposits; Phillips and Groves, 1983; Goldfarb et al., 2005), acted as structural traps within hydrocarbon systems, or formed impermeable barriers that controlled water flow and hence aquifer formation.

(4) Surficial effects, such as the weathering of LIP rocks to form Ni-Co laterites and Al bauxites from exposed LIP mafic-ultramafic rocks in tropical climates (e.g. Deng et al., 2010) and residual Nb, Ta, and REE laterites from LIP-associated carbonatites. This also includes LIP-related anoxia, a vital stage in the generation of hydrocarbon source rocks during Oceanic Anoxic Events (e.g. Ocean Anoxic Event (OAE) 2 at 94 Ma and OAE1 at 120 Ma, both of which are key targets for the oil industry; Kerr, 1998; Eldrett et al., 2014); and

(5) indirect links between LIPs and ore deposits, where LIP events linked to attempted or successful continental breakup generate a 'barcode' record that can be used to correlate and reconstruct Precambrian supercontinents, enabling the tracing of metallogenic belts between presently separated but formerly contiguous crustal blocks (e.g. Ernst and Bleeker, 2010). Regional mafic dyke

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swarms are a key target for U-Pb dating campaigns as they tend to be better preserved than the other components (flood basalts and layered intrusions) of LIPs, and thus are more useful in building the LIP ‘barcode’ record for cratonic blocks (Ernst et al. 2013).

This fifth classification type also includes links between major continental breakup (linked to LIPs) and distal compression and transpression in the plate tectonic circuit, leading to the formation of orogeny-related deposits, such as orogenic Au mineralization (e.g. Bierlein and Pisarevsky, 2007; Ernst and Jowitt, 2013).

This presentation will focus on outlining the associations between LIP events, their giant dyke swarms, and metallogeny and how these genetic links can be used to further our understanding of LIP and regional dyke magmatism throughout the geological record. We will also outline the use of dyke geochemistry in exploration for magmatic and hydrothermal mineralization as well as discussing how our understanding of the links between LIP events and metallogeny understanding can be used to enhance mineral exploration across the globe.

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