Guidelines for Site Survey and Safety[1,2]

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ABSTRACT

The fact that all drilling operations involve some risk of accident or pollution has been recognized throughout the history of the Deep Sea Drilling Project (DSDP) and the Ocean Drilling Program (ODP). Policies to minimize drilling hazards originally developed during DSDP have been continually updated and improved during ODP.

These revised guidelines were developed with input from the Pollution Prevention and Safety Panel (PPSP), the Site Survey Panel (SSP), Lamont-Doherty Earth Observatory (LDEO) of Columbia University, Texas A&M University (TAMU), and Joint Oceanographic Institutions (JOI), Inc. This document covers the following topics:

- Guidelines for Site Survey and Safety Reviews: helps proponents prepare for Site Survey and Safety Panel Reviews.
- Safety and Site Survey Checklists: assists proponents in completing the ODP Site Description Forms.
- Principal Hazards: discusses hazards that can be encountered during a cruise, including environmental hazards.
- Hydrocarbon Flow during Drilling: summarizes hydrocarbon flow, kicks, and abandonment procedures.
- Logging: lists some issues to consider during logging activities.
- Responsibilities and Authority: describes precruise and cruise responsibilities and authorities of key personnel.

INTRODUCTION

The value of cruise scientific objectives must be balanced against potential hazards to enable the Ocean Drilling Program (ODP) to achieve

[1]Graber, K.K., 2006. Guidelines for site survey and safety. *ODP Tech. Note,* 32 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/tnotes/tn32/INDEX.HTM>. [Cited YYYY-MM-DD]
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these objectives while maintaining high standards of safety and pollution prevention. With diligent planning and careful operational procedures, it is possible to achieve desired goals and minimize risks.

Adherence to the old adage "an ounce of prevention is worth a pound of cure" offers the surest route to safety and prevention of pollution. Money and time spent on extra care in preliminary site surveys, choosing site locations, and planning drilling operations minimizes risks of an accident that could cause loss of life or property, damage to the environment, or handicap or even termination of this major international scientific endeavor.

The diverse sites planned for ODP drilling require emphasis on pollution prevention and safety during both site evaluations and cruise operations. This is especially the case given the continued interest in deeper sediment penetrations, natural flow features, hydrates, high-temperature features, and shallower-water sites on continental margins.

Purpose

This document

- Explains the roles of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) Pollution Prevention and Safety Panel (PPSP) and Site Survey Panel (SSP) in the review process;
- Updates outdated information about the review process; and
- Documents shipboard, precruise, cruise, and postcruise safety activities.

The document provides a practical and flexible framework on which leg- and site-specific procedures can be based by mutual agreement of the science operator (ODP at Texas A&M University [TAMU]) and Transocean, scientific community, and shipboard supervisors. It is not possible to foresee and cover all the contingencies, combinations of reactions, or ultimate effects that may occur in a given situation; therefore, a team effort is crucial to determine the best course of action and coordinate operations.

The following references contain additional information concerning safety practices and assessment:

- Introduction to Shipboard Organic Chemistry on the *JOIDES Resolution,* ODP *Technical Note,* 30 (Pimmel and Claypool, 2001).
- ODP Safety Management Policies, ODP *Technical Note,* 35 (ODP Science Services, in press).
- Hydrogen Sulfide Drilling Contingency Plan, ODP *Technical Note,* 33 (Mills et al., in press).

GUIDELINES FOR SITE SURVEY AND SAFETY REVIEWS

Overview of Scientific Proposal Processing

The JOIDES office provides scientific direction and planning advice to the ODP prime contractor, Joint Oceanographic Institutions (JOI), Inc., the ODP Science Operator at Texas A&M University (TAMU), and the ODP Wireline Logging Services Operator at Lamont-Doherty Earth

Observatory (LDEO) of Columbia University through an advisory structure of panels and committees. The two main committees are the Executive Committee (EXCOM), which oversees all policies and procedures, and the Science Committee (SCICOM), which oversees the science. These two committees and their associate subgroups forward recommendations to JOI for action. Recommendations concerning the science operator are forwarded to ODP/TAMU.

JOIDES service panels include the SSP, PPSP (also known as the Safety Panel), and Scientific Measurements Panel (SciMP), all of which provide advice to the advisory structure. The Technology and Engineering Development Committee (TEDCOM) provides advice to ODP through the Operating Committee (OPCOM) on technical matters, drilling tools, and techniques to meet scientific objectives as well as monitoring the progress of their development.

Scientific proposals are reviewed by the Science Steering and Evaluation Panels (SSEPs) for Environment and Interior, which select scientifically mature proposals for external review. SCICOM (with advice from the SSEPs) creates small, focused short-term Program Planning Groups (PPGs) to work with proponents to produce mature proposals that cover specific scientific themes.

Following reviews of proposals by external panels, the SSEPs forward scientifically mature proposals to SCICOM with a recommendation for inclusion in the drilling program. SCICOM ranks all the proposals and sends them to OPCOM. OPCOM receives reports from the SSEPs and PPGs and recommends the drilling program schedule to SCICOM for approval. The SSP provides advice to ODP through OPCOM on the adequacy of and need for site survey information relating to proposed drilling targets. The PPSP provides advice to ODP through OPCOM regarding potential safety and pollution hazards that may exist because of general or specific geology of the seafloor or as a consequence of human activities.

The JOIDES PPSP and the ODP/TAMU Safety Panel (TAMUSP) make recommendations that are considered in the final decision on specific drill sites, including advice on maximum penetration depths and required precautionary procedures. The Co-Chief Scientists typically attend the formal joint safety review with the PPSP ~9–12 months prior to the leg. During the safety review, Co-Chief Scientists or a delegate document potential safety issues extant at proposed sites and the safety panels examine these data.

The ODP/TAMU Drilling Services Department (DSD) provides ODP/TAMU management with a preliminary leg review, and ODP/TAMU management advises SCICOM and OPCOM on operational feasibility, time, cost, location, and environmental factors. SCICOM reviews and approves the proposed drilling schedule recommended by OPCOM and forwards it to EXCOM for approval. ODP/TAMU management assembles a ship schedule and assigns key personnel, and the ODP/TAMU DSD formulates a detailed operating plan in concert with the Staff Scientist/Leg Project Manager (LPM), Co-Chief Scientists, Transocean, and LDEO.

A precruise meeting is held with the Co-Chief Scientists at ODP/TAMU ~6–12 months prior to the leg, and the ODP/TAMU Operations Manager, Staff Scientist/LPM, and Laboratory Officer become involved in detailed planning with the Co-Chief Scientists. A detailed Scientific Prospectus that reflects the agreed-upon priorities and implementation strategies is prepared at the precruise meeting.

Site Survey and Safety Panel Reviews

On notification from the JOIDES office, proponents of proposals that have been highly ranked by the SSEPs must submit supporting site survey data packages to the ODP Site Survey Data Bank for archiving (see "Safety and Site Survey Checklist" in "Appendix A"). These data packages are evaluated by the SSP and PPSP to determine if

1. The proposed sites are adequately imaged from the data,
2. The sites selected based on the data can answer the scientific questions that have been posed,
3. The sites are in feasible places for the *JOIDES Resolution* to core,
4. The package contains sufficient information to support both the science and the drilling operations at each site, and
5. No natural or man-made hazards are evident near the proposed drill site that will endanger the ship, its crew, or the environment.

The SSP reviews highly ranked proposals as advised by the JOIDES office and follows those placed on the drilling schedule until each leg sails. The PPSP, on the other hand, generally reviews only scheduled legs but will preview proposals that are identified as having potential safety concerns. The PPSP previews provide proponents an opportunity to address safety issues before the final PPSP review.

Site Survey Review

At their winter and summer meetings, the SSP reviews full proposals that have undergone external review. The SSP provides advice to proponents on specific data requirements for each proposed site. These requirements are based upon the objectives of each site and the local geologic environment. SSP only reviews data submitted to the ODP Site Survey Data Bank.

The time required for a proposal to become a scheduled drilling leg depends to a large degree on completeness of the site survey data package. Proponents are therefore urged to submit as much of the required data as early as possible, once they are notified to do so by the JOIDES Office. Data must be received in the Data Bank no later than 15 February or 1 July to be reviewed by SSP at their winter or summer meetings, respectively. If survey data are to be collected in the future, the proposal should note information on the timing of cruises, firmness of funding, and period required for data processing before submission.

The Site Survey Panel will review these proposals and the supplied data and provide advice to proponents on how to improve their data packages. SSP also provides comments to SCICOM and OPCOM on the status of the site survey data package with respect to its readiness for drilling. At the same time, the panel identifies those proposals that may have potential safety problems and passes this information along to the PPSP and the proponents. Proponents of these proposals may be asked to present their data to the PPSP for a safety preview at the panel's earliest convenience. The PPSP, on examination of the data package, will provide guidance on site selection and data processing to improve imaging of the sites and on modification of site locations so they will be safe to drill and still meet the scientific objectives.

Site Survey Target Types and Data Standards

Proponents should be aware that the comments below are only guidelines. The SSP's advice to SCICOM/OPCOM on the acceptability of a data set is based on scientific judgment. In particular, SSP seeks to determine (1) whether the regional and site-specific survey data are of sufficient quality and quantity that it will be possible to select the best sites at which to address the scientific questions posed in the proposal and (2) if a site is drilled, whether the regional and site-specific survey data are of sufficient quality and quantity that the results from this borehole could likely be extrapolated over a usefully broad portion of the ocean and/or applied to related questions and analogous sites worldwide.

Target Types

Target categories describe broad types of drilling objectives (see Table T1). Individual sites with multiple objectives may be required to meet the standards of more than one of the target categories. For example, sites frequently have shallow advanced piston corer (APC) objectives (Target A) and deeper sedimentary and basement objectives (Targets D or E).

T1. Target types, p. 58.

These guidelines cover drilling targets in >650 m of water. Proposed sites in <650 m of water, regardless of target type, are governed by additional shallow-water hazard survey requirements. See **"Shallow-Water Operations"** in "Principal Hazards" for details on these specialized requirements.

Types of Survey Data

The most commonly used site survey techniques are conventional and swath bathymetry, magnetic and gravity field measurements, coring and dredging, heat flow, single- and multichannel seismic (SCS and MCS, respectively) reflection profiling, side-scan sonar, and crustal seismic refraction using ocean-bottom seismometer (OBS) and wide-angle reflection sonobuoy measurements. All survey methods are not appropriate for all sites, and specific combinations are chosen by proponents to obtain the maximum useful information for the minimum cost.

The following matrix (see Table T2) shows site survey guidelines for each target environment. Sites that lack a data type characterized as "X: required" will generally not be scheduled for drilling. Lack of a data type characterized as "Y: recommended" will not prevent scheduling drilling; however, if data of a recommended type do exist, the proponents are expected to submit the data for use by the ODP community in site selection and postdrilling interpretation. For data types marked as "X*" or "Y*," the SSP will advise, on a site by site basis, whether the specific data type is required or recommended to support the proposed science.

T2. Data-type requirements, p. 59.

Data in support of each proposed site must be submitted to the ODP Site Survey Data Bank. For details on the proper format and annotation of the data packages, go to **www.ldeo.columbia.edu/databank.**

The major data categories are:

- High-resolution seismic reflection: Acquisition and processing are designed for optimal imaging of the shallow (<1 s two-way traveltime [TWT]) section. Seismic reflection data should penetrate at least as deep as proposed total depth of drilling. Digital acquisition is preferred.

- Target B: High-resolution seismics may be required in areas where there is concern about slumping or shallow gas.
- Targets D and E: Basement objectives must be clearly imaged using either high-resolution or deep-penetration seismics, as appropriate.
- Target H: High-resolution seismic data and/or 3.5-kHz echo sounder data will be required if spudding into sediment pockets is proposed.
- Target F: Regional high-resolution seismics and/or 3.5-kHz echo sounder survey are recommended to identify potential backup sites in sediment pockets.

- Deep-penetration seismic reflection: Acquisition and processing are designed for optimal imaging of the deep (>1 s TWT) section (i.e., MCS with a large-volume, low-frequency source and a long enough streamer to provide adequate multiple suppression).
    - Targets D and E: Basement objectives must be clearly imaged using either high-resolution or deep-penetration seismics, as appropriate.
    - Target H: Regional MCS or OBS refraction survey (not necessarily including lines exactly over the site) is recommended to determine the regional crustal structure before tectonic dismemberment.
- Seismic velocity: These data are used to determine sediment thickness and drilling depths at proposed sites. Sound velocity data should include a brief description of how they were derived and where they apply, along with an estimate of their accuracy. SSP suggests that the data presentation include a graph of TWT below seafloor vs. calculated meters below seafloor (mbsf) and actual (proven by drilling) vertical seismic profile (VSP) logging velocity data in similar geologic/lithologic settings. Velocity information is required when drilling is proposed for sites with >400 m of sediment penetration.
- Grid of intersecting seismic profiles: Seismic grid and/or crossing lines over the proposed site are required. Required density of the seismic grid depends on each particular situation.
- Refraction: See Table T2 for requirements on (5a) near-surface and (5b) near-bottom collected refraction data from sonobuoy or OBS refraction profiles, tomographic imaging, expanding spread profiles, or wide-angle refraction profiles.
    - Target H: Regional MCS or OBS refraction survey is recommended to determine the regional crustal structure before dismemberment.
    - Targets F and H: near-bottom source/receiver seismic imaging is an experimental technique that holds great promise as a site survey tool. SSP is following the development of this technology with great interest and may upgrade this data type to “required” at a future date. OBS surveys are especially important in vertical relief areas (e.g., ridges and canyons).
- 3.5 kHz: High-frequency echo sounder data resolves small-scale features and gives some indication of sediment type.
    - Target H: High-resolution SCS data and/or 3.5-kHz data will be required if sites will spud into sediment pockets.

- Target F: Regional SCS and/or 3.5-kHz data are recommended to identify potential backup sites in sediment pockets.

- Swath bathymetry: Swath bathymetry from a multi-narrow-beam echo sounder or an interferometric side-scan sonar system is required for all bare-rock drilling sites. This information also may be required for any site with steep or complex topography. Areas where slumping may occur should have swath bathymetry and/or side-scan sonar data.
- Side-scan sonar imagery: See Table **T2** for requirements for (8a) surface collected and (8b) near-bottom tow data. Acoustic reflectivity from sonar devices is needed on fans and in topographically complex terrains. Areas where slumping may occur should have swath bathymetry and/or side-scan sonar data.
- Photography or video: Visual imagery from a towed vehicle or submersible is required for siting bare-rock guide bases and may be desirable to understand the tectonic or geological setting of specific nonbare rock sites.
- Heat flow: Detailed pogo-type profiles or piston core heat flow measurements are required, with in situ thermal conductivity for highest accuracy, as appropriate to the scientific problem.
- Magnetics: Regional magnetics are required if magnetic age of crust is important.
  - Target H: Regional magnetic survey is required to determine the age of the oceanic crust and the plate kinematic history of the site.
  - Gravity: Gravity for subsidence studies; sea satellite (Seasat) data may complement regional gravity picture.
- Sediment cores: Cores should be taken near all paleoenvironmental sites. All reentry sites should be supported by cores, core descriptions, and geotechnical measurements (contact ODP/TAMU for geotechnical requirements). The two limiting factors for reentry operations are (1) sufficient sediment thickness and (2) the ability to wash through the sediment section. Sediment cores will be required for Target Types F and H only if backup sites are proposed in sediment pockets.
- Rock sampling: Dredging, submersible sampling, and/or rock coring may be required when basement drilling is included in the objectives.
  - Target H: A closely spaced, precisely positioned suite of samples is required in the immediate vicinity of the drill sites, as well as a less dense suite of samples over a broader region. Samples must be analyzed for geochemical and/or petrological and structural characteristics.
  - Targets B and C: Recommended rock sampling refers to outcrops in nearby canyons or other exposures, where available.
- Water current data: This information is required when currents exceed 2 kt or frequently change directions (gyres) or when bottom shear might be a problem. Shallow-water sites may need tidal current information as well.
- Ice conditions: These data are needed for hazard assessment, scheduling drilling, and planning for ice boat support in northernmost and southernmost latitudes, as appropriate.

- OBS microseismicity: Microseismicity as determined from ocean bottom seismometers is recommended in regions where active basement faulting is expected.
- Navigation: Navigation will be accepted in date/time or shot-point units for newly acquired data. Submission of common depth point (CDP) and common midpoint (CMP) navigation is discouraged, as the numbering schemes often change with further processing. The type of navigation submitted must match the units that appear on the actual seismic lines.
- Other: Any type of data that is not listed but which may be useful in documenting the geological environment of the proposed site is acceptable. Examples of these data include weather forecasts from local/regional sources, historical data, and man-made hazards (e.g., pipelines, submarine cables, munitions dumps, abandoned holes, etc.).

Commercial Data

Proponents should be aware that in addition to SSP's data requirements they will eventually have to meet the additional requirements of the PPSP. For a brief overview of safety reviews, see **"Pollution Prevention and Safety Panel (PPSP) Review,"** below. As part of a safety review, proponents should present maps of commercial well locations near their proposed drill sites and information regarding nearby hydrocarbon occurrences (production data, reservoir and source intervals, shows, etc.) to PPSP. Seismic ties to nearby commercial wells and heat flow data with which to assess potential hydrocarbon maturation may also be requested. As it can take considerable time to acquire such information from commercial sources, proponents are urged to begin the effort as early as possible. Leaks in existing wellbores can change previously unpressured zones.

Pollution Prevention and Safety Panel Review

The PPSP is composed of petroleum geologists, geophysicists, engineers, and organic geochemists drawn from industry, government, and academia who are recognized authorities in the fields of marine research and offshore oil exploration. They provide independent advice on the safety of drill sites to both JOIDES and ODP. The PPSP is actually composed of two separate groups, the JOIDES Safety Panel and the TAMUSP. In questioning presenters during a PPSP review, reviewing data, and discussing problems, there is no distinction between the two groups. After reviewing the site data and PPSP advice, ODP/TAMUSP makes a final recommendation regarding site safety and the operations plan.

The diverse sites planned for ODP drilling involve additional hazards not encountered in previous DSDP drilling. Holes are planned for deeper sediment penetration and/or in shallower water on continental margin sites. Moreover, the *JOIDES Resolution* continues to face drilling hazards inherent in operating without a drilling riser to the surface, return circulation, or standard blowout preventers. Although improved seismic surveys, an expanded borehole logging program, and advanced hydrocarbon monitoring capabilities help detect hazardous conditions during the cruise, the key to preventing an accident is the selection of safe drilling locations before the ship sails.

Once a full proposal has undergone SSP review and is placed onto the drilling program, it will be scheduled for further review by the PPSP at least 6 months prior to departure. Co-Chief Scientists (or their delegate) of the newly scheduled leg must prepare a written safety report that examines each site from the perspective of potential hazards, and they must also make an oral presentation of the existing data to the PPSP at their meeting. Failure by Co-Chief Scientists or their delegate to meet their responsibility of providing adequate data for review will result in rejection of drill sites by the PPSP.

Written Safety Report

Prior to the scheduled PPSP review, the Co-Chief Scientists (or their delegate) of the scheduled leg must produce a written synthesis of geological, geochemical, and geophysical data at each site, with an emphasis on hydrocarbon potential, possible trap structures, and other possible hazards. This report is submitted to the ODP Site Survey Data Bank, which then provides electronic versions on the World Wide Web site for access by PPSP members prior to the meeting. Safety reports are also required for proposals being previewed by the panel. Generally, the reports contain the information in Table T3.

T3. Written report information, p. 60.

Material submitted for each site should be indexed and annotated to enable ready identification of structural features, line locations, line directions, wells, grab samples, cores, etc.

The purpose of the written report is twofold. First, it requires the individuals to shift focus from the science of their sites to safety and operational issues. Second, by having the report in hand prior to the meeting, the PPSP members are able to locate additional data from their own sources that can be brought to the meeting to assist in site discussion. Contact the ODP Site Survey Data Bank at **odp@ldeo.columbia.edu** for assistance in preparation of the report.

Oral Safety Presentation

At the PPSP meeting, Co-Chief Scientists or their delegate must make a formal presentation of pertinent data for each site and then discuss any safety issues with the panel. Most of the data needed for these safety reviews are also required for the SSP review; however, additional, safety-related items should be submitted to the ODP Site Survey Data Bank in an appropriate format prior to the PPSP meeting.

Based on the data presented, the PPSP will advise the presenter that a site (1) is recommended for approval as proposed, (2) should be moved to a safer location that is still compatible with the scientific objectives, or (3) is rejected because of inadequate data or inherent risk. The PPSP may recommend a preferred order of drilling if safety is a factor and may also specify conditions of approval, such as maximum depth of penetration or special monitoring requirements. It should be noted that proposing sites on structural highs will generally yield recommendations to relocate them onto the flank of the structure. The PPSP is also inclined to relocate drill sites to intersections of seismic lines, especially where sedimentary sections are thick and where traps could occur. In general, the panel will expect to see full-size copies of the information listed in Table T4.

T4. Oral report information, p. 61.

Shallow-Water Hazard Surveys

During their October 1992 meeting, concern regarding potential for gas blowouts in shallow-water settings caused the JOIDES and ODP/TAMU Safety Panels to disapprove a number of proposed drill sites on the New Jersey shelf. The special blowout danger in shallow-water drilling is that gas, with its attendant threats of fire and explosion, will reach the sea surface at or in close proximity to the drilling vessel. In ODP drilling, this danger is compounded by the drillship's lack of a blowout preventer (BOP) and limited ability to use weighted drilling mud to contain gas release on a scale comparable to a standard oil and gas exploration rig.

Shallow-Water Drilling Guidelines

JOIDES and ODP have seen an increasing number of drilling proposals with sites located in shallow water (<650 m) on the continental shelves. Shallow-water operations follow the recommendations adopted by the JOIDES panels of the Shallow-Water Drilling Working Group (SWDWG). These guidelines are as follows:

1. Open-hole drilling in shallow water is reasonably safe if proper hazard surveys are conducted and combined with proper data processing and interpretation. See **"Guidelines for Water Depth Ranges"** in "Principal Hazards."
2. Hazard surveys must be a requirement for ODP drilling on sedimented shelves in water depths of 650 m or less.
3. Subbottom penetrations at water depths of 650 m or less without BOP and mud-weight capabilities must be limited to 1000 m.
4. Operational procedures for shallow-water drilling such as maintaining kill weight mud, using slow coring for adequate evaluation, monitoring the seabed for gas escape, and following safety contingency plans must remain in force.
5. Interpretation of survey data in terms of shallow gas hazards should be made by experts in the field who are not associated with the scientific proposals justifying the program.
6. ODP's slim open-hole drilling from a dynamically positioned vessel is a relatively safe method for shallow-water operations, but blowouts must be avoided.

The guidelines developed by the SWDWG continue to be modified as necessary. Regulatory and scientific differences make change a necessity. Evolution of geophysical equipment used in high-resolution hazards surveys is continual. In general, state-of-the-art equipment will be required for ODP shallow-water surveys. The Shallow-Water Site Survey Guidelines are as follows:

1. The objective of a shallow-water gas hazards survey (SWGHS) is to identify the presence of gas, from the seafloor down to at least 1000 m, at a site proposed for ODP drilling. SWGHS is required at proposed sites to allow the Science Operator (ODP/TAMU), together with the JOIDES PPSP and the ODP/TAMUSP, to properly evaluate the safety aspects of a site and determine whether drilling should be undertaken.
2. ODP/TAMU shall be involved with the proponents in the planning of SWGHSs and shall be responsible (both technically and

fiscally) for quality control during data acquisition, processing, and interpretation of SWGHSs for full proposals undergoing review. Funds to conduct SWGHSs (including ship time, data acquisition, and data processing) are the responsibility of the proponent(s).

3. Shallow water is defined as water depths <650 m. The reason for selecting this depth is that gas blowouts at 650 m or shallower depths can be catastrophic to the drill rig, whereas blowouts at greater depths should not be.
4. It is assumed that prior to the SWGHS proponents will have acquired seismic data sufficient to justify the scientific objectives and to specify actual drill sites to address the science objectives.
5. The SWGHS specifications are designed so that safety aspects of specific sites can be evaluated. In general, the SWGHS will provide the proponent with images of the scientific targets that are better than those previously acquired. The proponent should bear in mind that sites may have to be moved for safety reasons and that alternate sites could be picked from the SWGHS if the area covered by the survey is large enough to do this.

A shallow-water hazard survey will have seven general requirements:

1. Accurate navigation,
2. A dense survey grid,
3. Side-scan surveys to identify seafloor features,
4. High-resolution MCS imaging of the subsurface down to at least 1000 m,
5. Independent quality control of MCS data acquisition,
6. High-resolution imaging of the subsurface down to ~100 m, and
7. Independent interpretation of the data by an expert in the field of shallow gas.

The current requirements for SWGHSs are described in detail in the Shallow-Water Drilling Working Group's Report. Proponents should consult the details of this report prior to planning any SWGHS.

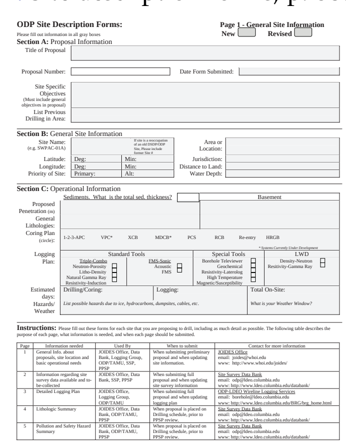
ODP Site Description Forms

Proponents must use the site summary forms (Fig. F1) to document the scientific objectives, available site survey information, logging plans, and safety at each proposed site. The set of forms uses a layered approach in describing each site, with the first page documenting basic site information and subsequent pages adding further details as the proposal matures and moves through the JOIDES review system. Proponents are instructed to fill out all parts of the form that are shaded in gray. Instructions for completing the forms are found below.

Page 1—General Site Information

This form should be submitted for each site when submitting a preliminary proposal and whenever sites are moved or updated. The purpose of this form is to document each site's name, location, basic objectives, and drilling plan.

F1. Site description forms, p. 53.



ODP Site Description Forms: **Page 1 - General Site Information**

Please fill out information in all gray boxes **New** **Revised**

Section A: Proposal Information

Title of Proposal

Proposal Number: Date Form Submitted:

Site Specific Objectives (Must include general objectives in proposal)

List Previous Drilling in Area:

Section B: General Site Information

Site Name: (e.g. SWPAC-01A) If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #

Area or Location:

Latitude: Deg: Min: Jurisdiction:

Longitude: Deg: Min: Distance to Land:

Priority of Site: Primary: Alt: Water Depth:

Section C: Operational Information

Sediments. What is the total sed. thickness? Basement

Proposed Penetration (m)

General Lithologies:

Coring Plan (circle): 1-2-3-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB

* Systems Currently Under Development

Logging Plan:

Standard Tools: Triple-Combo: Neutron-Porosity, Litho-Density, Natural Gamma Ray, Resistivity-Induction; FMS-Sonic: Acoustic, FMS

Special Tools: Borehole Televiewer, Geochemical, Resistivity-Laterolog, High Temperature, Magnetic/Susceptibility

LWD: Density-Neutron, Resitivity-Gamma Ray

Estimated days: Drilling/Coring: Logging: Total On-Site:

Hazards/ Weather: *List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.* *What is your Weather Window?*

Instructions: Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

Form last revised: 24 March 1997

Section A: Proposal Information

- New or Revised Checkboxes: Check “New” when initially proposing the site. Check “Revised” for all updates and changes.
- Title of Proposal: This should be the same as the title on the cover page of the proposal.
- Date Form Submitted: Insert the date the form was filled out. This is important for tracking the latest site revisions.
- Site-Specific Objectives: This should be a short description of the objectives for this site (e.g., Cenozoic history of [1] deepwater chemistry and [2] carbonate productivity).
- List Previous Drilling in Area: List any DSDP, ODP, or industry holes drilled at or near this site location.

Section B: General Site Information

- Site Name: Site naming conventions were developed to ensure that each point on the seafloor considered for drilling has a unique name that is never used to describe other points on the seafloor. This is extremely important for matching proposed sites to site survey data in the ODP Site Survey Data Bank. Moving a site without changing the site designation leads to mismatches between data and proposed sites.

  Proper site names are formatted as XXXXX-##X (e.g., SUBSAT-10A). Site names are constructed of three parts. The first part, to the left of the hyphen (-), is a string of up to 6 characters, which is the descriptive “name” of the proposed site. To the right of the hyphen is a two-digit number indicating the site number, along with one alpha character indicating the version of the site. As a proposal matures, site objectives may change or site locations may be shifted. It is important, therefore, that the right side of the site name be updated as well. Generally, small shifts in a site’s location that do not move it off of existing survey lines would be documented by a change in the one character version identifier. However, if a site is moved to such an extent that it is no longer within the same set of survey lines, then a new site should be designated with a higher two-digit number and a version designation of “A.” Please note that site names do not indicate the site’s priority or whether it is an alternate site. This information is provided on another part of the form.
- Latitude and Longitude: Latitude and longitude must be presented in degrees and decimal minutes. Please use as many significant digits for fractions of minutes as your navigation data allow.
- Priority of Site: Indicate whether your site is a primary or alternate site. If alternate, you may indicate for which site it is an alternate.
- Area or Location: Give a name to describe the area where the site is located, such as “Blake Outer Ridge.”
- Jurisdiction: This is the territorial jurisdiction of the area in which the proposed site is located.
- Distance to Land: Give distance to nearest land in kilometers.
- Water Depth: Give water depth in meters.

Section C: Operational Information

- Proposed Penetration: Give an estimate of the predicted total sediment thickness at the proposed site, as well as the proposed penetration of sediments, basement, and total penetration in meters.
- General Lithologies: Give a brief list of anticipated lithology or lithologies for both sediments and basement.
- Coring Plan: Circle the type of coring device proponent expects to use at each site. A short explanation of each device is provided below. Proponents are encouraged to contact the Science Operator (ODP/TAMU) for detailed information on coring options.
  - APC: The advanced piston corer recovers soft ooze and sediments. The hydraulically activated system strokes out in 2–3 s with 23,000 to 28,000 lb of force, plunging a knife-edged cutting shoe into the formation to recover an undisturbed core. If requested, a magnetic orientation system references the core to magnetic north. In some cases, more than one coring hole is required at a given site to provide an undisturbed composite core section.
  - XCB: The extended core barrel (XCB) continues coring in firm sediments after piston coring is no longer effective. A saw-toothed cutting shoe can either extend as far as 8.5 inches beyond the main bit face or retract back to the main bit face. In many formations, this trimming technique produces better core quality than roller cone bits alone.
  - RCB: The rotary core barrel (RCB) recovers medium to hard crystalline rocks. The RCB requires a separate bottom-hole assembly (BHA) from the APC/XCB and is rotated from the surface. The RCB uses a four-roller cone bit to cut the core. The inner barrel remains stationary to minimize core disturbance.
  - MDCB: The motor-driven core barrel (MDCB) recovers interbedded materials including hard and fractured rocks. Large quantities of seawater are pumped through a multilobed motor that produces higher torque and speed at the cutting shoe. Diamond-impregnated or surface-set cutting shoes trim the core.
  - PCS: The pressure core sampler (PCS) recovers core at in situ pressures as high as 10,000 psi. The hydraulically activated system retrieves core in a removable pressurized chamber. Once on deck, samples can be transferred for scientific testing and evaluation.
  - VPC: The vibra-percussive corer (VPC) uses percussion and vibration to recover unconsolidated sediments. Like the piston corer, the VPC is hydraulically activated. Seawater drives the percussion unit to create high-frequency vibration. The hammering action helps the tool penetrate compressed and unconsolidated sediment such as sands.
  - Reentry cone: A reentry cone may be used if a hole is to be entered more than once (e.g., when setting casing, making multiple bit changes, or deploying downhole equipment).
  - HRRS: The hard rock reentry system (HRRS) uses a unique percussion-drill BHA along with a fluid-powered hammer drill for

the purpose of installing a reenterable cased hole on sloping fractured hard rock surfaces.

- Logging Plan: Check boxes for logging tools expected to be used. Detailed information on available logging tools is given at the ODP/LDEO Web site (**www.ldeo.columbia.edu/BRG/ODP/LOGGING**).
- Estimated Days: Total on-site estimates should be given for the number of days of drilling/coring, logging, and any experimental operations. These estimates should be viewed as preliminary. To assist the proponent, guidelines have been prepared for estimating ODP coring and logging times (see **www.ldeo.columbia.edu/BRG/ODP/LOGGING/HELPER/helper.html** or *Preliminary Time Estimates for Coring Operations,* ODP *Technical Note,* 1 [Rabinowitz, 1986]). Manually prepared time estimates can be made using curves for drill string trip time and RCB, APC, and XCB coring cycles. The Web site also has a simplified Excel coring and trip time estimator, which can be used to estimate times in both single-bit and reentry holes. These curves, along with procedures for approximating coring and logging times, are available to assist proponents in developing realistic drilling time estimates. Whenever possible, time estimates for ODP holes should be based on data from similar locations and/or lithologies. Because of the complexity of ODP operations, however, the ODP Drilling Services Department should be contacted for detailed operational planning. Once a site has been approved and its objectives defined, a final time estimate based on detailed planning becomes the responsibility of the Science Operator.
- Hazards/Weather: List any information available on possible hazards from ice, hydrocarbons, shipping lanes, military exercise areas, dumpsites, cables, typhoons, and so on. Information on ice conditions must be provided with high-latitude proposals. Note the optimum weather window for the proposed drilling area. It is recommended that proponents begin to search for industry data on hydrocarbons at an early stage, as it can take some time to obtain this information and it will be required for the PPSP review should the proposal be scheduled as a leg.

Page 2—Site Survey Detail

This form should be submitted for each site when submitting a full proposal and whenever survey data need to be updated. The purpose of this form is to document the available survey data for each proposed site. Include as much detail as possible for each data type. Please be specific regarding the locations of data on survey lines by indicating exact dates/times or shotpoints.

New or Revised Checkboxes

Check "New" when initially proposing the site. Check "Revised" for all updates and changes.

Proposal Information

List proposal number, site number (e.g., SUBSAT-10A), and current date.

Data Type

List all data available for data types 1 through 18 for the proposed drill site. Please give as much information as possible, including cruise names, line numbers when available, and specific date/time or shotpoint locations of sites on track line data. List as much data as possible and indicate survey cruises that may collect additional data and their expected dates. For details regarding site survey requirements for specific drilling environments, please see **"Site Survey Target Types and Data Standards"** in "Site Survey and Safety Panel Reviews."

Page 3—Detailed Logging Plan

This form should be submitted for each site when submitting a full proposal and whenever the logging plan is updated. The purpose of this form is to outline the logging program for the proposed drill sites.

New or Revised Checkboxes

Check "New" when initially proposing the site. Check "Revised" for all updates and changes.

Proposal Information

List proposal number, site number (e.g., SUBSAT-10A), and current date.

Water Depth and Penetration

List depths in meters.

Measurement Type

Fill in as much detail as possible on the scientific objectives of each logging tool that will be run at this site. For details on what can be achieved with each tool, contact ODP/LDEO Wireline Logging Services (**www.ldeo.columbia.edu/BRG/ODP**).

Page 4—Pollution and Safety Hazard Summary

This page should be submitted for each site once the proposal is placed on the drilling schedule. The newly scheduled leg will need to be reviewed by the PPSP. The information presented on this form will be used by PPSP to evaluate the safety of each drill site.

New or Revised Checkboxes

Check "New" when initially proposing the site. Check "Revised" for all updates and changes.

Proposal Information

List proposal number, the site number (e.g., SUBSAT-10A), and the current date.

Safety information

Please provide information requested in items 1 through 9 with as much detail as possible. The PPSP will use this information to evaluate the safety of each site. It is recommended that proponents begin to search for industry data on hydrocarbon occurrences even before the proposal becomes a leg, as this information is often difficult to obtain.

Page 5—Lithologic Summary

This page should be submitted for each site once the proposal is placed on the drilling schedule.

New or Revised Checkboxes

Check "New" when initially proposing the site. Check "Revised" for all updates and changes.

Proposal Information

List proposal number, site number (e.g., SUBSAT-10A), and current date.

Lithologic Summary

A sketch of the general lithologies proponent expects to encounter should be drawn on this page.

Drill Site Selection

Whereas proposed drill sites are reviewed by both the SSP and the PPSP, their objectives are different. The SSP seeks to ensure that there are sufficient data of the appropriate kind to document a site's position and suitability for the proposed science. The PPSP then reviews these and other data to ensure that the drill site will be safe for ship operations and pose no pollution threat. Usually the data required for SSP review are sufficient for the PPSP review, but reprocessing or reformatting may be requested to enhance the data for use in hazard detection.

Site Survey Requirements Framework

Site survey data requirements vary depending upon the type of environment in which the proposed drill site is located and the proposed depth of penetration. The SSP has defined eight target types, each with different data requirements, summarized in Table **T1.** If proposed sites fall into two classes, they may need to meet requirements of both target types. The data requirements for each of these target types are summarized in Table **T2.**

Details on each of the data types listed in the table can be found on the ODP Site Survey Data Bank Web pages (**www.ldeo.columbia.edu/databank**) along with guidelines on submitting data packages. Contact the Data Bank Manager (**odp@ldeo.columbia.edu**) with questions regarding data formats or presentation styles.

Twice per year the Site Survey Panel reviews the data packages of proposals referred to them and reports to OPCOM and the drilling proponents on the readiness of each package. If any potential pollution or safety hazards are noted during SSP review, sites may be referred to the PPSP for a preview. Flagging these hazards at an early stage allows site locations to be adjusted to avoid the problem or allows time for the location of additional data (such as from the petroleum industry) to further document and assess the hazard.

Geologic Framework for Safety Requirements

Stratigraphic Framework

It is basic to pollution prevention and safety to make the best possible estimate of thickness of the sedimentary section at drill sites and to infer the nature of the rocks to be penetrated. Knowing the thickness of the sedimentary rock above igneous or metamorphic basement is most useful in deciding whether a drill site has potential petroleum hazards resulting from thermochemical action on organic matter in the sediments. It is difficult to predict whether there has been an adequate supply of organic matter in the section to have allowed substantial petroleum generation. However, seismic data usually provide adequate information on sedimentary rock thickness at a proposed drill site. If there is no definite information on the absence of petroleum source material, thick sedimentary sections (1500 m or more) must be considered possible progenitors of petroleum and should be drilled with appropriate caution.

For purposes of estimating petroleum hazards, ocean areas may generally be divided into those with >1000 m of sediment above basement (shelves, slopes, and rises adjacent to continents or islands; many small ocean basins and troughs; and a few sediment-filled basins far from land in the main oceans) and those with <1000 m of sediment (constituting most of the vast central areas of the major oceans, the mid-ocean ridges, and many trenches and local areas closer to land).

Sediment sections <1000 m thick usually have not experienced sufficient heating to generate abundant petroleum. An exception to this general rule is high heat flow areas near hydrothermal vents or mid-ocean ridges and gas hydrate or H_2S deposits. Areas of thin sediments are therefore relatively free of petroleum hazards, provided the following conditions are also fulfilled:

1. Such areas have no possibility of having once been more deeply buried,
2. Such areas are not pinchout margins of thicker downslope sedimentary sections from which lateral migration of hydrocarbons could have taken place, and
3. Such areas cannot have experienced greater than normal heat flow.

In general, the PPSP considers central oceanic areas with 500 m or less sediment above basement to be nearly free of petroleum hazards. Even in such areas, however, consideration must be given to the possibility that older sedimentary sections may underlie acoustic basement or that biogenic methane may be present.

Obviously, hydrocarbon hazards are enhanced if good potential reservoir strata are present in the section (Pimmel and Claypool, 2001). This factor has an important modifying effect on safety conclusions based on sedimentary thicknesses and organic contents. Seismic data and regional geologic considerations may give helpful information on the probability of substantial reservoirs being present.

The presence of evaporites, overpressured shales, gas hydrate zones, and other seals below which hydrocarbons may be trapped also has an important bearing on the depth to which a drill hole can be safely carried. Presence of diapirs or flowing faults is a danger signal.

Structure

At least one continuous seismic profile must be obtained across any prospective drill site, and two profiles intersecting at approximately right angles must cross at prospective sites on shelves, slopes, and rises or at any site where a single profile suggests the possibility of a trap. Features of significance on seismic profiles include anticlines, faults, pinchouts, unconformities, etc. Any sort of structural or stratigraphic trap should be avoided in choice of drilling locations. Whereas reliance for identification of traps must rest primarily on seismic sections, gravity, magnetics, and bathymetric data may also be helpful.

Regional Setting

Where thickness and character of rock sequences suggest adequate hydrocarbon source potential, quality of seismic data is critical. Migrated depth sections may be needed to evaluate faults as migration paths. Maps of key horizons may be necessary to document local structure and trapping configurations. Regional maps to ascertain relief on pinchouts may be needed to evaluate potential stratigraphic traps. Site proponents are urged to select sites off structure where desired objectives can be reached, even if this action means an increase in drilling depth.

Known Oil and Gas Presence. In planning a drilling leg, available information on oil and gas wells or seepages close to proposed sites, both on and offshore, must be obtained. This information is vital on continental margins. Shallow piston cores near proposed sites may provide information on hydrocarbon presence in surface sediments. Petroleum companies who hold or have held concessions in the general vicinity are good sources of information of this type. It must be noted that presence of an industry “dry hole” near a proposed site does not equate with a complete absence of hydrocarbons at that site. Drilled holes can breach seals and become a path for fluid migration and pressurization of shallow zones.

Abnormal Pressures. Areas and stratigraphic intervals containing fluids under greater than normal hydrostatic pressure should be avoided because of their common association with oil and gas and their tendency to cause blowouts. The presence of undercompacted shale is a warning that fluids may be encountered at greater than normal hydrostatic pressure. An undercompacted shale is one in which fluid expulsion has not kept pace with increased fluid pressure, so formation fluids in the shale and associated sands are not only under hydrostatic pressure but also bear part of the weight of the overlying rock column. Fluid pressures in such shales may also have a component of pressure generated internally by buoyant forces related to contained gas. Pressure-compacted shales may be identified by decreases in their interval velocities related to their abnormally high fluid content. They may also appear in seismic sections as distorted, convoluted reflections. Undercompacted shales may show up on gravity profiles because of their lower densities. Absence of velocity inversion does not preclude abnormal formation pressure, nor does its occurrence always result from an undercompacted shale section. Nevertheless, drill sites at which marked velocity inversions are detected should be avoided unless the inversion can be related to some other lithologic change.

Thermal Gradients. Heat flow data should be acquired at prospective drill sites to assess the possibility of migrated petroleum and because higher temperatures are commonly associated with abnormally high pressures and hydrocarbon accumulations.

Water Depth. Blowout danger to the ship diminishes greatly with increased water depth. Violent surface blowout may occur in water depths as great as 500 m, but there is little likelihood that such blowout danger exists in depths of 2000 m or more. Slow seepage of oil or gas into the sea, with consequent risk of pollution at remote downcurrent sites, can occur while drilling in any water depth.

PRINCIPAL HAZARDS

Hydrocarbons

Oil and Gas Escape

The main hazard in scientific ocean drilling with respect to pollution prevention and safety is the possibility of encountering a charged reservoir, thereby allowing oil or hydrocarbon gas to escape in large quantities into the sea and atmosphere. Because natural submarine seeps of both oil and gas exist in many parts of the world with little apparent deleterious effect on the environment, it is difficult to determine what amount of oil or gas release during drilling operations should be termed hazardous. Certainly, as a pollutant, oil must be considered more serious than gas. However, as a hazard to personnel and property, gas is more dangerous than oil because of its mobility, high flammability, and negative effect on water buoyancy and because of the difficulties in controlling its pressure.

Hydrocarbon Origin and Occurrences

The term "petroleum" is applicable to any hydrocarbon substance, although it is popularly reserved for crude oil, natural gas, and asphalt. Mixtures of petroleum hydrocarbons exist as gaseous, liquid, and solid phases depending on temperature, pressure, and composition of the system. Under Earth surface conditions, C_1–C_4 hydrocarbons (methane, ethane, propane, and butane) are predominantly in the gaseous phase, whereas C_5 and heavier hydrocarbons are predominantly liquid.

Hydrocarbon gases, largely methane (C_1), may be generated in significant quantities from organic matter in sediments (Pimmel and Claypool, 2001), either under near-surface conditions by bacterial action (Claypool and Kaplan, 1974) or at greater depths by thermochemical action (Schoell, 1988). Liquid petroleum (oil), however, is almost exclusively the product of thermochemical generation from hydrogen-rich organic matter in deeply buried sediments. This generation appears to become quantitatively important only as temperatures reach 50°–150°C (typically at burial depths of 1500–5000 m for average geothermal gradients). Hydrocarbon gases are generated with the oil, and, although they consist largely of methane, they usually include quantities of ethane, propane, butane, and heavier hydrocarbons. Thermochemical conversion of organic matter to hydrocarbons continues at accelerating rates with increasing depth and temperature until all organic matter including the oil itself has been converted largely to methane and carbon-rich residues. It should be stressed that, although biogenic hydrocarbons are generated at relatively shallow depths and thermochemical hydrocarbons at relatively greater depths, either may be found at any drilling depth because of migration, subsequent burial, or exhumation.

Biogenic methane is commonly found in swamps, where it is known as marsh gas, but it is also formed in marine sediments that contain sufficient concentrations of organic matter. Biogenic methane can usually be distinguished from thermochemical methane by means of isotopic ratio mass spectrometry; the biogenic form has a distinctly greater abundance of light carbon isotope ^{12}C relative to the heavy carbon isotope ^{13}C. Although thermochemical methane is formed along with ethane and heavier hydrocarbons in the early stages of hydrocarbon generation, the ratio of methane to ethane gradually decreases as hydrocarbons of thermochemical origin become more abundant. More complete discussion of geologic factors involved in the origin and occurrence of petroleum can be reviewed in Tissot and Welte (1984) and Hunt (1979).

Both biogenic and thermochemical methane may be found in many ODP boreholes. There is no appreciable difference in their physical and chemical properties. Both are flammable and can cause blowouts. Both can be associated with ethane and can occur in substantial quantities at shallow depths. The only significant difference is that the conditions that produce thermochemical methane may also produce liquid oil, whereas oil of microbial origin is unknown.

A common misconception is that methane that is identified as biogenic can be disregarded as a safety hazard. A serious blowout occurred in offshore drilling in Cook Inlet, Alaska, apparently due to biogenic gas. One of the world's largest gas fields and >20% of the world's gas reserves are apparently biogenic. It has been wrongly suggested that if methane/ethane or $^{12}C/^{13}C$ ratios exceed certain values, gas dangers can be dismissed because it is only "marsh gas," not true thermogenic gas. *It is the quantity of gas present in reservoir strata rather than its origin that is of primary concern.*

The PPSP and TAMUSP (usually referred to as the Safety Panel) strongly favor obtaining all information possible on the character of hydrocarbons in ocean sediments. However, because of the multitude of geological, geochemical, operational, and experience factors that enter into decision-making concerning safety, PPSP considers it a menace rather than an aid to safety to set "magic numbers" as substitutes for balanced judgment. *Arbitrarily imposed numerical guidelines for safety decisions are dangerous because numerical guidelines may be used blindly as crutches to obscure sound and reasoned judgment.*

Blowouts

In oil well drilling operations, formation fluids (water, oil, or gas) flow into the well bore when the pressure of the fluid in the reservoir exceeds the pressure in the drill hole. If the fluid entering the well bore is less dense than the drilling fluid, it moves upward in response to buoyancy.

When the formation fluid is gas, gas-charged water, or gas-charged oil, it may permeate the drilling fluid, causing it to be filled with gas bubbles (gas-cut), thus diminishing the drilling fluid's density and ability to exert pressure on surrounding formations. Gas entering the well bore undergoes rapid expansion because of pressure reduction while traveling up the hole. Because of the confinement of the narrow borehole, increasing expansion of gas in the drilling fluid as it moves upward causes a flow of displaced drilling fluid from the hole mouth, further reducing the weight and pressure of the fluid column in the hole. The consequence is a chain reaction. Gas enters the hole at ever-increasing rates as the pressure differential between the gas-bearing formation and hole is increased. If not promptly controlled, the process results in violent ejection of drilling fluid, a wild, unrestrained flow of gas or gas-charged formation fluid at the surface. Such an event is called a blowout and is extremely dangerous to life, property, and the environment.

ODP Operations vs. Petroleum Operations Blowout Risks

Elaborate measures are employed by the petroleum industry to prevent blowout occurrences: weighting of drilling muds, application of backpressure with pumps, use of mechanical BOPs, etc. The drilling equipment used for ODP operations is very different from that used in customary oil and gas drilling, mainly because of lack of means for return circulation, use of seawater rather than heavy drilling mud as a drilling fluid, lack of a riser and BOP, and generally greater water depths involved. In ODP operations, gas encountered under pressure sufficient to cause it to enter the hole, permeate the seawater drilling fluid, and move upward is confined by the hole walls only until it reaches the ocean floor or soft, soupy fluid sediment that often underlies the seafloor. Gas continuing upward would dissipate from the borehole into seawater and reach the ocean surface in lower, perhaps imperceptible, concentrations over a broad area, with dimensions proportionate to the water depth the gas traversed.

Considering the great water depths usually involved in ODP drilling, there is relatively less danger of violent discharge of gas at the sea surface. However, means of mechanically controlling gas flow into the hole in ODP operations are limited. Moreover, even though the escape of gas or oil at the ocean surface from holes drilled in water depths of thousands of meters might be so diffuse as not to be readily discernible, total pollution of the ocean by hydrocarbons might be substantial over time.

A gas blowout imperils the vessel and crew in several ways: releasing toxic gases, triggering fires, and causing a loss of buoyancy as a result of gas bubbles charging the surrounding seawater. The shallower the water at the drill site, the greater the potential of danger of buoyancy loss, which could destabilize the ship.

The greatest fire danger on the *JOIDES Resolution* would result if a blowout occurred *through* the drill pipe. In relatively shallow water, gas escaping to the surface from around the drill pipe may present a fire hazard. ODP drill crews are trained in standard oilfield practices to avoid and control these possibilities. Buoyancy impairment is unlikely in water depths usually encountered at ODP sites. However, buoyancy problems have occurred at least twice in commercial drilling for oil in shallow waters and cannot be ignored at shallow ODP sites.

Intercommunication between Reservoirs/Fluid Exchange

Situations can occur where formation fluids flowing up the borehole from deep, overpressured zones encounter shallower, lower-pressure zones. Under these conditions, the higher-pressured fluids (oil, gas, or water) may enter a zone that opens to the seafloor via fractures or permeable beds, resulting in an uncontrollable leak. The higher pressured fluids may charge shallower zones with fluids having greater than normal hydrostatic pressures, thus making even shallow future drilling in the area hazardous. It is also possible, though not likely under most ODP conditions, that deep saline formation water might contaminate shallower freshwater offshore aquifers in this way.

Drilling Active Ridges

High-temperature hydrothermal systems close to magma chambers present special hazards for scientific ocean drilling. The behavior of water in hydrothermal systems is governed by pressure-volume-temperature (PVT) relationships. When the specific volume of water at constant temperature is plotted as a function of pressure, there is an abrupt change of slope below the critical temperature of water (374°C) corresponding to the phase change resulting from boiling. Above the critical temperature, the rate of change of volume with pressure is gradual. Cold and thus denser seawater pumped down the drill pipe provides a hydrostatic overpressure that suppresses flow into the pipe. Steam flow to the surface through a cold drill string is extremely unlikely, especially if some seawater is being pumped periodically. Cold (2°–4°C) seawater cools the hole near the bit by as much as 90°C, which can cause thermal stressing and sloughing of rock chips into the hole. Gradually cooling the hole by circulation every 500 m while tripping in the hole can reduce thermal shock.

Bottom-Simulating Reflectors and Hydrates

The known presence of bottom-simulating reflectors (BSRs), hydrates (clathrates), gassy sediments, and H_2S should be considered at the precruise meeting, and special precautions should be reviewed with Transocean and noted in the *Scientific Prospectus* operations plan. Operations may be slowed to permit adequate evaluation and handling of the cores. Operations may be terminated if liner failures or unsafe levels of gas or H_2S are detected in the core handling area, laboratory cutting room, or enclosed ship areas.

There are several hazards that could occur from a combination of these effects. Hydrates and authigenic (biological methanogenic) carbonates can form an effective pressure seal and free gas can accumulate under the seal (Leg 164). PCS data have indicated that the biogenic gas pressure can be 350 psi above seawater hydrostatic pressure (i.e., it is overpressured) at 450 mbsf; however, no gas flow has been noted to date in BSR penetrations. Poor permeability in silty clays under hydrates may have restricted flow thus far, although this may not always be the case. Hydrates have been analyzed as 98.5% methane and 1.5% carbon dioxide. Typically, hydrates are not composed of thermogenic or liquid hydrocarbons; nevertheless, BSRs and hydrate sections should be penetrated carefully (see Sassen et al., 1998, for an exception).

Hydrogen Sulfide

Hydrogen sulfide (H_2S) is the principal noxious gas that could be released during ODP drilling operations. H_2S is easily detected in extremely low concentrations by its characteristic odor and by using commercially available monitors. It is a transparent, colorless, flammable, heavier-than-air gas that is lethal in concentrations measured at a few hundred parts per million. Below 100 ppm, this gas is characterized by its rotten egg odor. However, over a period of a few minutes at concentrations approaching 100 ppm, ability to smell this gas is lost. The threshold limit, 10 ppm, is the concentration at which it is believed that all workers may repeatedly be exposed, day after day, without adverse affects.

Concentrations of 250 ppm are considered hazardous and may cause death with prolonged exposure. Concentrations of 700 ppm are considered to be **lethal** *and will cause death with* **short-term exposure.**

Geochemical considerations, together with past drilling experience, direct observations, and sampling from research submersibles, have shown that excessive H_2S may interact with high temperature to further complicate active ridge drilling. H_2S solubility in water is a function of PVT conditions. This fact dictates a safety approach in which depths and temperature anticipated at specific drill sites determine safety measures to be taken for a given active ridge drilling leg. This approach was followed in drilling on the Juan de Fuca Ridge and Escanaba Trough (Legs 139 and 169) and the Trans-Atlantic Geotraverse (TAG) massive sulfide deposits (Leg 158). Extensive safety procedures for avoiding H_2S-related accidents were spelled out for Leg 139 in the Hydrogen Sulfide–High Temperature Drilling Contingency Plan, ODP *Technical Note,* 16 (Howard and Reudelhuber, 1991). ODP *Technical Note* 16 was updated in 1993 and became Revised Hydrogen Sulfide Drilling Contingency Plan, ODP *Technical Note,* 19 (Foss and Julson, 1993). ODP *Technical Note* 19 was recently updated to Hydrogen Sulfide Drilling Contingency Plan, ODP *Technical Note,* 33 (Mills et al., in press).

Unusual isolated concentrations of H_2S gas are possible, especially in cases of active hydrological downflow or sulfate-rich upflow in faults or in carbonate-rich sediments where H_2S is not quantitatively precipated as iron sulfides (e.g., pyrite) because of low iron contents. H_2S concentrations to 150,000 ppm (vacutainer) were handled safely in core sections from one site during Leg 182. However, coring operations should be suspended when H_2S concentrations in the ambient air on the core-handling deck exceed 10 ppm until proper safety measures can be implemented. Operations should be terminated if necessary core handling procedures on the catwalk and in the laboratories cannot be completed in a safe manner.

Most gas hydrates encountered by ODP have contained mostly C_1 with a small amount of CO_2; however, H_2S was noted in the presence of hydrates during Leg 146. Therefore, hydrates should be treated with extreme caution because of the potential for sudden high-volume releases of H_2S. If H_2S is noted in the presence of hydrates, a full H_2S alert should be declared and coring should be halted pending an evaluation of the situation.

ODP *Technical Note,* 16 (Howard and Reudelhuber, 1991) reviews extreme safety procedures for a heavy hydrogen sulfide leg; however, experience in handling H_2S cores and new safety equipment (such as air dilution fans, hose-fed air packs, and gas evacuation fans) has improved H_2S safety procedures and permitted safe handling of degassed (<10 ppm) H_2S cores.

If the potential for H_2S is known or suspected in an operating area, H_2S precautions should be reviewed before the leg, a training program should be conducted for all personnel, an H_2S evacuation drill should be conducted, general H_2S precautions should be in effect, safety equipment should be serviced and staged, laboratory personnel should receive safety equipment training, and monitors should be calibrated and in operation (Mills et al., in press). H_2S concentrations are normally <50 ppm in the normal near-seafloor sulfate reduction zone, which is fed by seawater (to ~40 mbsf). Cores containing H_2S are quickly degassed outside on the core-handling deck by drilling holes in the liner and sectioning the cores. The H_2S is diluted by normal airflow mixing aided by the fan on the core-handling deck. The suction fan in the core-cutting room should be used to further vent gas liberated by cutting the cores. Marine Laboratory Specialist (MLS) personnel may need to wear air packs when handling and cutting the cores. It is prudent to allow core sections with H_2S concentrations >10 ppm to degas on the outside core storage rack.

Environmental Hazards

Weather

Transocean is required to provide trained personnel for weather-related duties. ODP is responsible for providing and maintaining the weather equipment and providing training in its operation. The vessel's deck officers are responsible for copying and interpreting weather maps and satellite photos, as well as recording and transmitting routine weather observations. The Transocean Offshore Installation Manager (OIM), ODP Operations Manager, and Co-Chief Scientists should stay informed about the approach of storms or other weather conditions that could affect operations; however, the Master's (i.e., Captain's) decision is final in weather-related matters concerning the safety of the vessel and/or onboard personnel. This includes course changes to avoid or minimize weather effects, tripping or hanging-off the drill string, departing the area, etc.

The *JOIDES Resolution* may encounter extreme weather conditions such as cyclones, otherwise known as typhoons or hurricanes, and storm tracks and frequencies that are likely to threaten the ship's safety. The Master is required to follow policies for dealing with and avoiding tropical cyclones as set forth in the Transocean Hurricane/Cyclone Contingency Plan. The provisions of the document are highly conservative in terms of lead time to abandon site operations and depart the area.

Currents

DSDP and ODP operating experience indicates that deepwater ocean currents can be more complex and capricious than generally believed. Subsurface currents may exist with velocities and directions in complete disagreement with published charts and they also may come or go completely without warning or on a diurnal cycle. Major currents, such as the Gulf Stream or Arctic currents, can produce strong and deep-running eddies and spin-off vortices of surprising velocity and direction.

A strong current is defined in this document as a sustained general movement of subsurface water mass at a speed of 2.0 kt or more, which may induce swirling water motion by movement through, over, and around obstacles, or by interaction with tidal surges. Currents are deep running and distinct from transitory water-mass motion induced solely by surface waves or swells or wind action. Whereas current information on nautical charts and publicly available data can be characterized as generally accurate, the *JOIDES Resolution* is fixed at a specific site and experience has demonstrated that current effects vary locally and hourly.

Current velocities estimated as high as 3 kt (Kuroshio Current off Japan) and 4 kt (Gulf Stream in the Florida Straits) have been encountered during ODP operations. The current forces were handled by the *JOIDES Resolution*'s propulsion power, but stationkeeping and vessel-motion limits were exceeded when 50-kt winds and 20-ft swells developed at right angles to the Kuroshio Current. The strength of the current forced the vessel to maintain its heading into the current and to lie in the trough. Off northeast Australia and in the Florida Straits, the strong current extended to the seafloor in relatively shallow water and physically tilted the positioning beacon downcurrent, hampering the ship's stationkeeping capability.

The design/contractual capabilities for the *JOIDES Resolution* include the ability to maintain horizontal position within 3% of water depth with wind limits of 45 kt (gusts to 50 kt), maximum wave height of 27 ft, and surface current of 2.5 kt (with the prevailing environmental forcing function within 30° of the bow or stern).

ODP operations in areas with strong currents (of >2.0 kt) have been affected to a limited extent. Pipe has audibly and visibly vibrated (e.g., strummed by current like a taut string at 20–60 cycles/s) when used in strong current areas. BHAs, drill pipe, casing, and guide bases have been tilted off-vertical in excess of 5° by the force of the surface current against the sail area of the object, which resulted in problems making up the next (vertical) joint and latching the dual elevators. Running pipe can be difficult because the pipe and tool joints are pressed against the upper and lower guidehorns. Vibration-isolated television (VIT) frames have noticeably vibrated, tilted, and "weather vaned." VIT coaxial cables have vibrated, been wrapped around the pipe by a weathervaning frame, and been pushed against the edge of the moonpool, thereby damaging the cable.

Successful coring operations were conducted in the Gulf Stream and Kuroshio Current where deep-running current velocities were >2.5 kt. On a few occasions, the crew has experienced an inability to maintain the ship position during operations conducted under the following conditions:

1. A high angle of divergence between strong wind and strong current forces (such as sudden strong wind gusts from canyons or glaciers, storms approaching from the side of the ship, and sudden tidal surges in channels);
2. Swirling vertical and horizontal vortex-type currents that rapidly changed direction and force (such as Arctic eddy currents over underwater obstructions and sills in the Yermak Straits); and
3. A rapidly changing interaction of tidal surges and high current in shallow water, such as on the New Jersey Shelf in 100 m water depths, where tidal and (Gulf Stream) current eddies combined to produce strong and rapidly changing environmental forces.

High- and Low-Latitude Operations and Ice

The drillship is adapted for high-latitude operations, with winterized and heated work areas and an ice-strengthened hull to Class 1B for navigation in medium ice conditions. Successful operations have been conducted in both Arctic and Antarctic waters under hostile environmental conditions. Winterization of the ship includes adding special additives to lower the pour point of the fuel, changing to low-temperature coolants and lubricants in topside machinery, rigging windwalls around exposed work stations, activating the special boilers that circulate heated water to various locations, and adding antifreeze to tool storage shucks.

In areas where free-floating ice or other objects may be encountered, "alert zone" and "safety zone" radii are calculated in accordance with procedures jointly developed by ODP and Transocean:

1. An alert zone radius will be calculated once on site based on the time required to suspend operations, pull out to 50 mbsf, and set the safety landing sub or 500-ton elevators, plus contingency time. The alert zone is dependent on depth and expands as the penetration depth increases. If free-floating ice or other objects enter the alert zone, operations will be suspended and the bit will be pulled to 50 mbsf while the situation is evaluated.
2. A safety zone radius is also calculated based on the time required to terminate operations and pull above the seafloor far enough for safe maneuvering plus contingency time. The safety zone is also dependent on depth and expands as the penetration depth increases. If free-floating ice or other objects enter the safety zone, operations in the hole will be terminated and the bit will be pulled as far as required to clear seafloor obstacles and permit the ship to move.
3. If time permits, the Master should keep the Transocean OIM, ODP Operations Manager, Staff Scientist, and Co-Chief Scientists informed of the situation to make a joint decision on the suspension or termination of operations.
4. A drill-string landing sub below the top drive and/or 500-ton elevators should be used anytime an emergency drive-off situation may occur. If time permits, the compensator will be locked and the 500-ton elevators will be landed on the rotary. All personnel will be restricted from the rig floor.

Shallow-Water Operations

Operations in water depths of <75 m are not permitted at present, and operations in 76–650 m of water require special operational guidelines to ensure safety for the crew and equipment. ODP and Transocean management and supervisors, Master, and Co-Chief Scientists should reach agreement prior to the leg on detailed limitations, operational procedures, etc., that will be imposed to reduce the risk of stuck pipe and operational problems. The operational agreement should be reviewed on the ship prior to arrival at each site so that all personnel are aware of the limitations.

General Guidelines for Shallow-Water Operations

Positioning control is especially critical in shallow-water situations because the short drill string provides less flexure and elasticity if the ship moves off the hole. If a substantial loss of positioning or a horizontal excursion is anticipated, coring should be suspended and the core barrel should be withdrawn.

Guidelines for water depth ranges are as follows:

- 0–75 m: Operations will not be conducted in <75 m water depth.
- 76–300 m:
  - Operations will be terminated if a gas flow is detected. The driller is authorized to load the hole with 10.5-ppg kill mud pumped at 500–1000 gpm (for a dynamic kill effect) as soon as possible. 12.5-ppg kill mud may be pumped in holes in more consolidated formations. A flapper-type float valve will be run in the BHA to prevent flow up the pipe, and a drill string valve will be available on the rig floor. Both crews will conduct a drill to practice drill string valve installation. Hatch covers and water-tight doors will be closed. Combustible gas

detectors will be checked. Crews and watch standers will be alerted to watch for signs of gas flows.

- Operations will not be conducted in areas where the distance to unnavigable shallow water (<30 m deep) is <1 nmi to allow time to drop the anchor and stop drifting in the event of a total power failure.
- Transocean and ODP supervisors will be advised as soon as possible if overpull reaches 70,000 lb or if hole drag increases appreciably or reaches 30,000 lb. The initial response will be to attempt to circulate the hole clean with a high-viscosity mud sweep of 15–35 bbl. If the hole problem remains, a wiper trip will be made to the position in the hole above the problem area before coring proceeds. If hole problems cannot be reduced by corrective action, coring will be terminated to avoid stuck pipe.
- A hole-conditioning or "wiper trip" should be made as often as required to maintain good hole conditions (i.e., generally <30,000 lb drag up and down, <300 A torque off-bottom, and <150-psi increase in pump pressure). Experience has indicated that wiper trips should be planned about every 2–3 days under normal circumstances (if coring is expected to continue for another day). The first wiper trip should be made to ~50 mbsf (to get the top of the large-diameter drill collars above the seafloor). Subsequent wiper trips can be made to the previous wiper-trip depth (if hole conditions are good at that point). Any tight hole sections should be wiped through without rotation or circulation until they are trouble-free on the wiper trip. If firm obstructions are encountered, pick up the top drive and ream out the obstructions with the bit until they can be wiped through.
- In the event of stuck pipe, the compensator will be left partially open (allowing movement in either direction) while working the pipe.
- If stuck pipe cannot be pulled free with up to 200,000 lb overpull, preparations will be made to sever the lower 5½ inch joint of transition drill pipe above the tapered drill collar. If a mechanical bit release (MBR) is in the BHA, it may be possible to release the bit or pull the MBR apart in an attempt to free the pipe.
- A drill string landing sub below the top drive and/or 500-ton elevators should be used in shallow-water operations because time may not be available to take other action in the event of an emergency loss-of-positioning situation. If time permits, the compensator will be locked and the 500-ton elevators will be landed on the rotary. All personnel will be restricted from the rig floor.
- Coring will cease if the heave compensator stroke (top to bottom) exceeds 3.25 ft (1.0 m), if wind gusts exceed 40 kt, or if the weather/sea state is rapidly deteriorating. If free-floating ice or other objects may be encountered, alert zone and safety zone radii should be calculated (see above for definition). If time permits, the ODP Staff Scientist/LPM, Operations Manager, Co-Chief Scientists, Transocean OIM, and Master should

stay informed and make a joint decision on the suspension or termination of operations.

- The maximum allowable overpull on the drill string will be posted in the dog house as part of the Standing Instructions to Drillers (SID), but should not exceed 200,000 lb.

- 301–650 m:
  - Operations will be terminated if a gas flow is detected. The driller is authorized to load the hole with 10.5-ppg kill mud pumped at 500–1000 gpm (for a dynamic kill effect) as soon as possible. 12.5-ppg kill mud may be pumped in holes in more consolidated formations. A flapper-type float valve will be run in the BHA to prevent flow up the pipe, and a drill string valve will be available on the rig floor. Both crews will conduct a drill to practice drill string valve installation. Hatch covers and water-tight doors will be closed. Combustible gas detectors will be checked. Crews and watch standers will be alerted to watch for signs of gas flows.
  - Operations will not be conducted in areas where the distance to unnavigable shallow water (<30 m deep) is <1 nmi to allow time to drop the anchor and stop drifting in the event of a total power failure.
  - Transocean and ODP supervisors will be advised as soon as possible if overpull reaches 70,000 lb or if hole drag increases appreciably or reaches 30,000 lb. The initial response will be to attempt to circulate the hole clean with a high-viscosity mud sweep of 15–35 bbl. If the hole problem remains, a wiper trip will be made to the position in the hole above the problem area before coring proceeds. If hole problems cannot be reduced by corrective action, coring will be terminated to avoid stuck pipe.
  - A hole-conditioning or "wiper trip" should be made as often as required to maintain good hole conditions (i.e., generally <30,000 lb drag up and down, <300 A torque off-bottom, and <150-psi increase in pump pressure). Experience has indicated that wiper trips should be planned about every 2–3 days under normal circumstances (if coring is expected to continue for another day). The first wiper trip should be made to ~50 mbsf (to get the top of the large-diameter drill collars above the seafloor). Subsequent wiper trips can be made to the previous wiper-trip depth (if hole conditions are good at that point). Any tight hole sections should be wiped through without rotation or circulation until they are trouble-free on the wiper trip. If firm obstructions are encountered, pick up the top drive and ream out the obstructions with the bit until they can be wiped through.
  - In the event of stuck pipe, the compensator will be left partially open (allowing movement in either direction) while working the pipe.
  - If stuck pipe cannot be pulled free with up to 200,000 lb overpull, preparations will be made to sever the lower 5½ inch joint of transition drill pipe above the tapered drill collar. If a mechanical bit release (MBR) is in the BHA, it may be possible to release the bit or pull the MBR apart in an attempt to free the pipe.

- Operations will cease if the heave compensator stroke (top to bottom) exceeds 6.5 ft (2.0 m), if wind gusts exceed 40 kt, or if the weather/sea state is rapidly deteriorating.
- Coring will cease if the heave compensator stroke (top to bottom) exceeds 3.25 ft (1.0 m), if wind gusts exceed 40 kt, or if the weather/sea state is rapidly deteriorating. If free-floating ice or other objects may be encountered, alert zone and safety zone radii should be calculated (see above for definition). If time permits, the ODP Staff Scientist/LPM, Operations Manager, Co-Chief Scientists, Transocean OIM, and Master should stay informed and make a joint decision on the suspension or termination of operations.
- The maximum allowable overpull on the drill string will be posted in the dog house as part of the SID, but should not exceed 200,000 lb.

Positioning Control Considerations and Beacons

Positioning control is especially critical in shallow-water situations because the short drill string provides less flexure and elasticity if the ship moves off the hole. If a substantial loss of positioning or a horizontal excursion is anticipated, coring should be suspended and the core barrel should be withdrawn. As a practical matter, the standard yellow (2% of water depth) and red (3% of water depth) warning lights are overly cautious when operating in shallow-water areas with soft seafloors because they represent horizontal (lateral) excursions off the hole that are relatively minor. It is advisable in shallow-water areas with soft seafloors to increase the yellow and red warning-light tolerance (Table T5) so that frequent positioning warnings for minor lateral excursions do not unnecessarily shut down operations. The suggested yellow and red warning light tolerances are

T5. Warning tolerances, p. 62.

- 76–300 m: yellow = 5%, red = 8%
- 301–650 m: yellow = 3%, red = 6%
- >650 m: yellow = 2%, red = 3%

In areas with soft seafloor sediment, the pipe can pull into the soft wall of the hole near the seafloor and the curved 350-ft radius on the guide horn reduces severe bending angles at the ship. Excursions of 5%–20% have occurred without drill string damage, and coring was resumed without tripping the pipe. In areas with hard seafloors, a more cautious approach is required to avoid drill pipe damage or getting stuck in key seats.

Beacons for shallow-water operations should have lower power output (i.e., reduced from the standard 208–199 dB) to avoid multi-pathing, which is bouncing sound signals back and forth between the bottom of the ship and the seafloor. Low-powered beacon tests in shallow water and good weather have demonstrated that the narrow transmission angle of a standard beacon transducer can be acquired even with substantial ship excursions and thruster noise (±20% displacement in 200 m water depth with 80% thruster power rating).

Currents in shallow water are often stronger at or near the bottom and may cause the tethered beacon to sway; therefore, it has been necessary in some instances to fix the beacon to a frame (e.g., Leg 133). Operating primary and backup beacons shall be deployed in shallow water, especially where operations could be impacted by confined locations, shipping lanes, potential high currents, severe weather, hard seafloors, or deep-penetration (long term) operations.

Logging in Shallow Water

Logging should not be attempted in shallow water (0–650 m) unless hole conditions are good. The conical side-entry sub (CSES) should not be used to log holes in shallow water. This reduces potential exposure to stuck pipe (especially while handling and rigging the CSES) and the added danger of sticking a logging tool because of bad hole conditions. Holes in shallow water that are logged should be loaded with sepiolite mud after the wiper trip as a precaution to provide the best hole conditions for logging. Upper hole sections (0–250 mbsf) may start to react and swell into the hole after 3–5 days. Upper hole sections down to 400 mbsf tend to wash out to progressively larger diameters and become unstable with extended drilling.

The best hole conditions are normally obtained by logging the upper hole sections as soon as practical; therefore, if time permits, drilling a dedicated logging hole should be considered in reactive formations that require 5 or more days to core. A dedicated logging hole usually provides a fresh and more in-gage hole that has not had time to react or become unstable. This is especially true in shallow water because the trip for a drill bit requires less time and logging operations in unstable holes are more risky.

High-Temperature Formations

Operations have been successfully conducted in 316°C high-temperature hydrothermal zones; however, in high-temperature formations there is a potential danger of steam flash problems, swabbing in corrosive (pH = 2–6) wellbore fluids, and/or H_2S. When retrieving core barrels or when a core barrel is in place (holding the float valve open), circulation should be maintained at low pump rates (50 gpm) to prevent swabbing or prevent fluid from U-tubing (see below) up into the drill string. It is sometimes possible to cool high-temperature holes by stopping every 500 m on trips to circulate at 500 gpm. The primary danger of getting stuck in a high-temperature hole is that the temperature limit of the Schlumberger explosive severing devices might be exceeded, especially if the pipe and hole are plugged or cannot be cooled by circulation.

HYDROCARBON FLOW DURING DRILLING

Flows and Kicks

Backflow

Backflow from the drill pipe is a normal occurrence when a connection is broken at the rig floor. Backflow can result from the density differential of warm (low density) surface water pumped down the pipe against cold (denser) water in the ocean, air that has been trapped during connections and pumped down the pipe, dense cuttings or mud in the annulus flowing back ("U-tubing") to equalize hydrostatic pressure, and so on. Backflow into the pipe is usually reduced by the closure of the downhole float valve but also occurs while retrieving core barrels and through the bit nozzles. Hydrocarbons, hot acidic fluids, H_2S, and/or cuttings and debris from the hole may backflow into the pipe and plug the pipe or bit nozzles or jam the downhole float valve open. Backflow will usually gradually decrease within a short time as the pressure differential is equalized.

Detecting a Kick

In deep water, an uncontrolled flow (or "kick") of hydrocarbon gases or fluids exiting from a drilled hole at the seafloor probably would be diluted by mixing with the seawater column and dispersed by currents so that the flow might not be visibly evident on the ship. Fluctuating pump pressures, packing off in the annulus, decreasing string weight, and hole problems may indicate that a kick is in progress. The precision depth recorder (PDR) could be used to look for suspicious plumes in the water column if a gas flow is suspected. The VIT televiewer could be used to check the hole at the seafloor for flow (i.e., an unusual debris cloud or turbidity). If a hydrocarbon kick is suspected, a kill procedure should be started immediately.

A kick up the pipe is most likely to occur when the annulus is packed off, the pipe is open-ended (i.e., no float valve), or the float valve is held open by a core barrel, debris, or malfunction. A kick inside the drill pipe might be differentiated from normal flow-back events because the flowback rate from the pipe becomes progressively stronger with time.

Note: As the pressure is reduced when gas rises, gas expands in inverse proportion (Boyle's law: $P_1V_1 = P_2V_2$). In the event of heavy and increasing flow from the drill string, circulation should be reestablished as quickly as possible to pump intruding fluid out of the pipe. If the top drive is in use, it should be made back up to the drill string immediately. If the top drive has been racked, it will be faster to install the rig-floor safety valve and close the valve to stop backflow. The top drive or a circulating head can then be used to circulate down the drill string.

Running Back to Bottom

It is more difficult to kill a flow if the bottom of the pipe is not below the flow. If the pipe is off-bottom and the ODP Operations Manager, Transocean OIM, and Master agree that an attempt to kill the flow does not pose a risk to the ship and personnel, an attempt may be made to run pipe back in to bottom. If a drill string safety valve has been installed, it may be necessary to install a sub with a Baker model G (5f6R) float valve above the safety valve so the safety valve can be opened at the rig floor. A rig-floor safety sub with a Baker float valve is on the rig floor at all times to act as a check valve, permitting fluid to be pumped down the pipe but preventing backflow on connections. The Baker float valve can be used in instances when the top drive is set back and/or a float valve is not in the string, such as when using a logging bit or after dropping a bit.

Most often, the pipe can be run back down into the good open-hole section using the top drive to fill the pipe (to ensure gas is not moving up the pipe). The drill string should not be forced down into bad hole conditions because stuck-pipe severing operations would not be possible through a drill string float valve. Bad hole conditions probably indicate that the hole is collapsing and the flow will kill itself. The crew should attempt to pump kill mud as deep as possible under good hole conditions.

Controlling a Kick

The record of DSDP/ODP remains unblemished with regard to hydrocarbon pollution from scientific boreholes. That is a tribute to the careful screening procedures of scientific planning and safety panels, adherence to shipboard monitoring procedures, and application of proper abandonment procedures by shipboard personnel. The possibility remains that an uncontrolled flow of gas or petroleum could occur despite all the safety precautions. In case a kick should occur, the Operations Manager must be prepared to take immediate and appropriate action in concert with the Transocean OIM to kill the flow if possible.

The *JOIDES Resolution* has no riser, recirculating mud system, BOP, or choke and kill lines to control hydrocarbon or water kicks in the normal oilfield manner (i.e., circulating heavy mud through a choke with backpressure). Penetrating a significant hydrocarbon reservoir is unlikely because potential traps for significant hydrocarbon accumulations are strictly avoided. In ODP's scientific operations, open (uncased) holes are cored to relatively shallow penetration depths in soft to semiindurated sediments in deep water; therefore, the formations could not withstand the pressure of a heavy-mud hydrostatic column.

The objective in killing a flow is to quickly fill the hole with a mud column that has enough hydrostatic pressure to slightly exceed the formation pore pressure. However, the kill-mud weight must not exceed the formation fracture pressure, which would cause the mud to flow laterally, reducing the effective height and hydrostatic pressure of the kill mud column.

It may be prudent to advance the bit on a core-by-core basis if there is an increasing indication of migrated (but not liquid) hydrocarbons. In most circumstances, the detection of migrated and more thermally mature or liquid hydrocarbons requires suspension of drilling operations. Some areas with known gas seeps or dead hydrocarbon stains have been cored successfully using data from offset holes and a series of pilot test holes downdip from the primary site.

Any flow or kick is likely to be from flow along a fault or a flow of the low-pressure and low-volume shallow gas pocket or salt water variety. Without casing for hydrostatic pressure containment, circulating dense (heavy) mud weights exceeding 10.5 ppg (1.26 gm/cm^3) might fracture soft sediments.

The fracture gradient at the weakest point in the hole (usually the casing shoe) is the effective limit on the imposition of additional hydrostatic kill pressure. A standard Gulf of Mexico pore pressure/fracture gradient/mud weight graph for riserless drilling can be used to predict formation pore pressures. For example, in 915 m (3000 ft) water depth and 915 mbsf (3000 ft) of penetration, the predicted formation pore pressure is 10.1 ppg (2925 psi). If the hole was loaded with 10.1-ppg kill mud, the formation fracture gradient would be exceeded at ~150 m (500 ft) with normal trip (surge) and circulation pressures. Therefore, 10.1-ppg mud would probably fracture (i.e., break down) the formation and the mud would flow out into the formation at that point (i.e., more or heavier mud would not increase hydrostatic pressure control).

At 1500 mbsf penetration, the pore pressure is 10.5 ppg and the fracture gradient would be exceeded above 450 m (1500 ft). Therefore, overall considerations indicate that a 10.5-ppg kill mud is probably the heaviest practical kill mud for holes with <1500 mbsf penetration under normal circumstances. A volume of heavier kill mud (perhaps 100 bbl of 12.5 ppg) could be placed on bottom (i.e., below 10.5-ppg mud) in deeper holes if fracture gradient conditions permit. Note that cement does not set in the presence of a gas flow; therefore, mud must be used to kill a gas flow before the hole is plugged with cement.

If a kick occurs, an attempt should be made if practical (and safe) to run pipe to total depth and fill the hole with premixed kill mud and/or cement slurry. As in all well-control situations, judgment and rapid response are critical. It is probable that regardless of any attempt at human intervention, the turbulence from flowing fluids during the kick would destabilize the soft sediments in the borehole wall and the hole would load up with debris and/or collapse and reseal itself (which is what happens in natural flow events).

Minor Flows

A relatively minor or weak flow of gas or liquid hydrocarbons could seep into the hole from a formation that has been penetrated and go completely undetected for the duration of drilling operations in deep water. A minor flow could manifest itself in unstable hole conditions and "packing off" around the drill string. If a flow is suspected, the PDR could be used to look for suspicious plumes in the water column. it might be possible to run the VIT televiewer to look for gas bubbles or liquids escaping from the hole, which might be detectable as white hotspots on the Mesotech sonar. An attempt should be made to kill such a suspected flow if it appears to be a safe operation.

ODP policy requires that sufficient 10.5-lb/gal kill mud should be premixed and in the reserve pit at all times to completely fill the hole being drilled (usually ~250–350 bbl). If the pipe is open-ended or the downhole float valve is malfunctioning, the drill string safety valve and drill string float valve should be put into the drill string below the top drive before the pipe is run to total depth to displace the kill mud (in case the annulus packs off during pumping operations and flow is diverted up the pipe). While the kill mud is being displaced, preparations should be made to follow it with heavier mud or cement, if required. If the flow can be stopped, the hole should be plugged with cement in accordance with PPSP guidelines.

Major Flows

In the event that a hydrocarbon flow is detected, coring or drilling operations will be terminated immediately. The Operations Manager, Transocean OIM, Staff Scientist, and Master, in dialog with the Co-Chief Scientists, should review the situation and agree on a plan of action. ODP is a self-regulating program with a long history of pollution-free scientific ocean drilling and is committed to maintaining an environmentally sound, pollution-free operation. However, if the Operations Manager, Transocean OIM, or Master feel that a kill attempt is too risky to the ship or personnel, the bit should be pulled above the seafloor and the ship should be moved off location upwind in dynamic positioning (DP) mode before the remainder of the drill string is recovered. On the positive side, environmental damage from shallow gas blowouts is usually limited because the soft sediments in shallow holes tend to collapse and kill the flow after a relatively short time. Activities depend on water depth as follows:

- <650 m: Refer to "Shallow-Water Operations" in "Principal Hazards."

- >650 m: An attempt should be made to kill hydrocarbon flows by pumping 10.5-lb/gal kill mud at high pump rates (500–1000 gpm) as soon as possible if
  - The Operations Manager, Transocean OIM, and Master agree that a kill attempt is safe, and
  - There are no other mitigating risk factors (such as bad hole conditions).

The kill mud should be followed by heavier kill mud (if required to control the flow) and cement to permanently plug the hole. A flowing open hole is often unstable, and the chances of getting the pipe stuck are significant. If the drill string becomes stuck, the normal through-the-drill-string severing procedures might be impossible or too hazardous. In an emergency situation that requires moving the ship immediately away from hydrocarbons, the options would be to intentionally offset or drive-off or drop the drill string. However, the danger to the ship and personnel from a hydrocarbon flow in deep water (with riserless operations) would be small under normal conditions. Hasty actions such as offsetting the ship before the pipe is clear of the seafloor or dropping the drill string might aggravate the situation, endanger personnel, or lead to the unnecessary loss of expensive hardware, if not done properly.

Abandonment

Drilling and Early Abandonment Practices

Rapid pipe or tool movements that may swab fluid into the hole or fracture formations should be avoided. If hydrocarbons are detected or anticipated in substantial quantities, drilling will be stopped and the hole plugged.

Plugging and Abandonment Procedures

Plugging with Cement

The hole should be filled with viscous gel barite mud of 10.5 ppg (78 lb/ft^3) weight, allowing extra volume for hole enlargement and loss by displacement. The hole should be filled to the uppermost competent layer and a cement plug spotted. A minimum-sized plug should be 200 sacks of 12–15 ppg. Where possible, a plug catcher or calibrated displacement tanks should be used in placing the cement.

If hydrocarbons are indicated and the hole has penetrated semiconsolidated or consolidated rocks, proper placement of cement should be confirmed by probing with the drill string or sampling the cement with the core barrel. The cement plug should be calculated to be at least 15 m and preferably 30 m in length.

Plugging without Cement

The hole should be filled with viscous gel barite mud of 10.5 ppg (78 lb/ft^3) weight, allowing extra volume for hole enlargement and loss during displacement.

Standard Abandonment Procedures

Holes drilled in consolidated or semiconsolidated rocks on the continental shelf, slope, or rise should be plugged with cement. Holes drilled in unconsolidated sediments in which shows of oil or gas occur should be filled with mud. Holes on the deep ocean floor in which no shows are encountered or holes in igneous rocks may be abandoned without plugging.

LOGGING

ODP Logging Services

ODP Logging Services provides downhole logging operations, as well as logging data processing, distribution, and database services for ODP. ODP Logging Services is managed by the Borehole Research Group of LDEO, but also includes logging groups in the United Kingdom, France, Germany, and Japan. ODP Logging Services is responsible for (1) shipboard logging operations and staffing, (2) shore-based log analysis, (3) log database development and management, (4) data publication and distribution, and (5) engineering development.

Situations to Avoid while Logging

Holes containing bridges and ledges can pose extreme risk of loss to logging tools. Numerous scenarios to be avoided are detailed in the Logging Manual (Borehole Research Group, 2004) and therefore will not be listed here. Use of the CSES can greatly assist logging operations in difficult holes; therefore, its use should be thoroughly considered.

High-Temperature Logging Precautions

There are several procedures that should be followed before, during, and after logging operations in high-temperature environments. Prior to the leg, the Logging Staff Scientist should make arrangements with the logging subcontractor and Logging Engineer to have the capability of measuring in situ borehole fluid temperatures during all tool deployments. Discussions prior to the leg should also include the availability of high-temperature wireline cable and cable heads. This will ensure that high-temperature logging operations can be carried out during the leg and that borehole temperatures will be monitored closely, thus avoiding potential damage to the tool strings.

The Logging Staff Scientist and the Operations Manager should plan to perform several hours of hole circulation procedures before any tool deployment if the temperatures exceed the safe operational limits of the tool strings. In some cases where there is a quick thermal rebound, the deployment of the sidewall entry sub (CSES) might be necessary for avoiding tool damage and saving time if more hole circulation is needed once the logging operations have already begun. The Logging Staff Scientist, Operations Manager, and Co-Chief Scientists should also discuss time estimates, potential benefits, and procedures for such deployment.

Cautionary measures should be taken at the time of retrieving a tool string, as hot fluids may spray a large area of the rig floor. Significant amounts of H_2S and hot fluids may also concentrate along joints in large tool strings; therefore, protective clothing and eyewear should be used when dismantling the tools. If a memory tool that uses lithium batteries has been deployed in these environments, extreme caution will be needed before dismantling the tool, as exploding batteries can be extremely harmful.

After logging operations in a high-temperature environment have been completed, the Logging Staff Scientist and Logging Engineer should conduct a careful inspection of the wireline cable and tools in order to assess any potential damage from prolonged exposure to H_2S. At this time, it may be necessary to discard sections of the cable that show signs of corrosion due to exposure to high concentrations of H_2S.

Logging-While-Drilling Precautions

Drilling operations with logging-while-drilling (LWD) and measurement-while-drilling (MWD) collars can proceed by following standard drilling guidelines under most circumstances. Because the physical nature of these tools is vastly different than that of a standard drill collar, special care and attention must be paid to key drilling procedures in order to avoid a stuck or lost drill pipe situation. LWD and MWD collars deployed in ODP operations are typically 6¾ inches in diameter, whereas drill collars are >8¼ inches. This difference in size creates two problems: (1) a stabilizer on the density neutron tool must be used to ensure constant contact with the borehole wall and (2) the interface between the drill collars and LWD/MWD collars is not as strong as a drill collar to drill collar connection. Caution must be used when spudding into a hardened or crusty substrate to avoid excessively loading the drill pipe and possibly causing a weak-link failure between the drill collars and LWD/MWD collars. Caution must continue to be used until the LWD/MWD collars have penetrated below the seafloor.

Jars can be used to provide assistance in freeing a stuck BHA. In past ODP experience, however, jars were frequently jammed by cuttings or were located below the stuck point, where they could not be operated. In addition, jars further weaken the BHA and the sediments may leak, providing undesirable pathways for downgoing circulated seawater.

In the event an LWD/MWD collar becomes irretrievably stuck, the stored data and radioactive sources must be retrieved using the wireline LWD Inductive Coupling (LINC) tool. The LINC retrieval operation consumes approximately the same amount of time as one standard wireline run.

Fluid Pumping Strategies

Drilling muds such as sepiolite are used to stabilize the borehole prior to logging. Fluids are never pumped while a tool is in the open hole or while a logging tool is in the BHA. If drilling in unconsolidated materials and the LWD/MWD collars become lodged, make all attempts using standard drilling techniques to free the tool. If this is unsuccessful, allow the formation to relax by not pumping for 10–15 min and then apply overpull. This scenario occurred during Leg 174, where the LWD collar was considered hopelessly stuck, yet it was eventually recovered after pumping ceased.

Overpressure

LWD/MWD tools are most often used where difficult formations are expected and hole stability is a significant concern. Environments such as convergent margins and, in particular, décollements pose a serious risk to high-dollar drilling equipment. More conservative drilling techniques must be used to prevent a LWD/MWD assembly from becoming lodged in a zone of overpressure where hole instability is a possibility.

Recovery Attempts and Tool Abandonment

If a tool is lost downhole, a reasonable effort must be made to recover it to satisfy our obligations to the environment, Schlumberger, and the insurance provider. The recovery effort should follow accepted practices and include multiple recovery attempts if technically feasible. The shore-based ODP Logging Services representative must be notified of the stuck or lost tool situation by the Logging Staff Scientist or the Operations Manager.

If all reasonable efforts have been made to recover a stuck or lost tool without success, then the decision to abandon the tool must be made collectively by the Logging Staff Scientist, Operations Manager, OIM, Co-Chief Scientists, Staff Scientist, and the Schlumberger engineer. In the event of loss involving a radioactive source, the tool and hole must be filled with cement, plugged, and abandoned to safely entomb the sources. Following the incident, a report must be filed by the Operations Manager and delivered to the Logging Staff Scientist for possible use for insurance purposes. A copy of the ship's log must be included in this report.

Tool Replacement Strategies

If a wireline or LWD/MWD tool is lost downhole, a backup tool should be put into service only after an appropriate recovery effort. Duplicate LWD/MWD and wireline tools are often, but not always, available. Substitutes for all routine measurements are available. The backup strategy is shown in Table T6.

T6. Tool replacement strategies, p. 63.

Hazardous Material Safety

Logging operations often involve the use of radioactive sources and, seldom, explosive sources. The Schlumberger or Anadrill engineer is trained and qualified in the safe handling and use of such sources. The radioactive and explosive materials must only be handled by authorized personnel. Several key safety steps must be followed by all other shipboard personnel when radioactive or explosive source handing is occurring: (1) all personnel besides the logging engineer must clear the vicinity of the source work and (2) when a source is loaded into a tool or collar, the tool must not be raised above the rotary table when personnel are on or near the rig floor. Additionally, electronic neutron generators (minitrons) must not be switched on when the tool is above rotary table.

The Schlumberger engineer will maintain an up-to-date hazardous material manifest, and a copy will be provided to the Master. Any changes to the hazardous material manifest are registered with the bridge.

RESPONSIBILITY AND AUTHORITY

Precruise Responsibilities

Proponents, SSP, and PPSP Interaction

EXCOM presides over JOIDES and advises the ODP prime contractor, JOI, on policy issues. Scientific leadership is provided by SCICOM, which heads the JOIDES science advisory structure. Scientific proposals are reviewed by the SSEPs for Environment and Interior, which select scientifically mature proposals for external review.

SCICOM (with advice from the SSEPs) creates small, focused short-term PPGs to work with proponents to produce mature proposals that cover specific scientific themes. JOIDES service panels provide advice to the advisory structure and include the SSP, PPSP, and SciMP.

Following reviews of proposals by external panels, the SSEPs forward scientifically mature proposals to SCICOM with a recommendation for inclusion in the drilling program. SCICOM ranks all the proposals and sends them to OPCOM. OPCOM receives reports from the PPGs and recommends the drilling program schedule to SCICOM for approval. TEDCOM provides advice to ODP through OPCOM on technical matters, drilling tools, and techniques to meet scientific objectives, and monitors the progress of their development. The SSP provides advice to ODP through OPCOM on the adequacy of and need for site survey information relating to proposed drilling targets. The PPSP provides advice to ODP through OPCOM regarding potential safety and pollution hazards that may exist because of general or specific geology of the seafloor or as a consequence of human activities.

Both the JOIDES PPSP and the ODP/TAMUSP give advice and make recommendations that are considered in the final decision on whether a specific site will be drilled.

Science Operator

The operation of the drillship, which includes planning and implementation of cruises, is managed from ODP facilities at TAMU in College Station, Texas. This facility also houses the Gulf Coast Repository, which contains cores from the Pacific and Indian Oceans. As science operator, TAMU is responsible for

- Selecting Co-Chief Scientists (based on recommendations from SCICOM);
- Implementing science planning and operations;
- Approving final drilling plans;
- Guiding engineering development and improvement of drilling technology;
- Selecting scientists for the shipboard scientific parties;
- Designing, furnishing, and maintaining shipboard and shore-based laboratories necessary to meet the needs of the shipboard scientific staff;
- Curating and distributing all core samples and data;
- Maintaining shipboard safety;
- Obtaining clearance to drill/core;
- Publishing scientific results; and
- Providing public information about ODP

Staff Scientist/Leg Project Manager

The advisory structure of ODP determined in 1996 that the program would incorporate the principles of project management as an operational paradigm. With this shift, the Staff Scientist was assigned as the LPM. This position is pivotal for successful completion of each cruise, coordination of the leg team, and management of leg-related resources.

LPM/Staff Scientists are supervised by the Deputy Director for Operations, who oversees LPM tasks, and the Manager of Science Operations, who oversees all other job functions. The Staff Scientist is responsible for ensuring the successful implementation and completion of the cruise-based science plan as defined by the JOIDES panels through project management of the cruise-related resources. As cruise project manager, the Staff Scientist

- Interacts with Co-Chief Scientists,
- Coordinates the shipboard scientific party before and during the cruise, and
- Coordinates operational planning.

In addition, the Staff Scientist

- Coordinates development of shipboard measurement procedures and laboratory equipment;
- interfaces with scientists as customers and with the JOIDES advisory and planning structure;
- Contributes to shaping ODP's future through continued improvements in strategies, policies, and services; and
- Conducts scientific research to maintain and expand the expertise required to act effectively as a Staff Scientist.

Specific duties of the Leg Project Manager/Staff Scientist include:

- Coordinating a leg project team composed of representatives from each department to ensure efficient precruise and cruise operations;
- Working closely with the Co-Chief Scientists to prepare the cruise Scientific Prospectus in a timely manner;
- Scheduling, coordinating, and hosting precruise meetings with the Co-Chief Scientists to complete precruise planning and related ODP policies and procedures; and
- Providing a link at ODP/TAMU for communication with shipboard scientists and ensuring that all pertinent cruise information is sent to them prior to the cruise.

Co-Chief Scientists

The Co-Chief Scientists are responsible for the scientific success of the cruise. Their responsibilities include

- Aiding ODP staff in refining the scientific objectives of the cruise, taking into account operational constraints and ensuring that the necessary geologic, geophysical, oceanographic, and meteorological data are assembled;
- Aiding ODP Site Survey Data Bank personnel as necessary in preparation of the safety package for formal review by JOIDES (PPSP);
- Reviewing scientists' applications for participation on the cruise and making recommendations to the ODP Manager of Science Services for the selection of participants.

- Participating in the Co-Chief Scientists' precruise meeting to finalize cruise planning and meet ODP personnel:
  - Finalizing cruise operation strategy;
  - Finalizing the *Scientific Prospectus*
    - Ensuring agreement between Co-Chief Scientists, panels, and TAMU/LDEO concerning cruise operations in meeting cruise objectives;
    - Providing shipboard participants with specific cruise strategy for completion of individual sample requests; and
    - Processing clearance documents; and
  - Providing guidance concerning services available from ODP/TAMU and LDEO;
- Completing the cruise scientific prospectus for distribution to cruise participants and the JOIDES community by the end of the precruise meeting;
- Reviewing requests for samples from the cruise, aiding curatorial personnel in addressing "problem" requests prior to the cruise, and preparing a letter to participants addressing a team approach;
- Arriving at the ship the first day of port call; and
- Crossing over with previous Co-Chief Scientists during port call, when appropriate.

Logging Staff Scientist

Shortly after the drillship schedule has been set by SciCOM at the August meeting, ODP Logging Services appoints a Logging Staff Scientist for each scheduled leg. The Logging Staff Scientist is considered to be the leader of the Logging Services project team. In addition to all shipboard participants, the team usually consists of the following personnel:

- LDEO Manager of Technical Services, for tool deployment and engineering issues;
- Engineering Assistant, for shipping issues;
- Manager of Information Services, for data handling issues;
- Log Analysts, for log processing services;
- CD-ROM coordinator, for issues involving the Logging Data CD; and
- Systems Analyst, for any computer or software issues.

In addition, there may be other engineering or scientific personnel involved if special projects are planned for the cruise. The LDEO Deputy Director of Operations is responsible for coordinating the activities of the LPMs and is available, along with the Director of Operations, to assist as needed.

The Logging Staff Scientist is responsible for ensuring the successful implementation of the logging program for each cruise. He/she provides a link between ODP Logging Services and the shipboard scientists before, during, and after the cruise. The role of the Logging Staff Scientist during the cruise includes

- Coordinating all leg-related logging activities;
- Training new logging scientists; and
- Interfacing with the Co-Chief Scientists, TAMU Staff Scientist, JOIDES Logger, Geophysical Properties Specialist, Operations Manager, and Drilling Superintendents.

Cruise Responsibilities

Co-Chief Scientists

The Co-Chief Scientists are responsible for the scientific success of the cruise. At sea they are responsible for optimum use of the vessel's time, except as abridged by policies set by the ODP Program Plan (available from ODP/TAMU), safety considerations, and/or laws of the sea. The Co-Chief Scientists are charged with implementing the recommendations of the JOIDES Planning Committee for drilling, coring, and logging, after the recommendations have been reviewed operationally and approved by ODP management.

Specific cruise duties include:

- Representing the JOIDES community in the shipboard leadership team (with the LPM/Staff Scientist, Operations Manager, Laboratory Officer, and Curator) in coordinating the shipboard science activities toward attaining cruise objectives set by the JOIDES scientific and operational committees;
- As a member of the Sample Allocation Committee (SAC), supervising the implementation of the cruise sampling plan and seeing that all shipboard scientists help in its completion;
- Ensuring that scientific data obtained during the cruise are entered into the ODP database by the shipboard scientific party;
- Sharing with the Operations Manager the responsibility of avoiding drilling into hydrocarbon accumulations by ensuring that all hydrocarbon monitoring procedures are carried out and that recommendations of the JOIDES PPSP are followed during the cruise;
- Determining when and what types of underway geophysical data are collected while under way between sites and to and from ports;
- Providing ODP with a concise report of the scientific results obtained at each site immediately upon its completion (Site Summary) and providing a weekly science progress summary when sites are occupied for extended times;
- Reporting information generated during the cruise in a cruise *Preliminary Report* and a cruise press release. These reports must be completed prior to docking at the end of the cruise; and
- Completing a Cruise Evaluation Form, or otherwise provide written assessment of performance of equipment, procedures, and ODP and Transocean personnel to the manager of Science Services.

Staff Scientist/Leg Project Manager

The ODP Staff Scientist/LPM is responsible for the following:

- Aiding the Co-Chief Scientists in preparing and finalizing the cruise sampling plan;
- Acting as liaison to further communication between the Co-Chief Scientists, Operations Manager, and scientific party;
- Acting as liaison between internal departments and the external science community concerning leg activities;
- Ensuring that departments comply with appropriate regulations concerning shipments to foreign ports where the research vessel is locating;
- Ensuring that shipboard reports for the *Initial Reports* are properly written and submitted in a timely manner (including Site Reports, Leg Summaries, and Barrel Sheets);
- Ensuring that the Weekly Reports and press releases are properly written and submitted in a timely manner;
- Coordinating science meetings during the cruise;
- Coordinating shipboard measurements, including use of standard and special instrumentation; data quality control; data archiving; and use of data acquisition, analyses, and reporting programs;
- Assisting the Operations Manager and Co-Chief Scientists in daily operations planning;
- Acting as a member of the shipboard scientific party;
- Compiling a draft table of contents for the *Initial Reports* and *Scientific Results* volumes with the shipboard party; and
- Ensuring successful implementation of port call activities, including shipping and receiving.

Operations Manager

The Operations Manager is the senior ODP/TAMU representative aboard ship. He/she is responsible for

- Executing the recommendations and procedures made by the JOIDES Safety Panel and approved by ODP/TAMU;
- Dealing with all matters affecting the technical and operational success of the expedition;
- Planning and directing the activities of shipboard Transocean personnel through their designated supervisors;
- Ensuring that the best possible techniques, equipment, and work efforts are used to maximize scientific results with minimum risk of loss of equipment or personal safety;
- Representing ODP/TAMU in determining acceptable drilling conditions;
- Dealing with matters pertaining to discipline of the ship, drilling, and scientific crews;
- Approving on-site changes in equipment or drilling and coring procedures; and
- Completing accurate reports of drilling, coring, and ship operation/maintenance, and for transmitting this information ashore (daily operations reports).

The Operations Manager, if necessary, reminds the Co-Chief Scientists and other scientific party members that if any hole at a site is drilled to a depth >400 m, at least one of the holes must be logged. All communications with Transocean personnel regarding cruise operations or any other business matters must go through the Operations Manager. The Operations Manager also has direct supervision of the Operations Engineer. It is the Operations Manager's obligation, after consulting the Co-Chief Scientists and Staff Scientist, to terminate drilling operations whenever necessary to prevent any possible release of hydrocarbons. Final authority to terminate drilling/coring resides with the Operations Manager.

The Contract between Texas A&M Research Foundation (TAMRF) and Ocean Drilling Limited (Transocean) specifies that the ODP Operations Manager is the *only* ODP contract representative on board who is authorized to issue orders to Transocean (the Contractor). All ODP instructions and business with the Contractor must come from the Operations Manager and should be given (preferably in writing) to the Transocean OIM.

The Operations Manager is responsible for working with the Contractor's supervisory personnel to ensure compliance with the contract and ensure the most effective safe use of time and materials in compliance with the Scientific Prospectus, science plan, and leg operations. The ODP/TAMU Administration Department is responsible for administering and interpreting the Contract. The Contract can have numerous amendments and additions that modify and extend the contract. A copy of the Contract is maintained in the Operations Manager's office on board the ship. The ODP Administration Department should be contacted for the latest additions and interpretation of the contract.

In addition, action by the Planning Committee (PCOM) and JOI have clarified policy with regard to the role of the Operations Manager in operational decision making. These interpretations concern not only logging and downhole instrumentation, but overall scientific site objectives.

Paragraph 562 of the JOI ODP Policy Manual states: "The ODP Operations Manager is the official representative of the Ocean Drilling Program and has the responsibility of seeing that the SCICOM (formerly PCOM) drilling and logging guidelines are followed during the cruise operations."

This is not to imply that the Operations Manager has the authority to make or alter scientific decisions. The operational plans and scientific objectives described in the cruise prospectus reflect the official directives and policies to be followed on a given leg.

Logging Staff Scientist

The LDEO Logging Staff Scientist is responsible for the following:

- Training new logging scientists sailing on the cruise;
- Interfacing with the Co-Chief Scientists, TAMU Staff Scientist, JOIDES Logger, Geophysical Properties Specialist, Operations Manager, and Transocean OIM;
- Cruise and postcruise reporting of logging objectives and operations;

- Participating in and supervising at-sea logging operations, including data acquisition, interpretation, and integration, and data distribution;
- Supervising and assuming responsibility for quality control of Schlumberger data acquisition; and
- Conducting scientific research to maintain and expand the expertise required to act effectively as a Logging Staff Scientist.

Master and Transocean Offshore Installation Manager

Maritime law states that the ultimate and overall responsibility for safety on board the ship resides with the Master of the vessel (i.e., the Captain). Transocean company policy is that the Transocean OIM is the senior Transocean representative on board and is in charge of Transocean drilling-related operations when the ship is in DP mode (except where the safety of the ship is involved). The vessel's viability as everyone's life-support system has first priority. The safety of individuals has priority over the safety of the drill string and other equipment.

Specific responsibilities of the Master include

- Overseeing safety, vessel stability, barge control, deck and hull load distribution, draft and trim adjustments, position of rig over hole, and monitoring of weather;
- Supervising navigation, port entry/exit, running and retrieving anchors, towing and steaming, material/personnel transfer, and crane operations;
- Supervising maintenance of safety equipment, operation of thrusters, preventive maintenance programs, pollution control, mooring systems, rig bulk systems, bilge alarm systems, and cathodic protection systems;
- Monitoring structural integrity of ship and supervises systematic inspections;
- Overseeing maintenance of medical, communications, sanitation, food preparation, and handling and storage facilities;
- Ensuring that rig meets all regulatory requirements;
- Assisting and planning crew training and oversees adherence to safety policies and procedures; and
- Directing and training crew in emergency operations.

Specific duties of the OIM include

- Supervising coring and drilling, including casing and cementing, out-of-the-ordinary operations, well control measures, and weather monitoring;
- Overseeing preventative and planned maintenance programs on equipment;
- Overseeing maintenance of medical, communications, sanitation, food preparation, and handling and storage facilities;
- Directing crew in emergency situations and making decisions to evacuate/abandon rig; and
- Preparing crew schedules and training crew.

Tool Pusher

Specific duties of the Tool Pusher include

- Supervising coring operations; drilling, including casing and cementing; and out-of-the-ordinary operations;
- Monitoring vessel stability, rig stationing on location, and weather;
- Overseeing preventative and planned maintenance programs on equipment;
- Directing crew in emergency situations; and
- Preparing crew schedules and training crew and overseeing company rig training program and adherence to requirements of the regulatory agency.

Laboratory Officer

While at sea, the Laboratory Officer reports to the Operations Manager and is responsible to the Co-Chief and Staff Scientists for (1) the direct supervision, performance, and safety of the ODP technical staff in the collection of core material and recording of data and (2) proper, efficient, and safe operation and maintenance of the ship's laboratories and related equipment. On most cruises, a member of the technical staff is designated Assistant Laboratory Officer, handling part of these responsibilities. The technical staff on board *JOIDES Resolution* usually consists of a Laboratory Officer, eight Marine Laboratory Specialists (laboratory technicians), one photographer, one yeoperson, two chemists, two electronics technicians, two computer system managers, and one curatorial representative. In normal practice, the Laboratory Officer directs these activities in a way consistent with the guidelines and overall priorities, policies, and assignments made by ODP/TAMU.

The Laboratory Officer is responsible for all shipboard scientific equipment and supply items. All samples, data, and equipment, including necessary paperwork, are prepared for shipment under his direction.

The Laboratory Officer works with Transocean through the Operations Manager when his areas of responsibility involve ship's personnel, equipment, or operations.

SCICOM/Safety Panel

It is rare in ODP operations that the prospectus can be followed in its entirety. Time limitations, delays, and unexpected drilling results usually dictate that certain objectives or operations must be deleted or changed. The authority to alter the science objectives does not reside on the drillship. Changes can be effected only with the approval of the SCICOM and/or the Safety Panel through communications with ODP/TAMU management. Changes to the approved operational plan require the approval of ODP/TAMU management.

It is the Operations Manager's responsibility to keep the Co-Chief Scientists and ODP management sufficiently informed about events that will force a departure from the prospectus plan. Co-Chief Scientists may need to be reminded to submit their recommendations for alternative plans to ODP management for discussion with SCICOM and/or PPSP, as appropriate. If it is avoidable, resolution of a situation should not be postponed, forcing a last-minute shipboard decision.

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APPENDIX A

Safety and Site Survey Checklist

Proposal Information

__ New or revised proposal
__ Title of proposal
__ Date the form is being submitted
__ Site-specific objectives (must include general objectives in proposal)
__ List of previous drilling in area

General Regional Information

__ Leg number, if assigned
__ Site name (e.g., BON-9A)
__ Latitude and longitude of site in degrees and minutes
__ Priority of site (e.g., primary or alternate)
__ General location or geomorphic province of site
__ Jurisdiction
__ Distance to land (nmi)
__ Water depth (m)
__ Probable thickness of sediments (m)
__ List of possible hazards (ice, hydrocarbons, dumpsites, cables, etc.)
__ Indication of a weather window? If so, what is it?

Operations

__ Proposed penetration (m)
__ General lithologies
__ Coring tools
__ Logging plan (check as many as apply)
__ Estimated number of days of drilling/coring and logging
__ Total days on site

Detailed Coring Plan

__ Coring plan (circle as many as apply)
__ Sediment penetration (m)
__ Basement penetration (m)

Detailed Logging Plan

__ Answer conical side-entry sub question.
__ Answer high-temperature question.
__ Answer whether there are any other special requirements for logging. Describe if answer is yes.
__ List scientific objectives for different logging measurement types (see page 3 of Site Description Forms) and relevance logging tool has to meeting scientific objectives.

Detailed Site Survey Information

__ Fill in the data type boxes 1–17 on page 2 of site survey form (seismic reflection, seismic velocity, seismic grid, refraction, 3.5-kHz, swath bathymetry, side-scan sonar, photography or video, heat flow, magnetics, gravity, sediment cores, rock sampling, water current data, ice conditions, OBS microseismicity, navigation, other (List all that apply).
__ List DSDP/ODP Holes
__ List piston cores

Pollution and Safety Hazard Summary

__ List all hydrocarbon occurrences greater than background levels based on previous DSDP/ODP drilling.
__ List all commercial drilling that produced or yielded hydrocarbon shows.
__ List indications of gas hydrates.
__ List any reasons to expect hydrocarbon accumulations at this site.
__ List any special precautions during drilling.
__ List abandonment procedures.
__ List other natural or man-made hazards.
__ Summarize the major risks.

APPENDIX B

Definition of Acronyms

AACT = aluminum activation clay tool
ADN = Azimuthal Density Neutron tool
APC = advanced piston corer
bbl = barrel(s)
BHA = bottom-hole assembly [drilling]
BHTV = Borehole Televiewer tool
BOP = blowout preventer
BSR = bottom-simulating reflector
CD = compact disc
CDP = common depth point
CDR = Compensated Dual Resistivity tool
CD-ROM = compact disc read-only memory
CMP = common midpoint
CNT-G = Compensated Neutron Tool
CSES = conical side-entry sub [drilling]
dB = decibel
DIT = Dual Induction Tool
DLL = Dual Laterolog (resistivity) [logging]
DP = dynamic positioning
DSD = Drilling Services Department
DSDP = Deep Sea Drilling Project
DSI = Dipole Sonic Imager
EXCOM = Executive Committee
FMS = Formation MicroScanner
ft = foot or feet
gal = gallon(s)
GHMT = Geological High Resolution Magnetic Tool
GLT = Geochemical Logging Tool
gm/cm^3 = grams per cubic centimeter
gpm = gallons per minute
H_2S = hydrogen sulfide
HLDS = Hostile Environment Litho-Density Sonde
HLDT = Hostile Environment Litho-Density Tool
HNGS = Hostile Environment Gamma Ray Sonde
HRRS = hard rock reentry system
JOI = Joint Oceanographic Institutions, Inc.
JOIDES = Joint Oceanographic Institutions for Deep Earth Sampling
kt = knot(s)
lb = pound(s)
lb/ft^3 = pounds per cubic foot
LDEO = Lamont-Doherty Earth Observatory of Columbia University
LINC = LWD Inductive Coupling tool
LSS = Long Spacing Sonic Tool [logging]
LWD = logging while drilling
m = meter
MBR = mechanical bit release
mbsf = meters below seafloor
MCS = multichannel seismic
MDCB = motor-driven core barrel
MLS = Marine Laboratory Specialists
MWD = measurement while drilling
NGT = Natural Gamma Ray Spectrometry Tool

nmi = nautical mile
OBS = ocean-bottom seismometer
ODP = Ocean Drilling Program
OIM = Offshore Installation Manager
OPCOM = Operating Committee
PCOM = Planning Committee
PCS = pressure core sampler [drilling]
PDR = precision depth recorder
ppg = pounds per gallon
ppm = parts per million
PPSP = Pollution Prevention and Safety Panel
psi = pounds per square inch
PVT = pressure-volume-temperature
RCB = rotary core barrel
SAC = Sample Allocation Committee
SCICOM = Science Committee
SciMP = Scientific Measurements Panel
SCS = single-channel seismic
Seasat = sea satellite
SID = standing instructions to drillers
SSEP = Science Steering and Evaluation Panel
SSP = Site Survey Panel
SWDWG = Shallow-Water Drilling Working Group
SWGHS = shallow-water gas hazards survey
TAMRF = Texas A&M Research Foundation
TAMU = Texas A&M University
TAMUSP = Texas A&M University Safety Panel
TEDCOM = Technology and Engineering Development Committee
VIT = vibration-isolated television
VPC = vibra-percussive corer
VSP = vertical seismic profile
WST = Well Seismic Tool (used in VSP experiments) [logging]
WWW = World Wide Web
XCB = extended core barrel

CHAPTER NOTES*

N1. Mills, B. unpubl. doc. *Laboratory safety and Hazard Communication Compliance Manual*.

N2. 26 May 2010—Corrected yellow warning light tolerance on pg 29 to 5%.

*Dates reflect file corrections or revisions.

PUBLISHER'S NOTES

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DISCLAIMER

Figure F1. ODP site description forms. (Continued on next four pages.)

ODP Site Description Forms:

Page 1 - General Site Information

New ☐ **Revised** ☐

Please fill out information in all gray boxes

Section A: Proposal Information

Title of Proposal			
Proposal Number:		Date Form Submitted:	
Site Specific Objectives (Must include general objectives in proposal)			
List Previous Drilling in Area:			

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)		If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	
Latitude:	Deg:	Min:	Jurisdiction:	
Longitude:	Deg:	Min:	Distance to Land:	
Priority of Site:	Primary:	Alt:	Water Depth:	

Section C: Operational Information

	Sediments. What is the total sed. thickness? ☐	Basement
Proposed Penetration (m)		
General Lithologies:		
Coring Plan (circle):	1-2-3-APC VPC* XCB MDCB* PCS RCB Re-entry HRGB * *Systems Currently Under Development*	

	Standard Tools		Special Tools	LWD
Logging Plan:	Triple-Combo Neutron-Porosity ☐ Litho-Density ☐ Natural Gamma Ray ☐ Resistivity-Induction ☐	FMS-Sonic Acoustic ☐ FMS ☐	Borehole Televiewer ☐ Geochemical ☐ Resistivity-Laterolog ☐ High Temperature ☐ Magnetic/Susceptibility ☐	Density-Neutron ☐ Resitivity-Gamma Ray ☐

Estimated days:	Drilling/Coring:	Logging:	Total On-Site:
Hazards/ Weather	*List possible hazards due to ice, hydrocarbons, dumpsites, cables, etc.*		*What is your Weather Window?*

Instructions: Please fill out these forms for each site that you are proposing to drill, including as much detail as possible. The following table describes the purpose of each page, what information is needed, and when each page should be submitted.

Page	Information needed	Used By	When to submit	Contact for more information
1	General Info. about proposals, site location and basic operational needs	JOIDES Office, Data Bank, Logging Group, ODP/TAMU, SSP, PPSP	When submitting preliminary proposal and when updating site information.	JOIDES Office email: joides@whoi.edu www: http://www.whoi.edu/joides/
2	Information regarding site survey data available and to-be-collected	JOIDES Office, Data Bank, SSP, PPSP	When submitting full proposal and when updating site survey information	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
3	Detailed Logging Plan	JOIDES Office, Logging Group, ODP/TAMU	When submitting full proposal and when updating logging plan	ODP-LDEO Wireline Logging Services email: borehole@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/BRG/brg_home.html
4	Lithologic Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/
5	Pollution and Safety Hazard Summary	JOIDES Office, Data Bank, ODP/TAMU, PPSP	When proposal is placed on Drilling schedule, prior to PPSP review.	Site Survey Data Bank email: odp@ldeo.columbia.edu www: http://www.ldeo.columbia.edu/databank/

Form last revised: 24 March 1997

Figure F1 (continued).

ODP Site Description Forms:

Please fill out information in all gray boxes

Page 2 - Site Survey Detail
New ☐ **Revised** ☐

Proposal #:	Site #:	Date Form Submitted:

	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			Primary Line(s): Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) Crossing Lines(s):
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			
8a	Side-looking sonar (surface)			
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			
15	OBS microseismicity			
16	Navigation			
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 last revised: 24 March 1997

Figure F1 (continued).

ODP Site Description Forms:

Page 3 - Detailed Logging Plan

New ☐ **Revised** ☐

Proposal #:	Site #:	Date Form Submitted:
Water Depth (m):	Sed. Penetration (m):	Basement Penetration (m):

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:________

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.

Form last revised: 24 March 1997

Figure F1 (continued).

ODP Site Description Forms:

Please fill out information in all gray boxes

Page 4 - Pollution & Safety Hazard Summary

New Re

Proposal #:	Site #:	Date Form Submitted:

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	
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:	
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.	
4	Are there any indications of gas hydrates at this location?	
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	
6	What “special” precautions will be taken during drilling?	
7	What abandonment procedures do you plan to follow:	
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	
9	Summary: What do you consider the major risks in drilling at this site?	

Form last revised: 24 March 1997

Figure F1 (continued).

ODP Site Description Forms:

Page 5 - Lithologic Summary

New **Revised**

Proposal #:	Site #:	Date Form Submitted:

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Ave. rate of sediment accumulation (m/My)*	*Comments*

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Table T1. Target types.

Target	Description
A	Paleoenvironment or fan, generally APC/XCB penetration into undeformed sediments.
B	Greater penetration than a few hundred meters on a passive margin.
C	Greater penetration than a few hundred meters on an accretionary wedge, forearc, or sheared margin.
D	Greater penetration than a few hundred meters in a deep ocean environment. May or may not include basement penetration.
E	Sediment thickness of less than a few hundred meters on oceanic crust, typically with basement as a primary objective.
F	Bare rock drilling (e.g., ridge crest or fracture zone ridge).
G	Topographically elevated feature. Elevated features with widely varying sediment thickness (e.g., seamount or fracture zone ridge). Basement is often an objective.
H	Offset drilling into tectonic windows.

Notes: APC = advanced piston corer, XCB = extended core barrel.

Table T2. Site survey data-type requirements for each drilling environment (target type).

	Target type:	A	B	C	D	E	F	G	H
	Data type:	Paleo environment or fan (APC/XCB)	Passive margin	Active margin	Open ocean crust (>400 m sediment)	Open ocean crust (<400 m sediment)	Bare-rock drilling	Topographically elevated feature	Tectonic window
1	High-resolution seismic reflection	X	Y, X*	Y, X*	X or 2	X*	Y, X*	Y, X*	X* or 6
2	Deep penetration seismic reflection		X	X	X or 1	X*	Y, X*	Y, X*	Y or 5a
3	Seismic velocity determination	X*	X	X	X*	X*		X*	
4	Grid of intersecting seismic profiles	Y, X*	X	X	Y, X*	Y, X*	Y*	Y, X*	
5a	Refraction (surface source)		Y, X*	Y, X*	Y, X*	Y, X*	Y, X*	Y, X*	Y or 2
5b	Refraction (near bottom source and receiver)						Y*		Y*
6	3.5 kHz	X	X	X	X	X	Y, X*	X	X* or 1
7	Swath bathymetry	Y, X*	Y, X*	X	Y*	Y, X*	X	Y, X*	X
8a	Side-looking sonar (shallow towed)	Y*	Y, X*	Y		Y*	Y	Y, X*	Y
8b	Side-looking sonar (near-bottom towed)	Y, X*	Y, X*	Y, X*		Y*	Y, X*	Y, X*	Y, X*
9	Photography or video			Y			X	Y, X*	X
10	Heat flow		Y, X*	Y, X*		Y, T	Y		
11a	Magnetics		Y	Y	Y, X*	Y, X*	Y, X*	Y	X
11b	Gravity		Y	Y	Y*	Y*	Y*	Y	Y
12	Sediment cores	X	Y, R	Y, R	R	R, T	X*	Y, X*, R	X*
13	Rock sampling		Y	Y		Y, X*	X	Y, X*	X
14a	Water current data	X*	X*	X*			X*	X*	X*
14b	Ice conditions	X*	X*	X*	X*	X*	X*	X*	X*
15	OBS microseismicity						Y*		Y*
16	Navigation	X	X	X	X	X	X	X	X
17	Other	X*	X*	X*	X*	X*	X*	X*	X*

Notes: Data on ice conditions are for sites in high-latitude areas. X = required, X* = may be required for specific sites, Y = recommended, Y* = may be recommended for specific sites, R = required for reentry sites, T = required for high-temperature environments.

Table T3. Information required for the written safety report to PPSP.

1	Regional map showing bathymetry, latitude and longitude, nearest land areas, and proposed site locations.
2	Track charts showing proposed sites and specific lines or line segments included for review.
3	Cross-tied seismic reflection lines of sufficient length and details to define closures. Seismic events should be legible to the depth of proposed penetrations. Seismic data may be presented as records or photographic prints. Suitable annotated negatives of prints must be sent to the ODP Site Survey Data Bank. The following annotations should be included on these lines (a) site number, location, and penetration depth; (b) traverse direction; (c) horizontal scale in kilometers; (d) vertical scale in seconds or meters; (e) course changes; (f) identification of important reflections; and (g) cross-line intersection points.
4	Sketches of major structural elements, sediment thicks and thins, and areas of distinctive reflection character.
5	Safety review check sheets.

Table T4. Information required for the oral report to PPSP.

1	All available bathymetric data.
2	Track charts with locations of geological, geophysical, and geochemical data; seismic lines to be reviewed; site locations.
3	Structure maps, sedimentary thickness maps, and maps of estimated depth to base of clathrate horizons.
4	Seismic reflection data sufficient to defend the safety of each site. In the event a site is moved, it is necessary to base the new location on additional seismic data. Documentation should be available for alternate locations. Drilling below the depth of resolution of seismic data will not be approved. Interval velocity information should also be provided.
5	Seismic refraction, gravity and magnetic data.
6	Hydrocarbon occurrences at nearby boreholes or exploration wells should be tabulated. Oil companies should have been encouraged to release such data. Potential source rocks should have been identified and mapped.
7	International jurisdiction and extent of nearby oil leases.
8	Lithologic descriptions of available cores and dredges, together with existing analyses of sediments and bottom water for presence of hydrocarbons.
9	Regional geologic maps and cross-sections for consideration of possible relationship of onshore and offshore geologic sections. Reservoir data should also be made available, if possible.

Table T5. Warning tolerances for water depths at various horizontal offsets.

Water depth (WD) (m)	Horizontal excursion at 2% WD = 1.1° angle	Horizontal excursion at 3% WD = 1.7° angle	Horizontal excursion at 4% WD = 2.3° angle	Horizontal excursion at 6% WD = 3.4° angle	Horizontal excursion at 8% WD = 4.6° angle
76	1.5 m	2.3 m	**3.0 m**	4.6 m	**6.1 m**
301	6.0 m	**9.0 m**	12.0 m	**18.1 m**	24.1 m
651	**13.0 m**	**19.5 m**	26.0 m	39.1 m	52.1 m

Note: Bold values indicate yellow and red warning light values.

Table T6. Tool replacement strategies for use if a wireline or LWD/MWD tool is lost downhole and appropriate recovery efforts are unsuccessful.

Primary tool	Alternate I	Alternate II
Wireline		
HNGS	NGT	NGT
HLDS	HLDT	CNT-G
DSI	LSS	No backup
FMS	FMS	No backup
GHMT	No backup	
DLL	DLL	DIT
DIT	DIT	DLL
BHTV	No backup	
WST	WST	No backup
GLT	No backup	
AACT	No backup	
LWD		
CDR	CDR	No backup
AND	AND	No backup
MWD	MWD	No backup
LINC	No backup	

Notes: LWD = logging while drilling, MWD = measurement while drilling, HNGS = Hostile Environment Gamma Ray Sonde, NGT = Natural Gamma Ray Spectrometry Tool, HLDS = Hostile Environment Litho-Density Sonde, HLDT = Hostile Environment Litho-Density Tool, CNT-G = Compensated Neutron Tool, DSI = Dipole Sonic Imager, LSS = Long Spacing Sonic Tool, FMS = Formation MicroScanner, GHMT = Geological High Resolution Magnetic Tool, DLL = Dual Laterolog, DIT = Dual Induction Tool, BHTV = Borehole Televiewer tool, WST = Well Seismic Tool, GLT = Geochemical Logging Tool, AACT = aluminum activation clay tool, CDR = Compensaged Dual Resistivity tool, ADN = Azimuthal Density Neutron tool, LINC = LWD Inductive Coupling tool.