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LIPs in Space and Time

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An important global magmatic context is Large Igneous Provinces (LIPs) (www.largeigneousprovinces.org), [1,2]. LIPs represent large volume (>0.1 Mkm^3; frequently above >1 Mkm^3), mainly mafic (-ultramafic) magmatic events of intraplate affinity, that occur in both continental and oceanic settings, and are typically of short duration (<5 myr) or consist of multiple short pulses over a maximum of a few 10s of myr. LIPs comprise volcanic packages (mainly flood basalts), and a plumbing system of dykes, sills and layered intrusions, and magmatic underplating (at the base of the crust). Mesozoic-Cenozoic LIPs are typically dominated by flood basalts, Paleozoic-Proterozoic LIPs are typically more affected by erosion exposing their plumbing systems, and Archean LIPs consist of continental flood basalts and komatiite-tholeiitic greenstone belts. LIPs can also be associated with silicic magmatism, carbonatites and kimberlites, and there are planetary analogues (on Venus, Mars, Mercury, the Moon and Io).

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 (e.g. related to Ni-Cu-PGEs) [3]. In addition, LIPs can also affect hydrocarbon and aquifer systems [1]. LIPs occur at an average rate of one every 20-30 myr back to at least 2.5 Ga. However, the number and size of identified LIPs is increasing through U-Pb dating campaigns (e.g. through the recent 2010-2017 industry-supported LIPs-Resource Exploration project (www.supercontinent.org) with >220 –Pb ages, mainly of baddeleyite obtained from units around the world. One outcome of this project has been the discovery of many new LIPs of huge scale (e.g. comparable to the extent of the Siberian Trap LIP). Every major breakup margin through time is considered to be associated with a LIP (e.g. CAMP), although there are major LIPs that are not linked with successful breakup (e.g. Siberian Trap LIP). Coeval LIPs can occur in different parts of a large (reconstructed) cratonic block and may be caused by a single plume ascending beneath the thick lithospheric root and moving laterally to multiple lithospheric thinspots. However, those coeval LIPs that are more widely separated may reflect a major thermal event across the core mantle boundary.

While a variety of mechanisms can explain intraplate magmatism, that of LIP-scale requires the thermal input equivalent to an ascending mantle plume. A plume can provide direct partial melts or lead to melting of metasomatised lithosphere or ambient asthenosphere. The resulting magma ascends through the lithosphere and is potentially modified in route. Ponding at the base of the crust forms a magmatic underplate. If the lower crust is fusible, then silicic magmatism is generated producing a Silicic LIP [2,1]. Otherwise voluminous mafic-ultramafic magma ascends, and during crustal transit, can pause at different levels (in magma chambers), each time becoming further differentiated. The compositional history (from source to final emplacement within the crustal profile or onto the surface as flood basalts) can be monitored using geochemistry, e.g. [4,5]. In the plume centre region, significant volumes of magma are emplaced above the underplated region[6], and are also linked to both giant radiating and circumferential dyke swarms [7,8].

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