Integrated Ocean Drilling Program Expedition 330 Scientific Prospectus

Louisville Seamount Trail

Implications for geodynamic mantle flow models and the geochemical evolution of primary hotspots

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Abstract

The Louisville Seamount Trail is a 4300 km long volcanic chain that is inferred to have been built in the past 80 m.y. as the Pacific plate moved over a persistent mantle-melting anomaly or hotspot. Because of its linear morphology and its long-lived age-progressive volcanism, Louisville is the South Pacific counterpart of the much more extensively studied Hawaiian–Emperor Seamount Trail. Together, the Louisville and Hawaiian–Emperor seamount trails are textbook examples of two primary hotspots that have been keystones in deciphering the motion of the Pacific plate relative to a set of fixed deep-mantle plumes. However, drilling the Emperor Seamount Trail during Ocean Drilling Program (ODP) Leg 197 revealed a substantial ~15° southward motion of the Hawaiian hotspot prior to 50 Ma, calling into question whether the primary Pacific hotspots constitute such a fixed frame of reference. Is it possible that the Hawaiian and Louisville hotspots have moved in concert and therefore constitute a moving reference frame for modeling plate motion in the Pacific? Alternatively, is it possible that they have moved independently, as predicted by modeled mantle flow patterns that reproduce the observed latitudinal motion of the Hawaiian hotspot but predict essentially no latitudinal shift (but rather a longitudinal shift) for the Louisville hotspot? These two end-member geodynamic models will be tested during Integrated Ocean Drilling Program (IODP) Expedition 330 to the Louisville Seamount Trail.

In addition, existing data from dredged lavas suggest that the mantle plume source of the Louisville hotspot has been remarkably homogeneous for as long as 80 m.y. These lavas are predominantly alkali basalts and likely represent a mostly alkalic shield-building stage that differs distinctly from the massive tholeiitic shield-building stage of Hawaiian volcanoes. Geochemical and isotopic data for the recovered lavas will consequently provide key insights into the magmatic evolution and melting processes of Louisville volcanoes between 80 and 50 Ma. These measurements will yield new information about the fundamental homogeneity of the Louisville mantle plume, the progression from shield-building to postshield and (perhaps) posterosional volcanic stages during the construction of these volcanoes, and the temperature and depths of partial melting in the mantle plume source. Collectively, this will enable us to characterize the Louisville Seamount Trail as a product of one of the few primary Pacific hotspots and constrain its interaction with the lithosphere on which it formed.

During Expedition 330 we will replicate the drilling strategy of Leg 197, which provided compelling evidence for the motion of the Hawaiian mantle plume between 80 and 50 Ma (Tarduno et al., 2003; Duncan et al., 2006). For this reason, we will target four Louisville seamounts that have ages similar to the Detroit, Suiko, Nintoku, and Koko seamounts of the Emperor Seamount Trail. Our principal drilling goal is to drill 350 m (or deeper) into the igneous basement of these Louisville seamounts in order to core and recover as many individual lava flows as possible. By analyzing these lava flows using modern paleomagnetic, $^{40}Ar/^{39}Ar$ geochronological, and geochemical techniques, we will be able to directly compare paleolatitude estimates and geochemical signatures between seamounts in the two longest-lived hotspot systems in the Pacific. Using data from Expedition 330 we hope to resolve whether the Hawaiian and Louisville mantle plumes have moved in concert or independently, constrain the magmatic evolution of the Louisville Seamount Trail and its possible plume–lithosphere interactions, and more definitively test the hypothesis that the Ontong Java Plateau formed from the plume head of the Louisville mantle plume at ~120 Ma. Finally, the thin sediment cover on these guyots may provide additional information about the subsidence history of the Louisville seamounts and guyots and may be a valuable contribution to the southern hemisphere paleoclimate record.

Schedule for Expedition 330

Integrated Ocean Drilling Program (IODP) Expedition 330 to the Louisville Seamount Trail is derived from IODP Proposal 636-Full3 and Addendum (available at **iodp.tamu.edu/scienceops/expeditions/louisville_seamounts.html**). Expedition 330 is planned for the riserless drillship R/V *JOIDES Resolution*, operating under contract with the United States Implementing Organization (USIO). The expedition is currently scheduled to begin on 12 December 2010 in Auckland, New Zealand, and end in Auckland, New Zealand, on 11 February 2011, providing 56 days at sea to achieve the expedition's scientific objectives. Supporting site survey data for Expedition 330 are archived at the **IODP Site Survey Data Bank.** Details about the facilities aboard the *JOIDES Resolution* can be found at **iodp.tamu.edu/publicinfo/drillship.html.**

Introduction and background

Understanding the nature of mantle plumes is a critical goal of modern Earth sciences. The extent to which hotspots conform to the Wilson–Morgan fixed plume hypothesis (Wilson, 1963; Morgan, 1971) fundamentally constrains the assumptions used in models of mantle convection. To date, studies of the Hawaiian–Emperor Seamount Trail have dominated our thinking about hotspot volcanism, and as a consequence, models for the construction and evolution of intraplate volcanoes, plate motion, and hotspot motion are strongly biased toward the Hawaiian hotspot. Without comparable data from any other important hotspot trail, many key questions remain unanswered. The Louisville hotspot trail (Figs. **F1, F2**) is one of only three primary hotspots (together with Hawaii and Easter) in the Pacific (Courtillot et al., 2003; Koppers and Watts, 2010), and it has great potential for providing answers to these questions. New results from IODP drilling of the Louisville Seamount Trail during Expedition 330, together with existing data and future drilling of other hotspot trails in the Atlantic and Indian oceans, will provide the best available opportunity to assess the importance of the motion between hotspots (or groups of hotspots) and true polar wander. These data, in turn, will provide valuable information about Earth's convection regime and will allow for a crucial calibration of current mantle flow models and global plate circuit reconstructions.

Hotspots, as well as the (deep) mantle plumes presumed to be their underlying cause (e.g., Morgan, 1971), are essential features in geodynamic models of Earth's mantle. One of the attributes frequently assigned to mantle plumes is their fixity in the mantle. This fixity contrasts distinctly with the motion of the overlying plates, which move at speeds up to 100 mm/y. However, plume theory does not demand fixity (e.g., Steinberger and O'Connell, 1998; Koppers et al., 2001), and paleomagnetic evidence collected during Ocean Drilling Program (ODP) Leg 197 from four Emperor seamounts (Detroit, Suiko, Nintoku, and Koko) indicates that the Hawaiian hotspot has moved at a speed similar to that of plate motion for tens of millions of years (Kono, 1980; Petronotis et al., 1994; Tarduno et al., 2003, 2009; Duncan et al., 2006). Three-dimensional mantle-convection computations confirm this notion by generating mantle plumes with long, narrow thermal conduits that may migrate at speeds of 10 mm/y and higher. From these simulations it follows that plume migration primarily depends on the assumed viscosity contrast between the lower and upper mantle and the configuration of the subducting plates (Lowman et al., 2004).

These observations raise critical questions. Is the rapid motion documented at the Hawaiian hotspot an isolated event, or does motion occur at other hotspots as well? If motion is not an isolated event, do other hotspots move in a sufficiently coherent fashion that subsets can be used as a moving reference frame for reconstructing past plate motion? To address these questions, we must distinguish between the following geodynamic end-member models:

1. The primary hotspots in the Pacific (Hawaii, Louisville, and Easter) move coherently over geologic time and thus show minimal interhotspot motion, as argued by Courtillot et al. (2003) and Wessel and Kroenke (1997).
2. The primary hotspots have very different motions that result in increased interhotspot motion, as predicted by mantle flow model calculations (Steinberger et al., 2004; Koppers et al., 2004; Steinberger, 2002; Steinberger and Antretter, 2006; Steinberger and Calderwood, 2006).

The first model predicts the motion of the Louisville hotspot to be equivalent to the 15° southern motion documented for the Hawaiian hotspot between 80 and 50 Ma. The second model predicts an essentially eastward motion of the Louisville hotspot over the last 120 m.y., with a maximum shift in paleolatitude not exceeding 2°–6° between 80–50 Ma and the present day, depending on the various assumptions used in the applied mantle flow models (Fig. **F3**). Both models will be tested by drilling the Louisville Seamount Trail during Expedition 330 and by accurately determining paleolatitudes (from detailed paleomagnetic measurements on individual lava flows) and $^{40}Ar/^{39}Ar$ age dates for seamounts between 80 and 50 Ma. For this purpose, Expedition 330 will provide a direct comparative test that mirrors Leg 197 drilling in the Emperor seamounts as closely as possible (Tarduno et al., 2003; Duncan and Keller, 2004; Duncan et al., 2006, 2007) by targeting guyots equivalent in age to the Detroit (76–81 Ma), Suiko (61 Ma), Nintoku (56 Ma), and Koko (49 Ma) seamounts (Fig. **F2**).

Although determining paleolatitudes in the context of a high-resolution $^{40}Ar/^{39}Ar$ age framework is the main objective of Expedition 330, we also seek to understand the eruptive cycle and geochemical evolution of typical Louisville volcanoes. The Hawaiian and Louisville hotspots have been labeled as “primary” hotspots in the Pacific Ocean based on the presence of obvious linear age progressions, long-lived and continuous volcanism, large buoyancy fluxes, and high (in the case of Hawaii) $^{3}He/^{4}He$ ratios (Courtillot et al., 2003; Koppers et al., 2003). Such hotspots are theorized to represent plumes rising from deep in the mantle, possibly from near the core/mantle boundary (Clouard and Bonneville, 2001; Davaille et al., 2002; Courtillot et al., 2003).

Unlike earlier studies that postulated that many (or even all) hotspots represent plumes originating from the core/mantle boundary, Courtillot et al. (2003) have argued that most hotspots arise from relatively shallow levels and only a small number of primary plumes ascend from the core/mantle boundary. In the case of the poorly studied Louisville Seamount Trail, only its remarkably linear age progression (Watts et al., 1988) and its long-lived ~80 m.y. volcanic record have been used to label it a primary hotspot; no $^{3}He/^{4}He$ analyses and only sparse other geochemical data are available at present.

Nonetheless, some marked differences in geochemistry and volcanic evolution are apparent between the primary Pacific hotspots. For example, the almost exclusive recovery of alkali basalts in the Louisville Seamount Trail (Hawkins et al., 1987; Vanderkluysen et al., 2007) raises the question of whether Louisville volcanoes have an alkalic shield-building phase instead of the tholeiitic shield-building phase that is a trademark of Hawaiian volcanoes. One possibility is that the shield stage of a Louisville volcano reflects systematically lesser amounts of partial melting than in Hawaiian volcanoes because of deeper melting under a uniformly thicker lithosphere over 80 m.y. for the entire Louisville Seamount Trail. In addition, isotopic and trace element data from Louisville suggest a long-lived and remarkably homogeneous mantle source (Cheng et al., 1987; Hawkins et al., 1987; Vanderkluysen et al., 2007) that apparently does not include any of the depleted source material that typically produces mid-ocean-ridge basalt (MORB). If Louisville volcanoes prove to have entirely alkalic shield-building phases that are isotopically homogeneous over 80 m.y., this will have major implications for how we think volcanism works for the Louisville Seamount Trail and intraplate volcanism in general.

In the following sections, we review current thinking on mantle geodynamics and hotspot motion, the unique geochemical evolution of the Louisville volcanoes and their mantle sources, and why the Louisville Seamount Trail is key in meeting our science objectives. We then summarize previous research and site surveys on the Louisville Seamount Trail. Finally, we explain how our hypotheses can be tested by coring four seamounts using a riserless drilling program for the Louisville Seamount Trail.

Mantle geodynamics and hotspot motion

Recently, it has been proposed that plume conduits may become strongly tilted at times because of large-scale mantle flow (e.g., Steinberger and O'Connell, 1998), which may possibly explain the fast (~40 mm/y) southward hotspot motion observed at the Hawaiian hotspot between 80 and 50 Ma (Tarduno et al., 2003). Such strong tilts may occur if the conduit is affected by a lower mantle return flow between cold downwellings associated with subduction and large-scale upwellings in the neighborhood of "superplumes." The capturing, bending, and releasing of the Hawaiian mantle plume by an ancient ridge system may also explain these observations (Tarduno et al., 2009). All of these ingredients are present at the Hawaiian hotspot, including a zone of past subduction to the north, a large-scale upwelling related to the Superswell to the south (Tarduno et al., 2003), and the waning of the Kula–Pacific ridge system north of the hotspot, which would allow a possibly captured Hawaiian plume to quickly return to its original straight position in a dominant southward flow (Tarduno et al., 2009). However, because the Louisville hotspot is located south of the Superswell, the closest subduction system has always been located west of the hotspot, and no spreading center is in close proximity or located to the north of it for most of its geological history, the Hawaiian pattern taken at face value is not compatible with a similar rapid southward motion of the Louisville hotspot.

Recent modeling by Steinberger et al. (2004) shows the expected results of this configuration, whereby the Louisville hotspot is predicted to have moved in an easterly direction between 130 and 60 Ma and only ~2.5° southward since 60 Ma (Fig. **F3A)**. In these models, a large-scale mantle flow field is first calculated from mantle-density heterogeneities (as derived from seismic *S*-wave speed anomalies), simultaneously applied with a radial mantle rheology structure (with the lower mantle assumed to be more viscous) and tectonic plate motions that both serve as boundary conditions (Steinberger and O'Connell, 2000; Steinberger and Calderwood, 2006). Within this modeled mantle flow field, an initially vertical plume conduit is inserted that gets advected over time, resulting in sometimes strong tilting of mantle plumes and drifting of hotspots (Steinberger and O'Connell, 2000; Steinberger and Antretter, 2006). Advection dominates the motion of a plume, typically in the lower mantle where it rises relatively slowly in comparison to the overall mantle flow field. As a result, hotspot motion in these models appears in many cases (including Louisville) to be similar to the horizontal flow components in the mid-mantle, in which a transition from advection-dominated motion to more vertical motion dominated by the buoyant rising of mantle plume materials occurs, regardless of whether these mantle plumes originate at the core/mantle or 670 km boundary layers (Steinberger, 2000). In spite of the large uncertainties in data and the assumptions on which these mantle flow models are built, these models provide an excellent basis for placing geologic data from Louisville and other seamount trails into a more complex geodynamic context.

For example, using new high-resolution $^{40}Ar/^{39}Ar$ age data for the sample collection used in Watts et al.'s (1988) study, Koppers et al. (2004) found that the age progression for the Louisville Seamount Trail is not linear after all (blue squares in Fig. **F4A**). By using the modeling approach of Steinberger et al. (2004) and including the primary Pacific hotspots only (Hawaii, Louisville, and Easter), revised mantle flow models can fit this updated nonlinear age trend for the Louisville Seamount Trail by allowing for a slowdown and a different rotation of the Pacific plate before 62 Ma and by decreasing the initiation age of the Louisville hotspot from 120 to 90 Ma. These revised models show an eastward motion of ~5° for the Louisville hotspot between 90 and 30 Ma, which is very different from the ~15° southward motion of the Hawaiian hotspot during the same time interval. The primarily longitudinal Louisville hotspot motion is followed by only a minor ~2° latitudinal shift to the south over the last 30 m.y. (Fig. **F3B;** Model 5 in Fig. **F3C**).

Model predictions, however, vary largely depending on the assumptions used, including plume initiation age, root depth, viscosity structure, plume buoyancy and rising speed, plate motion history, and mantle viscosity. Antretter et al. (2004) and Steinberger and Antretter (2006) considered the possible effects of these assumptions for the Louisville hotspot in more detail and predicted southward paleolatitude shifts between almost 0° and ~8° over the last 80 m.y. However, the majority of their model runs (see six representative examples in Fig. **F3C**) show limited latitudinal motion for Louisville that is significantly less than that observed for Hawaii. The models that do show rather fast Louisville hotspot motion predict a more eastward motion, away from the subduction zone and toward the spreading ridge. Drilling the Louisville Seamount Trail will thus provide an essential calibration of these numerical mantle flow models.

Preliminary $^{40}Ar/^{39}Ar$ age data from the SO167 and AMAT02RR site surveys underline the nonlinear character of the Louisville age progression (Fig. **F4A**). These new data point toward slower motion of the Pacific plate relative to the Louisville hotspot prior to 62 Ma rather than faster relative motion, as would be expected with a substantially southward-moving hotspot, thus indirectly supporting the above predictions for a minor paleolatitude shift. Results from the latest incremental heating experiments (Fig. **F4B**) plot above the original 64 mm/y linear age progression suggested by Watts et al. (1988) and have 2σ uncertainties as low as 0.2–0.5 Ma. Deviations from previously reported ages become noticeable at ~35 Ma but are most significant toward the oldest end of the trail, where some guyots are dated to be ~15 m.y. older than the ages predicted by the 64 mm/y age progression. For now, pending new results from Expedition 330, we presume that the age progression is best approximated by the purple line in Figure F4A, which simply envelops the oldest ages and follows the model of Koppers et al. (2004). Additional preliminary age information from SO167 dredges (averaged from the analyses of multiple plagioclase mineral separates) highlights the complex age distribution in the older portion of the chain, while adding to and confirming the monotonous, almost linear, age progression between 25 and 60 Ma.

Shifts in paleolatitude of the Louisville hotspot can also be predicted by transferring plate motion from Indo-Atlantic hotspots to the Pacific using global plate circuits. In this approach (Fig. F5), the plate circuit may go through East and West Antarctica (EANT-WANT) (Cande et al., 1995) or, alternatively, through the Lord Howe Rise (LHR) (Steinberger et al., 2004). Also critical is the current location of the Louisville hotspot, which is still a matter of debate because of its faint expression at the younger end of this seamount trail (Lonsdale, 1988; Raymond et al., 2000; Wessel and Kroenke, 1997). All plate reconstructions (using different combinations of plate circuits and present-day hotspot locations) yield predictions that are significantly different from the position of the Louisville chain prior to 45 Ma (Fig. F5). As with the mantle flow models, a large longitudinal shift is apparent at 78 Ma when the oldest seamounts in the trail are compared to the reconstructed position for Chron C33, which plots markedly west of the Louisville Seamount Trail. However, the predicted potential southward shift in these plate tectonic reconstructions seems less pronounced for the oldest seamounts (3.8° and 4.0°, depending on the plate circuit used) in the Louisville Seamount Trail, is largest (8.9° and 9.8°) for seamounts ~53 m.y. old (which actually indicates a possible 4°–5° northward motion of the plume between 80 and 50 Ma), and is nonexistent for seamounts younger than ~45 m.y. old.

The above geodynamic and plate tectonic models thus provide us with different predictions for the latitudinal history of the Louisville hotspot. These models will be groundtruthed during Expedition 330, proving one of the following:

1. The Louisville hotspot shows an increasing southward motion (as much as 15°) that is comparable to the motion of the Hawaiian hotspot between 80 and 50 Ma, providing evidence for a common motion of the mantle underlying the Pacific plate with respect to Earth's spin axis.
2. The Louisville hotspot shows an insignificant cumulative latitudinal shift (<2°–6°), supporting the mantle flow models of Steinberger et al. (2004) and Steinberger and Antretter (2006) that predict minimal latitudinal motion and more pronounced easterly longitudinal motion.

3. The Louisville hotspot shows a variable (but significant) latitudinal motion between 80 and 50 Ma in combination with a large longitudinal shift, reconciling the observations made with global plate circuit models.

By comparing paleolatitudes derived from paleomagnetic measurements on cored basalt flows and high-precision $^{40}Ar/^{39}Ar$ ages for the Hawaiian and Louisville seamount trails, Expedition 330 drilling results will offer strong constraints for one of these possibilities. Finding a large latitudinal shift between 80 and 50 Ma would clearly indicate that current assumptions made in mantle flow models are wrong. Finding no appreciable shift, on the contrary, would indicate significant interhotspot motion between the Hawaiian and Louisville hotspots and a stronger local control on the mantle flow regime.

In addition, paleolatitude measurements of the Louisville Seamount Trail can be used to compare interocean motion between hotspots in the Pacific, Indian, and Atlantic oceans. Previous studies reported discrepancies in motion as high as 20° between hotspot groups in the Pacific and Atlantic–Indian oceans (Cande et al., 1995; DiVenere and Kent, 1999; Raymond et al., 2000). These observations have led to models of large-scale motion of the mantle underneath each ocean and to explanations involving true polar wander, which is defined as a coherent shift of the entire mantle relative to Earth's spin axis (Goldreich and Toomre, 1969; Gordon, 1987; Besse and Courtillot, 1991; Torsvik et al., 2002; Argus and Gross, 2004). Drilling the Louisville Seamount Trail will be pivotal in establishing the necessary global paleolatitude and $^{40}Ar/^{39}Ar$ age databases that, in turn, will help us to evaluate the above scenarios. In fact, Expedition 330 will collect paleolatitude data for a period of time similar to that sampled in the Emperor Seamount Trail during Leg 197 (Kono, 1980; Tarduno et al., 2003), and in the future, similar data may be collected from ocean drilling expeditions to the Chagos-Laccadive and Ninetyeast ridges in the Indian Ocean and the Walvis Ridge in the Atlantic Ocean. In the end, future ocean drilling may provide us with a state-of-the-art paleolatitude database covering five major hotspot trails in three oceans, all between 80 and 50 Ma in age. At that point, it will be clear whether the observed paleolatitude shifts in hotspots are best explained by coherent motion of all hotspots relative to the spin axis, by coherent motion of hotspot groups within each ocean domain but with relative motion between these groups, or by incoherent motion of all individual hotspots.

Geochemical evolution of the Louisville hotspot

The construction and geochemical history of an intraplate seamount is often envisioned to resemble that of a typical Hawaiian hotspot volcano (Clague and Dalrymple, 1988; Staudigel and Clague, 2010). There is, however, little empirical evidence for a similar evolutionary sequence in the Louisville Seamount Trail. Almost all igneous rocks dredged from the Louisville Seamount Trail are alkalic basalts, basanites, or tephrites containing normative nepheline (Fig. **F6A**) (Hawkins et al., 1987; Vanderkluysen et al., 2007). In addition, isotopic and trace element data from this seamount trail suggest a long-lived and remarkably homogeneous mantle source equivalent to the proposed "common" components FOZO (Focal Zone) or C (Fig. **F6B**) (Cheng et al., 1987; Hawkins et al., 1987; Vanderkluysen et al., 2007). The minor variations in major and trace elements appear to be controlled mostly by variable extents of melting and fractional crystallization, with little influence from mantle-source heterogeneities.

This raises several first-order questions that can be addressed by geochemical studies of samples cored during Expedition 330. Do Louisville volcanoes evolve through geochemically distinct shield, postshield, and posterosional (or rejuvenated) stages similar to those of Hawaiian volcanoes? If so, is the volumetrically dominant shield stage characterized by eruption of tholeiites or, as suggested by presently available samples, alkalic lavas? Tholeiitic basalts generally represent greater amounts of partial melting than more alkalic lavas do. One possibility is that the typical shield stage of a Louisville volcano reflects systematically less partial melting than that of a Hawaiian volcano. Alternatively, dredging may have sampled only later stage lavas that in many locations may cover shield-stage flows, which would explain why the least alkalic lavas obtained by dredging are from Osbourn Guyot near the Kermadec Trench, where extensive faulting may have exposed older shield-building lavas (Hawkins et al., 1987). Although drill core penetration of an entire Louisville seamount would be necessary to conclusively demonstrate that no tholeiitic shield-building occurs in the Louisville Seamount Trail, the proposed basement penetration of ~350 m during Expedition 330 will provide the best approach for sampling the waning part of the shield-building stage (whether tholeiitic or alkalic), while maximizing the number of flows to be used for determining paleolatitudes.

Hawaiian shield-stage lava flows also possess a wide range of isotopic and incompatible element compositions, and the range is even greater when data for postshield and posterosional lavas are included. In contrast, isotope and incompatible element ratios (e.g., Zr/Y and Nb/Y) for the Louisville Seamount Trail are surprisingly homogeneous (Fig. **F6B**). These data indicate that the mantle (plume) source of Louisville hotspot lavas has been unusually homogeneous for a very long time. This raises important questions, such as how geochemically variable has the Louisville mantle source been over the last 80 m.y., and why has it stayed homogeneous? An important difference between the Louisville and Hawaiian–Emperor seamount trails may be the age of the underlying seafloor at the time of volcano formation. It has been assumed that all Louisville volcanoes have generally been erupting onto seafloor that is ~40–50 m.y. old (Lonsdale, 1988; Watts et al., 1988). This includes the older (northwestern) portion of the Louisville Seamount Trail that formed close to the Osbourn Trough paleospreading center, which ceased activity between 115 and 121 Ma (Downey et al., 2007). This notion is confirmed by recent three-dimensional flexural studies of the Louisville Seamount Trail (Lyons et al., 2000), which also suggest crustal ages of 40–50 Ma and perhaps older. However, a new study based on seismic refraction provides the first ever detailed two-dimensional tomographic image of the internal structure of the oceanic lithosphere beneath one of the older Louisville seamounts (Fig. **F7**). This image shows the internal intrusive structure of this Louisville seamount, with intrusions visible as shallow as 1.5 km beneath its top, but it also shows a downward-flexed Mohorovicic seismic discontinuity (MOHO) by ~2.5 km that can be explained only by an elastic plate model whereby this particular seamount was emplaced upon oceanic lithosphere that is only ~10 m.y. old (Contreras-Reyes et al., 2010). Similar ~10 m.y. age differences between seafloor and volcanic eruption are observed for the oldest seamounts in the Hawaiian–Emperor Seamount Trail, yet the age differences are much larger (>100 m.y.) for the younger Hawaiian volcanoes (Keller et al., 2000; Caplan-Auerbach et al., 2000). Overall, however, lithospheric thickness seems to have been less variable for the Louisville hotspot than for Hawaii, particularly because oceanic lithosphere tends to thicken more slowly after ~40 m.y. (e.g., Stein and Stein, 1993). Lithospheric thickness is a key control on partial melting because it determines the minimum depth of the top of the melting column and limits the extent of decompressional melting that occurs in the upwelling mantle (e.g., McKenzie and Bickle, 1988). Other things being equal, greater amounts of partial melting occur under thin lithosphere, and in a mantle containing isotopically and chemically distinct lithologies, different mantle components likely begin to melt at different depths (Sun and Hanson, 1976; Ellam, 1992; Phipps Morgan and Morgan, 1999; Hoernle et al., 2000; Niu et al., 2002; Ito and Mahoney, 2005; Devey et al., 2003). For the Emperor seamounts, much of the observed isotopic and chemical variation may be related to changing proximity to a spreading center and related changes in lithospheric thickness (Keller et al., 2004; Regelous et al., 2003). In contrast, for most of the Louisville Seamount Trail, the limited isotopic variation likely reflects a remarkably homogeneous plume source or relatively uniform melting conditions over 80 m.y.

Comparable to other primary hotspots (e.g., Hawaii), potential temperatures of the Louisville mantle plume sources are expected to be 100°– 300°C higher than the 1350° ± 50°C temperature of an upper mantle MORB source (Putirka, 2008; Courtier et al., 2007). Olivine-phyric rocks will likely be encountered within 350 m of drilling into the Louisville seamounts and can be used to determine Mg-Fe compositions of olivine phenocrysts and melt-inclusions therein. In turn, these compositions will yield information about source temperatures by relating the Mg/Fe ratio of olivines directly to that of the liquid from which they crystallized (e.g., Putirka et al., 2007). The challenge here is to determine the most magnesian-rich olivines that come closest to the parental magma compositions, a task that may be more complicated for the Louisville seamounts because all samples studied so far are relatively evolved and typically alkalic. Picritic basalts tend to be found deeper in the stratigraphy of a volcanic pile, providing another key reason for IODP drilling in the Louisville Seamount Trail. For example, during Leg 197, olivine-rich basalts were recovered only after drilling >250 m (Duncan et al., 2006). Melt inclusions also provide key insights into the "true" (lack of) heterogeneity in the mantle source from which the Louisville magmas have been generated.

Courtillot et al. (2003) have argued that most hotspots arise from relatively shallow levels and that no more than three primary plumes (Hawaii, Easter, and Louisville) ascend from the core/mantle boundary in the Pacific Basin. These authors suggest several criteria by which primary plumes may be assessed, the chief geochemical criterion being high $^3He/^4He$ ratios in hotspot lavas. Although agreement is not universal (e.g., Meibom et al., 2003), high $^3He/^4He$ is considered by the great majority of researchers to be a sign of deep-mantle origin (e.g., Allègre et al., 1983; O'Nions, 1987; Farley and Neroda, 1998). Hawaiian basalts, for example, have $^3He/^4He$ values as high as 35 R_A (where R_A is the atmospheric $^3He/^4He$ ratio measured today), and even higher values have been reported for samples from Iceland. In comparison, MORB typically has values of only 7–10 R_A (e.g., Graham, 2002). No He isotope data have been published for the Louisville Seamount Trail. Another geochemical indicator of a deep-mantle origin is high $^{186}Os/^{188}Os$, which is interpreted by some to signify Os derived from the outer core. Only a few studies of Os isotopes in oceanic hotspot lavas have been performed, but anomalously high $^{186}Os/^{188}Os$ and $^{187}Os/^{188}Os$ ratios have been discovered in at least some of the primary hotspots, such as Hawaii (e.g., Brandon et al., 1999). Although the interpretation of elevated Os isotope ratios is disputable (e.g., Smith, 2003), combined studies of Os and He isotopes have the highest potential to reveal a deep-mantle signature in oceanic lavas. Drilling is critical for obtaining samples with relatively unaltered olivine crystals and oxide minerals that can be used to successfully test these geochemical criteria and prove that, indeed, the Louisville hotspot is a primary hotspot. If these tests indicate that Louisville does not have a deep (lower) mantle origin, this outcome will place limits on the mantle flow models by forcing a shallower root for its mantle plume. Although geodynamic modeling likely will be unable to resolve the depth of origin between primary and secondary hotspots, geochemical results may be able to, particularly via characteristic high $^{3}He/^{4}He$ and $^{186}Os/^{188}Os$ deep-mantle plume-source ratios.

Finally, the Ontong Java Plateau (OJP) has been proposed to be a large igneous province (LIP) that is the product of the Louisville hotspot's initial plume-head phase (e.g., Richards and Griffiths, 1989; Mahoney and Spencer, 1991; Tarduno et al., 1991), even though this would require a significant amount of true polar wander and a 6° southward hotspot migration (Antretter et al., 2004). On the other hand, existing isotopic data for Louisville dredge samples (Cheng et al., 1987; Vanderkluysen et al., 2007) offer no support for such a connection (Mahoney et al., 1993; Tejada et al., 1996), and recent paleolatitude data for basalts recovered from the plateau during ODP Leg 192 differ significantly from the present-day latitude of the Louisville hotspot (Riisager et al., 2003). For example, the OJP and Louisville samples have similar age-corrected Nd and Sr isotope values, but the Louisville lavas have significantly higher Pb isotope ratios than the OJP basalts (Fig. **F6B**). This difference is more than can be accounted for by ingrowth of radiogenic Pb in the mantle source between 120 and 80 Ma (Vanderkluysen et al., 2007). However, as noted above, the existing Louisville dredge samples may come from late-stage flows that are not representative of the bulk of these seamount edifices. The ~350 m of basement penetration at the four Expedition 330 drill sites will provide a much more rigorous test of any geochemical connection between the OJP and the Louisville Seamount Trail.

Hydrothermal and seawater alteration

Each drilling project has its own scientific and technical challenges. In drilling the Louisville Seamount Trail we will face challenges related to hydrothermal and seawater alteration present in the cored seamount basalts. Most of the dredged samples from the Louisville Seamount Trail that are now available to us are highly to completely altered by seawater interaction. Although drilling will provide us with fresher basaltic material, alteration remains problematic and thus requires special analytic attention in order to maximize the amount of high-quality data on rock ages and original (erupted) compositions. Holocrystalline groundmass samples that have been carefully handpicked and acid leached to remove alteration have provided ages consistent with $^{40}Ar/^{39}Ar$ ages of co-magmatic minerals and can be interpreted as eruption ages (Koppers et al., 2000, 2004). Preliminary data on basalts from the AMAT02RR site survey emphasize the suitability of this technique for Louisville (Fig. **F4B**), with excellent reproducibilities between groundmass and plagioclase separates. This makes the $^{40}Ar/^{39}Ar$ groundmass dating technique perfectly suited to date and resolve the duration of multiple lava units in a single drill site, particularly if samples are enriched in potassium and are taken from relatively unaltered drill core material. Many studies also have demonstrated that altered rocks can be effectively used for determining a hotspot's geochemical characteristics, particularly data for elements (lanthanides, Nb, Ta, Zr, Ti, Fe, and Al) and isotopic systems (Sm–Nd and Lu–Hf) that are resistant to seawater alteration. In addition, useful data can be obtained for the more sensitive Sr and Pb isotopic systems by applying mineral separation and acid-leaching of rocks to remove secondary minerals (Cheng et al., 1987; Mahoney et al., 1998; Koppers et al., 2003; Regelous et al., 2003). Finally, magmatic compositions can be inferred from the microanalysis of major and trace elements in typically (relatively) unaltered portions of various phenocrystic phases and melt inclusions.

Paleosecular variation

Robust paleolatitude estimates require a sufficient number of flows be sampled to average out the secular variations of the geomagnetic field, which shows small deviations from a geomagnetic axial dipole on timescales ranging from years to millennia. The proposed penetration depth of at least 350 m during Expedition 330 is therefore primarily dictated by the necessity to obtain accurate paleolatitude data. Likely errors in paleolatitude estimates at a ~50° southern latitude appropriate for the Louisville hotspot can be illustrated via Monte Carlo simulations of field directions, as drawn from two recent paleosecular variation models based on a global database of directions from recent lava flows (0–5 Ma). These simulations suggest that we must recover >42 independent flow units at each site to achieve a nominal 2σ error of 4° in the paleolatitude estimates (Fig. **F8**) and only 25–30 flow units if we aim more conservatively for 5° errors. These results can also be compared to a compilation of Deep Sea Drilling Program (DSDP)/ODP drilling statistics from other expeditions to seamount trails and LIPs (Fig. **F8B**) that on average recovered >20 flow groups from ~200–300 m of volcanic basement coring. Measured uncertainties (Fig. **F8C**) in these DSDP/ODP cores are generally compatible with the Monte Carlo simulations but scatter significantly between 3° and 7° uncertainties for paleolatitude estimates based on five or more flow units. Because mantle flow models and global plate circuit reconstructions predict small paleolatitude shifts for the Louisville hotspot, we require a basement penetration of at least 350 m to achieve a paleolatitude uncertainty better than 5°.

Site survey data

Data acquisition

Three cruises surveyed and sampled the Louisville Seamount Trail before and in preparation for Expedition 330. In 1984, Lonsdale (1988) made a transit along the entire trail, collecting the first multibeam swaths and 3.5 kHz and magnetic profiles. During this cruise, 25 guyots and 12 other large volcanoes were mapped, and at least one single-channel seismic reflection profile was collected across their summits. A limited set of dredge samples (light blue circles in Fig. **F2C**) were used for total fusion $^{40}Ar/^{39}Ar$ age dating (Fig. **F4A**) and geochemistry (Fig. **F6**).

In November 2002, Cruise 167 of the F/S *Sonne* (SO167; Stoffers, 2003) surveyed the Louisville Seamount Trail between the Tonga Trench and the 169°W bend. Subaerial lavas and volcaniclastics were dredged from 11 guyots at 39 different stations (gray circles in Fig. **F2C**). Preliminary inductively coupled plasma–mass spectrometry results indicate that the dredged basalts are all alkali basalts, whereas preliminary $^{40}Ar/^{39}Ar$ age data indicate a sometimes complex age history for the oldest seamounts in the trail (orange circles in Fig. **F4A**).

In 2006, the SIMRAD EM-120 system was used during the AMAT02RR site survey cruise to map 72 seamounts and guyots, many with full coverage and all with at least 80% multibeam coverage. Multichannel seismic (MCS) data were collected along the oldest third of the seamount trail (Fig. **F2B**) using two 45–105 in^3 generator-injector air guns and an 800 m 48 channel streamer that generated 79 seismic lines with 69 crossing points on 22 seamounts. From these MCS data we selected four primary and seven alternate sites for IODP drilling on seven seamounts that (1) fall within the age constraints for the comparative Leg 197 experiment we propose to carry out, (2) have a sufficient sediment cover of at least 10 m based on 3.5 kHz profiling and sidescan reflection data, and (3) show consistent reflectors below these sediments representing basaltic basement. Additionally, 58 groundmass and mineral separates from 47 samples of dredge hauls from 29 sites on 21 seamounts and guyots (green circles in Fig. F2C) dredged during the AMAT02RR cruise were age dated using the $^{40}Ar/^{39}Ar$ incremental heating technique (red diamonds and plateau diagrams in Fig. F4) (Lindle et al., 2008). Major and trace element analyses have been carried out on 61 samples, and Sr-Nd-Pb isotope analyses have been carried out on 49 samples (Fig. F6) (Vanderkluysen et al., 2007).

Detailed magnetic surveys of two seamounts and the small guyot at 168.6°W that is targeted for drilling (proposed Site LOUI-4B) were conducted in preparation for Expedition 330. The resulting magnetic anomaly for 168.6°W is very low amplitude (Fig. F9) and yields an unreasonable paleopole position, but the complexity of the anomaly pattern suggests that dual polarities may be present. If cored, these changing polarities could provide a more robust paleolatitude estimate. In contrast, the 35.8°S seamount (located 1.1° north of proposed Site LOUI-3B) has a well-defined (root mean square crossover error = 3 nT) and simple anomaly with a normal polarity, presumably reflecting formation during Chron 26n from 57.5 to 57.9 Ma (Cande and Kent, 1995). Seminorm inversions (Parker et al., 1987) yield paleopole positions that are relatively stable over a range of misfits (Fig. F10) and generally compatible with the Pacific apparent polar wander path (Sager and Pringle, 1987). These inversions give a paleolatitude of ~49° ± 7°S, similar to the present-day 50.9°S latitude of the Louisville hotspot but with a relatively large 1σ uncertainty estimate. Despite ambiguity in the interpretation of seamount anomalies (Parker, 1991), this result seems to suggest that only little discernible paleolatitude shift has occurred since the seamount formed at ~58 Ma, at which time the contemporary Suiko Seamount in the Emperor Seamount Trail shows at least a 6° paleolatitude shift.

Seismic interpretation

Interpretation of MCS data collected during the AMAT02RR site survey cruise is complicated because the Louisville seamounts have not been drilled before—neither by DSDP/ODP nor using piston coring. In fact, samples and data collected during Expedition 330 will be essential in groundtruthing the seismic interpretation and improving the final seismic images of this group of intraplate seamounts. Nevertheless, the available MCS data provide us with the first-order information needed to meet the objectives and goals of Expedition 330.

Seismic imaging and 3.5 kHz data show that at all primary sites the overall thickness of the pelagic sediment cap is <20 m, underlain by a <55 m thick sequence of volcaniclastics and followed by what largely appears as “opaque” volcanic basement without any significant reflectors. The intermediary sequence of volcaniclastics themselves appear to be intercalated with some lava flows and/or carbonates because they show strong reflectors dispersing outward from the centers of the targeted seamounts. In fact, on many of the larger guyots (not targeted for drilling) in the Louisville Seamount Trail, these layered sequences (most probably volcaniclastics) have substantial thicknesses of as much as several hundred meters that dip and thicken toward the margins of the guyots. Dredge samples from depths corresponding to the outcrop of this unit have recovered volcaniclastic sediments, including rounded cobbles from supposedly shallow beach deposits (SO167 cruise report; Stoffers, 2003). Based on the sparse information presented above and the observations of the Emperor seamounts made during Leg 197, we therefore interpret this unit to be an outward-thickening sequence of volcaniclastics. The bottom of this sequence provides us with the depth at which we expect to begin coring 350 m into lava flow–dominated basaltic seamount basement. Note that similar layered sequences drilled from the Nintoku Seamount during Leg 197 proved to be lavas with some (minor) intercalated sediments/paleosols (Kerr et al., 2006).

The thickening of the volcaniclastic sequence also has been imaged by the seismic refraction experiment carried out during the German SO195 cruise (Grevemeyer and Flüh, 2008). During this experiment, a single 370 km long refraction line was conducted orthogonally to the overall northwest trend of the Louisville Seamount Trail, crossing the summit of the 27.6°S guyot, which is located one seamount down and about 1.1° south of proposed Site LOUI-1C. Based on the outcome of this refraction experiment (using 35 ocean-bottom seismometer stations spaced every ~10 km), Contreras-Reyes et al. (2010) were able to image the internal structure of this seamount, the oceanic crust underneath it, and the flexed shape of the MOHO (Fig. **F7**). Although their data do not provide sufficient resolution for the uppermost 500 m of this seamount to image individual volcanic sequences or seismic reflectors, the data give us a good idea of the overall velocity structure of the 27.6°S guyot, including (1) a sequence of “basaltic extrusives” (i.e., lava flows of 4.0–6.0 km/s seismic velocity) extending to shallower regions and to a significantly <0.5 km basement depth in the center of this seamount and (2) a thickening sequence of “volcaniclastic infill” (i.e., 2.0–3.0 km/s seismic velocities), starting with a very thin layer at the seamount summit that substantially thickens outward, particularly on the seamount flanks and in its flexural moat. This outcome lends confidence to our interpretation of the AMAT02RR seismic reflection profiles and our placement of drill sites away from the shelf edges of the guyots and the center of these volcanic structures.

Scientific objectives

Primary objectives

1. Determine the paleolatitude change (if any) over time for the Louisville hotspot.

High-quality paleolatitude data for the Louisville seamounts are required to establish its potential hotspot motion between 80 and 50 Ma relative to Earth's spin axis and to compare this movement to the 15° shift in paleolatitude that has been observed for the Hawaiian–Emperor seamounts during the same time period. Together with the measurement of high-resolution $^{40}Ar/^{39}Ar$ age dates for the cored lava flows, these paleolatitude data will help us to determine whether primary Pacific hotspots moved coherently before 50 Ma or, alternatively, show significant interhotspot motion, with the Louisville hotspot possibly showing less or no discernible latitudinal motion and a considerable longitudinal shift toward the east. Comparison of these results with predictions from geodynamic mantle flow and plate circuit models will allow us to critically test, calibrate, and improve these models. The outcome of these comparisons is fundamentally important to understanding the nature of hotspots, the convection of Earth's mantle, and true polar wander.

2. Determine the volcanic history of individual seamounts and age progression along the Louisville Seamount Trail through $^{40}Ar/^{39}Ar$ age dating.

Because volcanic activity for a single hotspot volcano can span as much as 10 m.y. when including the possibility of posterosional volcanism, it is essential to establish an accurate framework of $^{40}Ar/^{39}Ar$ ages to successfully determine paleolatitude change over time and map the magmatic evolution within single seamounts and along the Louisville Seamount Trail. Shield-building and postshield lavas typically form within 1–2 m.y. for Hawaiian-type volcanoes and can be readily distinguished from possible overlying posterosional sequences because of the high precision in $^{40}Ar/^{39}Ar$ age dates on the order of 0.2–0.5 Ma. For this reason, incremental heating $^{40}Ar/^{39}Ar$ age dating will allow us to establish age histories within each drilled core that can be used to establish the cessation of volcanism at the end of the shield-building phase and determine the starting time (and minimal duration) of the postshield capping and posterosional stages (if recovered). Drilling of the Louisville seamounts will likely recover mostly alkali basalts that contain high abundances of potassium, making the $^{40}Ar/^{39}Ar$ technique especially suitable for providing high-precision age dates necessary to test and calibrate geodynamic and geochemical models.

3. *Determine the magmatic evolution of the Louisville seamounts and their mantle source through major and trace element and isotope geochemistry.*

Existing data from dredged lavas suggest that the mantle source of the Louisville hotspot has been remarkably homogeneous for as long as 80 m.y. In addition, the recovered basalt samples are predominantly alkalic and likely represent a mostly alkalic shield-building stage, which sharply contrasts with the massive tholeiitic shield-building stage of volcanoes and seamounts in the Hawaiian–Emperor Seamount Trail. Therefore, geochemical and isotopic data for lavas from the proposed drill sites will provide key insights into the magmatic evolution and melting processes that produced and constructed the Louisville volcanoes during their progression from shield to postshield (and perhaps posterosional) volcanic stages. In turn, these data will help us to characterize the Louisville Seamount Trail as a product of one of only three primary hotspots in the Pacific and test the apparently long-lived homogeneous geochemical character of its mantle source. Detailed analyses of melt inclusions, volcanic glass samples, primitive basalts, and high-Mg olivine pheno- and xenocrysts (if recovered) will provide further constraints on the asserted homogeneity of the Louisville mantle plume source and the compositional evolution of this source between 80 and 50 Ma. Together, these geochemical and isotopic studies will allow us to map the fundamental differences between primary Hawaiian and Louisville hotspot volcanism.

Secondary objectives

1. *Determine whether the Ontong Java Plateau formed from the plume head of the Louisville mantle plume at ~120 Ma.*

One hypothesis states that the OJP formed from massive volcanism at ~120 Ma, coincident with when an oversized plume head preceding the deep Louisville mantle upwelling reached the base of the Pacific lithosphere and began extensive decompression melting (e.g., Richards and Griffiths, 1989; Mahoney and Spencer, 1991). Expedition 330 will generate essential data for the Louisville seamounts that will have significant implications for the origin of the OJP and LIPs in general. If the Louisville Seamount Trail corresponds to the plume tail stage of the Louisville mantle plume itself and the OJP corresponds to the plume head, then new paleolatitude estimates, $^{40}Ar/^{39}Ar$ ages, and geochemical data will help us to determine whether the oldest Louisville seamounts were formed close to the 18°–28°S paleolatitude determined from Leg 192 basalts for the OJP (Riisager et al., 2003) and whether they are genetically linked or not.

2. *Determine the degree, potential temperature, and degree and depth of partial melting at which Louisville magmas were generated.*

Characterizing Louisville as one of the primary hotspots in the Pacific requires the estimation of the minimum potential temperature of its mantle plume source, the degree of partial melting in this source, and the depth of the melting zone beneath the oceanic lithosphere in order to distinguish this model from alternate models (e.g., Foulger and Anderson, 2005), such as intraplate volcanism originating in the upper mantle from more “fertile” (i.e., more refractory) source materials. Evidence for temperatures higher than the mean 1350° ± 50°C temperature of an upper mantle MORB source (Putirka, 2008; Courtier et al., 2007) will be important for proving the deep thermal origin of the Louisville mantle plume. Evidence for changes in the degree and depth of partial melting, on the other hand, will be important for documenting the changing plume–lithosphere interactions along the Louisville Seamount Trail.

3. *Provide paleoceanographic and paleoclimate data at 40°–50°S paleolatitudes in the southern ocean from cored Louisville pelagic sediments.*

The flat-topped Louisville seamounts are capped by thin packages of pelagic sediments <10–40 m thick. These sediments possibly contain abundant calcareous fossils (e.g., foraminifers and nannofossils) because they were deposited in shallow waters and above the carbonate compensation depth (CCD). If so, this will provide good stratigraphic age control in these sediments. Similar sediments may also be recovered intercalated between lava flows deep in the volcanic basement, providing a fossil record that can be directly compared with the $^{40}Ar/^{39}Ar$ radiometric age dates for the basement samples. In addition, nummulitic limestones have been dredged from a few guyots in the Louisville Seamount Trail, indicating the possible presence of Eocene shallow-water reefs in the high- to mid-latitude Pacific (Lonsdale, 1988). The timing of reef formation, and eventually the drowning of such carbonate banks, is of considerable interest because it provides evidence from the southeast Pacific for the expansion of tropical climates during past warm periods (Adams, 1967, 1983; Premoli Silva et al., 1995; Huber et al., 1995; Wilson et al., 1998; Jenkyns and Wilson, 1999). Although the rotary core barrel (RCB) system that we will use to drill through the hard igneous rocks is not suitable for undisturbed and continuous recovery of soft pelagic sediment, we will attempt to maximize the recovery of these thin pelagic caps by applying a “gravity-push” technique or by reducing RCB bit rotation and pump rate for this interval. Although not a primary objective during Expedition 330, these sediments may provide a unique data set that adds to the very sparse paleoclimate record in the South Pacific at high southern latitudes (Corfield and Cartlidge, 1992; Corfield and Norris, 1996; Barrera and Savin, 1999; Norris et al., 2001).

Coring and drilling strategy

Site selection

The primary drilling strategy for Expedition 330 is to core 350 m (or deeper) into the volcanic basement of four Louisville seamounts in order to retrieve the largest possible number of lava flows to cancel out secular variations in the paleomagnetic measurements. By scientific preference we will drill the Louisville seamounts from oldest to youngest (proposed Sites LOUI-1C to LOUI-4B) because we expect to see the largest paleolatitude shift in the oldest targeted seamounts. Our principal science objectives are to acquire accurate paleolatitudes, geochemistry and isotope compositions, and $^{40}Ar/^{39}Ar$ age dates for four Louisville seamounts that have formation ages similar to those of the Emperor seamounts drilled during Leg 197. In addition, we have generally selected drill sites where seismic lines cross midway between the center of the targeted flat-topped seamounts (i.e., guyots) and their margins, a compromise designed to avoid eruptive centers (which may harbor fewer lava units) while at the same time avoiding marginal sites with potentially thicker volcaniclastic units and higher potential for tectonic disruption. The Louisville seamounts targeted for drilling are relatively small structures (particularly proposed Sites LOUI-2B, LOUI-3B, and LOUI-4B) that have typically thin sediment cover and few subsidiary peaks and pinnacles that we interpret as late-stage (posterosional) lavas.

Four primary sites (Fig. **F1;** Table **T1**) on four flat-topped seamounts at the oldest end of the Louisville Seamount Trail were selected. Based on the new $^{40}Ar/^{39}Ar$ ages from the AMAT02RR site survey, we estimate the ages of these dormant volcanic structures to be 75–77 Ma (proposed Site LOUI-1C on the 26.5°S guyot), 58.5 Ma (proposed Site LOUI-2B on the 33.7°S guyot), 54.0 Ma (proposed Site LOUI-3B on the 36.9°S guyot), and 50.1 Ma (proposed Site LOUI-4B on the 168.6°W guyot).

Seven alternate sites (proposed Sites LOUI-1B, LOUI-6A, LOUI-7A, LOUI-7B, LOUI-8A, LOUI-8B, and LOUI-9A) were selected (Fig. **F1;** Table **T2**). Except for the 36.9°S guyot, which has a second set of crossing lines close to primary proposed Site LOUI-3B, most of the alternate sites are located on different but closely neighboring seamounts (also surveyed during site survey Cruise AMAT02RR) in order to stay as near as possible to our original age-selection criterion and our overall drilling strategy.

Coring plan

We propose to drill four sites into shield-building lavas at the summits of four Louisville seamounts and guyots (Table T3). Drilling and logging plans for each of these sites are similar, with basaltic basement penetration of 350 m planned for proposed Sites LOUI-1C, LOUI-2B, and LOUI-4B and nearly that much (~330 m) for proposed Site LOUI-3B. All primary and alternate drill sites are capped with a thin layer of pelagic sediments (on average 10–20 m thick, but as thick as 50 m in the case of alternate Site LOUI-8B) that will be cored with the RCB using a gravity-push technique (if applicable) to maximize sediment recovery for paleoceanographic studies. This soft sediment is possibly underlain by a sequence of volcaniclastics that are perhaps interspersed with some basaltic lava flows and/or carbonates. Although it is unlikely that thick sequences of coral rocks were formed between the paleolatitude at which the oldest sediments were deposited (close to the present-day ~50°S latitude of the Louisville hotspot) and the northernmost location of the seamounts today (~26°–38°S), we will still account for this possibility because dredging has occasionally recovered coral debris. From the seismic cross sections we estimate that this sequence is maximally ~55 m thick (0.025–0.035 s two-way traveltime) below each primary drill site and ~110 m below each alternate drill site before transitioning into a seismically opaque zone that we interpret to represent basaltic basement, our principal 350 m total drilling and coring objective.

Table T3 summarizes estimated drilling and logging times, showing a total operation time (on site time) of 45.1 days. Penetration of several hundred meters into basement will require multiple bit changes and reentries. We assume basalt penetration rates of 1.5–3.5 m/h depending on drill depth (consistent with average 3.1 m/h rates achieved during Leg 197; Tarduno et al., 2002) and the use of three RCB drill bits per hole (two bit trips) for proposed Sites LOUI-1C, LOUI-2B, and LOUI-4B. Because of time constraints, only one bit replacement is currently planned for proposed Site LOUI-3B.

The time estimates shown in Table T3 are based on the assumption that we will use free-fall funnels (FFFs) for reentry. The use of FFFs carries the risk that we may have to terminate drilling early if reentry fails or the sidewalls collapse. As a backup, reentry cones and single-string casing may be used (depending on availability onboard).

The number of lava flow units encountered during Expedition 330 drilling will determine whether 350 m of basement penetration is adequate, because we seek to recover a sufficient number of these flow units to average out secular variation and attain nominal 2σ uncertainties of <5° in the paleolatitudes (Fig. F8). Approval of additional penetration of basement (>350 m), however, will need to be reviewed by the operator (USIO) during drilling operations. On the other hand, depending on sufficient coring results, we may decide to terminate a hole before reaching the 350 m basement penetration target, permitting us to begin drilling elsewhere early. We will apply real-time monitoring of onboard paleomagnetic data, geochemical data, and physical volcanology to recognize basaltic (independent cooling) flow units and determine when the most effective termination depth has been reached.

Logging/downhole measurements strategy

Downhole logging will aid in achieving expedition objectives by assisting in lithologic identification and recognition of the structural characteristics of cored sequences (particularly in the volcanic basement) and providing detailed monitoring of changes in magnetic properties and paleomagnetic directions within and between lava flows. Wireline logs will provide a continuous record to aid the detection of lava flow boundaries, interlayered (baked) sediments, and alteration zones in the basement section and will enable the tilting of lava flows to be evaluated. Determination of the number of lava flow units has implications for how well geomagnetic secular variation has been sampled and hence the extent to which paleomagnetic paleolatitudes can be most precisely constrained. Logging measurements will complement core measurements by determining the characteristics of lithologic units in any intervals where core recovery is poor. In addition, wireline logging data can be compared to analyses of discrete core samples.

Combinations of four wireline logging tool strings will be deployed during Expedition 330: (1) the standard triple combination (triple combo), (2) the Formation MicroScanner (FMS)-sonic, (3) the Ultrasonic Borehole Imager (UBI), and potentially (4) the third-party Göttingen Borehole Magnetometer (GBM). Operational time estimates for each site can be found in Table T3. The tools and their applications are described below, and further information is available at **iodp.ldeo.columbia.edu/TOOLS_LABS/index.html.**

The triple combo tool string consists of several probes that record geophysical measurements of the penetrated formations and measure the total and spectral natural gamma radiation, density, porosity, and resistivity of the formation. These measurements will enable changes in lithology and variations in alteration to be assessed. The

FMS-sonic tool string acquires oriented high-resolution electrical images of the borehole wall and measures compressional and shear wave forms. Velocity data can be used to determine preferred mineral and/or fracture orientations and fracture densities. The sonic and density logs can be used together to create synthetic seismograms, improving correlation between the seismic records and the lithologic units recovered from the boreholes. The UBI will be deployed at the first site (LOUI-1C), with data acquisition at subsequent sites depending on the time available and the quality of the logs acquired. The UBI provides high-resolution acoustic amplitude images with 100% borehole wall coverage. The high-resolution FMS and UBI images will allow detection of small-scale fractures and lithologic variations, enable the tilt of lava flows to be evaluated, and may allow reorientation of core pieces. The General Purpose Inclinometry Tool (GPIT) will be deployed with both image tools to collect accelerometer and magnetometer data, which will allow orientation of the images and provide information about borehole geometry. Constraining the deviation of the hole from vertical is a factor in evaluating possible biases in paleolatitude estimates derived from paleomagnetic measurements on the core.

The GBM was previously deployed as a third-party tool during Leg 197 and IODP Expedition 305 and is planned to be available during Expedition 330. This tool has three fluxgate sensors that measure three orthogonal components of the magnetic field (Steveling et al., 2003). The GBM includes a gyroscope that measures tool rotation during data acquisition and accordingly allows the orientation of the tool to be determined with respect to the borehole walls and thus with respect to magnetic north. Data from the magnetometer will be used to monitor changes in the magnetic properties of the lithologies as well as changes in paleomagnetic direction. The GBM requires a science party member/technician onboard who has had previous training and who will be responsible for operating the tool. For optimum data quality, the GBM requires centralization during logging, but GBM centralizers that fit through the bottom-hole assembly used on the *JOIDES Resolution* are not available at present. The final decision to deploy this tool on Expedition 330 will depend on whether an expedition participant can be trained and whether centralization of the tool can be successfully achieved.

Risks and contingency strategy

Three principal factors could affect the implementation of the drilling plan during Expedition 330: (1) adverse hole conditions, (2) weather conditions that limit our ability to continue coring or stay on station, and (3) time delays (arising from equipment breakdowns, inclement weather, or measures taken to respond to hole conditions).

Hole conditions

Because the Louisville seamounts have not been drilled or piston cored before, no previous data regarding the nature of the overlying sediments exist. Based on MCS and dredge expedition site survey data, a thin pelagic cover 10–40 m thick is expected to rest above a 50–110 m thick layered material assumed to consist of volcaniclastics, limestone(?), and/or minor intercalated late-stage (posterosional) lava flows. It is unclear how consolidated this material is, but the overlying sediments/clastics drilled during Leg 197 (Emperor seamounts) were stable during drilling. Nevertheless, basaltic debris repeatedly jammed the float valve and bit throats at three out of four sites during Leg 197, resulting in empty core barrels and requiring time-consuming pipe trips for inspection/cleaning.

The sediment surfaces on top of the Nintoku (Hole 1200A) and Koko (Hole 1206A) Emperor seamounts were apparently too consolidated to allow proper impingement of the FFF, so the FFF tipped over when the drill string was pulled out of the hole for bit replacement. The operators were able to reenter the open hole, but such success cannot always be expected. As a backup, a reentry cone and single-string casing (reaching down to the beginning of basement) could be deployed, but this would be time consuming, and availability of the required hardware on the ship cannot be guaranteed for this expedition.

In contrast, unusually adverse hole conditions are not expected when drilling into the igneous basement section at the Louisville seamounts. Hole conditions in igneous sections depend on the type and consolidation of the igneous rocks. It is common to encounter fractured friable zones while drilling lava-flow sections, usually between flows. Occasionally, rock pieces from the borehole wall cave into the hole after being knocked loose by the drill string. Loose rocks above the drill bit can cause the drill string to bind and may require clearing the hole. On rare occasions, such debris causes so much difficulty that the hole must be abandoned. Depending on time estimates and the importance of the site for achieving the overall objectives of this expedition, a new "B" hole may be drilled at the same site. To save valuable time, coring in the new hole will not start before reaching the maximum penetration depth of the abandoned "A" hole.

Weather

Another potential issue that may shorten operations time is weather. Expedition 330 will take place from December to February. The area of the northernmost sites (primary Site LOUI-1C and alternate Sites LOUI-1B and LOUI-6A) has a moderate cyclone risk from November to April. All other primary sites have a moderate cyclone risk from January to March. Therefore, it is possible that Expedition 330 could lose several operation days because of a nearby cyclone. If a hole must be abandoned because of an approaching storm, we may deploy an FFF if return to this site and reentry is deemed necessary.

Timing

If significant time is spent responding to poor hole conditions, slower than expected penetration rates, and/or weather-related delays, a primary site may be dropped from the schedule. Such a decision will only be made following consultation with the science party. In terms of meeting scientific objectives, the primary sites are currently prioritized in the following order: LOUI-1C, LOUI-2B, LOUI-4B, and LOUI-3B.

If additional contingency time is available (e.g., because of faster than expected average penetration rates), extra time may be allotted for advanced piston corer (APC) coring of a "B" hole to obtain a better recovery of the pelagic sediments or penetrate deeper into the volcanic basement at a later primary site. However, such a decision will be based on evaluation of the scientific value (and quantity) of the sediment recovered at the previous sites with the RCB (gravity-pushing) technique.

Sample and data sharing policy

Shipboard samples and data acquisition

Following core labeling, nondestructive whole-core measurements, and core splitting, samples will be selected from the working halves of cores by members of the shipboard party for routine measurement of physical and magnetic properties and bulk chemical and mineralogical analyses by, as needed, inductively coupled plasma–atomic emission spectrometry and X-ray diffraction spectrometry. Thin sections of samples will be prepared for identification of minerals, determination of mineral modes (e.g., by point counting), and studies of texture and fabric. Detailed visual core description will be conducted on the archive halves.

Personal sampling for shore-based research

Shipboard and shore-based researchers should refer to the IODP sample, data, and obligations policy (**www.iodp.org/program-policies/**). This document outlines the policy for distributing IODP samples and data. It also defines the obligations incurred by sample and data recipients. All requests for data and core samples must be approved by the Sample Allocation Committee (SAC). The SAC is composed of the co-chief scientists, the expedition project manager (staff scientist), and the IODP curator on shore and curatorial representative in place of the curator onboard the ship.

Scientists must submit their research plans using the sample/data request system (**smcs.iodp.org:8080/smcs/**) no later than three months before the expedition begins. This planning process is necessary to coordinate the full spectrum of research to be conducted and ensure that the scientific objectives of Expedition 330 to the Louisville Seamount Trail are addressed and, indeed, can be achieved. Based on sample requests (shore based and shipboard), the SAC and shipboard scientific party will formulate a tentative expedition-specific sampling and data-sharing plan for shipboard and postexpedition activities. This plan will be subject to modification depending upon the actual material recovered and collaborations that may evolve between scientists during the expedition. Modifications to the sampling plan during the expedition require the approval of the SAC.

All personal sample frequencies and sizes must be justified scientifically and will depend on core recovery, the full spectrum of other sample requests, and the cruise objectives. Generally, the size of individual samples will be <15–25 cm^3 and samples will be taken from the working halves of the cores. Some redundancy of measurements is unavoidable, but minimizing the duplication of measurements among the shipboard party and identified shore-based collaborators will be a key factor in evaluating sample requests. Our goal is to identify representative intervals ("community samples") that should be sampled by multiple scientists using multiple investigation methods to maximize the science output, to address the primary and secondary objectives of Expedition 330 effectively and thoroughly, and to establish the most comprehensive data set possible for these key intervals. All shipboard scientists will be expected to collaborate and cooperate within the framework of this sampling plan.

Personal sampling will take place onboard during the expedition (i.e., after completion of every site, depending on recovery). If critical intervals are recovered (e.g., small sills or dikes, veins, mineral cumulates, fresh olivine phenocrysts containing melt inclusions, volcanic glass, ores, erosion horizons, paleosols, beach pebbles, and ash layers), there may be considerable demand for samples from a limited amount of cored material. These intervals may require modifications to the sampling plan during the expedition that would specify new special handling protocols, reduced sample size, or deferral of sampling to onshore sampling after completion of the expedition.

Following Expedition 330, cores will be delivered to the IODP Gulf Coast Core Repository at Texas A&M University, College Station, Texas, USA. All collected data and samples will be protected by a 1 year postcruise moratorium, during which time data and samples will be available only to the Louisville Expedition 330 science party and approved shore-based participants.

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Table T1. Primary drill sites. (See table note.)

Site	Seamount name	Latitude	Longitude	Estimated age (Ma)	Water depth (mbsl)	Pelagics (m)	Clastics (m)	Basement (m)
LOUI-1C	26.5°S	26°29.60′S	174°43.75′W	75–77*	1950	15	40	≥350
LOUI-2B	33.7°S	33°41.90′S	171°26.94′W	58.5†	1259	15	44	≥350
LOUI-3B	36.9°S	36°54.26′S	169°47.91′W	54*	982	10	55	≥350
LOUI-4B	168.6°W	38°10.98′S	168°38.26′W	50.1†	1248	8	52	≥350

Note: * = interpolated, † = new $^{40}Ar/^{39}Ar$ ages.

Table T2. Alternate drill sites. (See table note.)

Site	Seamount name	Latitude	Longitude	Estimated age (Ma)	Water depth (mbsl)	Pelagics (m)	Clastics (m)	Basement (m)
LOUI-1B	26.5°S	26°28.66′S	174°43.46′W	75–77*	1840	10	40	≥350
LOUI-6A	28.6°S	28°33.93′S	173°16.78′W	72–73*	1480	10	110	≥350
LOUI-7A	32.3°S	32°12.99′S	171°52.84′W	64*	1550	10	110	≥350
LOUI-7B	32.3°S	32°13.44′S	171°53.87′W	64*	1560	10	110	≥350
LOUI-8A	36.9°S	36°56.51′S	169°46.90′W	54*	970	40	80	≥350
LOUI-8B	36.9°S	36°56.64′S	169°45.76′W	54*	960	50	80	≥350
LOUI-9A	168.3°W	37°59.72′S	168°17.11′W	48–50†	1150	10	105	≥350

Note: * = interpolated, † = new $^{40}Ar/^{39}Ar$ ages.

Table T3. Expedition 330 operations summary. (See table notes.)

Exp. 330 Louisville Seamounts

Operations Plan and Time Estimate

Site	Location (Latitude, longitude)	Seafloor depth (mbrf)	Operations Description	Transit (days)	Drilling Coring (days)	Log (days)
Auckland, NZ			Start of Expedition 330 5.0 days in port			
			Transit 821 nmi to Site LOUI-1C @ 10.5 kt	3.3		
LOUI-1C	26°29.60′S	1961	Hole A: RCB to ~420 m with FFF and two bit trips.		11.2	
	174°43.75′W		Logging: Triple combo, FMS-sonic, UBI, and magnetometer (GBM)			1.4
			Days on-site: 12.6			
			Transit 465 nmi to Site LOUI-2B @ 10.5 kt	1.8		
LOUI-2B	33°41.90′S	1270	Hole A: RCB to ~420 m with FFF and two bit trips.		10.4	
	171°26.94′W		Logging: Triple combo, FMS-sonic, and magnetometer (GBM)			1.0
			Days on-site: 11.4			
			Transit 209 nmi to Site LOUI-3B @ 10.5 kt	0.8		
LOUI-3B	36°54.26′S	993	Hole A: RCB to bit failure (~395 m) with FFF and 1 bit trip.		8.7	
	169°47.91′W		Logging: Triple combo, FMS-sonic, and magnetometer (GBM)			0.9
			Days on-site: 9.6			
			Transit 95 nmi to Site LOUI-4B @ 10.5 kt	0.4		
LOUI-4B	38°10.98′S	1259	Hole A: RCB to ~420 m with FFF and two bit trips.		10.4	
	168°38.26′W		Logging: Triple combo, FMS-sonic, and magnetometer (GBM)			1.1
			Days on-site: 11.5			
			Transit 793 nmi to Auckland @ 10.5 kt	3.1		
Auckland, NZ			Subtotals	9.4	40.7	4.4

Total on-site days:	45.1
Total operating days:	54.5
Port call days:	5.0
Total expedition days:	59.5

Notes: RCB = rotary core barrel, FFF = free-fall funnel, triple combo = triple combination, FMS = Formation MicroScanner, GBM = Göttingen Borehole Magnetometer. Seafloor depth is prospectus water depth plus 11.0 m adjustment from water line to rig floor (i.e., drillers depth). All transits were calculated at 10.5 knots. The Ultrasonic Borehole Imager (UBI) logging run is planned for the first site only.

Figure F1. Bathymetric map of the Southwest Pacific showing the prominent Louisville Seamount Trail and the location of planned primary and alternate dredge sites. This GMT-generated map uses GEBCO 1-min data (Mercator projection).

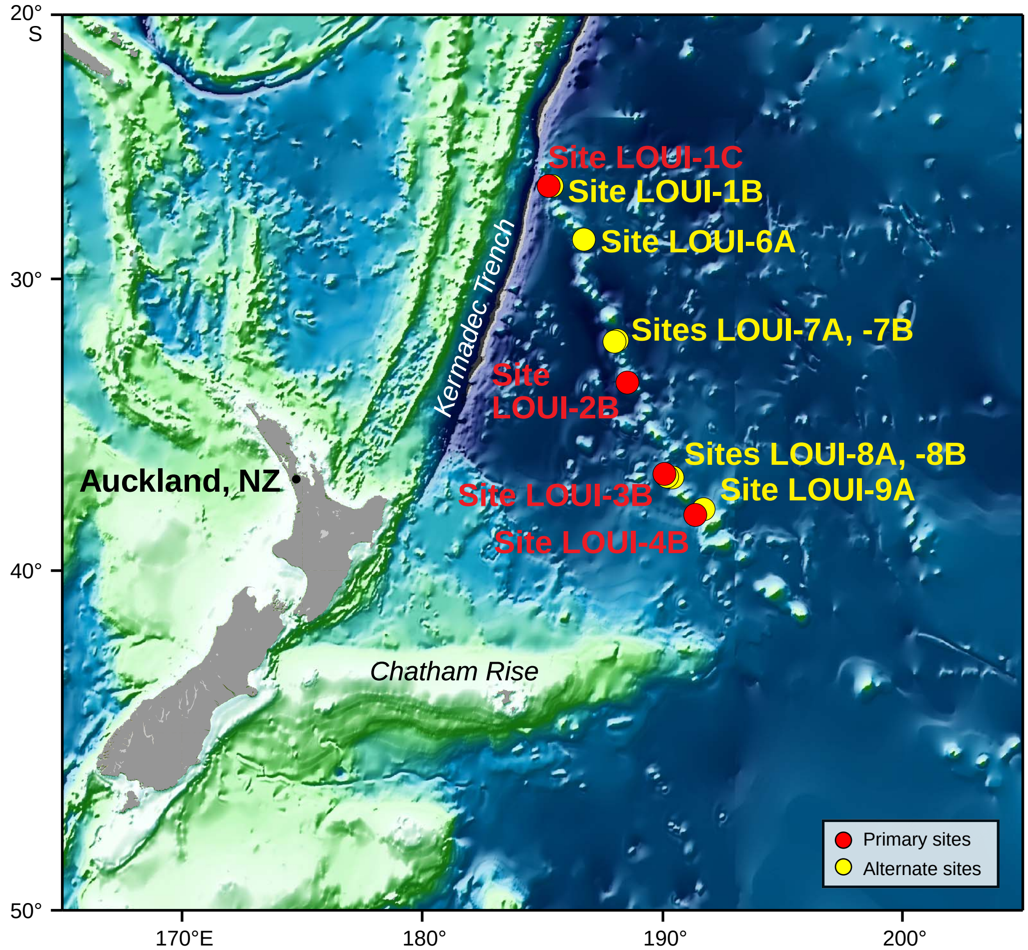


Figure F2. A. Louisville Seamount Trail with its narrow 75 km wide chain of guyots and seamounts. The four proposed primary drill sites are indicated by pink circles. **B.** AMAT02RR multichannel seismic coverage distinguishing between guyots with crossing lines and guyots with single seismic lines. **C.** Available samples from the SO167 and AMAT02RR site survey dredges. Note that preliminary results and data from both site surveys are included in diagrams in the following figures.

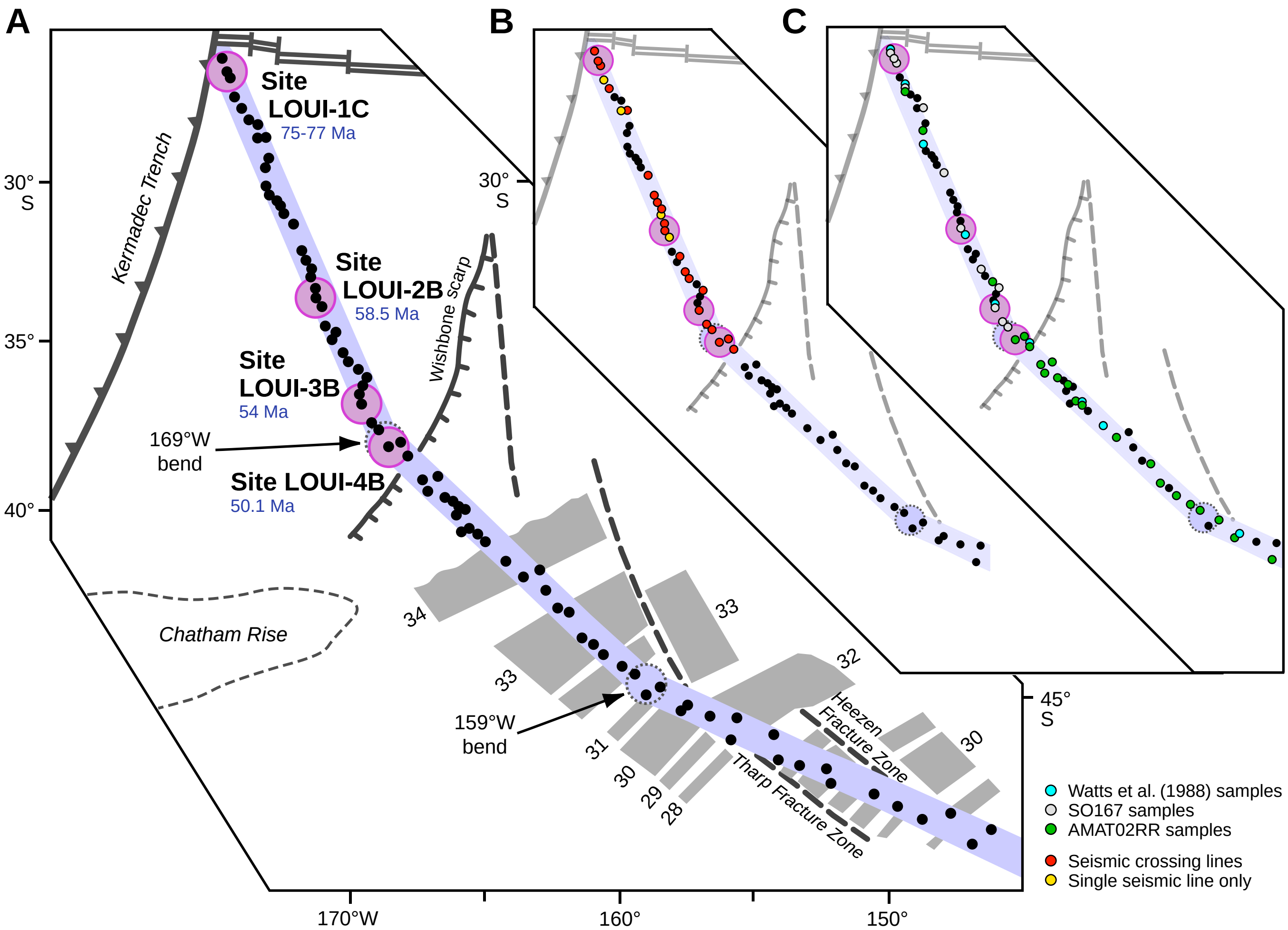


Figure F3. A. Results of mantle flow modeling for the Louisville hotspot showing a maximum paleolatitude shift of only ~2.5° at 60 Ma (similar to Steinberger et al., 2004). **B.** Revised model constrained by a plume initiation age of 90 Ma and new $^{40}Ar/^{39}Ar$ ages (Koppers et al., 2004). **C.** Variations in predicted motion of the Louisville hotspot based on a range of model assumptions, such as location of the present-day hotspot, mantle plume initiation ages, and mantle-viscosity models (Steinberger and Antretter, 2006).

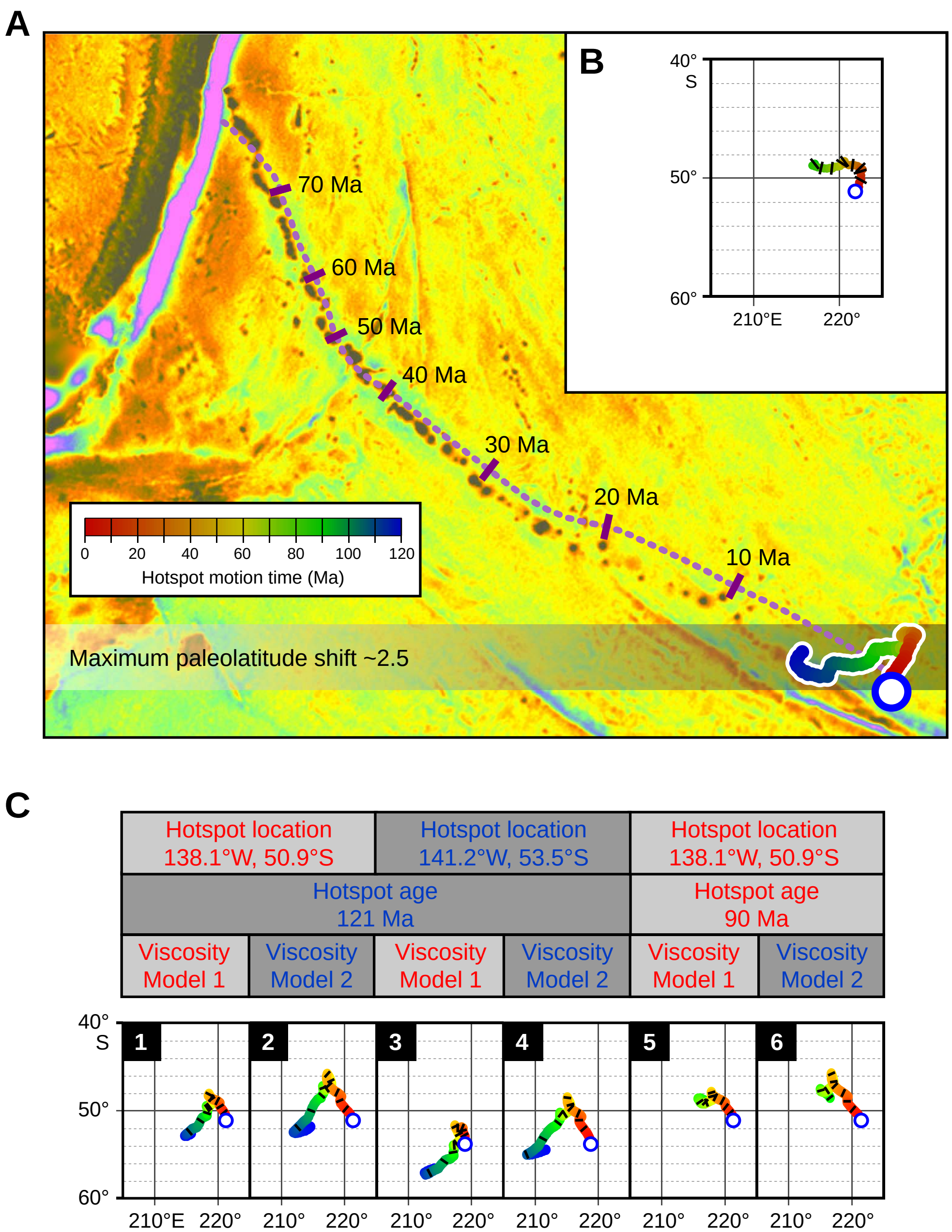


Figure F4. A. Comparison of preliminary (unpublished) incremental heating $^{40}Ar/^{39}Ar$ ages of A.A.P. Koppers (AMAT02RR) and J. O'Connor (SO167), with age data from Koppers et al. (2004) and total fusion ages after Watts et al. (1988). **B.** Example incremental heating diagrams on samples from the AMAT02RR site survey cruise.

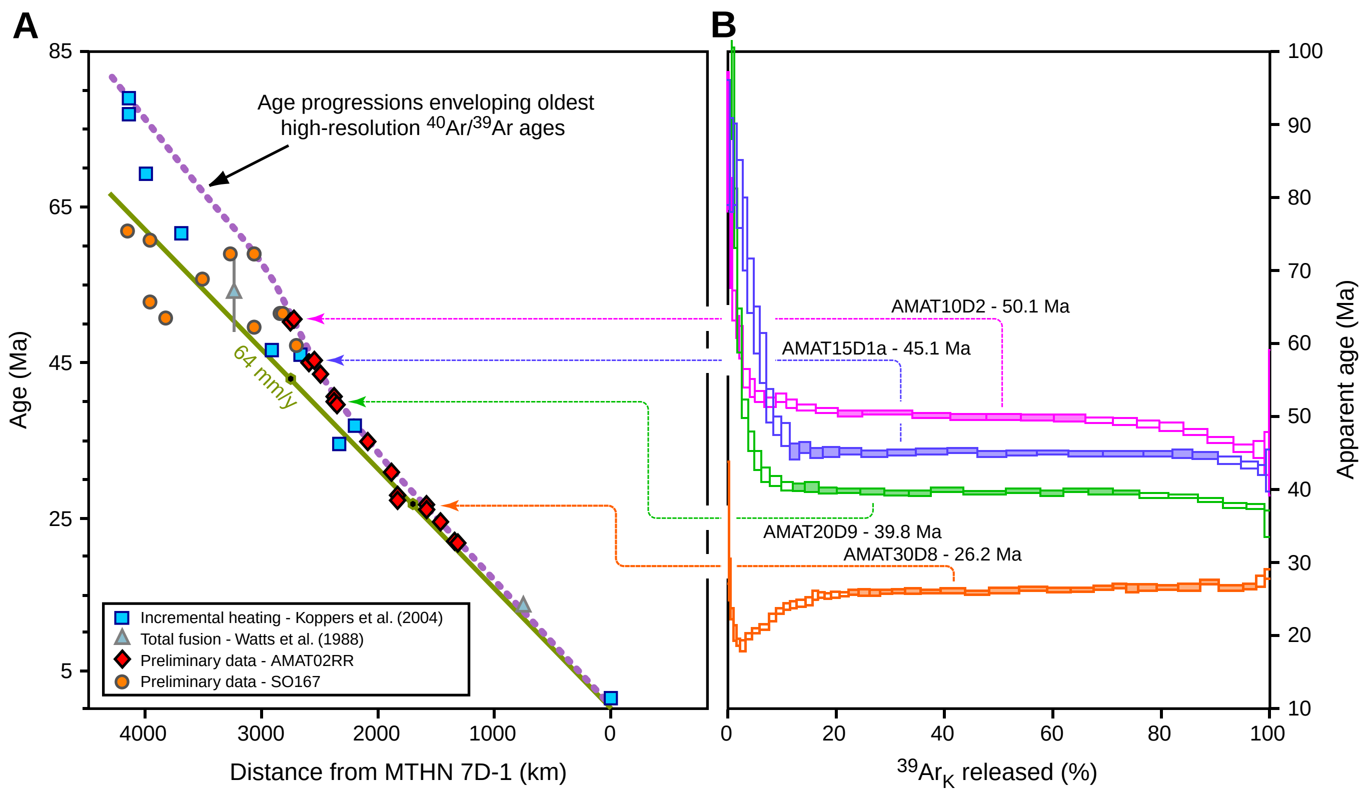


Figure F5. Location predictions of the Louisville hotspot track based on Indo-Atlantic data transferred to the Pacific plate via global plate circuits. Red = standard plate circuit (Cande et al., 1995), with transfer from the Atlantic basin through West Antarctica (WANT) and East Antarctica (EANT), based on the present-day hotspot location at 50.9°S, 138.0°W (Lonsdale, 1988). Blue = alternate plate circuit (Steinberger et al., 2004), with a transfer through the Lord Howe Rise (LHR). Brown = alternate location of the present-day hotspot location at 53.5°S, 141.12°W (Epp, 1978; Wessel and Kroenke, 1997) (no reconstruction is shown for this alternate hotspot location). From J. Tarduno, R. Cottrell, and P. Doubrovine (Rochester University) (unpubl. data).

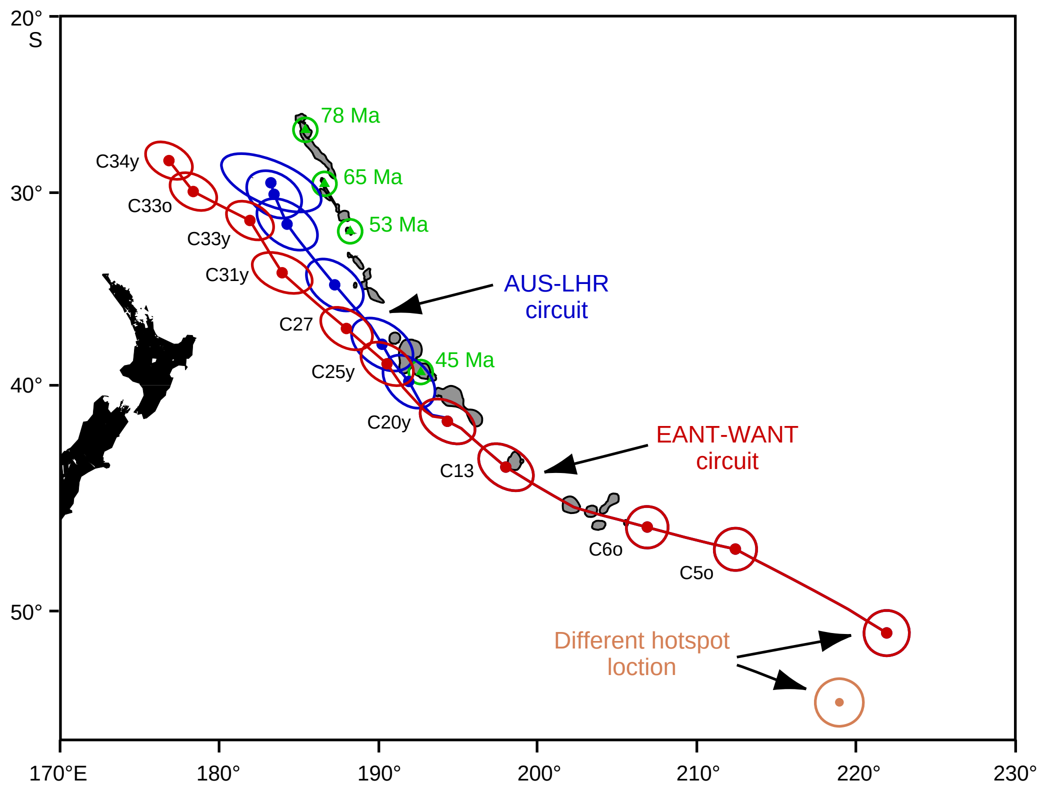


Figure F6. A. Alkalinity diagram from Le Bas (1986) showing a total absence of tholeiitic rocks in the current sample suites for the Louisville Seamount Trail. **B.** Correlation plot for Nd and Pb isotopes showing the remarkably homogeneous composition of Louisville samples spanning 80 m.y. Note the marked difference from the Ontong Java Plateau (OJP) basalts. Similarly homogeneous signatures are evident in the HFSE Zr/Y and Nb/Y trace element ratios (not shown). These diagrams include published data from Hawkins et al. (1987) and Cheng et al. (1987) as well as unpublished data from the AMAT02RR site survey cruise (Vanderkluysen et al., 2007). EM = enriched mantle, HIMU = "high µ" (high, time-integrated $^{238}U/^{204}Pb$ ratios).

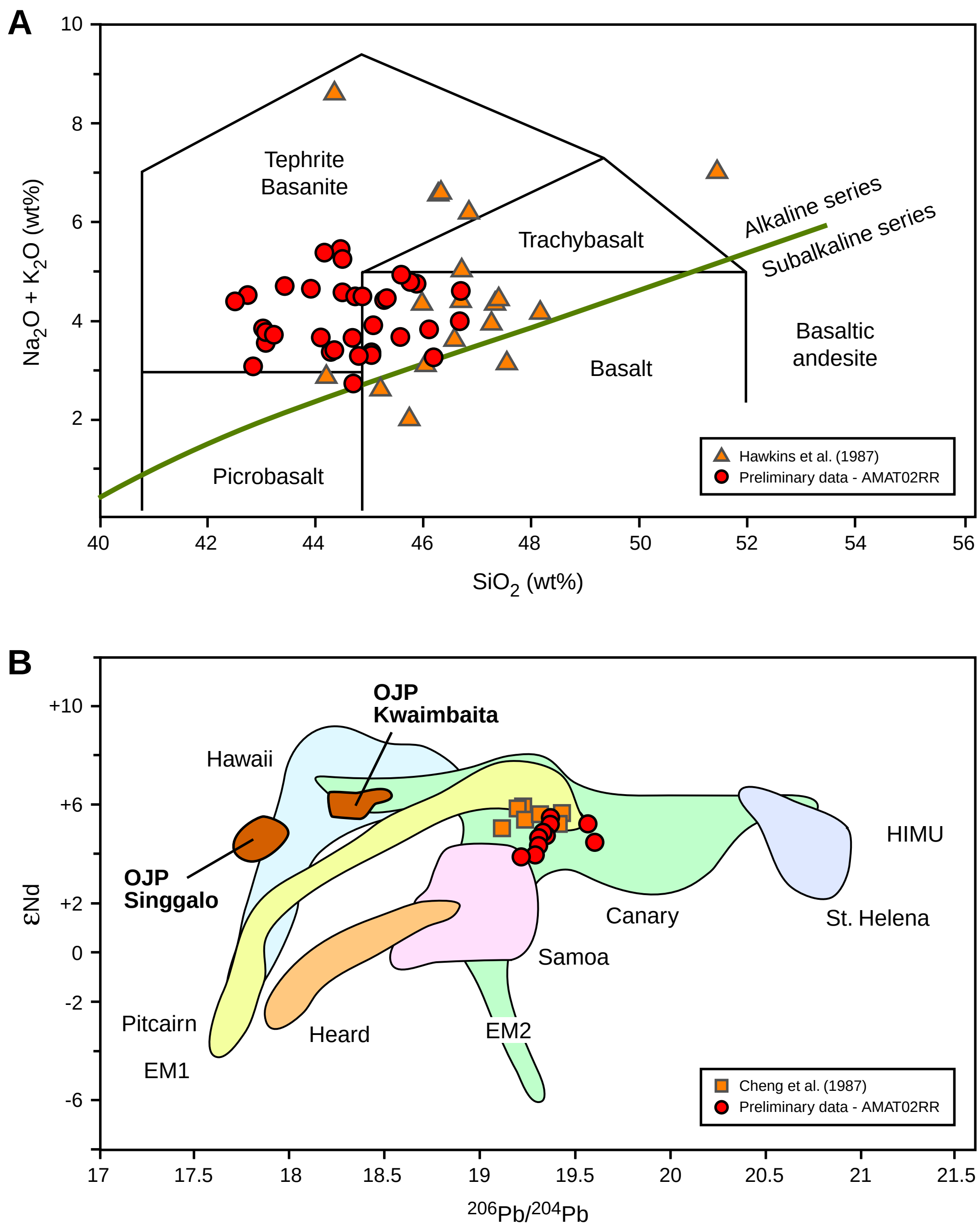
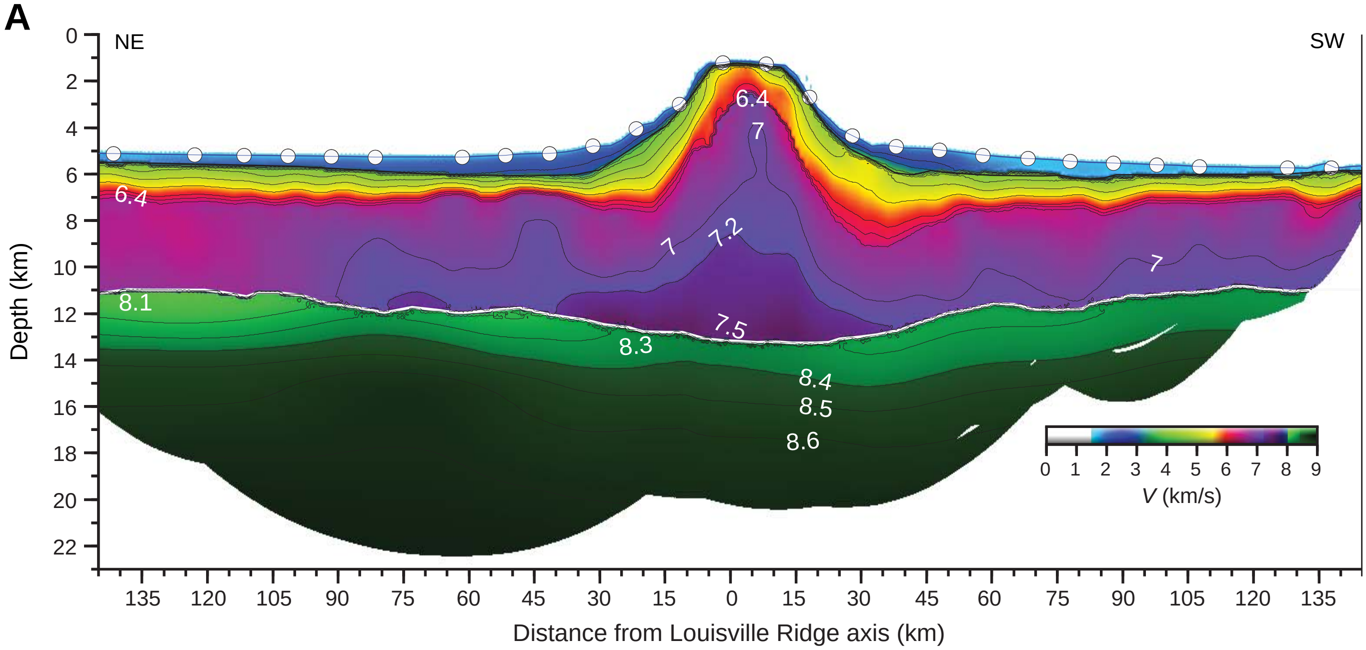


Figure F7. A. Velocity model obtained from topographic inversion of traveltimes from crustal and mantle phases along a single 370 km long seismic refraction line conducted orthogonally to the overall northwest trend of the Louisville Seamount Trail and crossing the summit of the 27.6°S guyot (~1.1° south of proposed Site LOUI-1C) during the German SO195 cruise (Grevemeyer and Flüh, 2008). **B.** Geologic interpretation revealing some internal seamount structures based on seismic velocity values: 1.5–4.0 km/s for volcaniclastic and mass wasting deposits; 7.2–7.6 km/s for intracrustal magma intrusion; 8.0 km/s for the upper mantle; 5.0–6.4 km/s for the extrusive volcano; and 6.4–7.0 km/s for the intrusive core. Assumed upper and lower crustal velocity ranges are 4.0–6.4 km/s and 6.4–7.2 km/s, respectively. The infill material is likely the volcaniclastic sequence directly underlying the pelagic cap that is thickening toward the edge of the guyot shelves, as seen on the AMAT02RR multichannel seismic reflection data. Both cross sections after Contreras-Reyes et al. (2010).

A



B

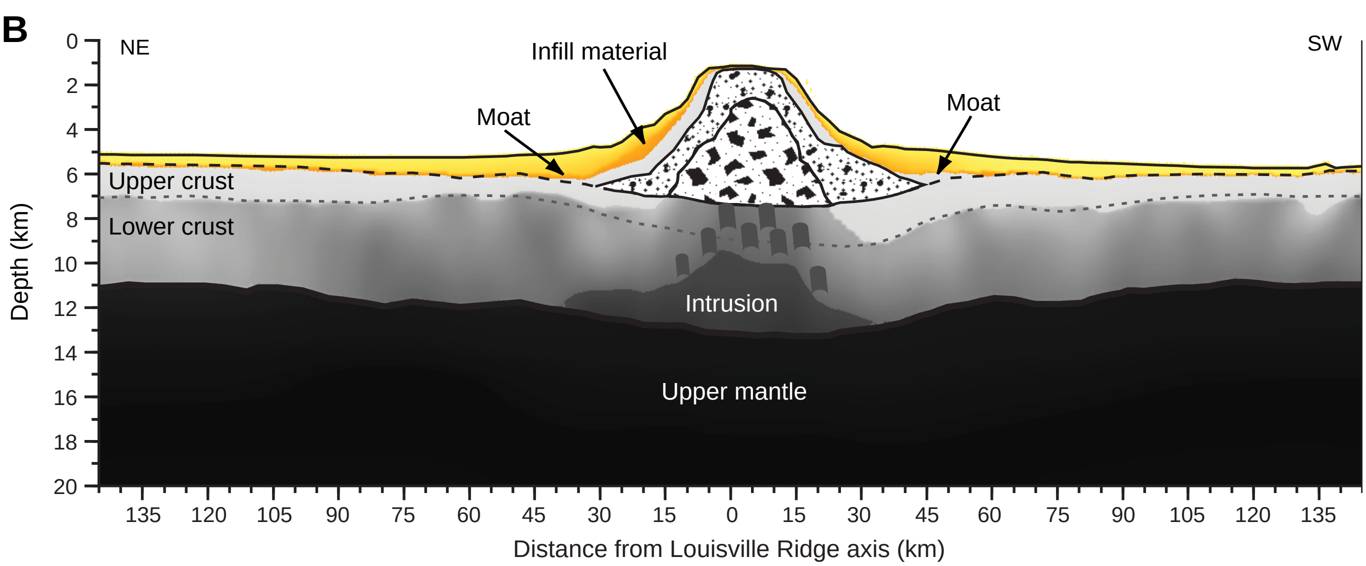


Figure F8. Paleosecular variation and paleolatitude uncertainties. **A.** Mean and 95% paleolatitude uncertainties as a function of the number of temporally independent flow groups sampled, as based on two recent paleosecular variation models. **B.** Number of independent flow groups from selected DSDP/ODP sites. Hawaii–Emperor data from DSDP Leg 55 (Kono, 1980) and ODP Legs 145 (Tarduno and Cottrell, 1997) and 197 (Tarduno et al., 2003). Total number of flow units, including volcaniclastic units, are provided for the Suiko and Detroit seamounts. Kerguelen-Ninetyeast Ridge data are from ODP Legs 120 (Inokuchi and Heider, 1992), 121 (Klootwijk et al., 1991), and 183 (Antretter et al., 2002). Pacific atoll/guyot data are from ODP Legs 143 (Tarduno and Sager, 1995) and 144 (Nakanishi and Gee, 1995). Ontong Java Plateau data are from ODP Legs 130 (Mayer and Tarduno, 1993) and 192 (Riisager et al., 2003). **C.** Paleolatitude uncertainties versus flow group numbers, based on the same references used in (B).

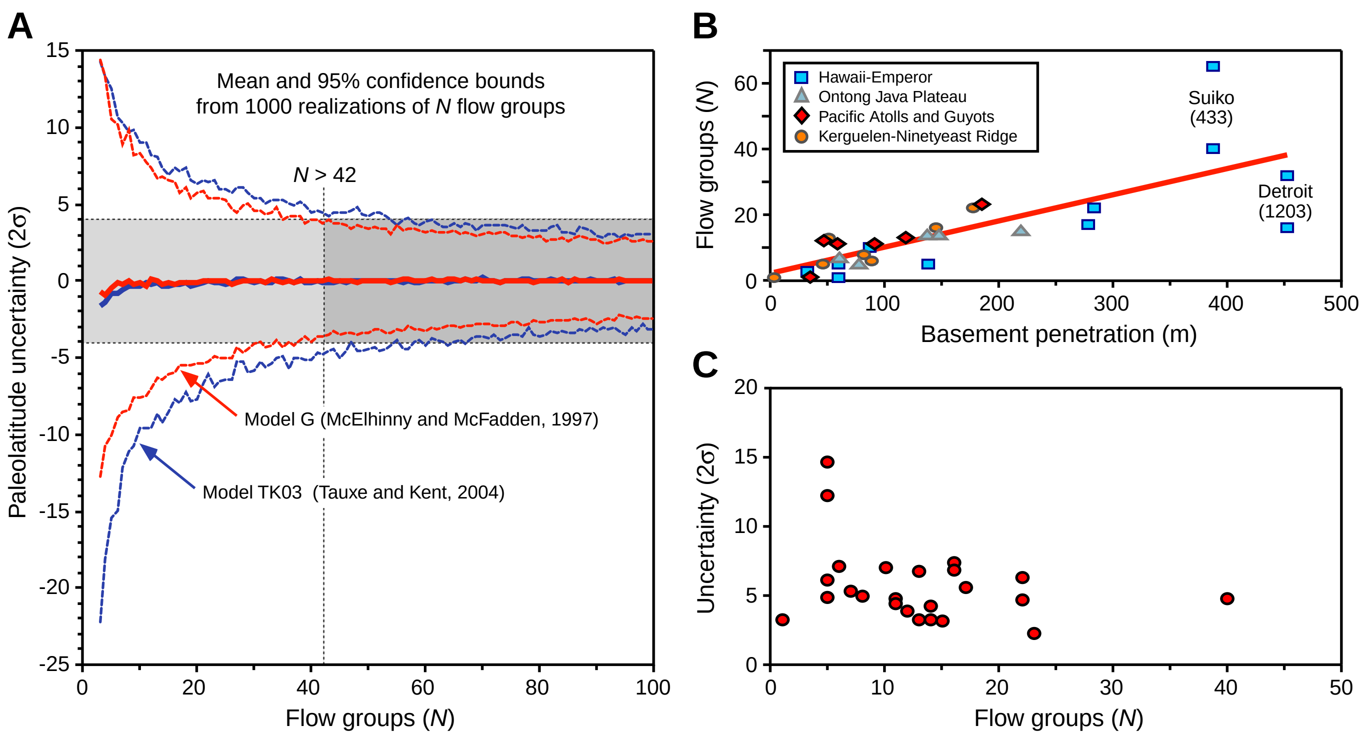


Figure F9. Magnetic anomaly pattern and paleopole positions for the seamount at 168.6°W. **A.** Magnetic anomaly pattern (red/blue scale) and topography (black lines = 500 m contours). Dashed green line = survey track. **B.** Paleopole positions (and 95% bounds [red]) derived from uniform magnetization component for misfits of 60–20 nT compared to Pacific poles from Sager and Pringle (1987) (black). LSQ = least squares solution. Note that the anomaly pattern is of quite low amplitude and relatively complex, possibly suggesting the presence of dual polarities (reversed polarity dominant).

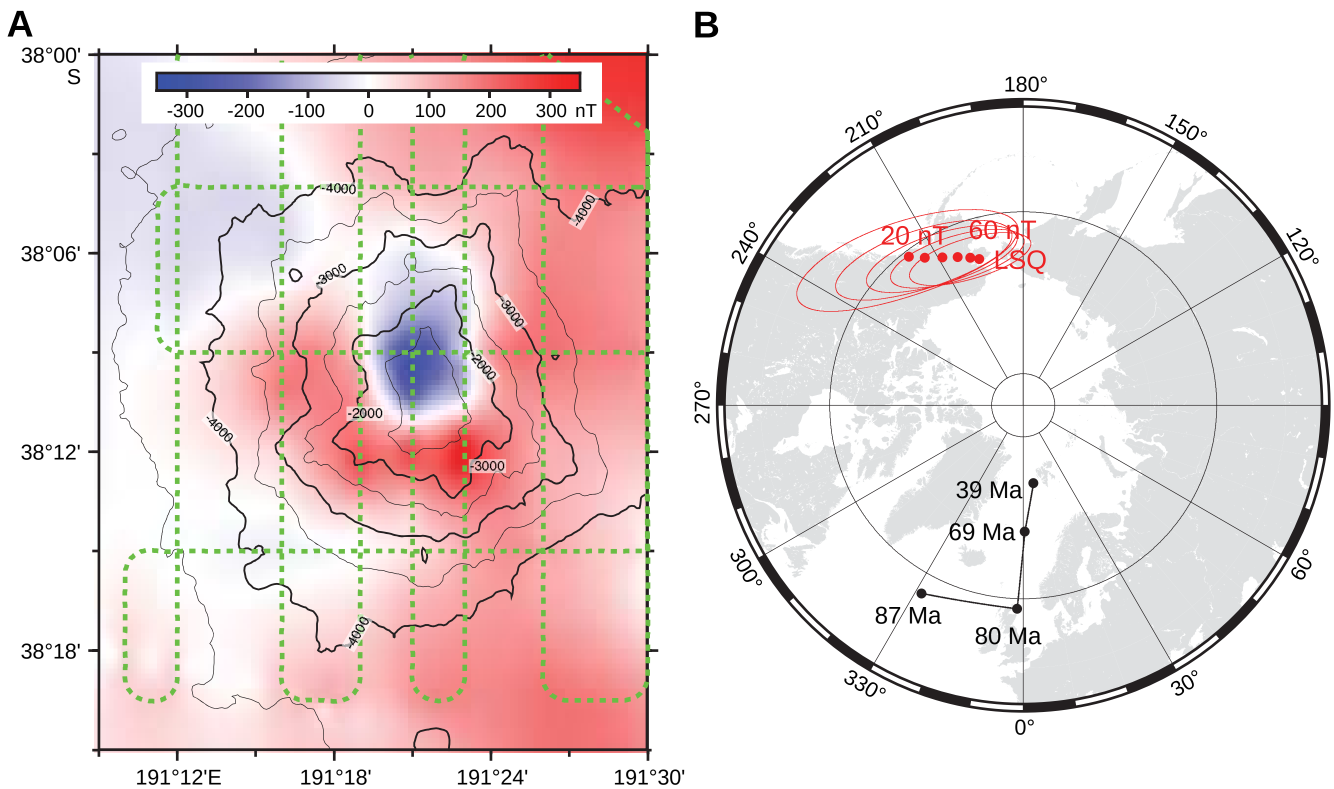
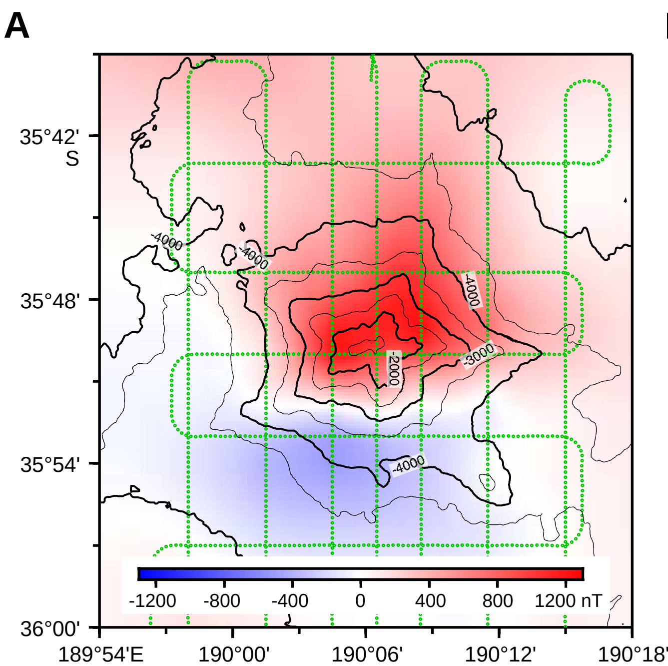


Figure F10. Magnetic anomaly pattern and paleopole positions for the seamount at 35.8°S. **A.** Relatively simple magnetic anomaly pattern (red/blue scale) and topography (black lines = 500 m contours). Dashed green line = survey track. **B.** Paleopole positions (and 95% bounds in red) derived from uniform magnetization component for misfits of 60–20 nT compared to Pacific poles from Sager and Pringle (1987) (black). LSQ = least squares solution.



Site summaries

Proposed Site LOUI-1C (Seamount 26.5°S - Detroit equivalent)

Priority:	Primary site
Position:	26°29.60′S, 174°43.75′W
Water depth (m):	1950
Target drilling depth (mbsf):	~405 (55 m sediment, ≥350 m basement)
Approved maximum penetration (mbsf):	Approval pending (420 m requested)
Survey coverage:	• AMAT02RR (Fig. **AF1**) • Line AMAT 26.5-2 (CDP 7270) (Fig. **AF2**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD. • FFF deployment and two bit changes (2 reentries). • Wireline logging (triple combo, FMS-sonic, magnetometer, and UBI).
Anticipated lithology (mbsf):	• 0–15: pelagic ooze • 15–55: lithified limestones, volcaniclastics, and minor lava flows(?) • >55: basalt (~75 m.y. old)
Site characterization:	The 26.5°S guyot shows <1° of tilting (in contrast to the older Osbourn Seamount to the north that approaches the Kermadec Trench) and has a simple (deeper) summit with less evidence of posterosional volcanism that contrarily characterizes the more southern 26.6°S guyot. Site LOUI-1C is also characterized by a thinner section (~40 m) of supposed volcaniclastics (which thicken toward the margins). Sidescan and 3.5 kHz data indicate this site is covered with 5–15 m of pelagic sediment or winnowed sand. Although it is not located at a crossing point of two seismic lines, Site LOUI-1C is proposed as a primary drill site because it is placed farther away from a possible posterosional cone (in contrast to Site LOUI-1B). Site LOUI-1C is located ~1.8 km south of Site LOUI-1B on seismic Line 26.5-2, which is nearer the seamount margin and in the middle of a large low-reflectivity sediment patch.

Site summaries (continued)

Proposed Site LOUI-1B (Seamount 26.5°S - Detroit equivalent)

Priority:	Alternate site
Position:	26°28.66′S, 174°43.46′W
Water depth (m):	1840
Target drilling depth (mbsf):	~400 (50 m sediment, ≥350 m basement)
Approved maximum penetration (mbsf):	420 (350 m basement, additional basement penetration needs to be reviewed by the operator during drilling operations)
Survey coverage:	• AMAT02RR (Fig. **AF1**) • Line AMAT 26.5-2 (CDP 7201) (Fig. **AF2**) • Line AMAT 26.5-3 (CDP 8162) (Fig. **AF3**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD • FFF deployment and two bit changes (2 reentries) • Wireline logging (triple combo, FMS-sonic, magnetometer, and UBI).
Anticipated lithology (mbsf):	• 0–10: pelagic ooze • 10–50: lithified limestones, volcaniclastics, and minor lava flows(?) • >50: basalt (~75 m.y. old)
Site characterization:	The 26.5°S guyot shows <1° of tilting (in contrast to the older Osbourn Seamount to the north that approaches the Kermadec Trench) and has a simple (deeper) summit with less evidence of posterosional volcanism that contrarily characterizes the more southern 26.6°S guyot. Site LOUI-1B is also characterized by a thinner section (~40 m) of supposed volcaniclastics (which thicken toward the margins). Sidescan and 3.5 kHz data indicate this site is covered with 5–10 m of pelagic sediment or winnowed sand. Nonetheless, this drill site is a bit too central (and near a possible posterosional cone) to be ideal. A better drill target would be 1–2 km farther south along line 26.5-2 (proposed primary Site LOUI-1C), which is nearer the seamount margin and in the middle of a large low-reflectivity sediment patch.

Site summaries (continued)

Proposed Site LOUI-2B (Seamount 33.7°S - Suiko equivalent)

Priority:	Primary site
Position:	33°41.90′S, 171°26.94′W
Water depth (m):	1259
Target drilling depth (mbsf):	~410 (59 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	420 (350 m basement; additional basement penetration must be reviewed by the operator during drilling operations)
Survey coverage:	• AMAT02RR (Fig. **AF4**) • Line AMAT 32.33-12 (CDP 45442) (Fig. **AF5**) • Line AMAT 32.33-13 (CDP 46611) (Fig. **AF6**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD. • FFF deployment and two bit changes (two reentries). • Wireline logging (triple combo, FMS-sonic, and magnetometer).
Anticipated lithology (mbsf):	• 0–15: pelagic ooze • 15–59: lithified limestones, volcaniclastics, and minor lava flows(?) • >59: basalt (~60 m.y. old)
Site characterization:	A preliminary $^{40}Ar/^{39}Ar$ age of 58.5 Ma, based on replicated plagioclase analyses of SO167 sample 154/2, makes this seamount approximately equivalent to the 61 Ma Suiko Seamount in the Emperor Seamount Trail. This relatively small edifice has a smooth pelagic cap between 10 and 15 m thick, based on 3.5 kHz CHIRP data. Also, it is void of any clear posterosional peaks beneath the thin sedimentary sequences. Site LOUI-2B is close to the center of the volcanic structure where a presumed intercalated sequence of volcaniclastic and lava flows is thinnest (~45 m).

Site summaries (continued)

Proposed Site LOUI-3B (Seamount 36.9°S - Nintoku equivalent)

Priority:	Primary site
Position:	36°54.26′S, 169°47.91′W
Water depth (m):	982
Target drilling depth (mbsf):	~415 (65 m sediment; ≥330 m basement)
Approved maximum penetration (mbsf):	420 (350 m basement; additional basement penetration must be reviewed by the operator during drilling operations)
Survey coverage:	• AMAT02RR (Fig. **AF7**) • Line AMAT 36.9-1 (CDP 19406) (Fig. **AF8**) • Line AMAT 36.9-2 (CDP 20564) (Fig. **AF9**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD • FFF deployment and one bit change (one reentry). Only one bit change is planned at this site because of time constraints. • Wireline logging (triple combo, FMS-sonic, and magnetometer).
Anticipated lithology (mbsf):	• 0–10: pelagic ooze • 10–65: lithified limestones, volcaniclastics, and minor lava flows(?) • >65: basalt (~54 m.y. old)
Site characterization:	Site LOUI-3B is placed toward the center of the 36.9°S guyot and away from a thick seaward-dipping sequence of volcaniclastics. Posterosional volcanism was not identified on this seamount based on bathymetry and seismic data. Seamount 35.8°S (located 1.1° south) has a magnetic anomaly pattern that yields a paleopole of ~49° ± 7°S, indicative of indiscernible hotspot motion since 59 Ma, and may serve as a direct comparison to drilling results at Site LOUI-3B (Fig. **F10**). Multichannel seismic reflection profiles show a relatively thin pelagic cap at Site LOUI-3B (compared to other places on this guyot platform) that is estimated to be ~10 m thick based on 3.5 kHz CHIRP data.

Site summaries (continued)

Proposed Site LOUI-8A (Seamount 36.9°S - Nintoku equivalent)

Priority:	Alternate site
Position:	36°56.51′S, 169°46.90′W
Water depth (m):	970
Target drilling depth (mbsf):	~470 (120 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	420 (a request for 470 m total penetration depth is pending). 350 m of basement penetration is approved; additional basement penetration must be reviewed by the operator during drilling operations.
Survey coverage:	• AMAT02RR (Fig. AF7) • Line AMAT 36.9-1 (CDP 19234) (Fig. AF19) • Line AMAT 36.9-3 (CDP 22075) (Fig. AF20)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD. • FFF deployment and two bit changes (two reentries). • Wireline logging (triple combo, FMS-sonic, and magnetometer).
Anticipated lithology (mbsf):	• 0–40: pelagic ooze • 40–120: lithified limestones, volcaniclastics, and minor lava flows(?) • >120: basalt (~54 m.y. old)
Site characterization:	This alternate drilling site is located on the same seamount targeted for primary Site LOUI-3B on the 36.9°S guyot. Its interpolated age of 54 Ma is very close to the 56 Ma age of Nintoku Seamount in the Emperor Seamount Trail. The estimated pelagic cap is well layered and, at ~30–40 m thick, it is thicker than the cap at primary Site LOUI-3B based on 3.5 kHz CHIRP data (0.039 s two-way traveltime at 1.6–1.9 km/s). The intercalated sequence of volcaniclastics and lava flows is estimated to be at least 55–80 m thick (0.045 s two-way traveltime at 2.5–3.5 km/s in volcaniclastic sediment).

Site summaries (continued)

Proposed Site LOUI-8B (Seamount 36.9°S - Nintoku equivalent)

Priority:	Alternate site
Position:	36°56.64′S, 169°45.76′W
Water depth (m):	960
Target drilling depth (mbsf):	Hole A: APC core to ~55 (50 m pelagic sediment) Hole B: RCB core to ~480 (130 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	Approval pending (480 m requested)
Survey coverage:	• AMAT02RR (Fig. AF7) • Line AMAT 36.9-3 (CDP 22010) (Fig. AF20)
Objective: (see text for details)	Hole A: Core thin sediment cover with APC to contribute to southern hemisphere paleoclimate record. Hole B: (1) Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. (2) Study the geochemical evolution of this guyot.

Drilling, coring, and downhole measurement program:	• Hole A:
	  • APC coring to TD.
	• Hole B:
	  • RCB coring to TD.
	  • FFF deployment and two bit changes (two reentries).
	  • Wireline logging (triple combo, FMS-sonic, and magnetometer).

Anticipated lithology (mbsf):	• 0–50: pelagic ooze • 50–130: lithified limestones, volcaniclastics, and minor lava flows(?) • >130: basalt (~54 m.y. old)
Site characterization:	This alternate drilling site is located on the same seamount targeted for Sites LOUI-3B and LOUI-8A on the 36.9°S guyot. Its interpolated age of 54 Ma is very close to the 56 Ma age of Nintoku Seamount in the Emperor Seamount Trail. Its estimated pelagic cap is well layered and, at ~50 m thick, is thicker than the cap at Site LOUI-3B and slightly thicker than the cap at Site LOUI-8A based on 3.5 kHz CHIRP data. This site has the thickest sediment cover of all Louisville sites and is proposed as a possible site for contingency APC coring. In addition, a potential B Hole could serve as an additional alternate site for primary Site LOUI-3B.

Site summaries (continued)

Proposed Site LOUI-4B (Seamount 168.6°W - Koko equivalent)

Priority:	Primary site
Position:	38°10.98′S, 168°38.26′W
Water depth (m):	1248
Target drilling depth (mbsf):	~410 (60 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	420 (350 m basement; additional basement penetration must be reviewed by the operator during drilling operations)
Survey coverage:	• AMAT02RR (Fig. **AF10**) • Line AMAT 168.6-0 (CDP 22417) (Fig. **AF11**) • Line AMAT 168.6-1 (CDP 23158) (Fig. **AF12**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD • FFF deployment and two bit changes (two reentries). • Wireline logging (triple combo, FMS-sonic, and magnetometer).
Anticipated lithology (mbsf):	• 0–8: pelagic ooze • 8–60: lithified limestones, volcaniclastics, and minor lava flows(?) • >60: basalt (~50 m.y. old)
Site characterization:	Dredge sample AMAT10D2 yielded a preliminary age of 50.1 ± 0.4 Ma, making this seamount very similar in age to Koko Seamount (49 Ma) in the Emperor Seamount Trail. Only a small 8 m thick patch of pelagic sediment cap is calculated at the location of this proposed drill site. Also, the presumed volcaniclastic sequence underneath the pelagic cap is relatively thin (~52 m) on this seamount. A detailed magnetic survey of this small guyot during the AMAT02RR cruise yielded an unreasonable paleopole position (Fig. **F9**), but the complexity of the anomaly pattern suggests dual polarities, which (if sampled) could provide a more robust paleolatitude estimate.

Site summaries (continued)

Proposed Site LOUI-6A (Seamount 28.6°S - Detroit equivalent)

Priority:	Alternate site
Position:	28°33.93′S, 173°16.78′W
Water depth (m):	1480
Target drilling depth (mbsf):	~470 (120 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	470 (350 m basement; additional basement penetration must be reviewed by the operator during drilling operations)
Survey coverage:	• AMAT02RR (Fig. **AF13**) • Line AMAT 28.6-3 (CDP 25887) (Fig. **AF14**) • Line AMAT 28.6-4 (CDP 26684) (Fig. **AF15**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD. • FFF deployment and two bit changes (two reentries). • Wireline logging (triple combo, FMS-sonic, magnetometer, and possibly UBI).
Anticipated lithology (mbsf):	• 0–10: pelagic ooze • 10–120: lithified limestones, volcaniclastics, and minor lava flows(?) • >120: basalt (~72 m.y. old)
Site characterization:	This alternate drill site for primary proposed Site LOUI-1C is located ~2.1° south of Sites LOUI-1C and LOUI-1B on the 26.5°S guyot, which gives an interpolated age of ~72–73 Ma that is distinctly younger than the Detroit Seamount (76–81 Ma) in the Emperor Seamount Trail. A pelagic cap is present but is not >10 m thick based on 3.5 kHz CHIRP data. The sequence of volcaniclastics and lava flows is estimated to be at least 70–110 m thick (0.055–0.060 s two-way traveltime at 2.5–3.5 km/s in volcaniclastic sediment), but there only is evidence for minimal posterosional volcanism.

Site summaries (continued)

Proposed Site LOUI-7A (Seamount 32.3°S [Burton Seamount] - Suiko equivalent)

Priority:	Alternate site
Position:	32°12.99′S, 171°52.84′W
Water depth (m):	1550
Target drilling depth (mbsf):	~470 (120 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	470 (350 m basement; additional basement penetration must be reviewed by the operator during drilling operations)
Survey coverage:	• AMAT02RR (Fig. **AF16**) • Line AMAT 32.33-1 (CDP 36334) (Fig. **AF17**) • Line AMAT 32.33-2 (CDP 36827) (Fig. **AF18**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD. • FFF deployment and two bit changes (two reentries). • Wireline logging (triple combo, FMS-sonic, and magnetometer).
Anticipated lithology (mbsf):	• 0–10: pelagic ooze • 10–120: lithified limestones, volcaniclastics, and minor lava flows(?) • >120: basalt (~64 m.y. old)
Site characterization:	This alternate drilling site is located on a small guyot ~1.4° north of proposed primary Site LOUI-2B on the 33.7°S guyot, which gives this site an interpolated age of ~64–65 Ma, older than the Suiko Seamount (61 Ma) in the Emperor Seamount Trail. Three other seamounts also have crossing seismic lines; however, the 32.3°S guyot has the thinnest sequence of volcaniclastics. The estimated pelagic cap is ~10 m thick, with an intercalated sequence of volcaniclastics and lava flows estimated to be at least 70–110 m thick (0.055–0.060 s two-way traveltime at 2.5–3.5 km/s in volcaniclastic sediment). This guyot has a reflective summit (possibly due to a manganese pavement) and some small-scale roughness (5–20 m high peaks) that may be posterosional in origin or an erosional remnant (close-spaced small guyots like these can be submerged quickly before planation is complete, particularly if they end up in the flexural moat of the next-youngest volcano to load the lithosphere). Accordingly, a better drill target is 1–2 km to the southwest along seismic Line 32.33-2 (e.g., alternate Site LOUI-7B), which is farther away from some of these minor posterosional peaks or erosional remnants.

Site summaries (continued)

Proposed Site LOUI-7B (Seamount 32.3°S [Burton Seamount] - Suiko equivalent)

Priority:	Alternate site
Position:	32°13.44′S, 171°53.87′W
Water depth (m):	1560
Target drilling depth (mbsf):	~470 (120 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	Approval pending (470 m requested)
Survey coverage:	• AMAT02RR (Fig. AF16) • Line AMAT 32.33-2 (CDP 36889) (Fig. AF18)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD. • FFF deployment and two bit changes (two reentries). • Wireline logging (triple combo, FMS-sonic, and magnetometer).
Anticipated lithology (mbsf):	• 0–10: pelagic ooze • 10–120: lithified limestones, volcaniclastics, and minor lava flows(?) • >120: basalt (~64 m.y. old)
Site characterization:	This alternate drilling site is located on another small guyot ~1.4° north of proposed primary Site LOUI-2B on the 33.7°S guyot, which gives this site an interpolated age of ~64–65 Ma, older than the Suiko Seamount (61 Ma) in the Emperor Seamount Trail. Three other seamounts also have crossing seismic lines; however, the 32.3°S seamount has the thinnest sequence of volcaniclastics. The estimated pelagic cap is ~10 m thick, with an intercalated sequence of volcaniclastics and lava flows estimated to be at least 70–110 m thick (0.055–0.060 s two-way traveltime at 2.5–3.5 km/s in volcaniclastic sediment). This guyot has a reflective summit (possibly due to a manganese pavement) and some small-scale roughness (5–20 m high peaks) that may be posterosional in origin or an erosional remnant (close-spaced small guyots like these can be submerged quickly before planation is complete, particularly if they end up in the flexural moat of the next-youngest volcano to load the lithosphere). This alternate site is preferred to alternate Site LOUI-7A because it is located farther away from the posterosional peaks or erosional remnants to the northeast.

Site summaries (continued)

Proposed Site LOUI-9A (Seamount 168.3°W - Koko equivalent)

Priority:	Alternate site
Position:	37°59.72′S, 168°17.11′W
Water depth (m):	1150
Target drilling depth (mbsf):	~465 (115 m sediment; ≥350 m basement)
Approved maximum penetration (mbsf):	465 (350 m basement; additional basement penetration must be reviewed by the operator during drilling operations)
Survey coverage:	• AMAT02RR (Fig. **AF21**) • Line AMAT 168.3-1 (CDP 24118) (Fig. **AF22**) • Line AMAT 168.3-2 (CDP 25393) (Fig. **AF23**)
Objective: (see text for details)	1. Core thin sediment cover and igneous basement until enough igneous units suitable to acquire accurate paleolatitudes and $^{40}Ar/^{39}Ar$ ages are recovered. 2. Study the geochemical evolution of this guyot.
Drilling, coring, and downhole measurement program:	• RCB coring to TD. • FFF deployment and two bit changes (two reentries). • Wireline logging (triple combo, FMS-sonic, and magnetometer).
Anticipated lithology (mbsf):	• 0–10: pelagic ooze • 10–115: lithified limestones, volcaniclastics, and minor lava flows(?) • >115: basalt (~48 m.y. old)
Site characterization:	This alternate site is very close to and only 0.3° northeast of proposed primary Site LOUI-4B on the 168.6°W guyot. Three new $^{40}Ar/^{39}Ar$ ages (48.2 ± 0.3, 47.4 ± 0.5, and 50.4 ± 0.5 Ma) have been measured, and these are similar to the 49 Ma age of Koko Seamount in the Emperor Seamount Trail. The estimated pelagic cap is ~8–10 m thick over large summit areas based on 3.5 kHz CHIRP data (0.010 s two-way traveltime at 1.6–1.9 km/s). The intercalated sequence of volcaniclastics and lava flows is estimated to be at least 75–105 m thick (0.060 s two-way traveltime at 2.5–3.5 km/s), although the sequence at this site is less developed in the multichannel seismic reflection data.

Figure AF1. Bathymetric map of the 26.5°S guyot along with the location of primary Site LOUI-1C and alternate Site LOUI-1B and seismic profiles (blue lines with track number). Pink lines indicate location of dredge hauls. Contour intervals = 100 m. Source of bathymetric map: **earthref.org/SBN/.**

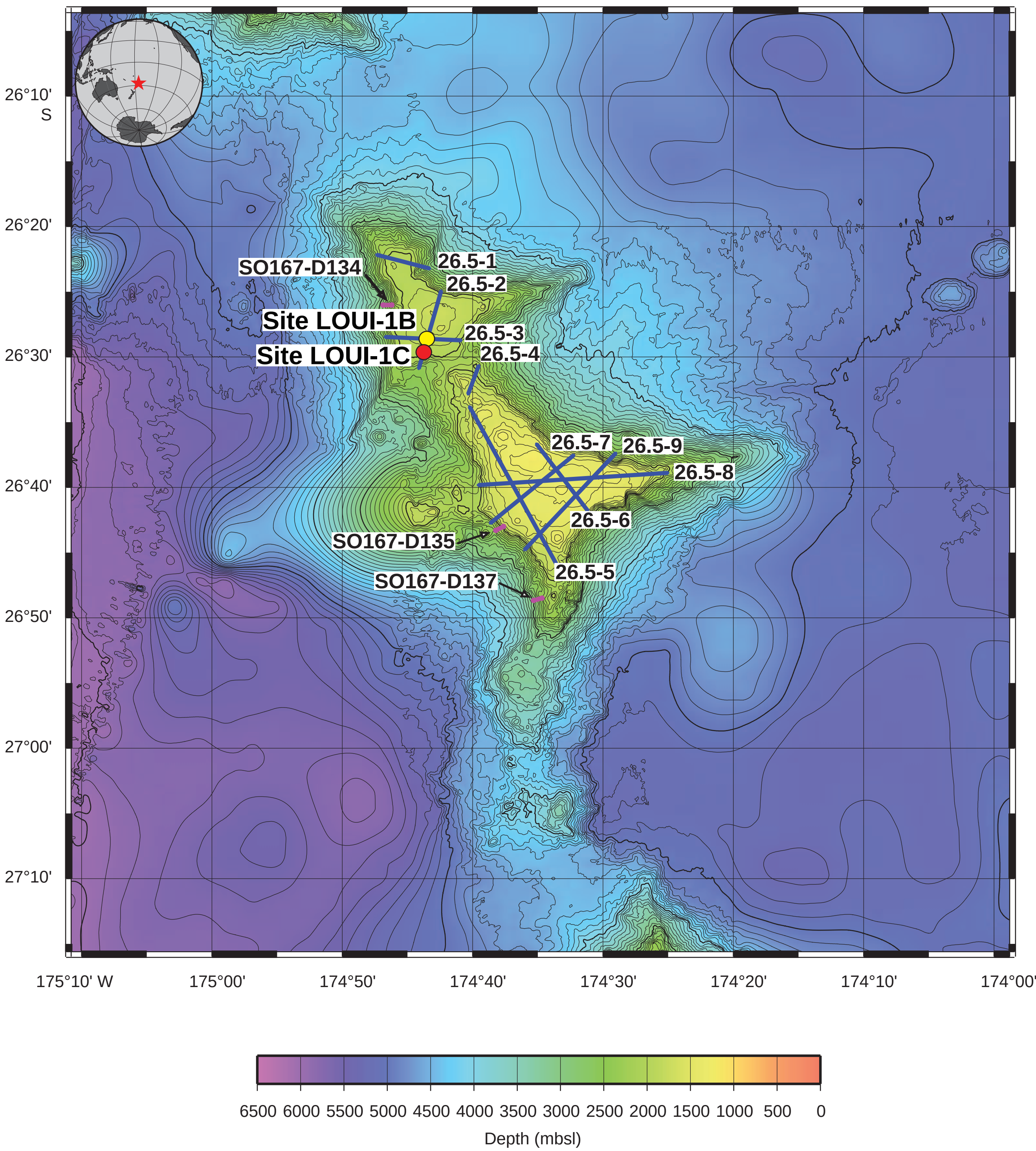


Figure AF2. Seismic Line 26.5-2 at proposed Sites LOUI-1B and LOUI-1C. Number in blue square indicates location of crossing Line 26.5-3 or absence of crossing line (A).

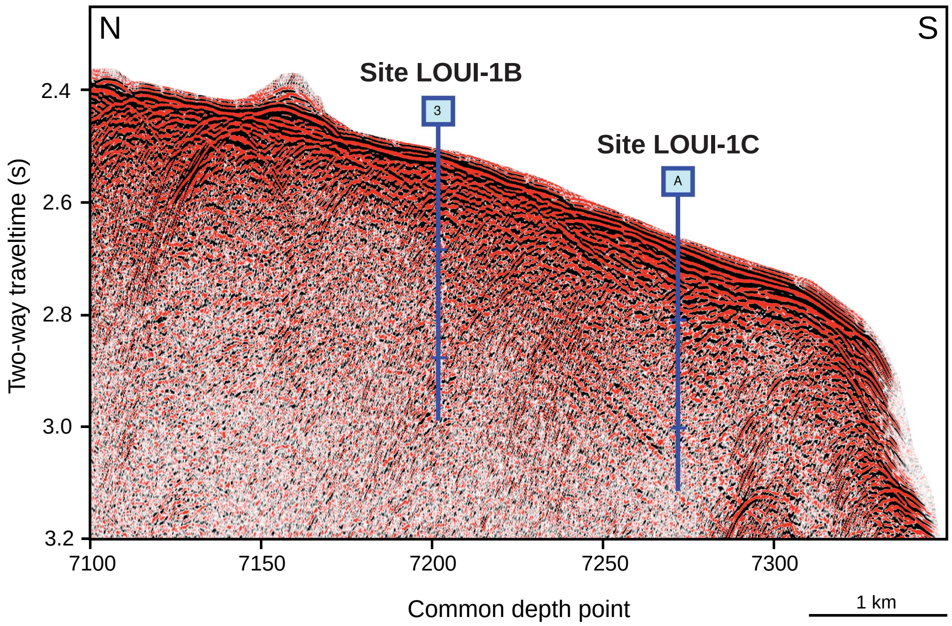


Figure AF3. Seismic Line 26.5-3 at proposed Site LOUI-1B. Number in blue square indicates location of crossing Line 26.5-2.

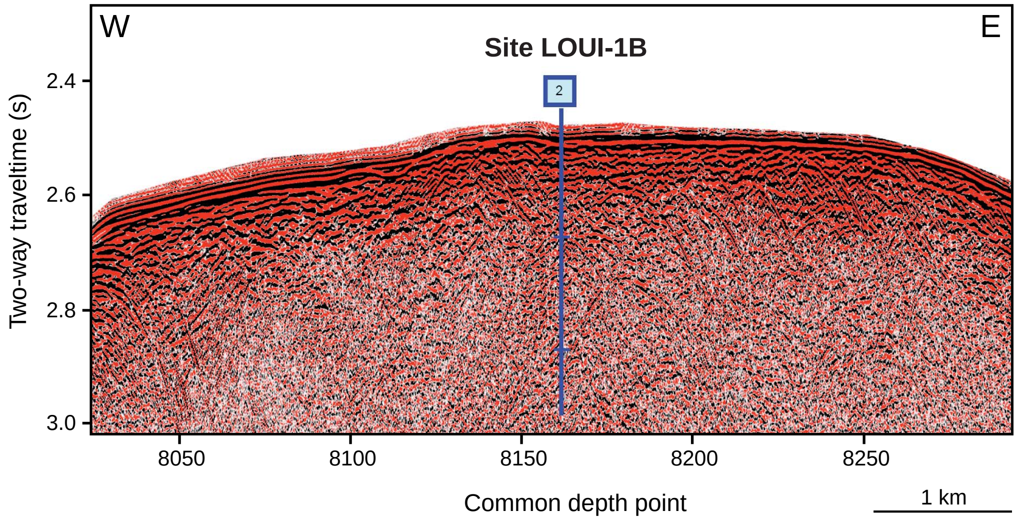


Figure AF4. Bathymetric map of the 33.7°S guyot along with the location of primary Site LOUI-2B and seismic profiles (blue lines with track number). Pink lines indicate location of dredge hauls. Contour intervals = 100 m. Source of bathymetric map: **earthref.org/SBN/.**

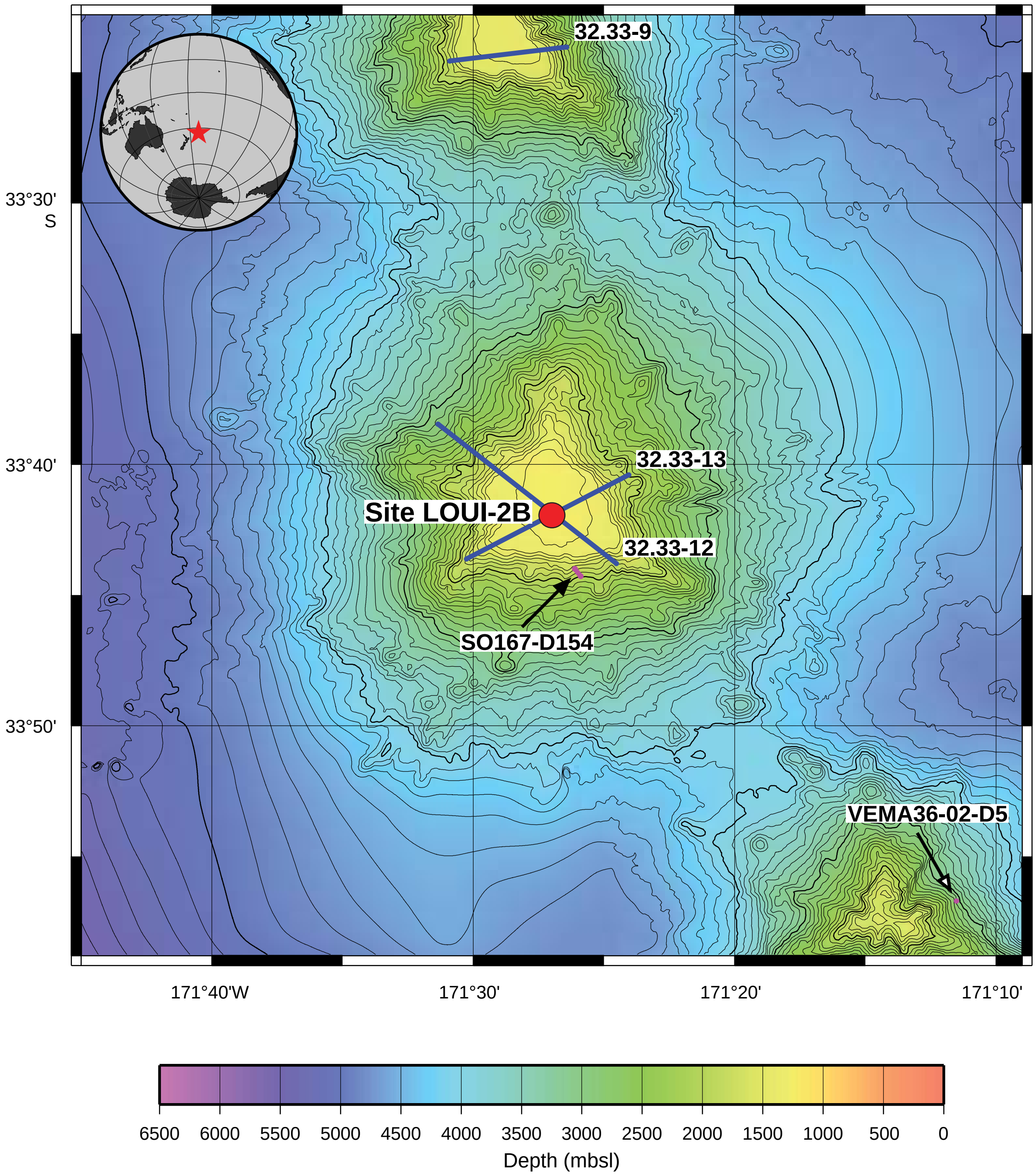


Figure AF5. Seismic Line 32.33-12 at proposed Site LOUI-2B. Number in blue square indicates location of crossing Line 32.33-13.

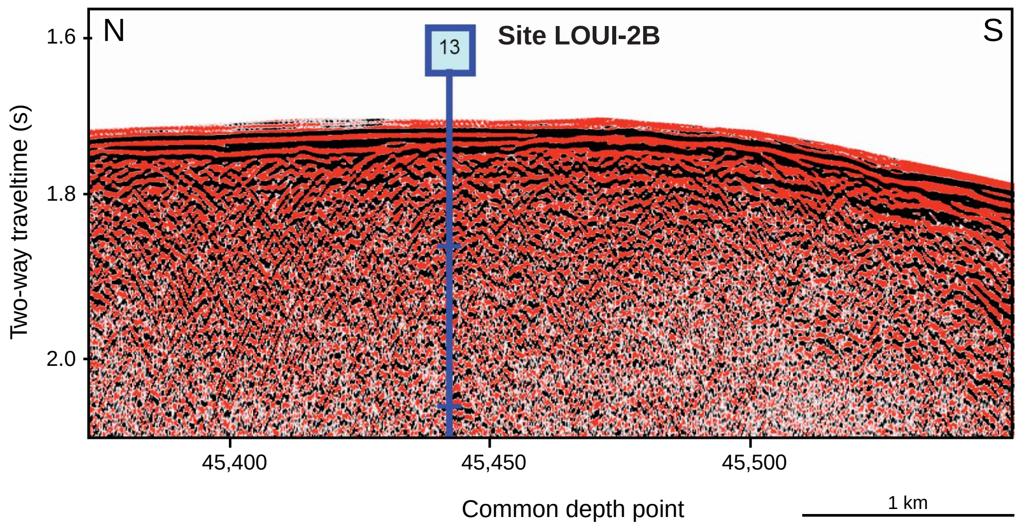


Figure AF6. Seismic Line 32.33-13 at proposed Site LOUI-2B. Number in blue square indicates location of crossing Line 32.33-12.

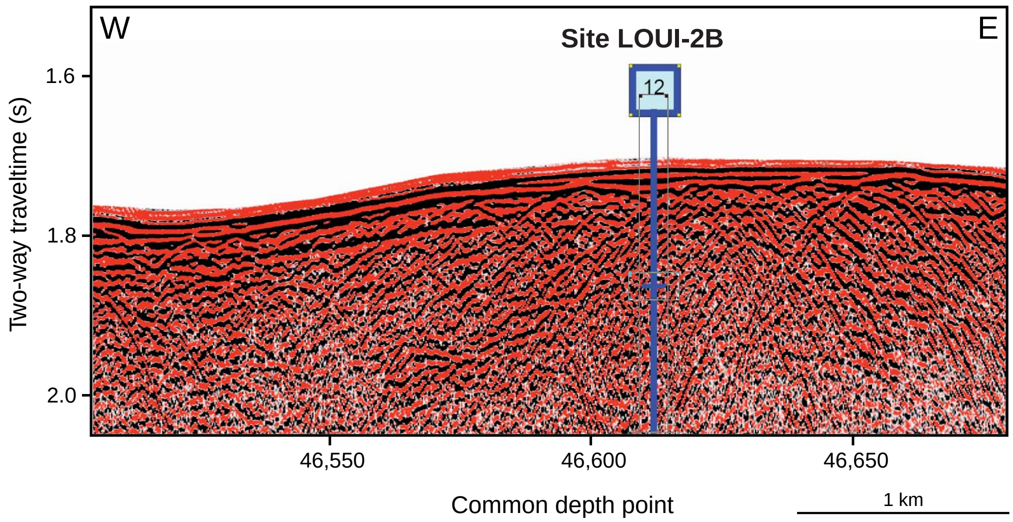


Figure AF7. Bathymetric map of the 36.9°S guyot along with the locations of primary Site LOUI-3B and alternate Sites LOUI-8A and LOUI-8B and seismic profiles (blue lines with track number). Pink lines indicate location of dredge hauls. Contour intervals = 100 m. Source of bathymetric map: earthref.org/SBN/.

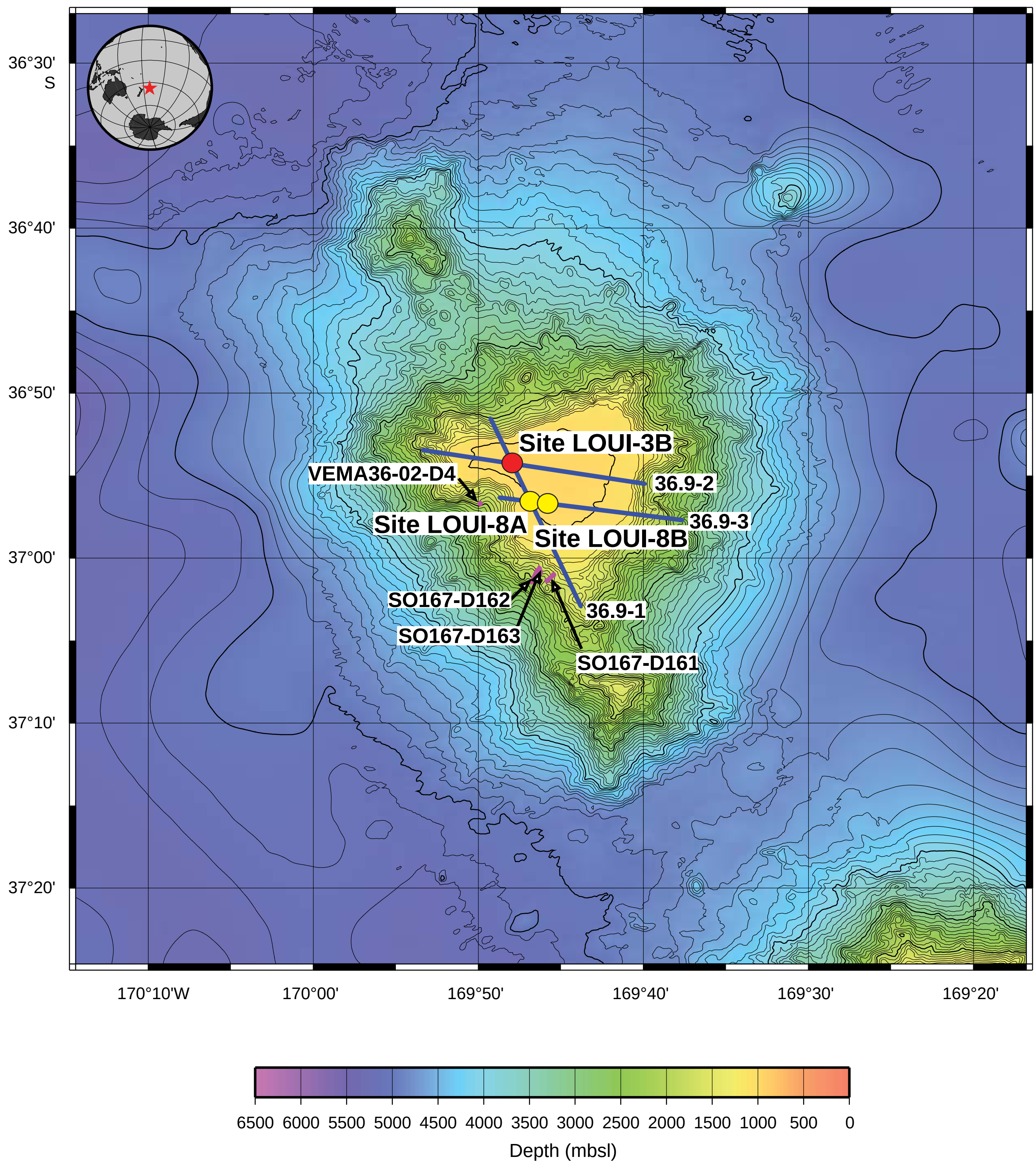


Figure AF8. Seismic Line 36.9-1 at proposed Site LOUI-3B. Number in blue square indicates location of crossing Line 36.9-2.

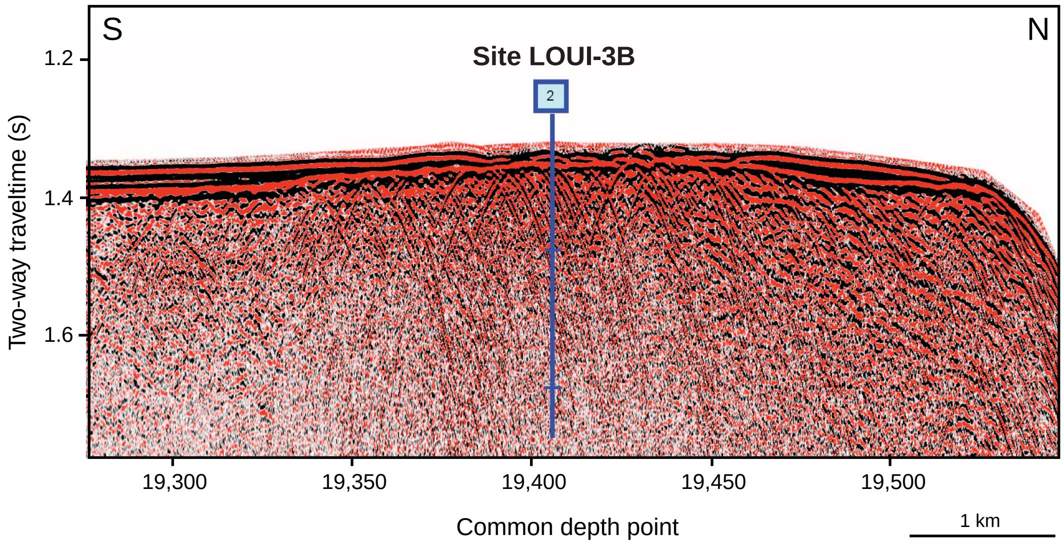


Figure AF9. Seismic Line 36.9-2 at proposed Site LOUI-3B. Number in blue square indicates location of crossing Line 36.9-1.

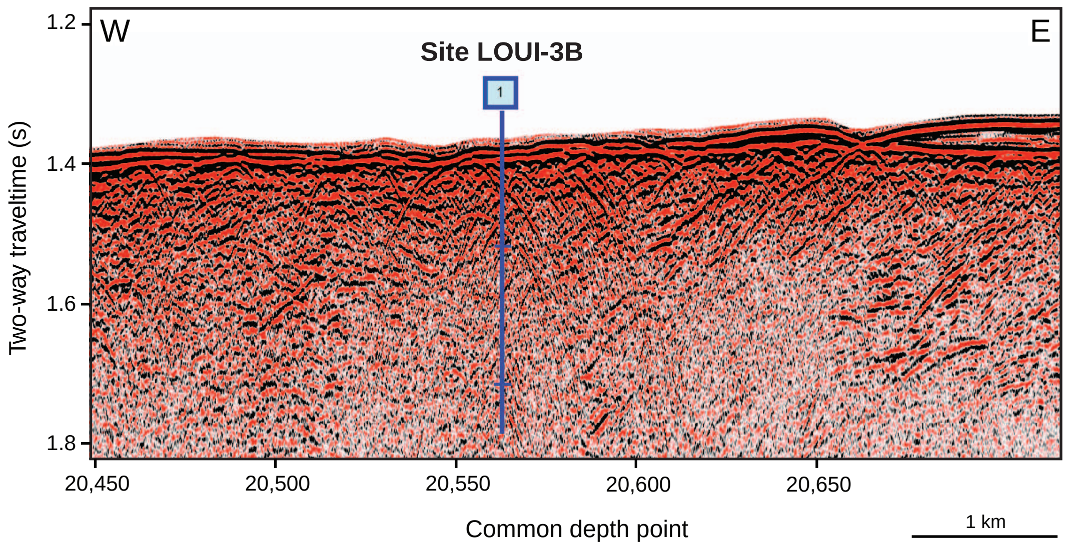


Figure AF10. Bathymetric map of the 168.6°S guyot along with the location of primary Site LOUI-4B and seismic profiles (blue lines with track number). Pink lines indicate location of dredge hauls. Contour intervals = 100 m. Source of bathymetric map: **earthref.org/SBN/.**

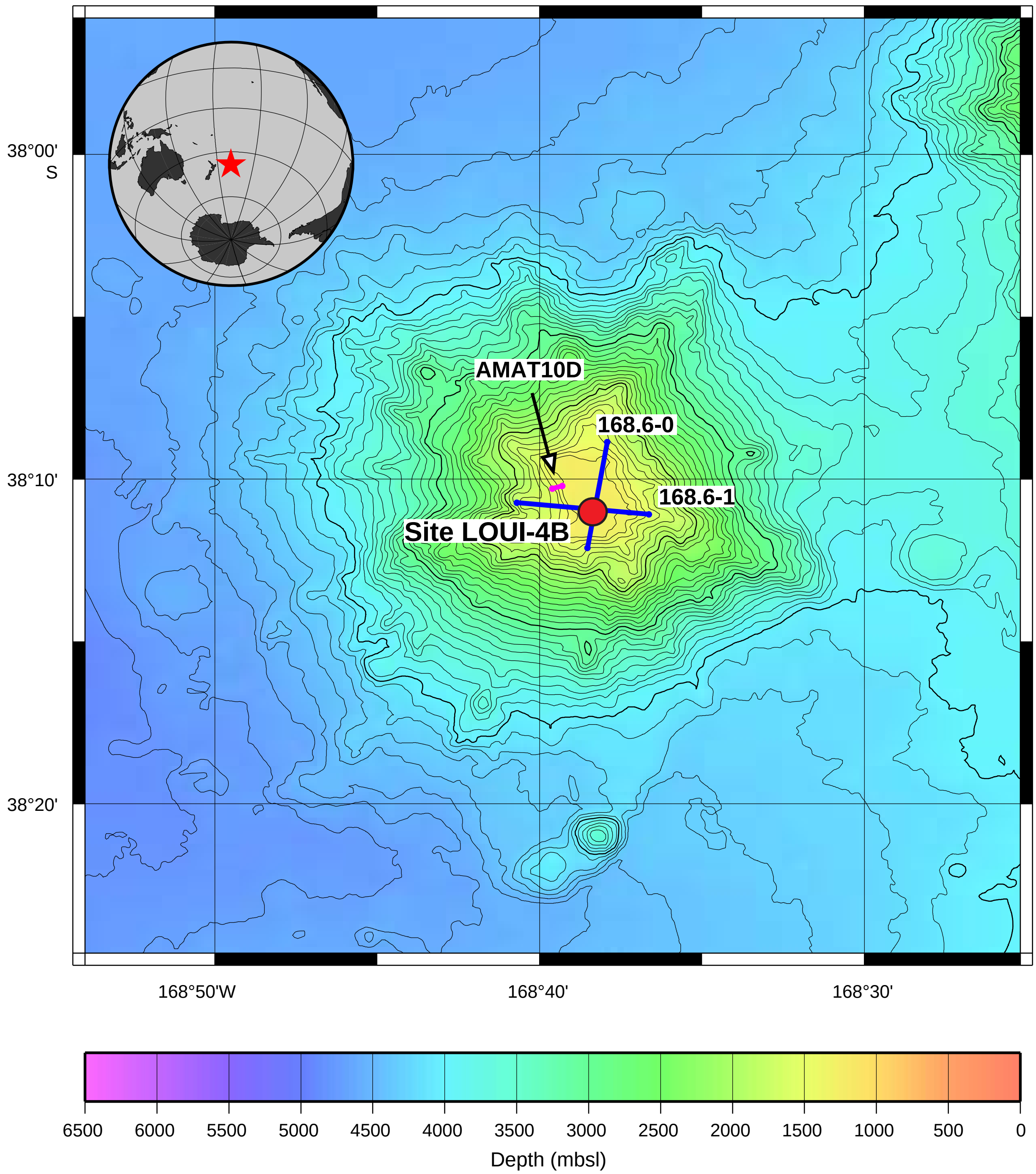


Figure AF11. Seismic Line 168.6-0 at proposed Site LOUI-4B. Number in blue square indicates location of crossing Line 168.6-1.

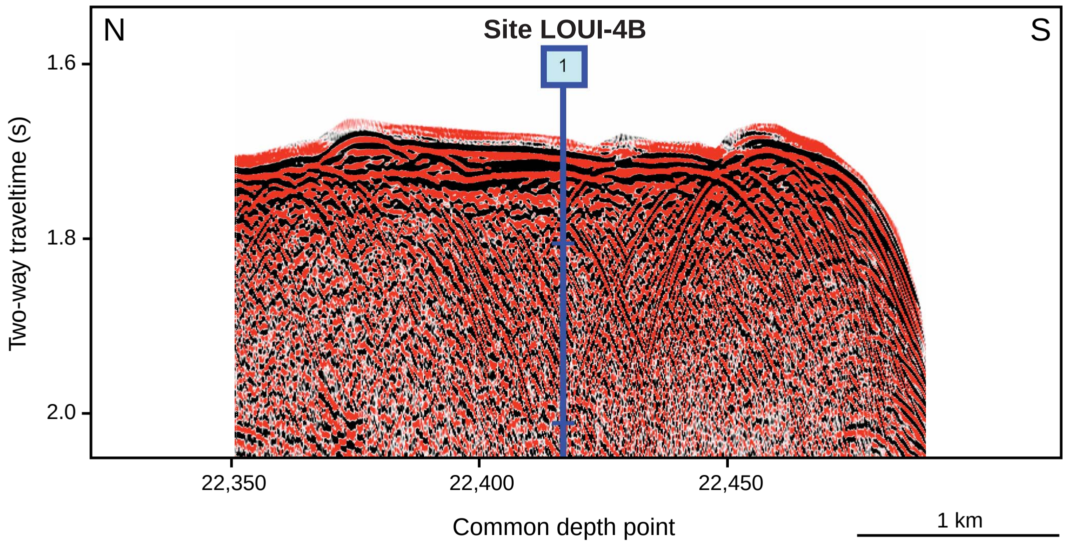


Figure AF12. Seismic Line 168.6-1 at proposed Site LOUI-4B. Number in blue square indicates location of crossing Line 168.6-0.

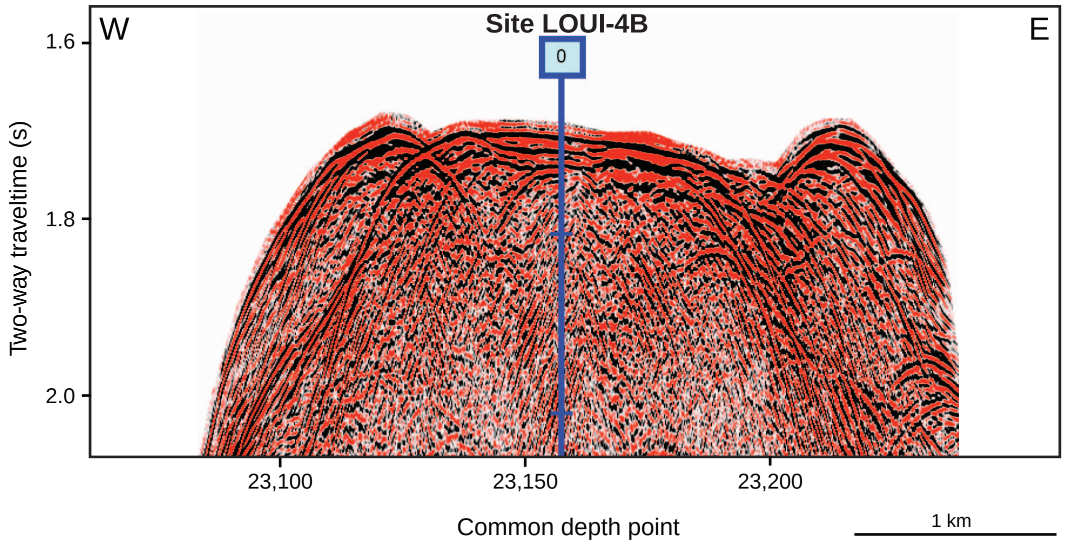


Figure AF13. Bathymetric map of the 28.6°S guyot along with the location of alternate Site LOUI-6A and seismic profiles (blue lines with track number). Pink lines indicate location of dredge hauls. Contour intervals = 100 m. Source of bathymetric map: **earthref.org/SBN/.**

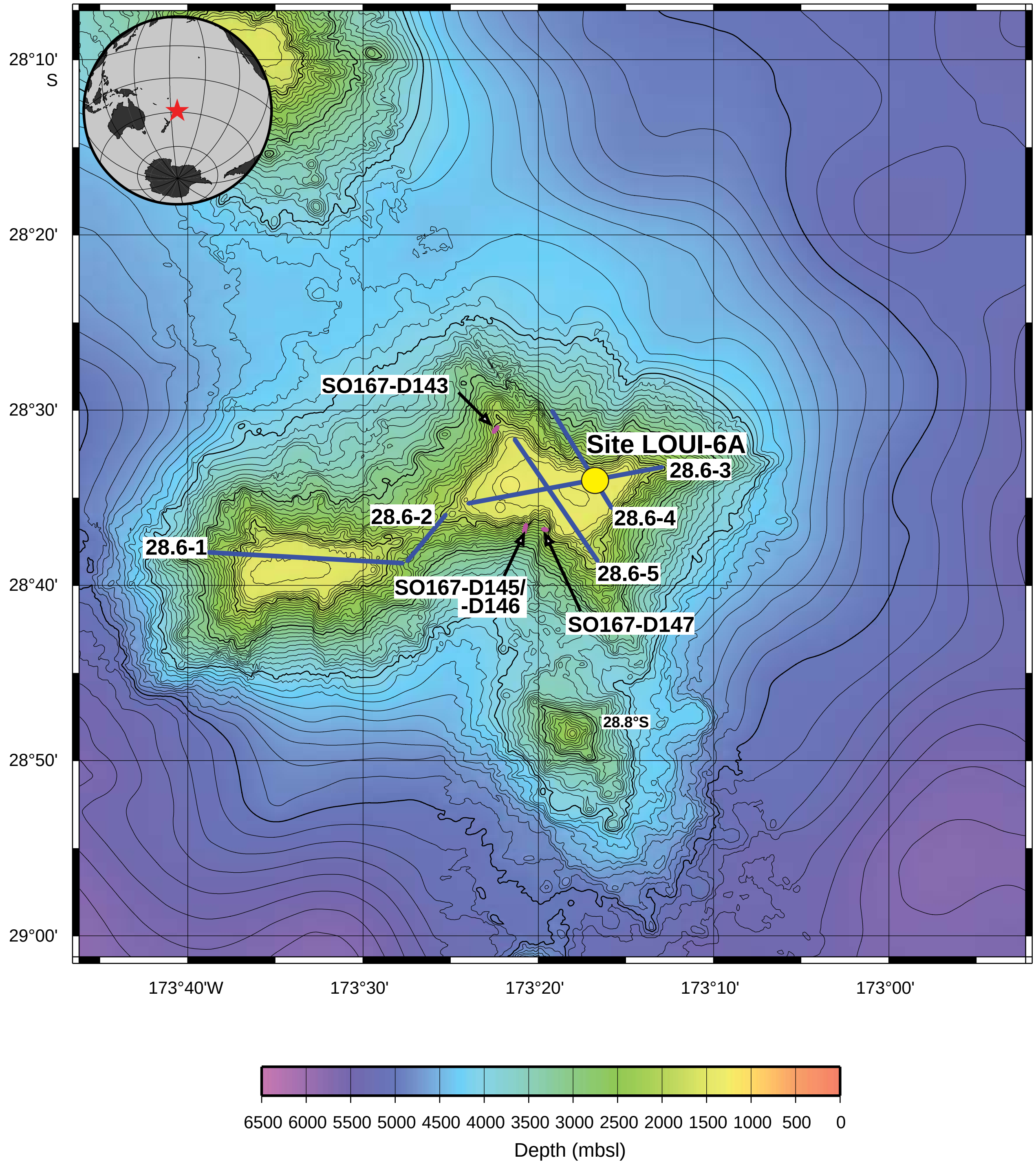


Figure AF14. Seismic Line 28.6-3 at proposed Site LOUI-6A. Number in blue squares indicates location of crossing Lines 28.6-4 and 28.6-5 (not shown).

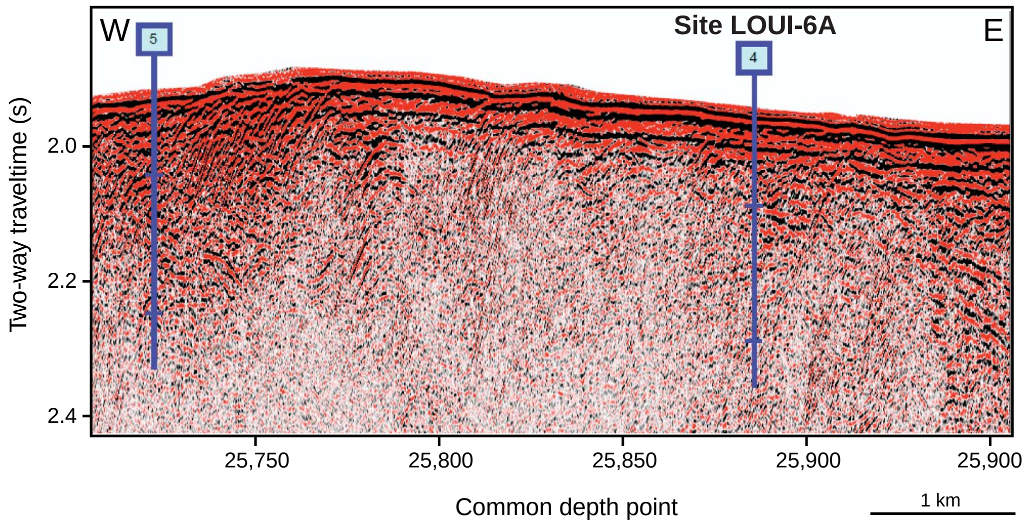


Figure AF15. Seismic Line 28.6-4 at proposed Site LOUI-6A. Number in blue square indicates location of crossing Line 28.6-3.

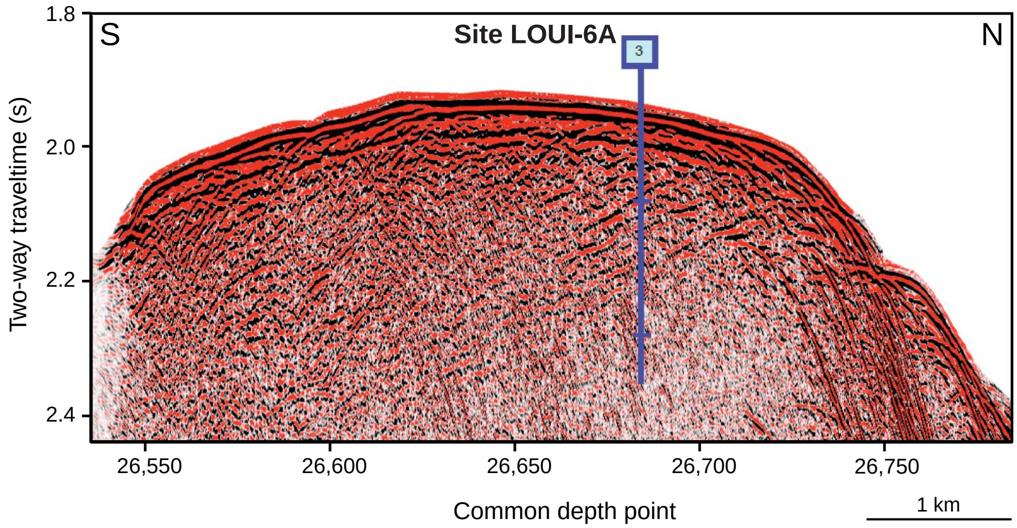


Figure AF16. Bathymetric map of the 32.3°S guyot ("Burton Seamount") along with the location of alternate Sites LOUI-7A and LOUI-7B and seismic profiles (blue lines with track number). Contour intervals = 100 m. Source of bathymetric map: **earthref.org/SBN/.**

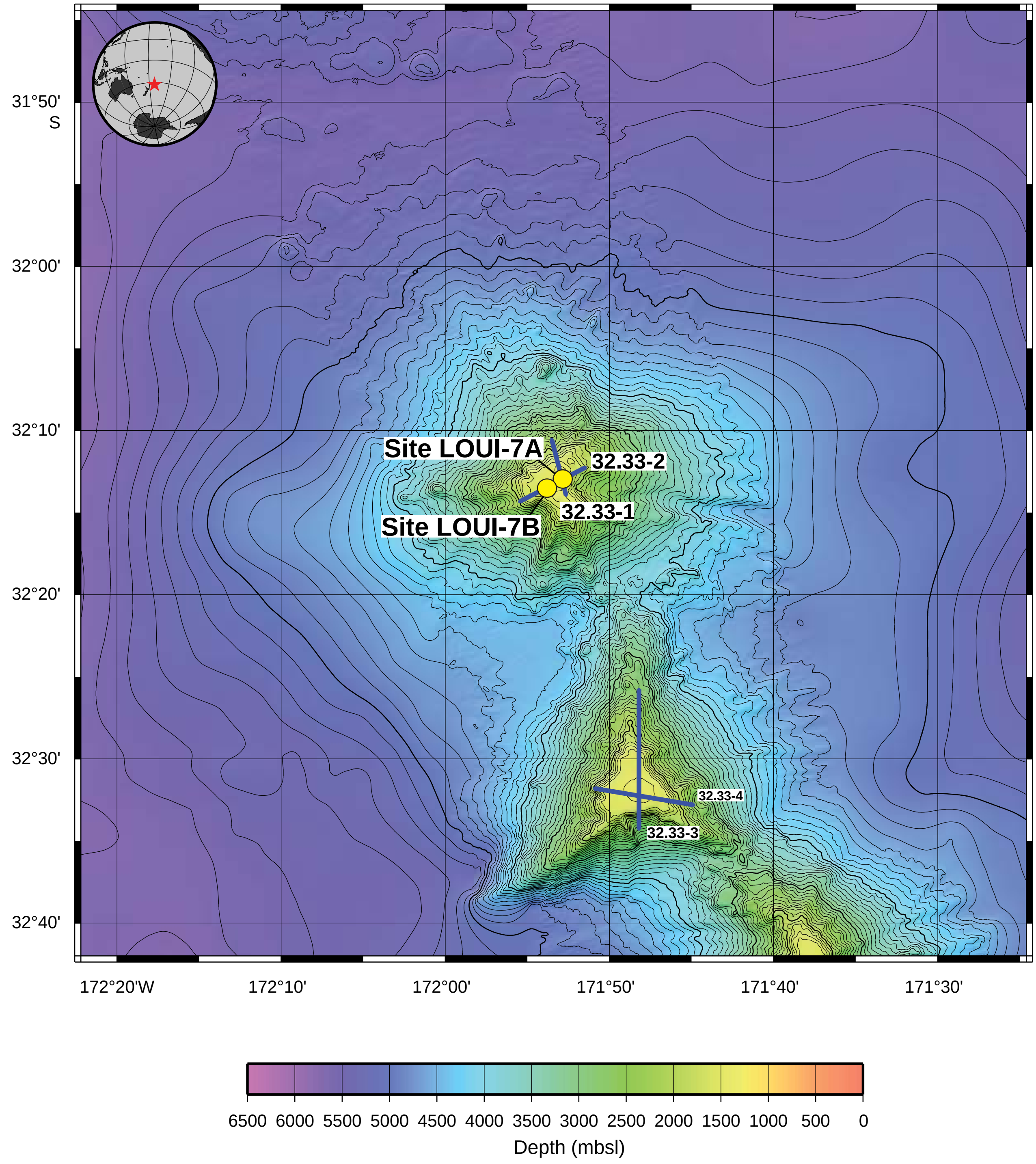


Figure AF17. Seismic Line 32.33-1 at proposed Site LOUI-7A. Number in blue square indicates location of crossing Line 32.33-2.

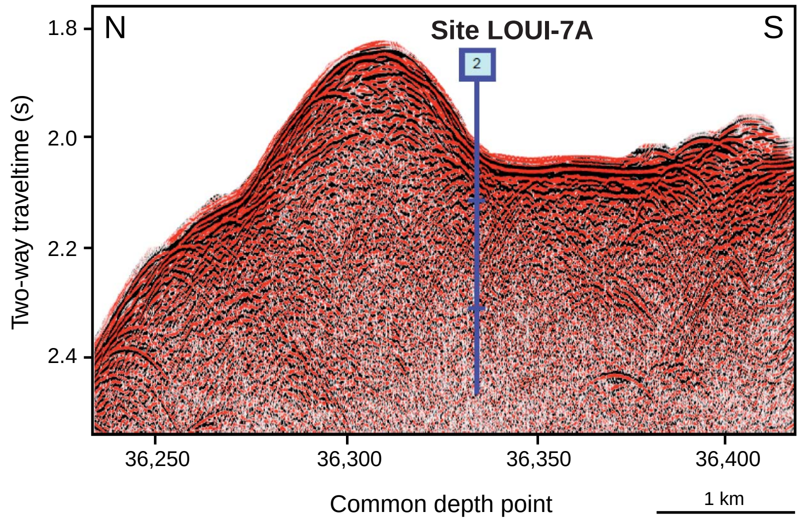


Figure AF18. Seismic Line 32.33-2 at proposed Sites LOUI-7A and LOUI-7B. Number in blue square indicates location of crossing Line 32.33-1 or the absence of crossing line (A).

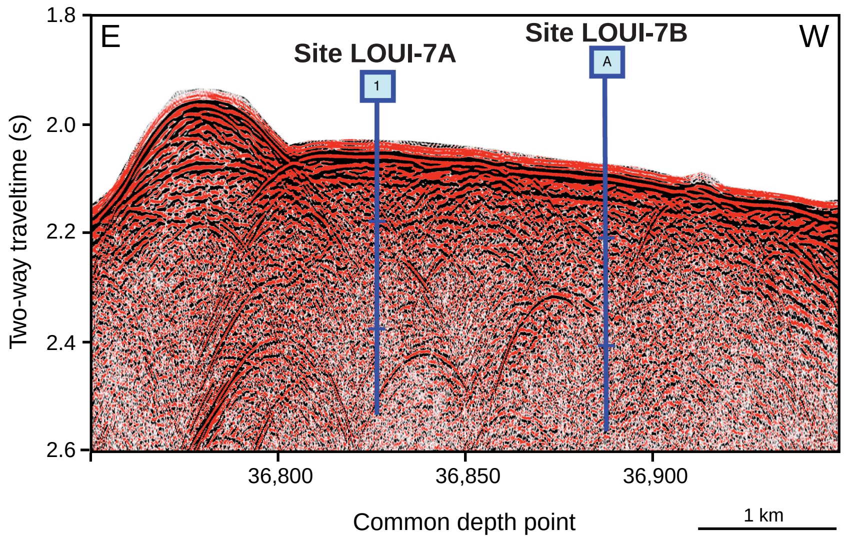


Figure AF19. Seismic Line 36.9-1 at proposed Sites LOUI-8A and LOUI-3B. Number in blue squares indicates location of crossing Lines 36.9-3 and 36.9-2.

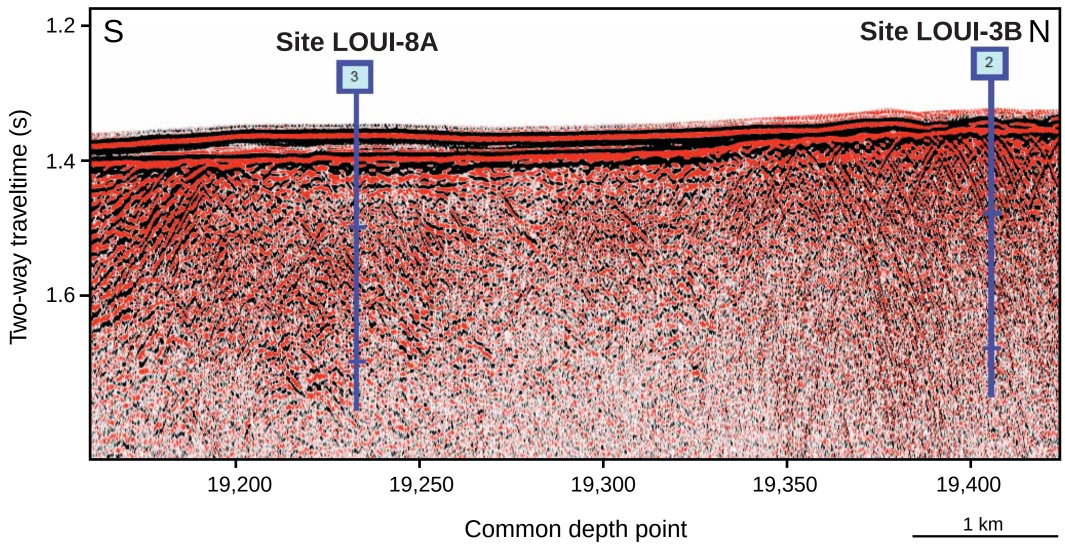


Figure AF20. Seismic Line 36.9-3 at Site LOUI-8A and LOUI-8B. Number in blue square indicates location of crossing Line 36.9-1 or absence of crossing line (A).

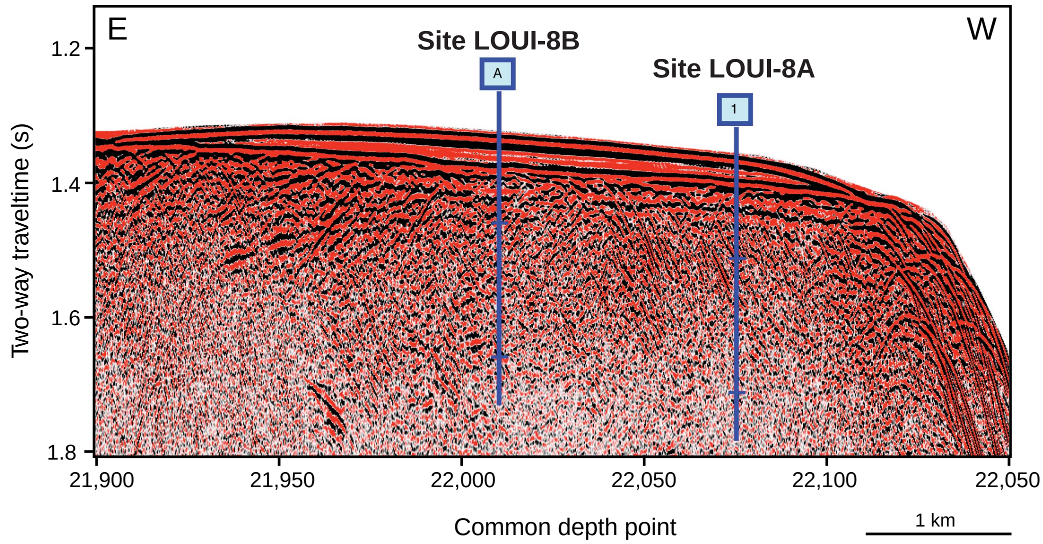


Figure AF21. Bathymetric map of the 168.3°S guyot along with the location of alternate Site LOUI-9A and seismic profiles (blue lines with track number). Pink lines indicate location of dredge hauls. Contour intervals = 100 m. Source of bathymetric map: **earthref.org/SBN/.**

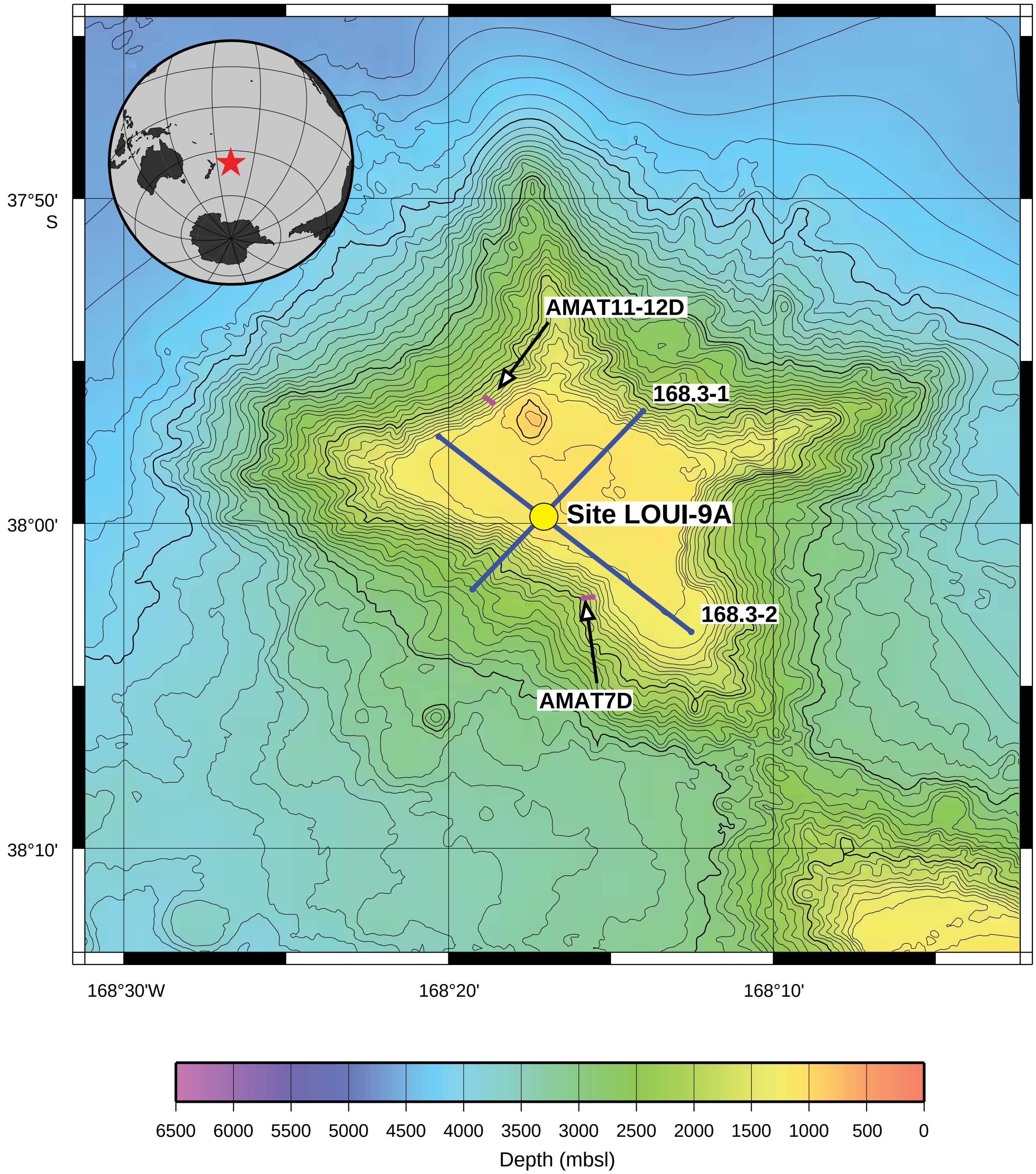


Figure AF22. Seismic Line 168.3-1 at proposed Site LOUI-9A. Number in blue square indicates location of crossing Line 168.3-2.

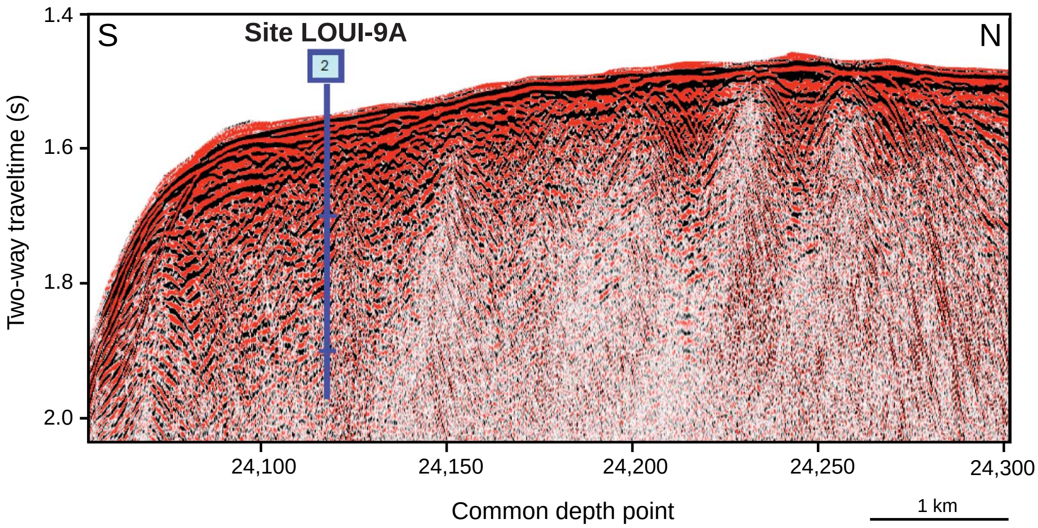
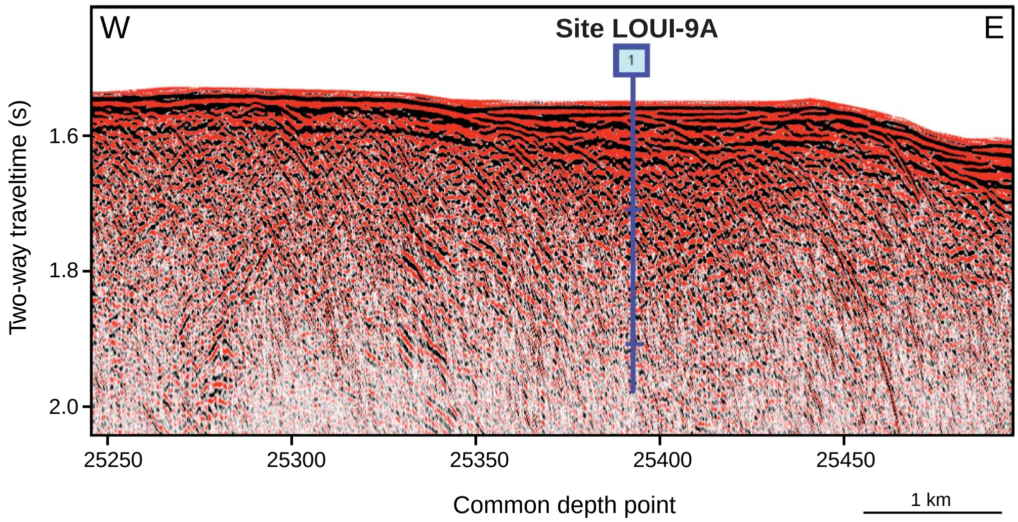


Figure AF23. Seismic Line 168.3-2 at Site LOUI-9A. Number in blue square indicates location of crossing Line 168.3-1.



Expedition scientists and scientific participants

The current list of participants for Expedition 330 can be found at **iodp.tamu.edu/scienceops/precruise/louisville/participants.html.**