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IODP Proposal Cover Sheet

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Title:	Testing Plume and Plate Models of Ocean Plateau Formation at Shatsky Rise, Northwest Pacific Ocean		
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Abstract: (*400 words or less)*

One of the most fundamental questions of modern geodynamics is the process of mantle convection and its impact on the Earth's surface through volcanism. The greatest source of non-ocean-ridge volcanism appears to be massive eruptive episodes that formed oceanic plateaus, volcanic passive margins, and continental flood basalts. A widely accepted hypothesis for such volcanism is that it results from the head of a starting plume, which rises from the deep mantle, spreads out beneath the lithosphere, and melts cataclysmically in a massive outpouring of volcanic activity. Despite the wide acceptance of this hypothesis, a convincing case for a plume head origin has not been made for any plateau; rather, significant complexities have been revealed by recent drilling of the Kerguelen and Ontong Java plateaus. Indeed, non-plume explanations for non-ridge oceanic volcanism recently have gained favor among some workers, and the very existence of mantle plumes has been questioned. One great difficulty with research to date is that the original setting, relative to mid-ocean ridges and plate tectonics, is poorly known for most plateaus because they were formed during the mid-Cretaceous when no magnetic reversals formed ridge-parallel anomalies to record ridge locations. Shatsky Rise, located 1500 km east of Japan, is unique in being the only large oceanic plateau formed during a time of magnetic reversals, permitting its tectonic setting to be resolved. Magnetic lineations show that the plateau formed along the trace of a triple junction, intimately related to ridge tectonics. Existing data demonstrate that several aspects of Shatsky Rise's history (e.g., massive, rapid initial growth, transition from large to small magma flux, capture of ridges) fit the plume head model. On the other hand, the coincidence of volcanism with the triple junction, ridge jumps, and the lack of isotopic evidence for a hotspot-type mantle source can all be taken as favoring a plate-controlled origin. Its unique combination of features makes Shatsky Rise the best location on Earth to test plume versus plate-tectonic hypotheses of ocean plateau formation. We propose a single leg on the non-riser drill ship to core ~1000 m of igneous basement at 6 sites on Shatsky Rise to examine the history, source(s), and evolution of this plateau. From the results, we hope to be able to put to rest the question of whether oceanic plateaus like Shatsky Rise were formed from deep-sourced mantle plumes or interaction of plate boundaries and the lithosphere with the shallow mantle.

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Scientific Objectives: (*250 words or less*)

The primary objective is to core igneous rocks from the volcanic massifs of Shatsky Rise todetermine the age, sources, and evolution of this plateau and to test hypotheses of a plume head or plate-controlled origin. Primary data will be radiometric ages, chemical and isotopic composition, and mineralogical information that will allow scientists to understand under what conditions and from what source the igneous rocks were derived. Other goals are to learn about the surface manifestation and environment of emplacement of this plateau through lithostratigraphic core and log data; to illuminate plate motions and volcanic structure from paleomagnetic data; and to explore links between Shatsky Rise formation and the synchronous Jurassic-Cretaceous boundary through stratigraphic, geochemical, and age data.

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SRSH-2A	30°49.17'N,156°21.90'E	4721	297	100	397	Recover igneous rock; TAMU Massif lower flank
SRSH-3	32°18.57'N,158°59.88'E	2987	311	300	611	Recover igneous rock: TAMU Massif summit
SRSH-5	32°50.98'N,157°52.92'E	3450	210	100	310	Recover igneous rock; TAMU Massif summit
SRSH-6	34°25.32'N,159°22.93'E	3268	150	100	250	Recover igneous rock; TAMU Massif faulted north flank
SRCH-3	36°00.52'N,158°20.97'E	3243	130	300	430	Recover igneous rock; ORI Massif summit
SRNH-1	37°49.27'N,162°59.19'E	3339	265	100	365	Recover igneous rock; Shirshov Massif summit

Responses to SSEP Review Questions

SSEP reviews (November, 2004) were generally positive, although the panel raised questions that require discussion. Rather than bury the answers in various parts of the proposal, we address them in this section. We feel none of the issues raised warrants a significant change in the proposed drilling program.

1. The SSEPs need to see the scientific reasoning for penetrating basement to only ~100 m or ~300 m and not just a logistical or scheduling argument. Given that subaerial exposure may have resulted in deep weathering or alteration profiles […], the outlined objectives may require deeper holes. […] it may be a good idea to include […] seismic profiles presented in Sager et al. (1999, JGR).

Penetration of plateau basement at several sites to a depth of 100-300 m is the recommended one-leg or first-leg drilling strategy developed in several workshops over the last 15 years, particularly a large ODP-IAVCEI-InterRidge workshop (Dick et al., 1996). The recommended strategy is to first document age differences and geochemical variability across a plateau before any single site is drilled more deeply. Indeed, this was the strategy followed for Legs 183 to Kerguelen Plateau and 192 to Ontong Java Plateau (Coffin et al., 2000; Mahoney et al., 2001). The same workshops recommended deep drilling as a second-leg scenario, after the broader picture is delineated. Because basement has been cored at only one site on Shatsky Rise (1213), the same strategy is appropriate. Furthermore, many of the questions about Shatsky Rise outlined below can only be answered by sampling in several widely spaced locations.

Can suitably fresh samples for the proposed studies be obtained with 100-300 m of basement penetration? We have reviewed six legs that cored Cretaceous seamounts and plateaus (Legs 55, 143, 144, 145, 183, and 192) at 26 sites having basement penetrations between 7.0 m and 385 m (mean 95.5 m). The general picture is that alteration in both submarine and originally subaerial basement rocks is pervasive but patchy, ranging from slight to complete. The greatest alteration tends to be in permeable zones associated with fractures, veins, vesicular basalt, and breccia, whereas massive flow interiors are often only slightly altered. Alteration state seems not to depend greatly on whether basalt flows were originally subaerial or submarine, except that clay zones related to weathering horizons occur more often in the former. In almost all holes with >~50 m basement penetration, samples with only slight or moderate alteration were recovered, allowing important geochronological and geochemical objectives to be met.

We would gladly introduce seismic profiles from Sager et al. (1999), but do not feel the profiles would be helpful for this discussion. They show the sediment column and basement interface, but give little information about sub-basement character.

2. The proponents seem to discount the importance of small seamounts, such as the Ojin Rise Seamounts[…]. We wonder if this viewpoint is strictly correct […].

For reference, the Ojin Rise seamounts are a chain located east of Shatsky Rise, trending from the Shirshov Massif to the Emperor Seamounts. Some investigators have postulated that they are a hotspot track (e.g., Henderson, 1985). These and other seamounts within Shatsky Rise may well represent an important facet of rise volcanism, but are not addressed in the current proposal because our focus is on the large edifices, which represent nearly all of the plateau volcanism. Our focus is on the development of the large edifices because may have flood-basalt-like eruption rates and appear to be associated with the triple junction trace. Proposing a site on a small seamount would require giving up one on the large edifices. For now, we do not feel this trade-off is worthwhile. Furthermore, these seamounts are mostly free of sediments, so they can be sampled by dredging.

3. […] While further drilling may provide even tighter controls on the age of volcanism, it will probably allow only a moderate revision of the eruption rates.

To a degree, this is true, but the criticism misses a critical point. At this time, we have one solid age from Shatsky Rise basement (Site 1213, Mahoney et al., 2005). All other ages are inferred. Estimates of eruption rates have been based on comparison of the ages of magnetic anomalies that surround the TAMU Massif and the Site 1213 age. The anomaly ages have uncertainties of several million years because of uncertainties in interpolating ages for the geomagnetic polarity timescale. This inherent uncertainty may bias eruption rate estimates. Furthermore, the highest inferred eruption rates come from assuming that TAMU Massif formed during a single magnetic polarity period. With additional high-quality radiometric dates and magnetic polarity determinations from sites on TAMU Massif, we can test whether the massif formed as quickly as inferred or whether volcanism was more prolonged. This is an important constraint on eruption mechanisms because ridge-related mechanisms should not be able to produce huge amounts of magma in short periods. Thus, it is important to know whether many or all TAMU Massif sites show contemporaneous volcanism or whether the duration of

volcanism was several million years or more. With current data, we cannot resolve this problem and the highest inferred rates are more than 4.5 times greater than the lowest ones.

4. […]The proponents must clearly articulate[…] what definitive geochemical and isotopic tests they will perform […]that will define the origin of the magmas. Will drilling at Shatsky Rise and the geochemical approaches developed be of global interest to the formation of LIPs or only of regional interest and of specific relevance to that particular plateau?

At the very least, Shatsky Rise represents a significant subgroup of oceanic plateaus, in that plateau formation at a triple junction seems to have occurred repeatedly in many locations. Shatsky Rise may be representative of all oceanic plateaus, but we do not know because the original tectonic settings of most plateaus are poorly known because they formed during the Cretaceous Normal Superchron. As we state in the Introduction, the study of plateaus is important because they represent a significant flux of material from the mantle that may not be explained by plate tectonics. Furthermore, the proposed research is a fundamental part of understanding the role of mantle plumes in transferring material from the mantle to the surface. If the plume head model is correct, plumes are a critical part of mantle convection; if spreading-controlledmodels are correct, plumes may be much less important.

Regarding definitive geochemical tests, this is a little like asking for a definitive biological test of evolution. Geochemical evidence must always be used in combination with geochronological, paleobathymetric, paleomagnetic, geophysical, and other evidence. This is illustrated by the Ontong Java case: the isotopic and chemical data are most consistent with a plume-head origin, but the anomalous paleobathymetry, lack of evidence for plume-head to plume-tail transition, etc. indicate problems with any standard plume-head model for Ontong Java (Tejada et al., 2004; Fitton et al., 2004). As geoscientists debate the role of plumes in the mantle, models and interpretation of data change – a sign of healthy debate and progress. Furthermore, all models and problems are simple until tested with data. For example, geologic complications from the drilling of Kerguelen and Ontong Java plateau show that first order models are probably over simplified. This is progress. Collecting new data from Shatsky Rise and other LIPs can be catalysts to encourage and accelerate the fruition of this debate.

That said, the plume-head model predicts that ocean-island-type Nd-Pb-Sr-Hf isotopic characteristics should be overwhelmingly predominant in Shatsky lavas. MORB-type isotopic compositions are not predicted in the main lava pile, or at least should be very rare. A non-

plume, ridge-controlled origin predicts that MORB-type isotopic ratios will be rare to nonexistent earlier in the volcanic sequence but are likely to become increasingly common, even dominant, higher in the lava pile. Thus, combined Nd-Pb-Sr-Hf isotope data will be critical to understanding the origin of Shatsky Rise. If suitable samples are recovered, more exotic types of data, such as ^{186}Os and W isotopes, can be used to search for evidence of a core-mantle boundary component in Shatsky lavas. If samples with fresh-enough olivine or clinopyroxene are recovered, helium isotopes could also be important; for example, very high ^{3}He/^{4}He values recently have been found in Emperor Chain seamount lavas (Keller and Graham, 2004) and early Tertiary flood basalts in Baffin Island (Ellam and Stuart, 2004).

INTRODUCTION

Knowledge about large igneous provinces (LIPs) has played a fundamental role in shaping the prevailing view of mantle geodynamics, that of largely upper mantle, plate-driven flow punctuated by rising, thermally driven plumes from the lower mantle (e.g., Davies, 1992). The largest LIPs, the oceanic plateaus, continental flood basalts, and volcanic passive margins, reach volumes of several 10^6 to several 10^7 km^3 and are apparently the product of relatively short-lived, massive magmatic episodes that represent the largest non-ridge volcanic process on Earth (e.g., Coffin and Eldholm, 1994). In terms of magma flux, volume, and extent, such LIPs dwarf even the most prodigious present-day hotspots, such as Iceland and Hawaii. Magma production rate for the largest LIPs rivaled or even surpassed that of the global mid-ocean ridge system for short periods of time (e.g., Tarduno et al., 1991; Duncan and Richards, 1991; Mahoney et al., 1993; Coffin and Eldholm, 1994). Moreover, because many of the largest LIPs formed during the Mesozoic, they may represent a mantle convection regime different from that of the ridge-dominated Cenozoic (e.g., Stein and Hoffman, 1994).

A widely accepted explanation for plateaus and continental flood basalts is the plume head hypothesis, which posits large (several hundred to 2000 km in diameter), bulbous, primarily thermal diapirs that are created at depth in the mantle, probably within the core-mantle boundary zone, and which rise toward the surface, causing cataclysmic volcanism when they impact the lithosphere (e.g., Richards et al., 1989; Griffiths and Campbell, 1990). Like the related plume hypothesis for volcanism at hotspots (Morgan, 1972, 1981), the plume head hypothesis has been accepted by many workers because it provides a simple framework that seems to tie together many observations. Moreover, the plume head phenomenon occurs naturally in numerical and

laboratory experiments, given appropriate rheologic conditions (e.g., Whitehead and Luther, 1975; Griffiths and Campbell, 1990, 1991). The trouble is that there is currently no unequivocal geological evidence proving that the plume head mechanism has operated within the Earth. Many existing data are indirect indicators of eruptive rate and magmatic volume and could be explained by alternative hypotheses. A growing debate about the number, characteristics, and even existence of mantle plumes (e.g., Smith and Lewis, 1999; Anderson, 2001, 2004; Foulger, 2002; Courtillot et al., 2003; Sleep, 2003; Foulger and Natland, 2003; DePaolo and Manga, 2003) makes it desirable to consider alternative explanations for plateaus. Because ocean plateaus are argued to be the most direct expression of mantle plume heads (i.e., unlike continental LIPs, where magmas must pass through continental lithosphere), understanding oceanic plateau formation is thus critical to understanding mantle dynamics.

ODP Legs 183 and 192 drilled Kerguelen and Ontong Java plateaus, respectively, seeking evidence that would test the plume head hypothesis (Frey et al., 2002; Fitton et al., 2004). These two plateaus were targeted because they are the largest and prior data suggested that each formed within a narrow range of ages, as predicted by the plume head model. However, both expeditions uncovered complications that do not fit the simple plume head model (e.g., Coffin et al., 2002; Fitton et al., 2004), so debate over plume heads has grown, especially with questioning of the existence of mantle plumes (e.g., Natland and Winterer, in press).

In order to address the plume head versus alternative hypotheses, it is necessary to study a plateau for which the relation of the plateau to contemporaneous mid-ocean ridges is known. Unfortunately, this condition is not met for plateaus formed during the Cretaceous Normal Superchron (a.k.a. Cretaceous Quiet Period)—like Ontong Java and Kerguelen—because of the lack of magnetic reversals and thus linear seafloor magnetic anomalies to mark the locations of ridges. Shatsky Rise is the only large intra-oceanic plateau formed at a time of magnetic reversals. Contemporaneous magnetic lineations exist around and within the plateau, providing a framework that allows development of a tectonic model (Nakanishi et al., 1999; Sager et al., 1999). This model is currently based on geophysical inference with little solid geological evidence from sampling.

Shatsky Rise is also unique because it has characteristics that suggest both plume head and ridge-controlled origins (Sager, in press). The plateau's size, morphology, apparent eruption rate, and age progression are consistent with a plume head origin (Sager and Han, 1993;

Nakanishi et al., 1999; Sager et al., 1999). In contrast, the plateau formed at a triple junction during a time of ridge reorganization, which suggests a link to ridge tectonics (Sager et al., 1999; Sager, in press). Furthermore, existing Nd-Pb-Sr isotopic data for the few basalts cored and dredged from Shatsky Rise show a Pacific-MORB-type signature, not the expected ocean-island-type signature of a plumehead eruption (Mahoney et al., 2005). Whether or not this MORB affinity is representative of the rise or characterizes only a few minor, late-stage magmas is unknown. However, the fact that existing data for Shatsky Rise can be interpreted both ways suggests that this plateau is uniquely suited for testing plume head vs. ridge tectonics models. Moreover, because several, perhaps many, oceanic plateaus formed at triple junctions (e.g., Winterer et al., 1976; Larson et al., 2002; Sager, in press; Ishikawa et al., in press), Shatsky Rise probably represents a significant class of ocean plateau, if indeed it is not representative of all.

In this proposal we review the state of plateau-formation hypotheses, existing knowledge of Shatsky Rise, and why the rise is uniquely suited for testing plume head and ridge-tectonics hypotheses. We explain how these hypotheses can be tested by drilling and outline a single-leg, non-riser drilling program to sample Shatsky Rise.

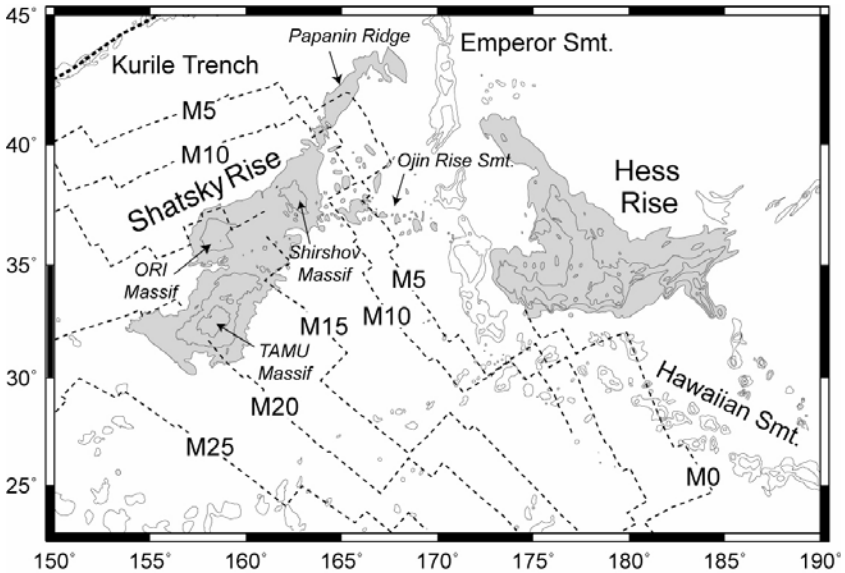

Figure 1. Location of Shatsky Rise, Hess Rise, and selected magnetic anomaly lineations in the northwest Pacific Ocean. Bathymetric highs of the two rises are highlighted in gray.

Plateau Formation Hypotheses

Ocean plateaus are remote and difficult to sample. The resulting geological ignorance has led investigators to propose several plateau-formation mechanisms. One class of explanation calls upon anomalous behavior of tectonic plates, such as leaky transform faults (Hilde et al.,

1976) or spreading ridge reorganizations (e.g., Anderson et al., 1992). Another class invokes a mantle plume, either as a steady-state plume "tail" beneath at a spreading axis or a plume head (Richards et al., 1989; Mahoney and Spencer, 1991; Duncan and Richards, 1991; Coffin and Eldholm, 1994). A third type of mechanism explains plateau formation as a result of a large meteorite impact (Rogers, 1982; Roddy et al., 1987).

The mantle plume hypothesis has been widely accepted, in part because of known shortcomings or lack of development of other hypotheses. The meteorite impact hypothesis was first proposed before discovery of the Chicxulub impact crater (e.g., Hildebrand and Boynton, 1990) and several other large impact sites that were subsequently documented on the continents. Combined with a lack of evidence linking plateaus and impacts, the idea lay fallow for many years. However, this hypothesis has been revisited for the Ontong Java Plateau (Ingle and Coffin, 2004; Tejada et al., 2004) because evidence from the plateau that does not neatly fit other hypotheses. Plate boundary mechanisms have gained only limited support, partly because they require the assumption of extensive regions of shallow, near-solidus asthenosphere that differ geochemically from the shallow asthenosphere that forms mid-ocean ridges, and partly because they may not be able to produce the volumes of magma required for the largest plateaus, such as the Ontong Java. Creating LIPs via cracks, even in a thick part of an oceanic plate, requires that a seemingly small perturbation unleash a massive volcanic event. Consequently, large volumes of anomalously warm asthenosphere or unusually chemically "fertile" (fusible) mantle primed to undergo massive decompression melting must be assumed (Anderson et al., 1992).

Plume-based explanations for plateaus have been bolstered by a wide acceptance of the mantle plume hypothesis for oceanic islands. The idea that thermal (and perhaps chemical) instabilities from the lower mantle rise to the base of the plate and cause hotspot volcanism initially became popular because it provided a neat explanation for age-progressive volcanic chains (Wilson, 1963; Morgan, 1971; 1972). As more age-progressive seamount chains have been found, this explanation has been used repeatedly, with one result being an unlikely large number of proposed plumes. In part, this problem stems from loose application of the plume definition. Recent re-examination of hotspots led Courtillot et al. (2003) and Anderson (in press) to conclude that only a small number fit the original plume concept, that of a thermal diapir originating at or near the core-mantle boundary. Instead, many hotspots, especially smaller ones, likely have shallower sources that may or may not be related to significant thermal upwelling.

The plume head hypothesis arose as an offshoot of the traditional plume hypothesis. It was observed experimentally that if viscosity conditions are appropriate, then perturbations in a gravitationally unstable fluid layer form large, bulbous heads that rise through the overlying fluid and that the heads are followed by tails of rising, lower-layer material (Whitehead and Luther., 1975; Richards et al., 1989; Griffiths and Campbell, 1990). Such models led to the idea that mantle plumes form near the core-mantle boundary, begin with massive diapirs (plume heads) that rise through the mantle, and are fed and followed by a narrow conduit of the same lower-layer material (plume tail). Other versions of the plume-head model start plumes from a shallower level, which serves either as the primary source region (e.g., Allègre and Turcotte, 1985; White and McKenzie, 1989; Kellogg et al., 1999) or as a barrier to a lower-mantle plume head, which then creates an upper-mantle plume head by heating from below (Tackley et al., 1993). All of these hypotheses are similar in that they require large thermal (and/or chemical) anomalies that arise at depth and carry deep mantle material to the base of the plate.

Impingementof a plume head on the lithosphere is thought to lead to voluminous production of basaltic magma, forming an oceanic plateau or continental flood basalt, depending on the type of lithosphere (e.g., Richards et al., 1989; Campbell, 1998). Wide acceptance of this hypothesis rests on radiometric ages indicating that several flood basalts and plateaus were formed rapidly, on the ocean-island-like Nd-Pb-Sr-Hf isotopic signatures of many flood basalt sources, and on several long-lived seamount chains that can be traced back to a flood basalt province (e.g., Campbell, 1998). Recently, however, dating results from ODP Leg 183 on Kerguelen Plateau indicate a longer, more complex emplacement history than previously thought (Duncan, 2002; Coffin et al., 2002). Also, although Ontong Java basalts have an ocean-island-type isotopic signature and most of the plateau appears to have formed rapidly (at ~120 Ma), an associated post-plateau seamount chain is lacking; plus, the initial depth of much of the plateau was well below that predicted by the plume-head model and the amount of post-eruptive subsidence has been less than predicted (e.g., Mahoney et al., 2001; Fitton et al., 2004). The effect of such complications for the plume head model is still being sorted out.

Why Study Shatsky Rise?

During the mid-1990s, a prior version of this proposal did not receive sufficient support for scheduling. The proposal was not passed over because of scientific criticism, but because the prevailing sentiment was that because Kerguelen and Ontong Java are by far the largest plateaus,

they should be drilled first — and they were. A serious limitation to understanding the origin of these two plateaus is that they formed mainly during the Cretaceous Long Normal Superchron, so their relationship to spreading ridges cannot be determined. Shatsky Rise should be studied because it is the only large intra-oceanic plateau that formed during a time of magnetic reversals; moreover, the seafloor reversal record shows that it formed at a triple junction. Knowledge of oceanic plateaus is still so rudimentary that we cannot be certain whether Shatsky Rise and Ontong Java Plateau, for example, formed by the same mechanism. Many other plateaus have formed at triple junctions (Sager, in press), so Shatsky Rise probably represents a class of ridge-related plateaus, if not all ocean plateaus.

A critique sometimes made of proposals to study Shatsky Rise is: "if you want to study plume-ridge interaction, why not just study Iceland?" First, Iceland and Shatsky Rise differ in estimated magmatic flux by more than an order of magnitude. If one accepts the plume hypothesis (which is not universally accepted; e.g., Foulger, 2002), Iceland is well suited for studying present-day plume-ridge interaction; however, Shatsky Rise permits study of the interaction between a plume *head* and a ridge. Second, Shatsky Rise formed at a triple junction, whereas Iceland did not. Third, the initial formation of Shatsky Rise appears coincident with a plate reorganization and large (800 km) jump of the triple junction, implying a connection with large-scale plate tectonics. Although small ridge jumps have occurred at Iceland, they have been far smaller than the scale of the jump associated with Shatsky Rise.

Although there are a dozen or so large oceanic plateaus, we believe that Shatsky Rise is unique in its setting and holds critical clues to understanding plateau formation. The reasons that Shatsky Rise should be a high priority for study are as follows:

1. With an area of ~4.8 x 10^5 km^2 (about the same as Japan or California) and total volume of ~4.3 x 10^6 km^3, Shatsky Rise is one of the largest ocean plateaus (Sager et al., 1999). Moreover, bathymetric ridges and lava geochemistry suggest Shatsky and Hess Rise (Fig. 1) may have arisen from the same source (Bercovici and Mahoney, 1994), which would nearly double the magmatic output. Magmatism of this scale requires something significantly unusual about the physical and/or chemical state of the source mantle.
2. The fact that Shatsky Rise formed during a time of magnetic reversals makes it easier to understand than any other large ocean plateau. Magnetic reversals recorded in Shatsky lavas provide constraint on the rise's structure and original tectonic setting (e.g., Sager

and Han, 1993, Sager, in press). Magnetic anomalies can be used not only to date the plateau and surrounding lithosphere, but also to understand how plateau morphology is related to ridge tectonics (e.g., Sager et al., 1999; Nakanishi et al., 1999).

3. Morphology, apparent age progression, and magnetic lineations together indicate that the rise volcanism was spread out laterally, perhaps owing to rapid movement of the Pacific plate over the source mantle (Nakanishi et al., 1999; Sager et al., 1999). In contrast, the volcanic record of Ontong Java maymainly consist of a vertically stacked pile. Therefore, the tectonic and geochemical evolution of Shatsky Rise is easier to address through drilling (i.e., shallow holes distributed laterally).
4. Shatsky Rise formed at a ridge-ridge-ridge (RRR) triple junction of rapidly spreading ridges; consequently, the lithosphere was young and thin, so that lithospheric contamination of magmas should be minimal. Likewise, variations in lithospheric thickness should not have influenced magma compositions significantly.
5. Because of its location exactly along the track of a migrating triple junction and the fact that it appears to share both ridge and plume characteristics, Shatsky Rise is uniquely suited to testing plume-head versus ridge-controlled hypotheses of plateau genesis.

Why is drilling required? Although the main edifices of Shatsky Rise have some basaltic outcrops, dredged samples of igneous basement suitable for geochemical and geochronological work have proven difficult to get and harder to study. Because of Shatsky's Late Jurassic to Early Cretaceous age, outcrops on these edifices have probably been exposed for long periods. All outcrops dredged to date are coated with thick ferromanganese oxide deposits that make basement rock recovery difficult. Likewise, all existing dredge samples are highly altered. We dredged the rise during the 1994 site survey cruise, but the samples that were recovered were too altered to produce reliable radiometric dates, even with the most modern techniques (A. Koppers, unpublished data). Likewise, all but a very few samples were unsuitable for chemical or isotopic studies (Tejada, 1998; Tatsumi et al., 1998). In addition, the dredge sites were all promontories, ridges, and other high points that may not be representative of the main plateau-building lavas. In sum, the only way to obtain samples that can address the origin of Shatsky Rise is by drilling a series of holes across the plateau and recovering hundreds of meters of basement igneous rock.

Prior Research on Shatsky Rise

By the late 1960s, it was known that Shatsky Rise is ancient, because Early Cretaceous sediments were cored from its summit (Ewing et al., 1966). Although seismic refraction experiments have not yet imaged the Moho beneath the high parts of the plateau, they have revealed anomalously thick crust, with a similar velocity structure to normal oceanic crust but several times thicker (Den et al., 1969; Gettrust et al., 1980). Seismic profiling showed that the tops of the rise edifices hold thick piles of pelagic sediments (up to 1.2 km), whereas sediments on the rise flanks are thin or absent in places (Ewing et al., 1966; Ludwig and Houtz, 1979; Neprohnov et al., 1984; Sliter and Brown, 1993).

Several DSDP and ODP cruises have cored Shatsky Rise over a span of 32 years. In succession, DSDP Legs 7, 32, 86 and ODP Leg 132 cored atop the highest, southern massif of the rise (TAMU Massif). Most of the penetration was shallow and only one hole reached basement, but no basalt was recovered (Leg 7). DSDP Leg 32 probed deep into the sedimentary cap, recovering Berriasian (earliest Cretaceous) sediments ~50 m above the expected level of basement at Site 306 (Fig. 2). This finding was significant because it implied that TAMU Massif formed during latest Jurassic or earliest Cretaceous time. Recently, ODP Leg 198 cored sediments from all three of the Shatsky Rise massifs (Bralower et al., 2002). The ages of the oldest sediments cored at each site were Cretaceous; furthermore, a 46-m section of little-altered basaltic sills was cored in earliest Berriasian sediments at Site 1213 on the southwest flank of TAMU Massif (Fig. 2). These basalts produced the first reliable radiometric date for Shatsky Rise, as well as valuable chemical and Nd-Pb-Sr isotopic data (Mahoney et al., 2005).

Magnetic lineations mapped in the northwest Pacific revealed that Shatsky Rise sits at the confluence of two lineation sets, the northeast-trending Japanese lineations and the northwest-trending Hawaiian lineations (Figs. 1, 2; Larson and Chase, 1972; Hilde et al., 1976). This circumstance indicates that the plateau formed at a triple junction separating the Pacific, Farallon, and Izanagi plates (Larson and Chase, 1972). Subsequent studies revealed that the triple junction jumped repeatedly during the time it occupied the location of the rise and that it must have been geometrically unstable to follow the path of the rise (Sager et al., 1988; 1999; Nakanishi et al., 1999). Furthermore, age constraints (mainly the Cretaceous sediments), seismic stratigraphy, and isostatic compensation all indicate that the age of the rise is near that of the adjacent seafloor (Sager et al., 1999), implying that the triple junction and rise formation are

linked. Current thought is that a plume head is the link – a source of heat, uplift, and volcanism that both created the rise and captured the triple junction (Sager et al., 1988; 1999).

Magnetic data were also instrumental in supporting the idea that Shatsky Rise formed from a plume head. Sager and Han (1993) postulated that the rise formed rapidly, based on modeling of the magnetic anomaly over TAMU Massif. They noted that the magnetic anomaly implies a mainly reversed polarity, in turn implying that most of the edifice may have formed during a single interval of reversed polarity. With simple calculations using the massif volume and an estimate of the length of the single polarity period, the authors inferred that the massif formed with an eruption rate similar to those of several large flood basalts (~1.8 km^3/yr).

Recent analyses have refined and expanded these conclusions. Paleomagnetic analysis of Site 1213 basalt samples gives inclination values that are most consistent with a reversed magnetic polarity (Tominaga et al., 2004). Furthermore, the mean ^{40}Ar-^{39}Ar age from two basalt samples from the sills is 144.6 ± 0.8 Ma (2σ error; Mahoney et al., 2005), a value identical with the age of the Jurassic-Cretaceous boundary and that correlates with magnetic anomaly M19 in the time scale of Gradstein et al. (1995). This result limits the formation of much of the TAMU Massif to between anomalies M21 and M19, a period of 1.5 Myr. If TAMU Massif formed during a single polarity interval, it is likely either M20 or M19, with durations of 0.4 and 0.75 Ma, respectively. Assuming the volume of the massif between anomalies M21 and M19 formed in 1.5 to 0.4 Myr (and making the conservative assumption that it formed on existing [very young] 7 km thick crust) implies emplacement at rates of 1.2 to 4.6 km^3/yr (Sager, in press). Again, such values are in the range of estimates for several large continental flood basalts (e.g., Richards et al., 1989; Johnston and Thorkelson, 2000). Although these estimates are intriguing, they were made by very indirect means and require confirmation from radiometric ages of igneous basement samples, particularly from other locations on the rise.

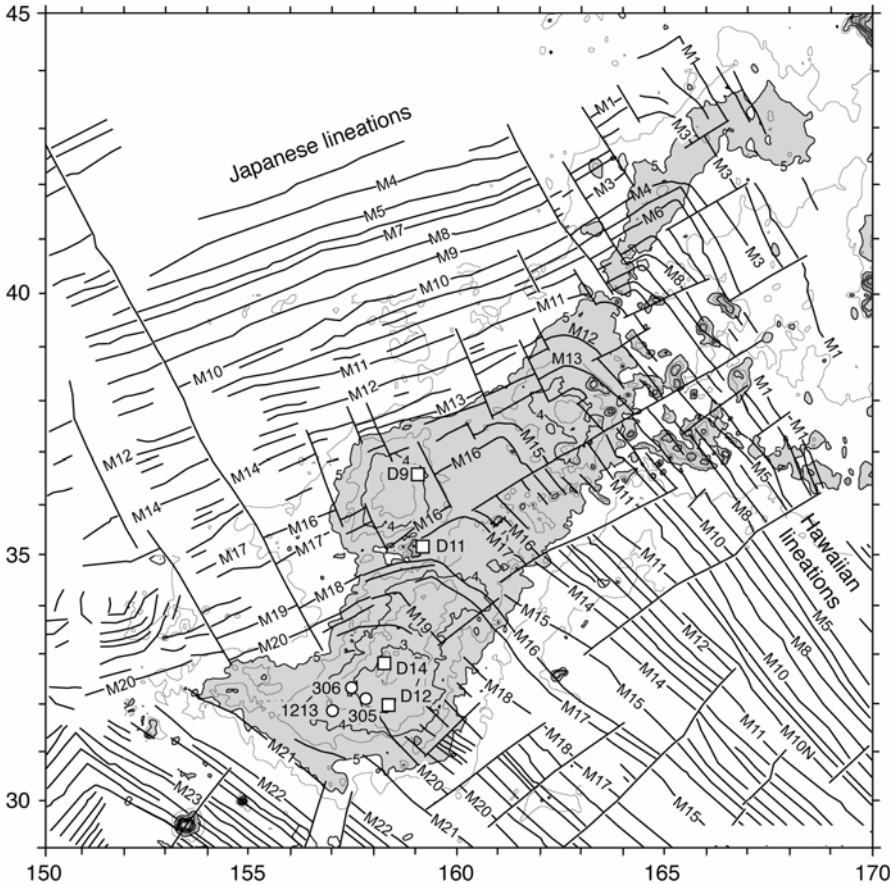

Figure 2. Magnetic lineations within and around Shatsky Rise. Heavy straight lines show magnetic lineations and fracture zones. Bathymetric contours shown at 500-m intervals, with depths <5 km on the rise highlighted by gray fill. Circles show DSDP and ODP sites mentioned in the text; squares denote dredge locations mentioned in the text. Modified from Nakanishi et al. (1999).

Formation and Tectonic History of Shatsky Rise

Much of what is known about the tectonics of Shatsky Rise is based on the magnetic lineations that surround the plateau and in some places transect it (Fig. 2; Sager et al., 1988; Nakanishi et al., 1989, 1999). The lineations range from M21 (147 Ma; polarity ages are from Gradstein et al., 1995), bordering the southwest edge of the plateau, to M1 (124 Ma) at the northern tip of Papanin Ridge (Figs. 1, 2). Magnetic lineations have been mapped on the southeast flank of TAMU Massif, on flanks all around ORI and Shirshov massifs, in the basins between massifs, and all through Papanin Ridge (Figs. 1, 2); indeed, little of Shatsky Rise is without magnetic lineations. This observation led to the conclusion that the rise consists of three large edifices (TAMU, ORI, and Shirshov massifs) surrounded by lithosphere that is not greatly modified by plateau-building igneous activity (Sager et al., 1999; Nakanishi et al, 1999).

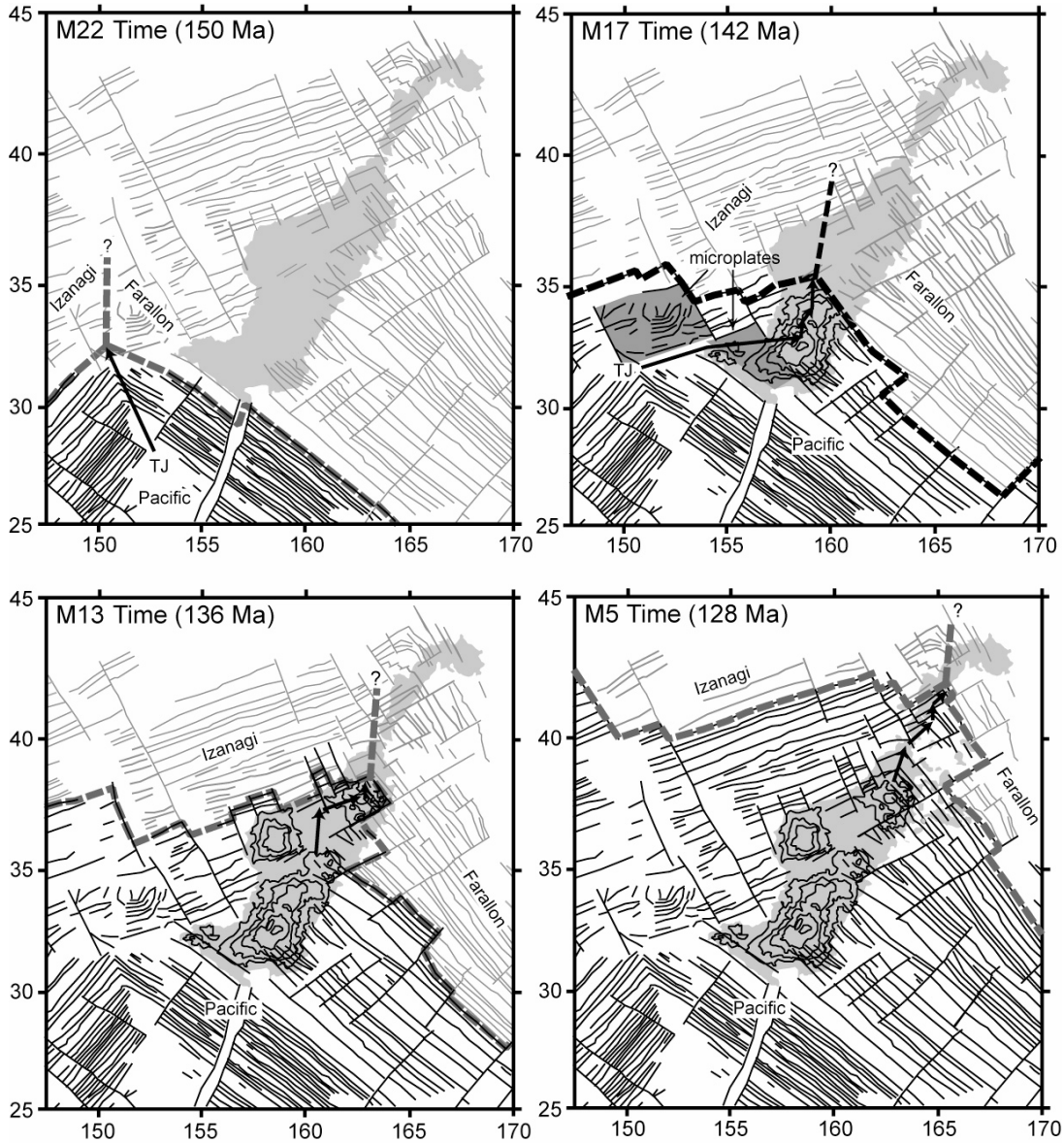

Figure 3. Tectonic history of Shatsky Rise, illustrating the migration of ridges and triple junction during formation of the rise. Heavy dashed lines denote ridges. Dark magnetic lineations existed on the Pacific plate at the time given for each panel; light lineations show future isochrons. Arrows show path of triple junction and illustrate jumps and changes in direction (modified from Nakanishi et al., 1999).

Shatsky Rise volcanism displays a progression in both age and volume along the trace of the triple junction. Rise volume decreases markedly with distance from TAMU Massif. This edifice has an estimated total crustal volume of 2.5 x 10^6 km^3, whereas ORI and Shirshov massifs both have volumes of 0.7 x 10^6 km^3. Papanin Ridge, at the north end of the plateau, has a volume of 0.4 x 10^6 km^3 and the low ridge implies a low volcanic flux over a long period (Sager et al., 1999). Age also apparently decreases with distance from TAMU massif with the ages of the volcanic edifices close to that of the underlying lithosphere, as suggested by isostasy

(Sandwell and MacKenzie, 1989). The 144.6 Ma date for the Site 1213 sills is coincident with anomaly M19, implying the bulk of the massif is M19 age or older. ORI and Shirshov massifs must be younger than TAMU Massif because they reside on lithosphere younger than M19. The youngest magnetic lineation beneath both ORI and Shirshov massifs is M14 (136 Ma) and Papanin Ridge is underlain by anomalies M10 to M1 (131 to 124 Ma). These observations are consistent with a northeastward-younging trend and volcanism following the triple junction path.

Magnetic lineations also show that a geometrically stable triple junction was moving northwest (in a Pacific plate reference frame) prior to M22 time (Fig. 3). At M21 time, the triple junction began to reorganize, with the Pacific-Izanagi isochrons showing a 30° rotation, leading to microplate formation and an 800 km eastward jump of the junction to the location of TAMU Massif (Sager et al., 1988, 1999; Nakanishi et al., 1999). Afterwards, until M3 time (126 Ma) Shatsky Rise formed along the trace of the triple junction. During this time the triple junction jumped repeatedly—at least nine times (Fig. 3; Nakanishi et al., 1999). In addition, the main volcanic massifs have sides parallel to spreading ridges and transform faults. Together, these observations imply that rise volcanism was episodic and tied to ridge jumps (Sager et al., 1999).

Geochemical Data

Chemical and isotopic data from igneous rocks are important for understanding the formation of ocean plateaus because such data provide key information on mantle sources and the conditions of magmagenesis. For Shatsky Rise, such data are few. Only a small number of dredges have recovered basalt and all of the samples are highly altered, making the interpretation of geochemicaldata difficult. Tatsumi et al. (1998) concluded from Nb-Zr-Y data that a seamount within the rise has an ocean-island-like composition similar to volcanoes of the South Pacific Superswell region, a finding that was interpreted as evidence for a plume-head, lower-mantle source. Whether or not Superswell mantle sources come from the lower mantle is a subject of debate (e.g., Janney and Castillo, 1999; Lassiter et al., 2003; Natland and Winterer, in press), but in any case the seamount is located in a basin between TAMU and ORI massifs (dredge D11, Fig. 2), and may have been formed well after the rise itself.

In contrast, the Site 1213 basalts and two of the least-altered dredge samples from the TAMU and ORI massifs (dredges D9 and D14; Fig. 2) display distinctly MORB-type isotopic characteristics (Mahoney et al., 2005). Age-corrected Nd and Pb isotope ratios of these rocks

(e.g., $\varepsilon_{Nd}(t)$ = +9.8 to +8.6) are within the range for Pacific MORB and, despite seawater alteration effects, Sr isotope values (0.70269- 0.70280) are also MORB-like. Furthermore, the Site 1213 basalts have broadly MORB-like incompatible element patterns. The plume-head model predicts ocean-island-like, not MORB-like, isotopic compositions (e.g., Campbell, 1998). Thus, at face value the few existing data do not support a plume-head origin. However, Site 1213 basalts are sills and the D9 and D14 dredge hauls sampled summit ridges; such late-stage volcanic products may not be representative of the main plateau-building lava pile beneath.

Sea Level Indicators

A plume head should produce both dynamic and constructional uplift, implying that much of the area atop a plateau will initially be subaerial, particularly if formed on young lithosphere as with Shatsky Rise (e.g., Griffiths and Campbell, 1990; 1991). For most of Shatsky Rise, evidence on basement paleo-depth is lacking; however, a dredge from the upper flank (D12 in Fig. 2) of TAMU Massif recovered shallow water fossils (rudist casts and corals; Sager et al., 1999). Because the summit of TAMU Massif is higher, it must have been at or above sea level. Furthermore, a flat summit on Shirshov Massif (beneath the sediment cap) is seen in seismic profiles (Sager et al., 1999) and indicate erosion by wave action. Thus, it appears likely that conditions during emplacement were sufficient to raise some areas of the rise above sea level.

What formed Shatsky Rise – a plume head or ridge tectonics?

Shatsky Rise initially was attributed to plume volcanism because it is a very large, somewhat linear, igneous construct (Sager et al., 1988; Nakanishi et al., 1989). Indirect evidence of a rapid eruption rate led to the proposal that the plateau formed from a plume head (Sager and Han, 1993; Nakanishi et al., 1989; Sager et al., 1999). At first blush, this explanation seems a good one. It predicts a trail of age-progressive volcanism tracking the motion of the plate over a nearly fixed source (Morgan, 1971, 1972). Shatsky Rise seems to fit this criterion because existing age constraints imply that the rise becomes younger northeastward. Aseismic ridges and seamount chains connect Shatsky Rise with Hess Rise, apparently continuing the younging-eastward trend. Moreover, a similarity of ages and trends between Shatsky-Hess rises and the Mid-Pacific Mountains even suggests that the volcanic tracks record the motion of the Pacific plate over nearly fixed mantle sources (Sager, in press).

Arrival of a plume head should cause voluminous flood-basalt-type magmatism, with peak volcanism occurring over a brief period (<2 Myr in several continental flood basalts), and significant amounts of initial uplift (e.g., Richards et al., 1989; White and McKenzie, 1989; Campbell and Griffiths, 1990; Duncan and Richards, 1991). As summarized above, existing evidence indeed suggests that at least the highest portions of TAMU Massif were initially shallow. As also noted, although emplacement rates are not known for most of Shatsky Rise, the radiometric age of the Site 1213 basalts combined with the nearby seafloor magnetic lineations suggests that TAMU Massif was constructed at a very high average rate between 1.2 and 4.6 km^3/yr. The upper value is more than a quarter of the 16.8 km^3/yr of new ocean crust (e.g., Larson, 1991) estimated to be formed worldwide today at ocean ridges. Moreover, the estimated 1.8×10^6 km^3 volume of the initial TAMU Massif eruption implies a source volume equivalent to a sphere 224-408 km in diameter, assuming a mean melt fraction between 5 to 30% (cf. Coffin and Eldholm, 1994), a volume consistent with supply by an actively upwelling plume head.

The geometry of Shatsky Rise also appears to support the plume head hypothesis. Apparently, the emplacement rate of igneous rock waned with time, as shown by the northeastward decrease in size coupled with the ages inferred from magnetic lineations; this decrease is consistent with a transition from plume head to plume tail (Sager et al., 1999). A plume-type hypothesis is likewise an attractive explanation for the odd behavior of the Pacific-Farallon-Izanagi triple junction during the ~20 Myr that the plateau was forming. The arrival of a plume head, a major source of heat and tensional stress on the lithosphere, is a potential reason for the initial 800 km jump of the triple junction. Heat and flux of upwelling mantle from a plume might have "pinned" the triple junction near the plume head (and later, tail), explaining the repeated triple junction jumps and the observation that the triple junction did not migrate away from the rise as it should have given the velocities of surrounding plates (Sager et al., 1988). In short, a plume head is a plausible explanation for many Shatsky Rise characteristics.

However, some important observations are not explained easily, if at all, by the plume head model. The MORB-type isotopic signature of the existing Shatsky basalts already has been noted. Another nagging point is the ridge reorganization that occurred near the time that Shatsky Rise formed. Just after M21 time, synchronous with the beginning of Shatsky Rise eruptions, the Pacific-Izanagi ridge rotated ~30° (Sager et al., 1988). It is generally accepted that plate motion is driven primarily by subduction (e.g., Lithgow-Bertelloni and Richards, 1998), so it is unclear

how a plume head could cause plate velocity to change by acting on the trailing boundary at the ridge. Although a plume may tend to "capture" nearby ridges because it is a major source of heat and actively upwelling mantle (e.g., Kleinrock and Phipps Morgan, 1988), the ridge reorientation occurred >800 km from the alleged plume center. If plume activity and plate motions are independent or only loosely coupled, as is widely believed (e.g., Eldholm and Coffin, 2000), the temporal proximity of these two events would have to be a coincidence.

Another apparent coincidence is the proximity of plume head and triple junction. Although a ridge or triple junction may jump or reorganize to stay near a plume (e.g., Kleinrock and Phipps Morgan, 1988), this assumes that the ridges are already near the plume. How likely is a plume head to rise within 800 km of a triple junction? Assuming plumes form randomly, the probability of one striking within 800 km of a triple junction is only ~0.4%. If more than one plume head erupted within a given period, the probability can be increased by a factor N, where N is the number of plumes. This simple calculation ignores mantle convection or basal lithosphere topography that might help steer plumes toward a ridge (e.g., Courtillot et al., 1999; Jellinek et al., 2003; Braun and Sohn, 2003). Nevertheless, having a plume head "find" a triple junction would seem a low probability event.

Curiously, western Pacific bathymetry and magnetic lineations seem to imply that other similar plume-ridge coincidences occurred. Some other plateaus formed along or near the paths of the Pacific-Farallon-Izanagi triple junction as well as the Pacific-Farallon-Phoenix triple junction, located on the east end of the Pacific plate (Fig. 4). Moreover, many of these plateaus are located near proposed ridge reorganizations. After Shatsky Rise, Hess Rise may have formed near the track of the Pacific-Farallon-Izanagi triple junction as it jumped eastward. Similarly, Magellan Plateau, the oldest part of the Mid-Pacific Mountains, and probably the Manihiki Plateau were all formed near the track of the Pacific-Farallon-Phoenix triple junction (Fig. 4; Sager, in press). Explaining all of these plateaus by plume heads independent of ridge dynamics requires many recurrences of a low-probability event. To remain plausible, the plume headhypothesis must assume that plumes and triple junctions are somehow attracted to each other.

How could ridge tectonics lead to plateau formation? Triple junctions could be the key. Ridges that meet at a triple junction are a focal point for strong upwelling (e.g., Georgen and Lin, 2002), but present-day triple junctions are clearly not sites of plateau formation. The

discrepancy between the excess volcanism associated with Late Jurassic and Early Cretaceous Pacific triple junctions and the paucity of such activity during the Late Cretaceous through Cenozoic may be explained by the "fertile" mantle hypothesis (a.k.a. the "perisphere" hypothesis; e.g., Anderson et al., 1992; Anderson, 1995; Smith and Lewis, 1999; Smith, 2003). This hypothesis states that extensive regions of the shallow asthenosphere have a lower melting point (because of higher volatile content, a more mafic composition, and/or higher potential temperature) than the asthenosphere beneath the present-day ridge system. Although the fertile mantle hypothesis is rejected as a general explanation by many workers, the Late Jurassic-Early Cretaceous Pacific may be a very special case. During this period, much of the Pacific plate (which was then far smaller than at present) may have been located over an anomalously hot region of asthenosphere that now lies beneath the South Pacific Superswell and which has long been an area of oceanic island and seamount production (e.g., McNutt and Fischer, 1987; Staudigel et al., 1991). Today, this region is far from a spreading center and is characterized by several short-lived, poorly understood hotspots that may represent shallow-sourced plumes or entirely non-plume processes (e.g., Janney and Castillo, 1999; Lassiter et al., 2003; Courtillot et al., 2003; Koppers et al., 2003). Triple junction formation in such an area may have promoted excess melting of anomalously fusible mantle and thus plateau formation. The MORB-type isotopic ratios of the few existing Shatsky samples, all of which are from the last stages of volcanism at their sites, are explicable in this context because isotopically normal MORB-source mantle is predicted to underlie the shallow asthenosphere and to well up and gradually replace it as it melts out and advects away from the melting region (e.g., Anderson, 1995).

Finally, could the rise have been formed by meteorite impact, as Rogers (1982) suggested? This hypothesis has recently been revisited for the Ontong Java Plateau (Ingle and Coffin, 2004; Tejada et al., 2004). It readily accounts for the MORB-type isotopic ratios of the Shatsky Rise basalts, as removal of the lithosphere by the impacting object would cause massive melting of the underlying mantle, which normally should be MORB-type mantle (in contrast, the Ontong Java basalts all lack a MORB-like isotopic signature). However, this hypothesis (a) requires the coincidence of a large impact (itself a rare event) within 800 km of a pre-existing triple junction, and it fails to explain (b) the 30° Pacific-Izanagi ridge reorientation at M21 time and (c) the lack of any evidence for the predicted massive destruction and disruption of seafloor over a very large area surrounding the impact site (Mahoney et al., 2005).

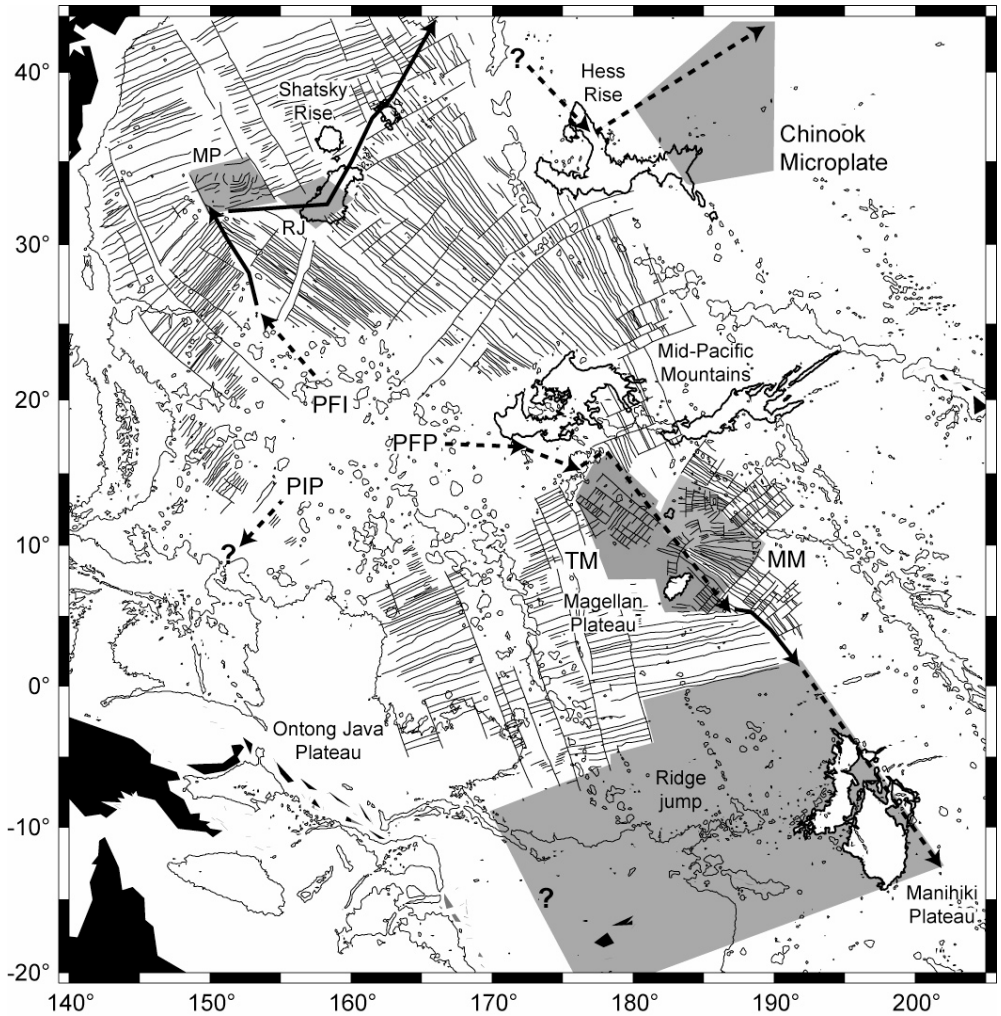

Figure 4. Mesozoic microplates and plateaus in the wake of two Pacific triple junctions. Thin solid lines are magnetic lineations. Heavy solid lines show the migration of triple junctions where clearly indicated by the lineations. Dashed heavy lines show inferred migration or jumps. Gray areas show microplates or lithosphere accreted by ridge jumps. Data sources: Tamaki and Larson (1988), Nakanishi and Winterer (1998), Nakanishi et al. (1989, 1992, 1999), Sager et al. (1999). MP = unnamed microplate; TM = Trinidad Microplate; MM = Magellan Microplate; P-F-I = Pacific-Farallon-Izanagi triple junction; P-F-P =Pacific-Farallon-Phoenix triple junction; P-I-P = Pacific-Izanagi-Phoenix triple junction.

In summary, Shatsky Rise clearly formed in association with plate-velocity changes and ridge and triple junction reorganizations during a period when several plateaus appear likely to have formed near ridges in general and triple junctions in particular. Although the plume head hypothesis can explain many features of Shatsky Rise, it requires significant *ad hoc* coincidences or modifications. Alternatively, the rise may be explained by anomalous volcanism induced by changes in plate boundaries and lithospheric stress over a region of anomalously fusible mantle.

Such a hypothesis requires no coincidence of triple junction location and site of plume impingement, and can explain the MORB-type signature of late-stage basalts from Shatsky Rise. However, it also relies on unusual circumstances. Indeed, no matter what the hypothesis, unusual circumstances of some sort appear to be required, as illustrated by the dichotomy of Pacific plateau formation in the Late Jurassic and Early Cretaceous versus the paucity of such features since. At the present, data for and against each hypothesis are incomplete and largely circumstantial. As a result, the mystery of how Shatsky Rise formed is still an open question.

PROPOSED DRILLING PROGRAM

Testing Hypotheses

The plume head model makes relatively specific predictions that can be tested with drilling. A plume head should cause significant uplift, implying that summit lavas from Shatsky Rise were subaerial. For this reason, several holes should be drilled on summit platforms of the plateau. Peak plume-head volcanism should occur over a short period of time. If so, radiometric ages from several locations on TAMU Massif, the edifice thought to represent the initial volcanic outburst, should have a narrow range of values. Furthermore, if TAMU Massif formed mainly within a single reversed polarity interval (Sager and Han, 1993), lavas drilled from this massif will have a reversed polarity. In contrast, magnetic lineations and lineation-parallel faulting on the northeast side of TAMU Massif imply that this part of the massif formed near the ridge over a longer period of time (Sager et al., 1999; Nakanishi et al., 1999). If true, samples recovered from basement in this region should give a range of younger ages; they also could be isotopically more MORB-like than those from the bulk of the massif. However, the existing, isotopically MORB-like samples from the upper parts of the TAMU and ORI massifs would be anomalous, representing only a tiny volume of late-stage magmas, perhaps derived from the periphery of the plume. Instead, rocks with ocean-island-type Nd-Pb-Hf-Sr isotopic compositions are predicted to make up the basement of all three massifs. Furthermore, if the plume head originates near the core-mantle boundary, then a core signature may be present in Os isotope signatures of basement lavas, particularly $^{186}Os/^{188}Os$ (e.g., Brandon et al., 2003); other platinum-group elements also might show enrichments (e.g., Chazey and Neal, 2004).

In contrast, the hypothesis of plateau formation by a ridge or triple junction jumping into a region of more-fusible, fertile perisphere predicts that lavas with ocean-island-type isotopic

characteristics are produced initially but gradually replaced by MORB-type isotopic signatures as magmatism proceeds. A core-derived signal is not predicted. Large-scale melting is focused at the plate boundary and may continue for a period of at least several million years, as long as fertile, shallow asthenosphere is present. Moreover, uplift is predicted to be less than for the plume-head, because dynamic uplift caused by actively upwelling buoyant mantle is not present.

Proposed Drill Sites and Program

To properly test plume and ridge-controlled hypotheses for Shatsky Rise formation, samples representing a wide geographic and tectonic range are needed. We would like to drill at many locations, but should penetrate basement by >100 m in order to gather samples below a weathered surface zone (if present) and to increase the odds of sampling a large number of flows. Following the general one-leg (or first-leg) plateau-drilling strategy recommended in several workshop reports (e.g., Dick et al., 1996) that emphasizes a wide distribution of sites, each with 100-300 m of basement penetration, we propose six drill sites, with four on the TAMU Massif and one each on ORI and Shirshov massifs (Fig. 5, Table 1). The plan is to drill 100 m into basement at four sites and 300 m at two sites, totaling 1000 m of igneous basement penetration. Sites with 100 m of basement penetration are planned as single-bit holes, a depth that is approximately what can be achieved by drilling through a thin sediment layer and into basement until the bit is worn out. A goal of lesser basement penetration is not efficient because of the time required to position the ship and lower/recover the drill string. Greater penetration is always desirable, but comes at the cost of time needed to change drill bits. In the two deeper-penetration sites, we propose multiple reentries using a free-fall funnel guide-base. Using this small, light guide-base can potentially save significant time that would be spent assembling and installing a large guide-base. Although the proposed site locations are chosen partly to minimize sediment cover, total sediment penetration will be ~1363 m (Tab1e 1). All sediment coring is planned using the rotary core barrel (RCB) to save time.

All sites have the primary goal of recovering a significant section of relatively fresh igneous rock that will allow investigators to obtain data on magmatic chemical and isotopic composition, and to determine radiometric ages, paleolatitudes, and other characteristics that will be critical in evaluating the mechanisms by which Shatsky Rise formed. The four sites on TAMU Massif are located to examine the duration and geochemical variability of volcanism at this initial and most massive edifice. Site SRSH-2A is positioned on the lower, southwest flank,

just above a basal-flank ridge at the edge of the rise. This site will provide a record of the earliest TAMU Massif eruptions. Moreover, this site will help characterize the unfaulted southwest flank, which appears to be an unmodified volcanic slope. Existing Site 1213 provides the middle-flank hole of a transect to the rise top. Two sites will sample the summit area. Site SRSH-3 is planned as a multiple-reentry hole to core 300 m into basement. This site is located on the east side of the summit to avoid sampling possible late-stage (even post-erosional) volcanism possibly represented by the summit ridge on the west side. Site SRSH-5, is located on the west side of the summit, ~22 km down-slope from the summit ridge, specifically to sample late-stage lavas, if present. Site SRSH-6 is located at the edge of the northeast "nose" of TAMU Massif, in an area where magnetic lineations are traced through the rise (Fig. 5). This site must have formed late in TAMU Massif history. What is more, it is at the location of the triple junction, on the faulted northeast flank of the massif. Thus this site contrasts with the others from TAMU Massif, which seem to be older and may have formed in a non-ridge setting.

Sites SRCH-3 and SRNH-1 are located at the summits of the ORI and Shirshov massifs, respectively (Fig. 5). They will provide records for these massifs comparable to those from the plateau summit of TAMU Massif. Site SRCH-3 is planned as a multiple-reentry hole, similar to SRSH-3 on TAMU Massif. This site will allow investigators to determine whether predictions of age progression are correct and to compare geochemical characteristics across the plateau. Likewise, the Shirshov Massif summit hole, SRNH-1, will address similar questions.

In all, the proposed drilling will require 41 days, assuming igneous penetration rates of 2.3 m/hr (the average for ODP Leg 192 on Ontong Java Plateau) and sediment penetration rates like those at Site 1213. The time estimates (Table 1) also assume that free-fall funnels are used for reentry cones. Logging is planned only in the two deeper holes, with a total of 2.6 days allotted. The logging goals are to obtain continuous physical properties measurements and images of the lava sequences to better understand geophysical records and volcanic construction. Transit time of 12.4 days is calculated assuming ports in Guam and Tokyo.

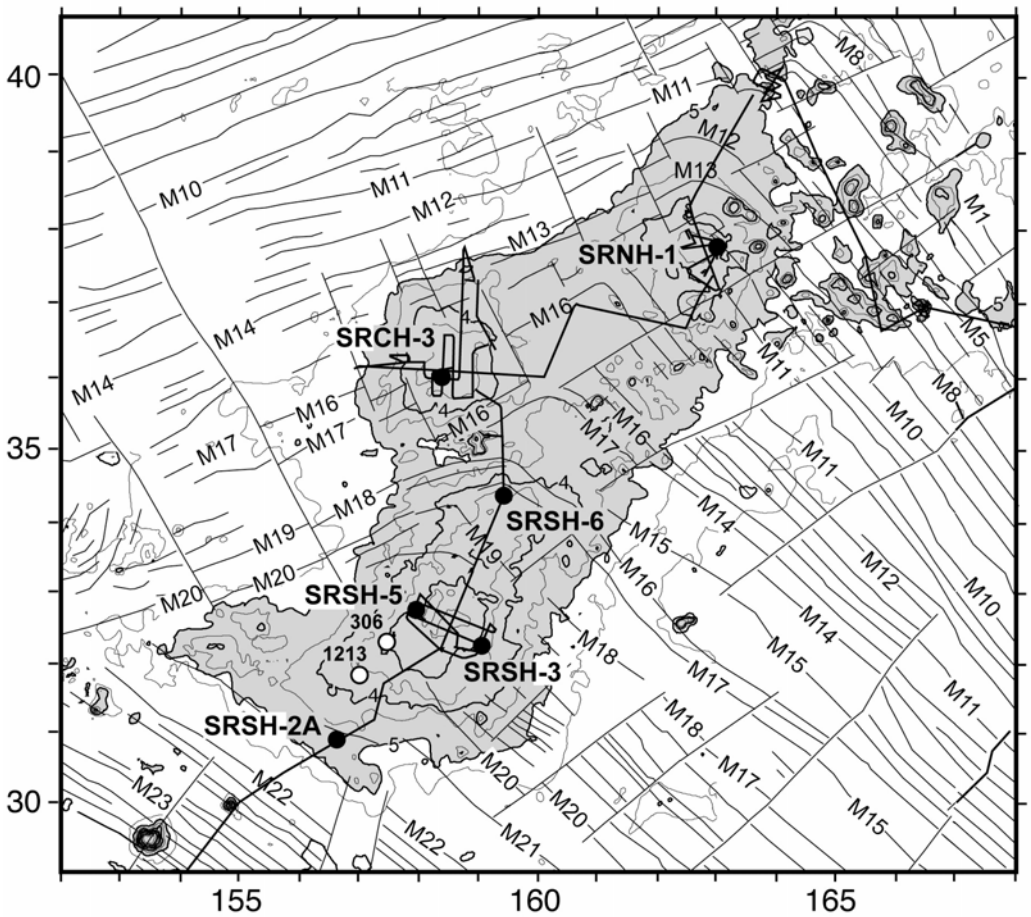

Figure 5. Proposed drill sites superimposed on bathymetry and magnetic lineation map. Open circles show DSDP and ODP sites mentioned in text. Heavy line is site survey cruise track (Cruise TN037, R/V *Thomas G. Thompson*).

Table 1. Drilling time estimates.

Site	Location Lat (N)	Lon (E)	Depth (m)	Sediment thickness (m)	Basalt Thickness (m)	Drilling time (d)	Logging time (d)
SRSH-2A	30° 49.17'	156° 21.90'	4721	297	100	6.4	0.0
SRSH-3	32° 18.57'	158° 59.88'	2987	311	300	11.5	1.4
SRSH-5	32° 50.98'	157° 52.92'	3450	210	100	4.6	0.0
SRSH-6	34° 25.32'	159° 22.93'	3268	150	100	4.2	0.0
SRCH-3	36° 00.52'	158° 20.97'	3243	130	300	9.3	1.2
SRNH-1	37° 49.27'	162° 59.19'	3339	265	100	5.0	0.0
totals				1363	1000	41.0	2.6
transit							12.4
grand total							56.0

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IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

654-Full2

New ■ **Revised** □

Section A: Proposal Information

Title of Proposal:	Testing Plume and Plate Models of Ocean Plateau Formation at Shatsky Rise, Northwest Pacific Ocean
Date Form Submitted:	1 October 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Coring igneous basement rocks for geochemiscal, isotopic, radiometric dating, paleolatitude, igneous geology. To determine the origin and emplacement history of Shatsky Rise basement rocks.
List Previous Drilling in Area:	DSDP 7, 32, 86 ODP 132, 198

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SRSH-2A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Shatsky Rise
Latitude:	Deg: 30	Min: 49.17	Jurisdiction:	International
Longitude:	Deg: 156	Min: 21.90	Distance to Land:	1500 km
Coordinates System:	WGS 84-X Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	4721m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	297 m What sed. thickness? 297 m	100 m
		Total Penetration: 397 m
General Lithologies:	Ooze – 41 m, Cherty chalk – 200 m Cherty shaley chalk – 56 m	Basalt – 100 m

Coring Plan: *(Specify or check)*

☐ 1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ■ RCB ☐ Re-entry ☐ HRGB

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	☐	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	☐	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma	☐
Gamma Ray	☐	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	☐	Side-Wall Core Sampling	☐				
Acoustic	☐						
Formation Image	☐			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* _____ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days: Drilling/Coring: 6.4 | Logging: 0.0 | Total On-Site: 6.4

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud olcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Typhoon season: July-November; Shatsky at edge of Kuroshio current; 2-3 kt currents at South High summit during site survey.

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-2A	Date Form Submitted: 1 October 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time Cruise TN037, R/V Thomas Thompson, Time: 0115Z 29 Aug 94 Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time Crossing Lines(s):
3	Seismic Velocity†		X	Can be reconstructed from previous drilling results.
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz		X	Location of Site on line (Time) Cruise TN037
7	Swath bathymetry		X	Cruise TN037
8a	Side-looking sonar (surface)			
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics		X	Cruise TN037
11b	Gravity		X	Cruise TN037
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation		X	Cruise TN037
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New ■ *Revised* □

Proposal #:	Site #: SRSH-2A	Date Form Submitted: 1 October 2004
Water Depth (m): 4721	Sed. Penetration (m): 297	Basement Penetration (m): 70

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■
Are high temperatures expected at this site? Yes ☐ No ■
Are there any other special requirements for logging at this site? Yes ☐ No ■
If "Yes" Please describe requirements:_____

_____

What do you estimate the total logging time for this site to be:_____0.0_____

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity		
Litho-Density		
Natural Gamma Ray		
Resistivity-Induction		
Acoustic		
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-2A	Date Form Submitted: 1 October 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	RCB coring through 237 m pelagic sediments and sedimentary rock with 100 m penetration into igneous basement
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	None
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	None
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No. Open ocean pelagic sedimentation. Insufficient source material, insufficient temperatures, and no trapping structure.
6	What "special" precautions will be taken during drilling?	None
7	What abandonment procedures do you plan to follow:	Standard IODP procedure
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Frequent typhoons in late summer and early fall; Kuroshiro current sometimes affects site
9	Summary: What do you consider the major risks in drilling at this site?	None

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New *Revised*

Proposal #:	Site #: SRSH-2A	Date Form Submitted:

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-41		Neo-gene		Pelagic ooze	mid-gyre		
41-200 m		Cretac-eous		Chert/chalk	pelagic		
200-297		Cretaceous		Shaly chalk	pelagic		

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

654-Full2

New ■ **Revised** □

Section A: Proposal Information

Title of Proposal:	Testing Plume and Plate Models of Ocean Plateau Formation at Shatsky Rise, Northwest Pacific Ocean
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List Previous Drilling in Area:	DSDP 7, 32, 86 ODP 132, 198

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SRSH-3	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Shatsky Rise
Latitude:	Deg: 32	Min: 18.57	Jurisdiction:	International
Longitude:	Deg: 158	Min: 59.88	Distance to Land:	1500 km
Coordinates System:	WGS 84-X Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	2987 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	311 m What is sed. thickness? 311 m	300 m
		Total Penetration: 611 m
General Lithologies:	Ooze – 50 m Cherty chalk – 150 m Cherty shaley chalk – 111m	Basalt – 300 m

Coring Plan: *(Specify or check)*

1-2-3-APC	VPC*	XCB	MDCB*	PCS	RCB	Re-entry	HRGB
☐	☐	☐	☐	☐	■	☐	☐

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* _____ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from	m	to	m,	m intervals
from	m	to	m,	m intervals

Basic Sampling Intervals: 5m

Estimated days: Drilling/Coring: 11.5 | Logging: 1.4 | Total On-Site: 12.9

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	■	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud olcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Typhoon season: July-November; Shatsky at eadge of Kuroshio current; 2-3 kt currents at South High summit during site survey.

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-3	Date Form Submitted: 1 October 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time Cruise TN037, R/V Thomas Thompson, Time: 1207Z 23 Aug 94 Crossing Lines(s): 2107Z 24 Aug 94
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time Crossing Lines(s):
3	Seismic Velocity†		X	Can be reconstructed from previous drilling results.
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz		X	Location of Site on line (Time) Cruise TN037
7	Swath bathymetry		X	Cruise TN037
8a	Side-looking sonar (surface)			
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics		X	Cruise TN037
11b	Gravity		X	Cruise TN037
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation		X	Cruise TN037
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New ■ *Revised* □

Proposal #:	Site #: SRSH-3	Date Form Submitted: 1 October 2004
Water Depth (m): 2987	Sed. Penetration (m): 311	Basement Penetration (m): 300

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ■
Are high temperatures expected at this site? Yes ☐ No ■
Are there any other special requirements for logging at this site? Yes ☐ No ■
If "Yes" Please describe requirements:_____

_____

What do you estimate the total logging time for this site to be:_____1.4 days__

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Characterization of formation porosity	1
Litho-Density	Continuous record of formation density	1
Natural Gamma Ray	Log – core correlation	1
Resistivity-Induction	Continuous record of formation porosity/density/resistivity	1
Acoustic	Continuous record of formation sonic velocity	1
FMS	Images of basalt flows, structure	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-3	Date Form Submitted: 1 October 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Coring with RCB through 311 m of sediment and 300 m basalt.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	None
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	None
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No. Insufficient source of organic matter; temperatures too low; no trapping structure.
6	What "special" precautions will be taken during drilling?	None
7	What abandonment procedures do you plan to follow:	Standard IODP
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	In typhoon area of western Pacific during summer and fall. Near edge of Kuroshiro current.
9	Summary: What do you consider the major risks in drilling at this site?	None

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New *Revised*

Proposal #:	Site #: SRSH-3	Date Form Submitted: 1 October 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-50 m		Neo-gene		Pelagic ooze	Pelagic		
50-200 m		Cret-aceous		Chalk with chert	Pelagic		
200-311 m		Cret-aceous		Shaly chalk	pelagic		

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

654-Full2

New **Revised**

Section A: Proposal Information

Title of Proposal:	Testing Plume and Plate Models of Ocean Plateau Formation at Shatsky Rise, Northwest Pacific Ocean
Date Form Submitted:	1 October 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Coring igneous basement rocks for geochemiscal, isotopic, radiometric dating, paleolatitude, igneous geology. To determine the origin and emplacement history of Shatsky Rise basement rocks.
List Previous Drilling in Area:	DSDP 7, 32, 86 ODP 132, 198

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SRSH-5	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Shatsky Rise
Latitude:	Deg: 32	Min: 50.98	Jurisdiction:	International
Longitude:	Deg: 157	Min: 52.92	Distance to Land:	1500 km
Coordinates System:	WGS 84-X Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3450 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	210 m What is the sed. 210 m ickness?	100 m
		Total Penetration: 310 m
General Lithologies:	Ooze – thin drape Cherty chalk – 210m	Basalt – 100 m

Coring Plan: *(Specify or check)*

☐ 1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ■ RCB ☐ Re-entry ☐ HRGB

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	☐	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	☐	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma	☐
Gamma Ray	☐	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	☐	Side-Wall Core Sampling	☐				
Acoustic	☐						
Formation Image	☐			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* _____°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days: Drilling/Coring: 4.6 | Logging: 0.0 | Total On-Site: 4.6

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	■	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud olcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Typhoon season: July-November; Shatsky at eadge of Kuroshio current; 2-3 kt currents at South High summit during site survey.

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-5	Date Form Submitted: 1 October 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time Cruise TN037, R/V Thomas Thompson, Time: 2246Z 25 Aug 94 Crossing Lines(s): 1114Z 27 Aug 94
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time Crossing Lines(s):
3	Seismic Velocity†		X	Can be reconstructed from previous drilling results.
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz		X	Cruise TN037
7	Swath bathymetry		X	Cruise TN037
8a	Side-looking sonar (surface)			
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics		X	Cruise TN037
11b	Gravity		X	Cruise TN037
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation		X	Cruise TN037
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New ☐ *Revised* ☐

Proposal #:	Site #: SRSH-5	Date Form Submitted: 1 October 2004
Water Depth (m): 3450	Sed. Penetration (m): 210	Basement Penetration (m): 100

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ☐
Are high temperatures expected at this site? Yes ☐ No ☐
Are there any other special requirements for logging at this site? Yes ☐ No ☐
If "Yes" Please describe requirements:_____

_____

What do you estimate the total logging time for this site to be:_____0.0_____

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity		
Litho-Density		
Natural Gamma Ray		
Resistivity-Induction		
Acoustic		
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-5	Date Form Submitted: 1 October 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	RCB coring through 210 m of pelagic carbonate sediments with chert; 100 m penetration into igneous basement
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	None
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	None
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No. No source of organic material; insufficient heat; no trapping structure
6	What "special" precautions will be taken during drilling?	None
7	What abandonment procedures do you plan to follow:	Standard IODP
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Typhoon area in summer-fall. Edge of Kuroshiro current.
9	Summary: What do you consider the major risks in drilling at this site?	None

IODP Site Summary Forms:

Form 5 – Lithologic Summary

Proposal #:	Site #: SRSH-5	Date Form Submitted: 1 October 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-20		Neo-gene		Pelagic ooze	Pelagic		
20-210		Cret-aceous		Chalk with chert	pelagic		

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

654-Full2

New **Revised**

Section A: Proposal Information

Title of Proposal:	Testing Plume and Plate Models of Ocean Plateau Formation at Shatsky Rise, Northwest Pacific Ocean
Date Form Submitted:	1 October 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Coring igneous basement rocks for geochemiscal, isotopic, radiometric dating, paleolatitude, igneous geology. To determine the origin and emplacement history of Shatsky Rise basement rocks.
List Previous Drilling in Area:	DSDP 7, 32, 86 ODP 132, 198

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SRSH-6	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Shatsky Rise
Latitude:	Deg: 34	Min: 25.32	Jurisdiction:	International
Longitude:	Deg: 159	Min: 22.93	Distance to Land:	1500 km
Coordinates System:	WGS 84-X Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3268 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	150 m What is the sed. thickness? 150 m	100 m
		Total Penetration: 250 m
General Lithologies:	Ooze – 20 m Cherty chalk – 130 m	Basalt – 100 m

Coring Plan: *(Specify or check)*

☐ 1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ■ RCB ☐ Re-entry ☐ HRGB

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	☐	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	☐	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma	☐
Gamma Ray	☐	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	☐	Side-Wall Core Sampling	☐				
Acoustic	☐						
Formation Image	☐			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* _____°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days: Drilling/Coring: 4.2 | Logging: 0.0 | Total On-Site: 4.2

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	■	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Typhoon season: July-November; Shatsky at eadge of Kuroshio current; 2-3 kt currents at South High summit during site survey.

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-6	Date Form Submitted: 1 October 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time Cruise TN037, R/V Thomas Thompson, Time: 0225Z 22 Aug 94 Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time Crossing Lines(s):
3	Seismic Velocity†		X	Can be reconstructed from previous drilling results.
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz		X	Location of Site on line (Time) Cruise TN037
7	Swath bathymetry		X	Cruise TN037
8a	Side-looking sonar (surface)			
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics		X	Cruise TN037
11b	Gravity		X	Cruise TN037
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation		X	Cruise TN037
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New ☐ *Revised* ☐

Proposal #:	Site #: SRSH-6	Date Form Submitted: 1 October 2004
Water Depth (m): 3268	Sed. Penetration (m): 150	Basement Penetration (m): 100

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ☐
Are high temperatures expected at this site? Yes ☐ No ☐
Are there any other special requirements for logging at this site? Yes ☐ No ☐
If "Yes" Please describe requirements:_____

_____

What do you estimate the total logging time for this site to be:_____0.0_____

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity		
Litho-Density		
Natural Gamma Ray		
Resistivity-Induction		
Acoustic		
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRSH-6	Date Form Submitted: 1 October 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	RCB through 150 m of sediment and 100 m into igneous basement
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	None
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	None
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No. Insufficient source organic material; insufficient temperatures; no trapping structure
6	What "special" precautions will be taken during drilling?	None
7	What abandonment procedures do you plan to follow:	Standard IODP
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Typhoon area from summer to fall. Occasional strong currents from Kuroshiro
9	Summary: What do you consider the major risks in drilling at this site?	None

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New *Revised*

Proposal #:	Site #: SRSH-6	Date Form Submitted:

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-20		Neo-gene		Pelagic ooze	Pelagic		
20-150		Cret-aceous		Chalk with chert	pelagic		

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

654-Full2

New **Revised**

Section A: Proposal Information

Title of Proposal:	Testing Plume and Plate Models of Ocean Plateau Formation at Shatsky Rise, Northwest Pacific Ocean
Date Form Submitted:	1 October 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Coring igneous basement rocks for geochemiscal, isotopic, radiometric dating, paleolatitude, igneous geology. To determine the origin and emplacement history of Shatsky Rise basement rocks.
List Previous Drilling in Area:	DSDP 7, 32, 86 ODP 132, 198

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SRCH-3	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Shatsky Rise
Latitude:	Deg: 36	Min: 00.52	Jurisdiction:	International
Longitude:	Deg: 158	Min: 20.97	Distance to Land:	1500 km
Coordinates System:	WGS 84-X Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3243 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	133 m What is the sed. 133 m ickness?	300 m
		Total Penetration: 333 m
General Lithologies:	Ooze – 25 m, Cherty chalk – 63m Cherty shaley chalk – 45m	Basalt – 300 m

Coring Plan: *(Specify or check)*

☐ 1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ■ RCB ☐ Re-entry ☐ HRGB

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	■	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	■	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma	☐
Gamma Ray	■	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	■	Side-Wall Core Sampling	☐				
Acoustic	■						
Formation Image	■			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* _____ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days: Drilling/Coring: 9.3 | Logging: 1.2 | Total On-Site: 10.5

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	■	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud olcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Typhoon season: July-November; Shatsky at eadge of Kuroshio current; 2-3 kt currents at South High summit during site survey.

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRCH-3	Date Form Submitted: 1 October 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time Cruise TN037, R/V Thomas Thompson, Time: 1745Z 19 Aug 94 Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time Crossing Lines(s):
3	Seismic Velocity†		X	Can be reconstructed from previous drilling results.
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz		X	Location of Site on line (Time) Cruise TN037
7	Swath bathymetry		X	Cruise TN037
8a	Side-looking sonar (surface)			
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics		X	Cruise TN037
11b	Gravity		X	Cruise TN037
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation		X	Cruise TN037
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New ☐ *Revised* ☐

Proposal #:	Site #: SRCH-3	Date Form Submitted: 1 October 2004
Water Depth (m): 3243	Sed. Penetration (m): 133	Basement Penetration (m): 300

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ☐
Are high temperatures expected at this site? Yes ☐ No ☐
Are there any other special requirements for logging at this site? Yes ☐ No ☐
If "Yes" Please describe requirements:_____

_____

What do you estimate the total logging time for this site to be:_____1.2 days__

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Continuous records of formation porosity.	1
Litho-Density	Continuous records of formation bulk density.	1
Natural Gamma Ray	Core log integration.	1
Resistivity-Induction	Continuous records of resistivity, porosity, and density proxies in igneous basement	1
Acoustic	Continuous records of igneous basement sonic velocity.	1
FMS	Imaging of igneous flow structure and porosity.	1
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRCH-3	Date Form Submitted: 1 October 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	RCB through 133 m of sedimentary cover and 300 m into igneous basement.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	None
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	None
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No. Insufficient organic source rocks; insufficient temperature for maturation; lack of trapping structures.
6	What "special" precautions will be taken during drilling?	None
7	What abandonment procedures do you plan to follow:	Standard IODP
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Typhoon area during summer and fall. Strong currents occasionally caused by Kuroshio current.
9	Summary: What do you consider the major risks in drilling at this site?	None

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New ■ *Revised* ▢

Proposal #:	Site #: SRCH-3	Date Form Submitted: 1 October 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-25		Neo-gene		Ooze	Pelagic		
25-88		Cret-aceous		Chalk with chert	Pelagic		
88-130		Cret-aceous		Shaly chalk	pelagic		

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

654-Full2

New **Revised**

Section A: Proposal Information

Title of Proposal:	Testing Plume and Plate Models of Ocean Plateau Formation at Shatsky Rise, Northwest Pacific Ocean
Date Form Submitted:	1 October 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Coring igneous basement rocks for geochemiscal, isotopic, radiometric dating, paleolatitude, igneous geology. To determine the origin and emplacement history of Shatsky Rise basement rocks.
List Previous Drilling in Area:	DSDP 7, 32, 86 ODP 132, 198

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SRNH-1	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Shatsky Rise
Latitude:	Deg: 37	Min: 49.27	Jurisdiction:	International
Longitude:	Deg: 162	Min: 59.19	Distance to Land:	1500 km
Coordinates System:	WGS 84-X Other ( )			
Priority of Site:	Primary: X	Alt:	Water Depth:	3339 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	265 m Whatis sed. thickness? 265 m	100 m
		Total Penetration: 385 m
General Lithologies:	Ooze – 83 m Cherty chalk – 113m Charty shaley chalk – 89m	Basalt – 100 m

Coring Plan: *(Specify or check)*

1-2-3-APC	VPC*	XCB	MDCB*	PCS	RCB	Re-entry	HRGB
☐	☐	☐	☐	☐	■	■	☐

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	☐	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	☐	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma	☐
Gamma Ray	☐	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	☐	Side-Wall Core Sampling	☐				
Acoustic	☐						
Formation Image	☐			Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* _____ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from	m	to	m,	m intervals
from	m	to	m,	m intervals

Basic Sampling Intervals: 5m

Estimated days: Drilling/Coring: 5.0 | Logging: 0.0 | Total On-Site: 5.0

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	■	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud olcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☐
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

Typhoon season: July-November; Shatsky at eadge of Kuroshio current; 2-3 kt currents at South High summit during site survey.

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRNH-1	Date Form Submitted: 1 October 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time Cruise TN037, R/V Thomas Thompson, Time: 0030Z 11 Aug 94 Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time Crossing Lines(s):
3	Seismic Velocity†		X	Can be reconstructed from previous drilling results.
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz		X	Cruise TN037 Location of Site on line (Time)
7	Swath bathymetry		X	Cruise TN037
8a	Side-looking sonar (surface)			
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics		X	Cruise TN037
11b	Gravity		X	Cruise TN037
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation		X	Cruise TN037
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New ☐ *Revised* ☐

Proposal #:	Site #: SRNH-1	Date Form Submitted: 1 October 2004
Water Depth (m): 3339	Sed. Penetration (m): 285	Basement Penetration (m): 100

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No ☐
Are high temperatures expected at this site? Yes ☐ No ☐
Are there any other special requirements for logging at this site? Yes ☐ No ☐
If "Yes" Please describe requirements:_____

_____

What do you estimate the total logging time for this site to be:_____0.0_____

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity		
Litho-Density		
Natural Gamma Ray		
Resistivity-Induction		
Acoustic		
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New *Revised*

Proposal #:	Site #: SRNH-1	Date Form Submitted: 1 October 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	RCB through 285 m of sediment and 100 m into igneous basement.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	None
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	None
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No. Insufficient source organic material; insufficient temperature; no structural traps
6	What "special" precautions will be taken during drilling?	None
7	What abandonment procedures do you plan to follow:	Standard IODP
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Typhoon area in summer and fall. Occasional strong currents from Kuroshiro
9	Summary: What do you consider the major risks in drilling at this site?	None

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New [redacted] *Revised* [redacted]

Proposal #:	Site #: SRNH-1	Date Form Submitted: 1 October 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-83		Neo-gene		Ooze	Pelagic		
83-196		Cret-aceous		Chalk with chert	Pelagic		
196-285		Cret-aceous		Cherty, shaly chalk	pelagic		