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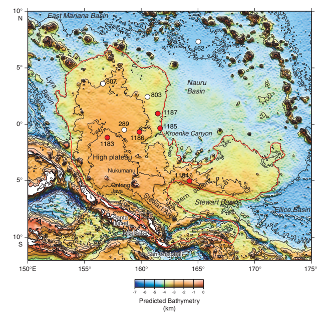
1. Leg 192 Synthesis: Origin and Evolution of the Ontong Java Plateau[1]

J.G. Fitton,[2] J.J. Mahoney,[3] P.J. Wallace,[4] and A.D. Saunders[5]

INTRODUCTION

This paper summarizes the results of recent research into the composition and origin of the Ontong Java Plateau (OJP) in the western Pacific Ocean (Fig. F1) following its successful drilling during Ocean Drilling Program (ODP) Leg 192. The plateau is the most voluminous of the world's large igneous provinces (LIPs) and represents by far the largest known magmatic event on Earth. LIPs are formed through eruptions of basaltic magma on a scale not seen on Earth at the present time (e.g., Coffin and Eldholm, 1994; Mahoney and Coffin, 1997). Continental flood basalt provinces are the most obvious manifestation of LIP magmatism, but they have oceanic counterparts in volcanic rifted margins and giant submarine ocean plateaus. LIPs have also been identified on the moon, Mars, and Venus and may represent the dominant form of volcanism in the solar system (Head and Coffin, 1997). The high magma production rates (i.e., large eruption volume and high eruption frequency) involved in LIP magmatism cannot be accounted for by normal plate tectonic processes. Anomalously hot mantle often appears to be required, and this requirement has been a key consideration in the formulation of the currently favored plume-head hypothesis in which LIPs are formed through rapid decompression and melting in the head of a newly ascended mantle plume (e.g., Richards et al., 1989; Campbell and Griffiths, 1990). Eruption of enormous volumes of basaltic magma over short time intervals, especially in the subaerial environment, may have had significant effects on climate and the biosphere, and LIP formation has been proposed as one of the causes of mass extinctions (e.g., Wignall, 2001).

F1. Bathymetry of the OJP, p. 14



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[2]School of GeoSciences, University of Edinburgh, Grant Institute, West Mains Road, Edinburgh EH9 3JW, United Kingdom.
Godfrey.Fitton@ed.ac.uk
[3]Department of Geology and Geophysics/School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, 49/10 East-West Road, Honolulu HI 96822, USA.
[4]Department of Geological Sciences, 1272 University of Oregon, Eugene OR 97403-1272, USA.
[5]Department of Geology, University of Leicester, University Road, Leicester LE1 7RH, United Kingdom.

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Several issues need to be addressed in order to understand LIP formation. These include

1. Timing and duration of magmatism;
2. Size, timing, and duration of individual eruptions;
3. Eruption environment of the magmas (subaqueous or subaerial);
4. Magnitude of crustal uplift accompanying their emplacement; and
5. Composition and temperature of their mantle sources.

The study of continental LIPs can address these issues to a large extent, and considerable progress has been made in these areas. Petrological and geochemical studies on the sources of continental flood basalt, however, are always compromised by the possibility of contamination of the magma by the continental crust and lithospheric mantle through which it passes. Basalt from plateaus that formed entirely in an oceanic environment is free of such contamination and therefore offers a clear view of LIP mantle sources, but is difficult and expensive to sample. Nevertheless, the basaltic basement of several ocean plateaus has been sampled during the course of Deep Sea Drilling Project (DSDP) and ODP cruises. ODP Leg 192 was the latest of these.

ONTONG JAVA PLATEAU

The OJP covers an area of ~2.0×10^6 km^2 (larger than Alaska and comparable in size with Western Europe), and OJP-related volcanism extends over a considerably larger area into the adjacent Nauru, East Mariana, and, possibly, Pigafetta and Lyra basins (Fig. **F1**). With a maximum thickness of crust beneath the plateau of 30–35 km (e.g., Gladczenko et al., 1997; Richardson et al., 2000), the volume of igneous rock forming the plateau and filling the adjacent basins could be as high as 6×10^7 km^3 (e.g., Coffin and Eldholm, 1994).

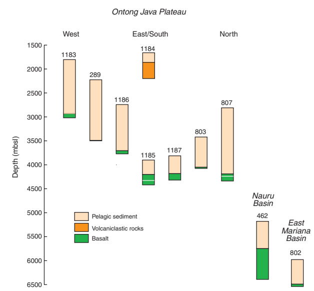
Seismic tomography experiments show a rheologically strong but seismically slow upper mantle root extending to ~300 km depth beneath the OJP (e.g., Richardson et al., 2000; Klosko et al., 2001). Gomer and Okal (2003) measured the shear wave attenuation in this root and found it to be low, implying that the slow seismic velocities must be due to a compositional, rather than thermal, anomaly in the mantle. The nature and origin of this compositional anomaly have not yet been established.

The OJP seems to have formed rapidly at ~120 Ma (e.g., Mahoney et al., 1993; Tejada et al., 1996, 2002; Chambers et al., 2002; Parkinson et al., 2002), and the peak magma production rate may have exceeded that of the entire global mid-ocean-ridge system at the time (e.g., Tarduno et al., 1991; Mahoney et al., 1993; Coffin and Eldholm, 1994). Degassing from massive eruptions during the formation of the OJP could have increased the CO_2 concentration in the atmosphere and oceans (Larson and Erba, 1999) and led or at least contributed significantly to a worldwide oceanic anoxic event accompanied by a 90% reduction in nannofossil palaeoflux (Erba and Tremolada, 2004).

Collision of the OJP with the old Solomon arc resulted in uplift of the OJP's southern margin to create on-land exposures of basaltic basement in the Solomon Islands (Fig. **F1**), notably in Malaita, Santa Isabel, and San Cristobal (e.g., Petterson et al., 1999). In addition to these exposures, basaltic basement on the OJP and surrounding Nauru and East

Mariana basins has been sampled at 10 DSDP and ODP drill sites (Fig. F2). Leg 192, however, was the first one designed specifically to address the origin and evolution of the OJP (Mahoney, Fitton, Wallace, et al., 2001). Earlier research on the OJP was reviewed by Neal et al. (1997). The principal results of Leg 192 are presented in a Special Publication of the Geological Society, London (Fitton et al., 2004). This publication complements the recent thematic set of papers on the origin and evolution of the Kerguelen Plateau, the world's second largest oceanic LIP, published in the *Journal of Petrology* (Wallace et al., 2002). The present synthesis summarizes the papers in the Special Publication, as well as results from Leg 192 that are published in the Leg 192 *Scientific Results* volume and elsewhere.

F2. OJP stratigraphic sections, p. 15



GEOLOGICAL EVOLUTION AND PALEOMAGNETISM

Several authors (e.g., Richards et al., 1991; Tarduno et al., 1991; Mahoney and Spencer, 1991) favor the starting-plume head of the Louisville hotspot (now at ~52°S) as the source of the OJP. Kroenke et al. (2004) used a new model of Pacific absolute plate motion, based on the fixed-hotspot frame of reference, to track the paleogeographic positions of the OJP from its present location on the equator back to 43°S at the time of its formation (~120 Ma). This inferred original position is 9° north of the present location of the Louisville hotspot and suggests that this hotspot was not responsible for the formation of the OJP or, alternatively, that the hotspot has drifted significantly relative to the Earth's spin axis (as the Hawaiian hotspot appears to have done; e.g., Tarduno et al., 2003). Kroenke et al. (2004) also note the presence of linear gravity highs in the western OJP, which they speculate may indicate formation of the OJP close to a recently abandoned spreading center. Antretter et al. (2004) point out that the paleomagnetic paleolatitude of the OJP (~25°S) determined by Riisager et al. (2003a, 2004) further increases the discrepancy with the location of the Louisville hotspot. Zhao et al.'s (2004) investigation of the rock magnetic properties of basalt from the OJP shows that original and stable magnetic directions are preserved, allowing robust estimates of paleolatitude. The discrepancy between the paleolatitudes calculated from the paleomagnetic data and from the fixed-hotspot reference frame is interpreted by Riisager et al. (2003a, 2004) as evidence for movement between hotspots. Antretter et al. (2004) show that the Louisville hotspot may have moved southward over the past 120 m.y. and that taking into account both hotspot motion and true polar wander reduces the discrepancy and makes the formation of the OJP by the Louisville hotspot barely possible, if still unlikely.

The determination of high-quality paleolatitudes is a major achievement of Leg 192, but these are not the only results to come out of paleomagnetic studies on the basaltic basement. Riisager et al. (2003b) note that unaltered basaltic pillow-rim glasses preserve a record of geomagnetic paleointensity at the time of their formation. These authors carried out Thellier experiments on basaltic glass recovered during Leg 192 in order to determine the intensity of the Early Cretaceous magnetic field. **Hall et al.** (this volume) found strong anisotropy of magnetic susceptibility in basalt sampled close to the boundaries between eruptive units. They interpret this to be a result of flow during emplacement and use the azimuths of the maximum anisotropy axis to infer lava flow directions. These azimuths are consistent within each site but differ from site to site.

The thickest exposures of the OJP basement rocks in the Solomon Islands are found on the remote island of Malaita (Fig. F1). Petterson (2004) presented the results of geological surveys that reveal a monotonous succession of Early Cretaceous tholeiitic pillow basalt, sheet flows, and sills (the Malaita Volcanic Group) 3–4 km thick. Rare and very thin interbeds composed of laminated pelagic chert or limestone suggest high eruption frequency and emplacement into deep water. The Malaita Volcanic Group is conformably overlain by a 1- to 2-km-thick Cretaceous–Pliocene pelagic sedimentary cover sequence, punctuated by alkaline basalt volcanism during the Eocene and by intrusion of alnöite during the Oligocene.

AGE AND BIOSTRATIGRAPHY

The age and duration of OJP magmatism has not yet been established with certainty. OJP basalts are difficult to date by the widely used $^{40}Ar/^{39}Ar$ method because of their very low potassium contents. Published $^{40}Ar/^{39}Ar$ data (Mahoney et al., 1993; Tejada et al., 1996, 2002) suggest a major episode of OJP volcanism at ~122 Ma and a minor episode at ~90 Ma. $^{40}Ar/^{39}Ar$ analysis (Chambers et al., 2002; L.M. Chambers, unpubl. data) of samples from ODP Leg 192 Sites 1185, 1186, and 1187 (Fig. F1) gives ages ranging from 105 to 122 Ma. Chambers et al. (2002) suggest that their younger apparent ages (and, by implication, the data on which the 90-Ma episode is based) are the result of argon recoil and therefore represent minimum ages. Biostratigraphic dating based on foraminifers and nannofossils (Sikora and Bergen, 2004; Bergen, 2004) contained in sediment intercalated with lava flows at ODP Sites 1183, 1185, 1186, and 1187 suggests that magmatism on the high plateau extended from latest early Aptian on the plateau crest to late Aptian on the eastern edge. This corresponds to age ranges of 122–112 Ma (Harland et al., 1990) or 118–112 Ma (Gradstein et al., 1995). However, Re-Os isotopic data on basalt samples from these same four drill sites define a single isochron with an age of 121.5 ± 1.7 Ma (Parkinson et al., 2002).

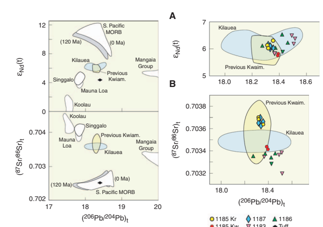
The oldest sediment overlying basement on the crest of the OJP occurs within the upper part of the *Leupoldina cabri* planktonic foraminiferal zone and corresponds to a prominent $\delta^{13}C$ maximum (Sikora and Bergen, 2004). This result shows that eruption of basaltic lava flows continued through much of Oceanic Anoxic Event 1a, of which the formation of the plateau is a postulated cause (e.g., Larson and Erba, 1999). Nannofossil studies (Bergen, 2004) reveal six unconformities in the lower Aptian to Miocene pelagic cover sequence recovered during Leg 192. The biostratigraphic data are in good agreement with the mid- to Late Cretaceous strontium isotope stratigraphy determined on samples from Sites 1183 and 1186 by **Bralower et al.** (this volume). Oxygen and carbon isotope analysis of bulk carbonate samples from the OJP and Manihiki Plateau (**MacLeod and Bergen,** this volume) provide evidence for cooling in the region during the Maastrichtian. These data extend existing evidence for Maastrichtian cooling into the southwestern tropical and subtropical Pacific. **Sano et al.** (this volume) determined boron contents in the sedimentary rocks recovered at Sites 1183 and 1186. They show a correlation between boron and hydrogen contents, suggesting that boron is expelled along with water during compaction of the sediments.

PETROLOGY AND GEOCHEMISTRY

The Malaita Volcanic Group (Petterson, 2004) was divided by Tejada et al. (2002) into two chemically and isotopically distinct stratigraphic units: the Kwaimbaita Formation (>2.7 km thick) and the overlying Singgalo Formation (~750 m maximum exposed thickness). Basalt of the Kwaimbaita Formation was found to be compositionally similar to the basalt forming Units C–G at ODP Site 807 on the northern flanks of the OJP (Fig. F1), whereas the Singgalo Formation is similar to the overlying Unit A at Site 807. Thus, Kwaimbaita-type and Singgalo-type basalt flows with the same stratigraphic relationship are found at two sites 1500 km apart on the plateau (Tejada et al., 2002). A third basalt type, with higher MgO and lower concentrations of incompatible elements than any previously reported from the OJP, was recognized during ODP Leg 192 at Sites 1185 and 1187 on the eastern edge of the plateau (Mahoney, Fitton, Wallace, et al., 2001). We propose the term *Kroenke-type basalt* because it was discovered on the flanks of the submarine Kroenke Canyon at Site 1185 (Fig. F1).

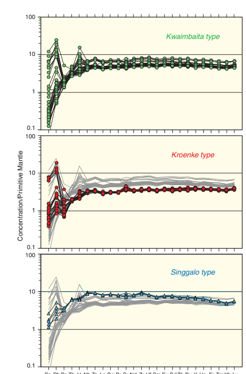
Tejada et al. (2004) use radiogenic isotope (Sr, Nd, Pb, and Hf) ratios to show that Kwaimbaita-type basalt is found at all but one of the OJP drill sites and therefore represents the dominant OJP magma type (Fig. F3). Singgalo-type basalt, on the other hand, appears to be volumetrically minor. Significantly, Kroenke-type basalt is isotopically identical to Kwaimbaita-type basalt (Tejada et al., 2004) and may therefore represent the parental magma for the bulk of the OJP. Age-corrected radiogenic isotope ratios in Kroenke- and Kwaimbaita-type basalts show a remarkably small range (Fig. F3). Tejada et al. (2004) model the initial Sr, Nd, Pb, and Hf isotope ratios in these two basalt types as representing originally primitive mantle that experienced a minor fractionation event (e.g., the extraction of a small amount of partial melt) at ~3 Ga or earlier.

F3. Sr, Nd, and Pb isotope ratios, p. 16



The remarkable homogeneity of OJP basalts is also seen in their major and trace element compositions (Fitton and Godard, 2004) (Fig. F4). Fitton and Godard (2004) use geochemical data to model the mantle source composition and, hence, to estimate the degree of partial melting involved in the formation of the OJP. Incompatible element abundances in the primary OJP magma can be modeled by ~30% melting of a peridotitic primitive mantle source from which ~1% by mass of average continental crust had previously been extracted. The postulated depletion is consistent with the isotopic modeling of Tejada et al. (2004). To produce a 30% melt requires decompression of very hot (potential temperature > 1500°C) mantle beneath thin lithosphere. Thin lithosphere is consistent with the suggestion by Kroenke et al. (2004) that the OJP may have formed close to a recently abandoned spreading center. Alternatively, lithospheric thinning could have resulted from thermal erosion caused by the upwelling of hot plume material.

F4. Incompatible elements, p. 17

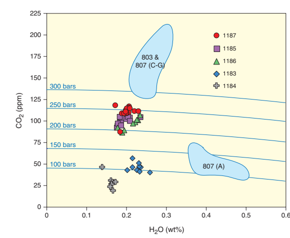


An independent estimate of the degree of melting is provided by Herzberg (2004), who uses a forward- and inverse-modeling approach based on peridotite phase equilibria. He obtains values of 27% and 30% for fractional and equilibrium melting, respectively. Further support for large-degree melting is provided by the platinum group element (PGE) concentrations determined by Chazey and Neal (2004). The PGEs are highly compatible in mantle phases and sulfides, so their abundance is sensitive to degree of melting and sulfur saturation. Concentrations of PGEs in the OJP basalts are rather high and consistent with ~30% melting of a peridotite source from which sulfide phases had been exhausted during the melting process. Some basalt samples have PGE abundances that are too high to be accounted for by a standard model peridotite source; an additional PGE source appears to be needed. Chazey and Neal (2004) speculate that a small amount of material from the Earth's core may have been involved in the generation of OJP magmas.

Derivation of the dominant, evolved, Kwaimbaita magma type through fractional crystallization of the primitive Kroenke-type magma is consistent with the isotopic (Tejada et al., 2004) and geochemical (Fitton and Godard, 2004) evidence and with melting experiments carried out by Sano and Yamashita (2004). Sano and Yamashita's (2004) results show that the variations in phenocryst assemblage and whole-rock basalt major element compositions can be modeled adequately by fractional crystallization in shallow (<6 km) magma reservoirs.

Glass from the rims of basaltic pillows recovered from most drill sites on the OJP preserves a record of the volatile content of the magmas at the time of eruption. Roberge et al. (2004) show that water contents in the glasses are uniformly low (Fig. F5) and imply water contents in the mantle source that are comparable with those in the source of mid-ocean-ridge basalt. This is an important observation because it shows that the large degrees of melting estimated for the OJP magmas cannot have been caused by the presence of water but require high temperatures. The sulfur contents of OJP glasses confirm Chazey and Neal's (2004) inference of sulfur undersaturation in the magmas. The water depth of lava emplacement controls the CO_2 content of the glasses, and data obtained by Roberge et al. (2004) imply depths ranging from ~1000 m on the crest of the OJP to ~2500 m on its eastern edge (Fig. F5). The amount of CO_2 released during formation of the OJP is difficult to determine without reliable information on primary magmatic CO_2 contents and precise knowledge of the duration of volcanism, but Roberge et al. (2004) estimate a maximum value that is ~10 times the flux from the global mid-ocean-ridge system. Erba and Tremolada (2004) estimate that the 90% reduction in nannofossil paleofluxes that they link to emplacement of the OJP requires a three- to six-fold increase in volcanogenic CO_2.

F5. CO_2 vs. H_2O, p. 18



The submarine emplacement of most of the OJP resulted in low-temperature alteration of the basalts through contact with seawater. The alteration ranges from slight to complete, and unaltered olivine and glass were found in some of the basaltic lava flows sampled in the drill cores. A detailed study of the alteration processes is reported by Banerjee et al. (2004) and **Banerjee and Honnorez** (this volume), who show that alteration started soon after emplacement and is indistinguishable from that affecting mid-ocean-ridge basalt. There is no evidence for high-temperature alteration in any of the basalt recovered from the OJP. The initial and most pervasive stage of alteration resulted in the replacement of olivine and interstitial glass by celadonite and smectite. Later interaction between basalt and cold, oxidizing seawater caused local replacement of primary phases and mesostasis by smectite and iron oxyhydroxides. The relationship between the state of alteration and physical properties of basaltic basement rocks recovered during Leg 192 is described by **Zhao et al.** (this volume). Glass shards in tuffs at Site 1184 show clear textural evidence of microbial alteration (Banerjee and Muehlenbachs, 2003).

VOLCANICLASTIC ROCKS

One of the most exciting discoveries of ODP Leg 192 was a thick succession of basaltic volcaniclastic rocks at Site 1184 on the eastern salient of the OJP (Fig. F1). Drilling at this site penetrated 337.7 m of tuff and lapilli tuff before the site had to be abandoned because of time restraints. A detailed volcanological study by Thordarson (2004) concludes that the volcaniclastic succession was the result of large phreatomagmatic eruptions in a subaerial setting. This setting contrasts strikingly with that of the lava flows sampled on the main plateau and in the Solomons, which were all erupted under deep water (Roberge et al., 2004; Petterson, 2004). Thordarson (2004) divides the succession into six subunits, or members, each representing a single massive eruptive event. Fossilized or carbonized wood fragments were found near the bottom of four of the eruptive members (Mahoney, Fitton, Wallace, et al., 2001). The volcaniclastic succession at Site 1184 provides the only evidence so far for significant amounts of subaerial volcanism on the OJP.

Three of the six eruptive members at Site 1184 contain blocky glass clasts with unaltered cores, and these cores allow the reliable determination of the composition of the erupted magma. White et al. (2004) used microbeam techniques to determine the major and trace element compositions of samples of the glass. The glasses are very similar in composition to the Kwaimbaita-type and Kroenke-type basalts sampled on the high plateau. Each member has a distinct glass composition and there is no intermixing of glass compositions between them, confirming Thordarson's (2004) conclusion that each is the result of one eruptive phase and that the volcaniclastic sequence has not been reworked. White et al.'s (2004) major and trace element data for the glass clasts suggest that the voluminous subaerially erupted volcaniclastic rocks at Site 1184 belong to the same magmatic event as that responsible for the construction of the main plateau. Thus, the OJP would have been responsible for volatile fluxes into the atmosphere in addition to chemical fluxes into the oceans. Both factors may have influenced the contemporaneous oceanic anoxic event (Sikora and Bergen, 2004; Erba and Tremolada, 2004).

The geochemical evidence (White et al., 2004; Fitton and Godard, 2004) linking the phreatomagmatic eruptions recorded at Site 1184 to the formation of the main plateau is supported by the Early Cretaceous age implied by the steep (–54°) magnetic inclination preserved in the volcaniclastic rocks (Riisager et al., 2004). However, this evidence appears to be contradicted by the presence of rare Eocene nannofossils at several levels within the succession (Bergen, 2004). In an attempt to resolve this paradox, Chambers et al. (2004) applied the $^{40}Ar/^{39}Ar$ dating method to feldspathic material separated from two basaltic clasts and to individual plagioclase crystals separated from the matrix of the volcaniclastic rocks. The clasts gave *minimum* age estimates of ~74 Ma, and the plagioclase crystals a mean age of 123.5 ± 1.8 (1 σ) Ma.

Shafer et al. (2004) analyzed a suite of 14 basaltic clasts extracted from four of the volcaniclastic units and, despite their extensive alteration, showed that the clasts were derived from a source similar to that of the Kroenke- and Kwaimbaita-type basalt on the main plateau. Significantly, the composition of the clasts (Shafer et al., 2004) varies with the bulk composition of their host volcaniclastic units (Fitton and Godard, 2004), showing that they must be cognate. Chambers et al. (2004) conclude that both the clasts and the plagioclase crystals that they used in their $^{40}Ar/^{39}Ar$ dating belong to the same magmatic episode as the host volcaniclastic rocks and are not xenoliths or xenocrysts from older basement. Thus, the combined $^{40}Ar/^{39}Ar$, geochemical, and paleomagnetic evidence favors an Early Cretaceous age for the volcaniclastic succession. Thordarson (2004) and Chambers et al. (2004) suggest that the Eocene nannofossils were introduced later, possibly along fractures.

Volcaniclastic rocks (recovered during previous ODP legs) are also found in thick, reworked, and redeposited successions overlying Early Cretaceous basalt in the Nauru and East Mariana basins east and north of the OJP, respectively. Much of the volcaniclastic material consists of hyaloclastite, and this, together with the presence of wood and shallow-water carbonate fragments, suggests that both the East Mariana Basin and the Nauru Basin volcaniclastic rocks were derived from once-emergent volcanic sources or from relatively shallow water. Castillo (2004) presents chemical and isotopic data for these volcaniclastic rocks and compares them with data for the OJP. The Nauru Basin volcaniclastic rocks have incompatible trace element and Nd isotope compositions typical of the Kwaimbaita-type tholeiitic lavas of the OJP, suggesting that these deposits were shed from the plateau itself. On the other hand, the East Mariana Basin volcaniclastic rocks have high concentrations of incompatible trace elements and Nd and Pb isotope ratios typical of alkalic ocean island basalts and are unrelated to the OJP.

MANTLE PLUME ORIGIN FOR THE ONTONG JAVA PLATEAU?

One of the principal objectives of ODP Leg 192 was to test the plume-head hypothesis for the formation of giant ocean plateaus, and many of the results presented in this volume are consistent with such an origin. The discovery of high-MgO Kroenke-type basalt allows us to calculate the composition of the primary magma and, hence, deduce the nature of the mantle source and the degree of melting. Isotopic (Tejada et al., 2004) and chemical (Fitton and Godard, 2004; Chazey and Neal, 2004) data are consistent with a mildly depleted peridotite mantle source, and phase-equilibria (Herzberg, 2004) and trace element (Fitton and Godard, 2004; Chazey and Neal, 2004) modeling independently constrain the degree of melting of this peridotite source to ~30%. Melting to this extent can only be achieved by decompression of hot (potential temperature > 1500°C) peridotite beneath thin lithosphere. To achieve an average of 30% melting requires that the mantle is actively and rapidly fed into the melt zone; a start-up mantle plume provides the most obvious mechanism. A plume head impinging on thin lithosphere theoretically should have caused uplift of a sizeable part of the plateau above sea level, as in Iceland, and, indeed, at least part of the eastern salient was emergent (Thordarson, 2004). However, the abundance of essentially nonvesicular submarine lava and the absence of any basalt showing signs of subaerial weathering show that all the other sampled portions of the OJP were emplaced below sea level (e.g., Neal et al., 1997; Mahoney, Fitton, Wallace, et al., 2001). Volatile concentrations in quenched pillow-rim glasses suggest eruption depths ranging from 1100 m at Site 1183 to 2570 m at Site 1187 (Roberge et al., 2004).

We have not yet been able to resolve the paradox of apparent high mantle potential temperature coupled with predominantly submarine emplacement. Widespread melting of the mantle following the impact of an asteroid provides a possible means of avoiding uplift (e.g., Ingle and Coffin, 2004), but the resulting magma would be generated entirely within the upper mantle and should normally be expected to have the chemical and isotopic characteristics of Pacific mid-ocean-ridge basalt. OJP basalt is isotopically (Tejada et al., 2004) and chemically (Fitton and Godard, 2004) distinct from Pacific mid-ocean-ridge basalt. Furthermore, no mass extinction occurred at the time of OJP formation, even though the required asteroid would have had a diameter significantly greater than that thought to have been responsible for the extinctions at the Cretaceous/Tertiary boundary (Ingle and Coffin, 2004). A more detailed case against an impact origin for the OJP is set out by Tejada et al. (2004). An eclogitic source does not provide an alternative to the plume hypothesis because the high-Mg parental magma would require almost total melting, and, consequently, a very high potential temperature would still be needed to provide the latent heat of fusion. We can also rule out a hydrous mantle source because the magmas have very low H_2O contents (Roberge et al., 2004).

This synthesis reviews the considerable progress that has been made in our understanding of the origin and evolution of the Ontong Java Plateau following its successful drilling during ODP Leg 192. We now have a much clearer view of the range and distribution of basalt types on the plateau, and we have identified a potential parental magma composition represented by Kroenke-type basalt. The age and duration of magmatism is still uncertain because we have still only scratched the surface of the 30- to 35-km-thick OJP crust. However, it now seems plausible that almost the entire plateau formed in a single, widespread magmatic event at ~120 Ma. The identification of a thick succession of volcaniclastic rocks at Site 1184 shows that at least part of the plateau was erupted in a subaerial environment. We conclude that the start-up plume hypothesis appears to fit more of the observations than do any of the alternative hypotheses, but the lack of uplift of the magnitude predicted by the plume hypothesis and the lack of an obvious hotspot track remain to be explained.

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Figure F1. Predicted bathymetry (after Smith and Sandwell, 1997) of the Ontong Java Plateau and surrounding areas showing the location of DSDP and ODP basement drill sites. Red circles = Leg 192 drill sites, white circles = pre-Leg 192 drill sites. Site 802, in the East Mariana Basin, is outside the map area at 12°5.8′N, 153°12.6′E. The edge of the plateau is defined by the –4000 m contour except in the southeastern part, where it has been uplifted through collision with the Solomon arc.

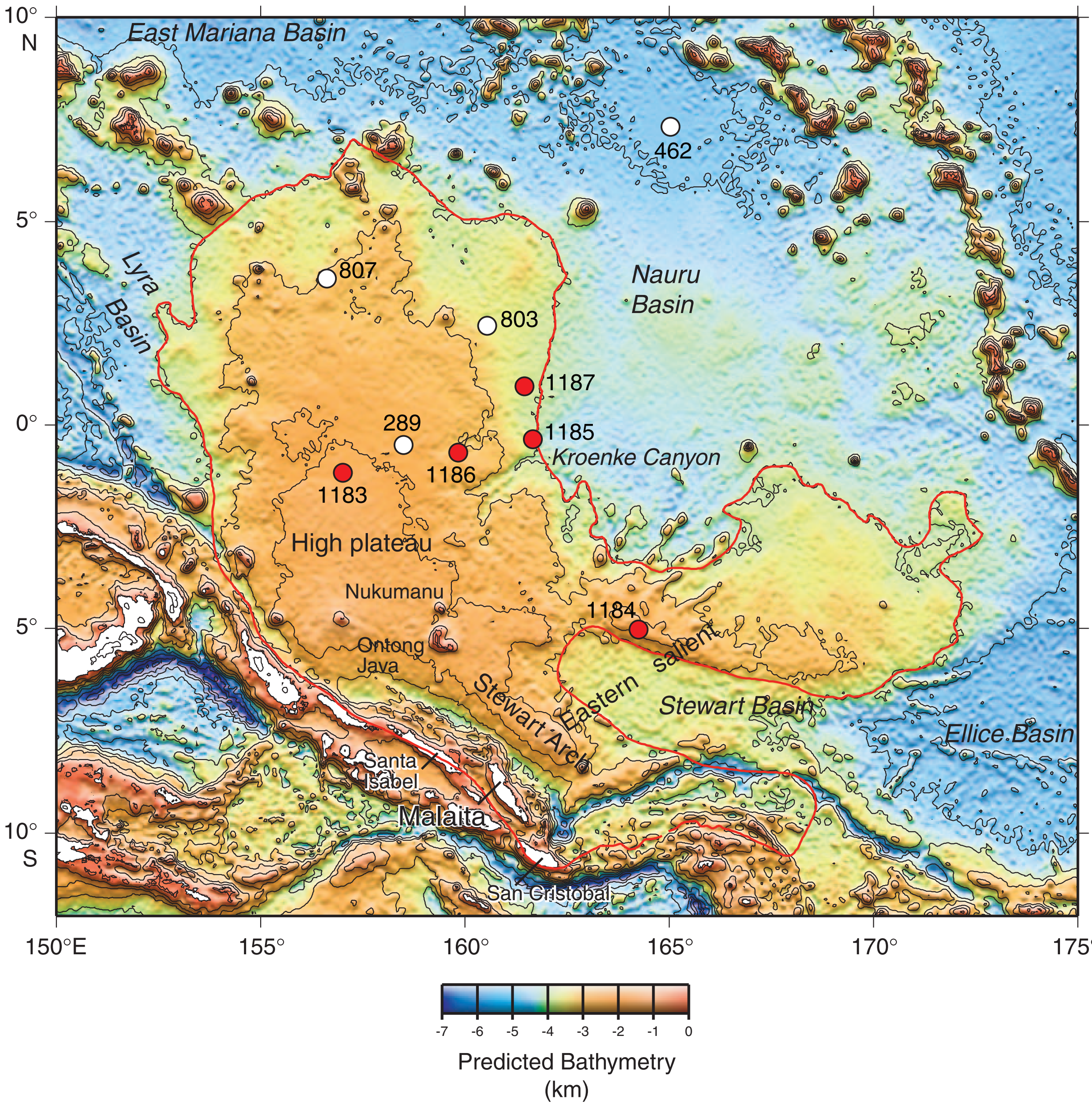

Figure F2. Stratigraphic sections (from Fitton and Godard, 2004) drilled at the 10 DSDP and ODP drill sites marked on Figure F1, p. 14. Seven of the OJP sites are arranged on a transect from the crest of the plateau (Site 1183) eastward to the plateau rim (Site 1185) and then north and north-westward to Site 807 on the northern flank. Site 1184 lies off the transect, 586 km southeast of Site 1185 on the eastern salient of the OJP. The white lines in the basement at Sites 807 and 1185 represent compositional breaks in the basaltic successions at these two sites. Basement penetration and data sources: DSDP Site 289 (9 m), Andrews, Packham, et al. (1975); Site 462 (640 m), Larson, Schlanger, et al. (1981), and Moberly, Schlanger, et al. (1986); ODP Site 802 (51 m), Lancelot, Larson, et al. (1990); ODP Sites 803 (26 m) and 807 (149 m), Kroenke, Berger, Janecek, et al. (1991); ODP Sites 1183 (81 m), 1184 (338 m of volcaniclastic rocks), 1185 (217 m), 1186 (65 m), and 1187 (136 m), Mahoney, Fitton, Wallace, et al. (2001).

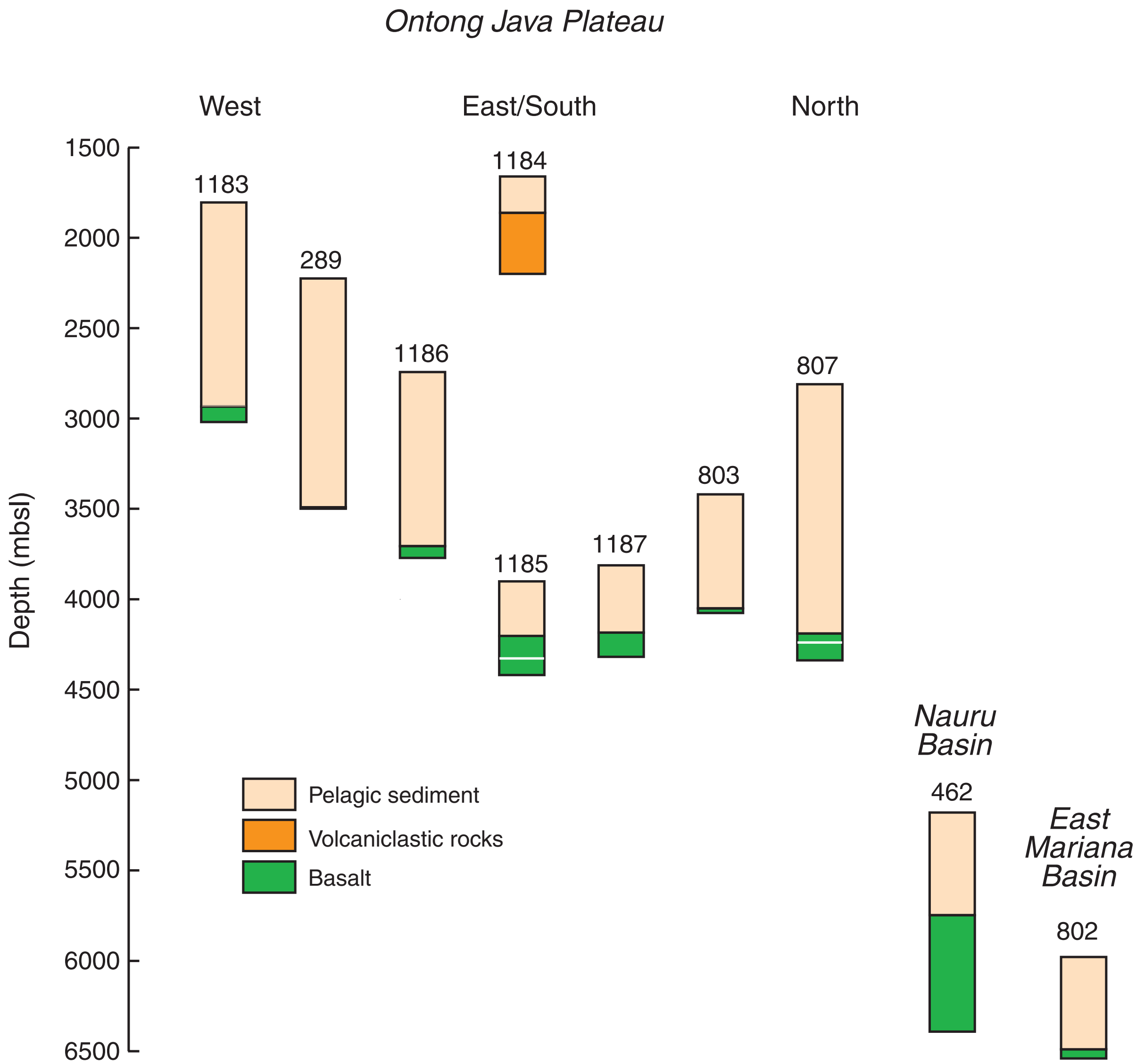

Figure F3. Age-corrected εNd and $^{87}Sr/^{86}Sr$ vs. $^{206}Pb/^{204}Pb$ for the Leg 192 lavas and tuff (t = 120 Ma) (after Tejada et al., 2004). **A, B.** Expanded portions of panels on the left. Kw = Kwaimbaita type, Kr = Kroenke type. Fields are shown for previous Kwaimbaita- (Kwaim.) and Singgalo-type basalt from the pre-Leg 192 drill sites, Malaita, and Santa Isabel, and glass from the Nauru and East Mariana basins (data sources: Mahoney, 1987; Mahoney and Spencer, 1991; Mahoney et al., 1993; Castillo et al., 1991, 1994; Tejada et al., 1996, 2002). See Tejada et al. (2002) for data sources for the fields of South (S) Pacific mid-ocean-ridge basalt (MORB), Kilauea, Mauna Loa (subaerial portion), Koolau (subaerial portion), and Mangaia Group islands. The shaded 120-Ma field is for estimated South Pacific mid-ocean-ridge source mantle (see Tejada et al., 2002).

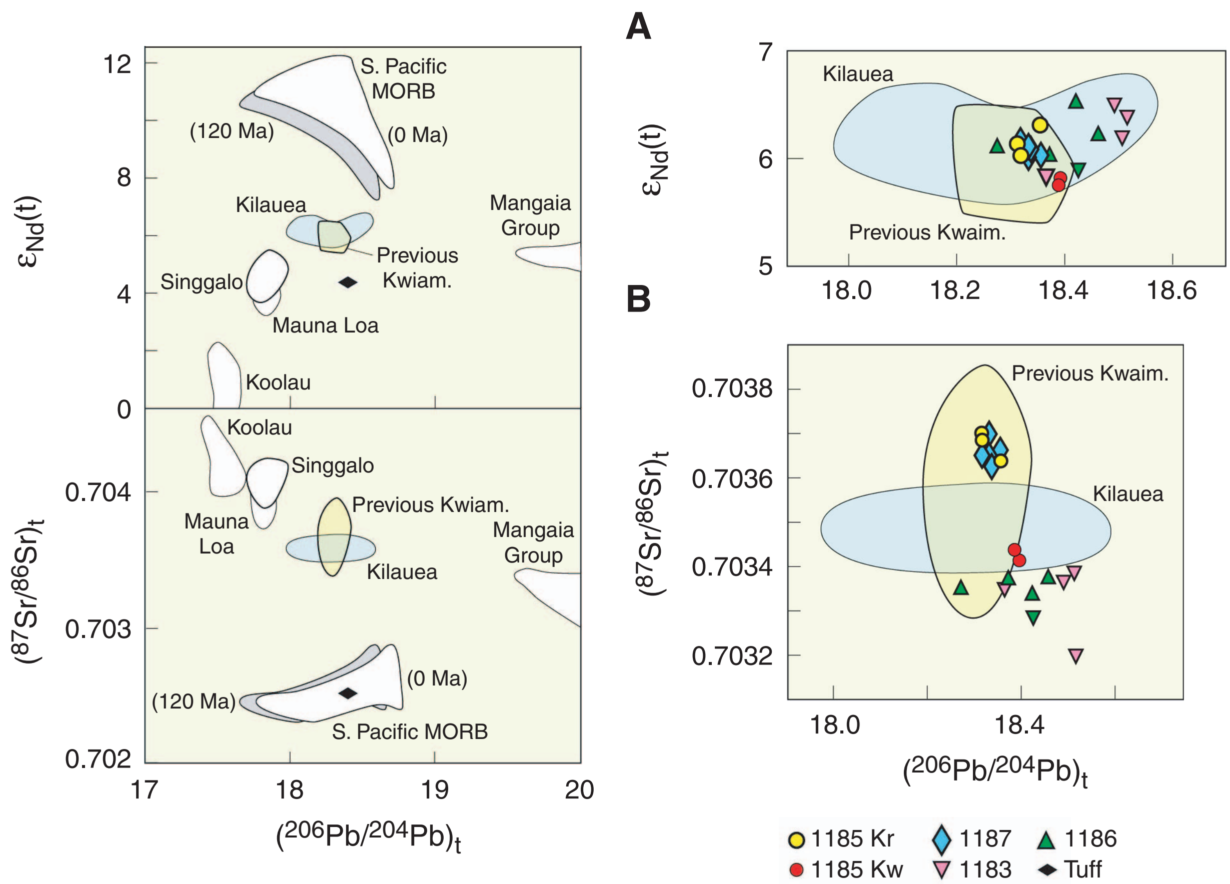

Figure F4. Primitive mantle–normalized incompatible-element concentrations (ICP-MS data for all elements) in Kwaimbaita-, Kroenke- and Singgalo-type basalt samples from the OJP (from Fitton and Godard, 2004). The patterns for Kwaimbaita-type basalt are reproduced as gray lines on the other diagrams for comparison. Note the similarity in the shape of the patterns for Kwaimbaita- and Kroenke-type basalt and the slight relative enrichment in the more incompatible elements shown by the Singgalo-type basalt (Site 807, Unit A).

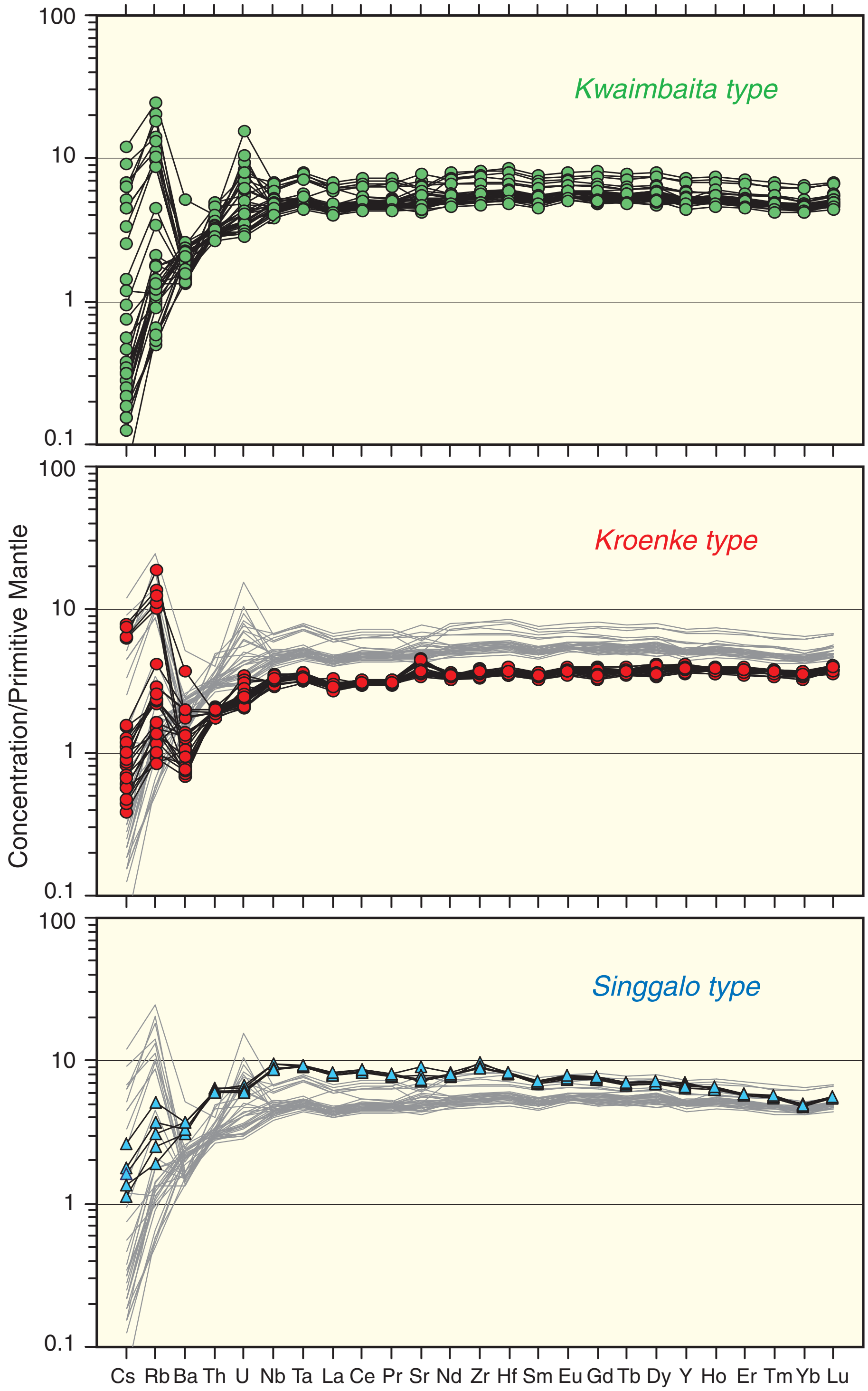

Figure F5. CO_2 vs. H_2O for OJP basaltic glasses (after Roberge et al., 2004). Vapor-saturation curves are shown for basaltic melts at pressures from 100 to 300 bar. Fields of data for Sites 803 and 807 are from Michael (1999).