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Large Igneous Provinces: Links to plumes, environmental changes and plate reorganizations

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Subducted lithosphere slabs restore mass to the mantle and trigger the return flow toward the surface, including mantle plumes, rising from the margins of thermochemical piles in the lowermost mantle. Their surface expressions include large igneous provinces (LIPs) and combining slab-sinking times and plume ascent times suggests that ~250 Ma may elapse from initial surface subduction until the eruption of a LIP.

LIPs provide a direct link between the deep Earth and the atmosphere but the severity of the environmental changes they impose depends on their volumes and composition of the crustal rocks they are emplaced through. Greenhouse gases can lead to global warming over timescales of 10^2–10^5 years, but extensive blankets of LIP-lava can subsequently enhance silicate weathering, leading to CO_2 drawdown on longer timescales (10^6 years). Weathering is largely controlled by relief and climate, where LIPs in cold and dry climates weather slowly whilst warm and wet environments lead to rapid weathering (e.g., Central Atlantic Magmatic Province, CAMP, at 201 Ma). Silicate weathering of LIPs emplaced at tropical latitudes have also been argued to be instrumental in triggering Snowball Earths.

Plume activity can also alter the tectonic setting by creating and modifying plate boundaries, changing the paleogeography and the long-term climate forcing**.** This is best exemplified for the Atlantic bordering continents: The opening of the central Atlantic at ~195 Ma led to the definite break between north and south Pangea (preceded by CAMP). Conversely, the Paraná-Etendeka (134 Ma) assisted the early opening of the south Atlantic (~130 Ma), whilst the North Atlantic Igneous Province, starting at 62 Ma, assisted the opening of the northeast Atlantic (54 Ma).

Continental break-up has fragmented many LIPs shortly after emplacement, with LIP rocks now located on opposed passive margins. Prime examples include CAMP, Paraná-Etendeka, and Karoo-Ferrar LIP. Plumes impinging the oceanic lithosphere have also influenced the plate tectonic configuration, relocating plate boundaries, generating micro-continents, or making entirely new plates. A prime example is the Ontong Java Nui “mega-LIP” that led to the break-up of the Phoenix Plate into four new plates at around 120 Ma.