5.2.45

Origin of the Ontong Java Plateau

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The submarine Ontong Java Plateau (OJP) is the most voluminous of the Earth's large igneous provinces. It covers an area of $2x10^6$ km^3 (comparable with Western Europe), but OJP-related volcanism extends over an even larger area into the adjacent Nauru and East Mariana basins. With an average 30-km-thick crust, the volume of igneous rock forming the plateau may be as high as $6x10^7$ km^3. The OJP was emplaced rapidly at ~120 Ma, and the peak magma production rate may have exceeded that of the entire global mid-ocean ridge system at the time. OJP basaltic basement rocks are exposed in thick (up to ~3.5 km) sections in the Solomon Islands and have also been sampled at ten DSDP and ODP drill sites on and around the plateau.

The discovery, during ODP Leg 192, of high-Mg (Kroenke-type) basalt that is isotopically identical to the dominant evolved tholeiite allows the primary magma composition to be estimated. Primary magma compositions, calculated by incremental addition of equilibrium olivine to Kroenke-type basalt, have MgO ranging from 15.6 wt.% (in equilibrium with Fo_{90}) to 20.4 wt.% (Fo_{92}). Incompatible-element contents, coupled with radiogenic isotope ratios, suggest a source consisting of primitive mantle depleted long ago by the extraction of 1% by mass of average continental crust. The degree of melting required to produce the primary magma from this source ranges from 27% (in equilibrium with Fo_{90}) to 31% (Fo_{92}). Independent estimates based on combined forward- and inverse-modelling of the major-element composition of the primary magma are in excellent agreement with these values and provide compelling evidence that the OJP had a fertile peridotite mantle source. Peridotite mantle with a potential temperature >1500ºC will melt to a *maximum* of around 30% if decompressed to shallow levels (i.e., at or close to a spreading centre). To achieve an *average* of 30% melting requires that the mantle is actively and rapidly fed into the melt zone, and a start-up mantle plume provides the most obvious mechanism. This should have caused uplift well above sea level, but the abundance of essentially non-vesicular pillow lava and the absence of any basalt showing signs of subaerial weathering show that the OJP was emplaced below sea level. We have not yet been able to resolve the paradox of apparent high mantle potential temperature coupled with submarine emplacement.

5.2.46

High-precision Pb isotope systematics of basalts from the Kerguelen Archipelago: New insights on the Kerguelen plume components

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The number and origin of components involved in mantle plumes is a subject of debate amongst geochemists. New high precision isotopic ratios (Hf and Pb) are allowing for a more refined analysis of individual oceanic islands. About 60 samples of Kerguelen Archipelago basalts were re-analyzed for their Pb isotopic compositions by MC-ICP-MS (Nu Plasma). We carefully selected the samples on the basis of their Sr-Nd-Hf and Pb (TIMS) characteristics to cover the range of age, geographic and compositional variations on the archipelago. Two new basaltic series were added to the compilation. High-precision Pb isotopic compositions (<150 ppm) reduce the total range of $^{207}Pb/^{204}Pb$ variations among Kerguelen basalts by a factor of 2. This provides an important new perspective on Kerguelen plume systematics and allows for the clear distinction of three groups: the 29-25 Ma tholeiitic-transitional basalts, the 25-24 Ma mildly alkalic basalts and the <10 Ma more evolved, alkalic lavas and intrusions. This age and compositional evolution corresponds to a geographic trend, where the older basalts are the closest to the Southeast Indian Ridge (~300-400 km) while the mildly alkalic basalts are further away, as are the younger evolved alkalic rocks. These alkalic rocks clearly result from lower degrees of melting and their distinctly lower $^{206}Pb/^{204}Pb$ (and $^{177}Hf/^{176}Hf$) together with their significantly younger age indicate some interaction with the older Kerguelen Plateau. These important differences clearly reflect a Miocene change of regime of the Kerguelen plume.

Among the flood basalts (>80% of the Kerguelen Archipelago), the mildly alkalic basalts of the 24 Ma Crozier volcanic section clearly stand out with distinctly higher $^{206}Pb/^{204}Pb$ and their isotopic compositions are interpreted as representative of those of the enriched component of the Kerguelen plume. These basaltic magmas had little, if any, interaction with either the surrounding depleted mantle or the Kerguelen Plateau during ascent, either because their magma conduits became isolated or/and because by 24 Ma, the SEIR was too far away. High-precision Pb isotope systematics do not show any role for a continental component in the genesis of the Kerguelen Archipelago basalts, contrary to the early stages of the formation of the Kerguelen Plateau.