

Site survey data requirements: A simple guide

Early in the life of a drilling proposal, the Integrated Ocean Drilling Program (IODP) Site Survey Panel (SSP) will begin to review the site survey data associated with the proposal. The primary purpose is to ensure that the proposed drilling target has been adequately imaged and has a good probability of being successfully drilled. For example, if the target is a continuous sedimentary succession, the SSP wants to check that there is no evidence for pinch-outs, unconformities or hiatuses in deposition; if the target is igneous basement, the SSP needs to be assured that it has been correctly interpreted and that its depth is consistent with the proposed drilling depth. The SSP normally briefly reviews Pre-proposals after the Science Steering and Evaluation Panel (SSEP) has recommended that a Full proposal be developed. For Pre-proposals, the SSP offers advice on the likely site survey needs. The SSP will also normally review brand new Full proposal submissions. Any proposal for which new data have been submitted to the IODP Site Survey Data Bank (SSDB) will also be reviewed. Once a proposal has been recommended for drilling, the Environmental Protection and Safety Panel (EPSP) will also review the site survey data. While the EPSP may use many of the same data as SSP, they may also require some additional data, which nevertheless it may be useful to collect in an early site survey cruise.

Once acquired, the site survey data should be submitted (in digital form) to the SSDB as described below under “Submitting data to the data bank”. The type of data required will depend on the geological and seafloor environment to be drilled, and will be considered by the SSP and EPSP on a site-by-site basis. This document provides a simple guide to some of the more common data types required, and an explanation of how they are collected and how the panels use them. The IODP is also developing a simple on-line tool that will provide a specific list of requirements in response to some simple questions to the proponent. However, because each site is unique, proponents are warned that these can only be guides, and that additional data may be requested at any stage by the panels. As an additional guide to those unfamiliar with site surveys, this document includes a glossary of the more common types, including an explanation of their use and the data formats required by the data bank.

Basic requirements

Certain basic data are required for all drill sites. These included position (latitude, longitude, water depth), proposed target depth below seafloor, geological or sea-floor setting (e.g., active continental margin, passive margin, open-ocean, ocean crust, bare-rock, palaeoenvironment...), and presence of nearby drill-holes or wells. An indication of man-made hazards (e.g., pipelines), environmental restrictions and/or hydrocarbon shows should be provided as appropriate. This basic information should be given in the site summary forms which accompany a proposal submission.

Surface characterisation

All drill sites require a bathymetric map showing the depth and shape of the surrounding seafloor, and a description of the seafloor lithology (sediment or rock type). Other data will be required depending on the setting. Seabed images (photography or video images) will be required where a site is located on hard rock or irregular rock outcrops. Multibeam bathymetry is *recommended* for all sites, it and/or side-scan sonar (acoustic backscatter) imagery may be *required* in areas of active margins, bare rock outcrop, suspected gas seeps, and when bottom-founded or riser drilling platforms are operationally required. Sea bed samples (rock or sediment) are needed to characterise palaeo-oceanographic, bare-rock,

“tectonic window”, proposed re-entry sites, and sites with seafloor slope $>10^\circ$. An assessment of geotechnical properties (sediment or rock strength, etc.) is needed where bottom-founded or anchored drilling platforms are envisaged.

Seismic reflection data

One of the most important site survey data types is seismic reflection, which uses acoustic energy to image sub-surface reflectors. There are several different types of seismic data depending on details of the source and receivers used in acquisition; these are described in the Glossary. A minimum requirement for all sites is two seismic lines that cross at near 90° *at the proposed drill-site*. Further data are often required, or at least highly desirable, to enable interpretation of drilling results to be properly placed in a regional context. The precise type and quantity of seismic data required is decided on a case-by case basis, but generally depends on sub-seafloor penetration depth and geological setting.

Soft rock (sediment)

For penetration up to 100m, two crossing high-resolution single-channel seismic lines may be adequate provided they image the target well.

On passive and active margins with penetration up to 1000 m, a *grid* of crossing multi-channel seismic lines is required, with line spacing typically a few kilometres.

In the open ocean, two crossing single-channel lines are often sufficient for penetration between 100 m and 400 m; for penetration between 400 m and 1000 m, a *grid* of crossing multi-channel seismic lines is required, with line spacing typically a few kilometres.

For sites with penetration greater than 1000 m, either a grid of multichannel seismic (with line spacing to be determined on a case-by case basis), or a full 3-D multichannel survey will be required.

Hard rock

Targets into the *top* of crystalline basement require one single channel or multichannel seismic line.

Targets *within* the crystalline basement require two crossing multichannel seismic lines.

Targets within structurally complex crystalline basement will require a grid of multichannel seismic lines *or* a 3-D multichannel seismic survey, to be determined on a case-by case basis.

Other sub-surface characterisation

Other types of data can supplement seismic data. An assessment of seismic velocity (usually derived either from seismic refraction data or from multichannel seismic processing or where available from borehole logging) is needed to accurately convert seismic travel-time to depth. Velocity information is recommended for all sites, and is required for all riser drilling and for non-riser drilling with greater than 200 m penetration.

Gravity and/or magnetic data may be required (on a case-by-case basis) to assist interpretation of sub-surface structure or rock type (e.g., magnetic data are very sensitive to volcanic rock intruded or buried in sediment, and to ferrous metal hazards on the seafloor such as wrecks and pipelines).

Heat flow data may be required for safety assessment where there are suspected hydrocarbon provinces or suspected high heat flow.

Other data

Additional data will be needed in certain circumstances for environmental and safety assessment. These include, but are not limited to, the following.

Environmental information such as water currents, ice cover, weather window and tidal data will be needed depending on the location.

Measurements of sediment pore pressure and fracture gradients, and predictions of pore pressure, may be needed for safety assessment for riser drilling or suspected areas of high pressure.

An estimate of maturity will be needed in potential hydrocarbon provinces with more than 2 km sediment thickness.

Where drilling in an Exclusive Economic Zone is planned, an Environmental Survey may be required.

Submitting data to the data bank

The IODP Site Survey Data Bank <http://ssdb.iodp.org/> is now entirely digital. See Eakins et al. (2006) for an article describing the SSDB. The SSP mainly uses image data (such as maps, graphs and seismic sections) in its reviews, so *all* data should be submitted in an image format (e.g., pdf, jpg, tiff) where appropriate (maps, seismic sections, graphs, velocity profiles, etc.). In addition, proponents are encouraged to upload original digital data in an acceptable format (ASCII table, SEGY, GMT grd file, etc.) A list of acceptable file types is posted on the SSDB web site [<http://ssdb.iodp.org/about.php>]. Please do not submit Adobe Illustrator or similar application files: convert them to one of the above formats first. *All* images should be fully annotated (including vertical and horizontal scales, latitude and longitude, contour interval, seismic CDP or shot point, etc., as appropriate). In addition, the data package should contain at least one map showing the location of each data object, and proposed drill sites must be marked on all data sections and maps.

Glossary

[Acceptable data formats for the Site Survey Data Bank are given after each item.]

Bathymetry. Consists of measurements and maps of seafloor depth. Usually made from ships using hull-mounted single-beam echosounders (usually with limited horizontal resolution) or **multibeam (swath)** bathymetry systems – see below. [SSDB: Bathymetry maps can be image files (PDF, TIFF, JPEG) or document files (PDF, RTF, Word Document); gridded data can be submitted as image files, grid data file, ASCII XYZ file, GMT GRD file, ARC GRD file]

Gravity. Measurements of very small fluctuations in the Earth's gravity field are made by instruments mounted in ships. The results reflect variations in the sub-surface density distribution, and can be used to help constrain sub-surface structure. [SSDB: Gravity maps

can be image files (PDF, TIFF, JPEG) or document files (PDF, RTF, Word Document); gridded data can be submitted as image files, grid data file, ASCII XYZ file, GMT GRD file, ARC GRD file]

High-resolution seismic. A type of (usually) **single-channel seismic reflection** in which a higher frequency acoustic source (such as the “Boomer”, “Parasound”, “Chirp” and 3.5 kHz systems) is used to image the shallow (~100 m) sub-seafloor at higher (sub-metric) resolution than conventional seismic. [SSDB: Seismic data can be submitted as image files (PDF, TIFF, JPEG) or in SEG-Y format]

Magnetics. Measurements of very small fluctuations in the Earth’s magnetic field are made using either instruments towed behind (or occasionally mounted on) ships, or, for improved resolution, mounted on deep-towed, remotely operated vehicles (ROVs) or submarines near the seafloor. Magnetic data reflect variations in the magnetisation of rocks and ferrous materials. They are sensitive to the presence of igneous rocks (e.g., lavas, sills and dykes) within or beneath sediments, and also to man-made ferrous objects such as pipelines and shipwrecks. [SSDB: Magnetic maps can be image files (PDF, TIFF, JPEG) or document files (PDF, RTF, Word Document); gridded data can be submitted as image files, grid data file, ASCII XYZ file, GMT GRD file, ARC GRD file]

Multibeam bathymetry (also known as swath bathymetry). Consists of measurements and maps of seafloor depth. Measurements are made with an array of many (~100) narrow acoustic beams projected from transducers mounted on the hull of a surface ship or of a deep-towed or remotely operated vehicle (ROV) near the seafloor. Typically these systems provide (from surface ships) swathes of bathymetry several kilometres wide with horizontal resolution of ~200 m or better. [SSDB: Bathymetry maps can be image files (PDF, TIFF, JPEG) or document files (PDF, RTF, Word Document); gridded data can be submitted as image files, grid data file, ASCII XYZ file, GMT GRD file, ARC GRD file]

Multichannel seismic reflection. A type of **seismic reflection** system in which multiple receivers (typically 48, 96 or more) are used, usually with an array of seismic sources. This gives much improved signal-to-noise ratio, and offers the possibility of extensive processing to improve the image resolution, penetration and accuracy, to remove interference such as multiple reflections, to estimate seismic velocities in the sub-surface, and to focus the imaging on specific depth intervals of interest. [SSDB: Seismic data can be submitted as image files (PDF, TIFF, JPEG) or in SEG-Y format]

Samples. Many types of samples may be collected. Rock samples are often collected by dredging (dragging a collector over the seafloor) or by using specialised corers or drills deployed from ships. Sediment samples can be recovered using ship-deployed “gravity” and “piston” corers, which can penetrate a few metres to tens of metres into soft sediment. Water samples can be obtained using special sampling tools lowered from ships or mounted on deep-towed or remotely operated vehicles (ROVs) or submarines. [SSDB: Sample descriptions should be submitted as document files (PDF, RTF, Word Document)]

Seismic reflection data. Seismic reflection (often just called “seismic”) data are collected by using relatively low frequency acoustic sources to provide a pulse that can penetrate the seafloor and superficial sediments and is reflected at interfaces to form an image of the sub-surface. The system uses sources and receivers towed near the sea surface behind ships. This is the most common data type used in site survey. It can show the disposition of features such as sediment horizons, igneous intrusions, faults, folds, channels and crystalline basement. Typical vertical resolution is a few tens of metres and penetrations can exceed several

kilometres. [SSDB: Seismic data can be submitted as image files (PDF, TIFF, JPEG) or in SEG-Y format]

Sidescan sonar. Unlike bathymetry, in sidescan sonar the acoustic beam is directed sideways with a shallow depression angle. Acoustic energy is reflected or scattered back toward the instrument, and its amplitude is displayed against travel-time (a measure of range). Repeated scans build up an acoustic image of the seafloor similar to an oblique aerial photograph over land. Sidescan data are usually acquired using an instrument towed behind a ship, either near the surface or (for improved resolution) near the seafloor. Sidescan is very useful for mapping rock outcrops among sediments, different types of sediment (e.g. mud, sand, gravel), geological structures such as submarine channels and slumps, sites of gas seeps, and hazards such as pipelines and wrecks. [SSDB: Sidescan sonar maps can be image files (PDF, TIFF, JPEG) or document files (PDF, RTF, Word Document)]

Single-channel seismic system A type of **seismic reflection** system in which a single sound source and receiver are used. A basic seismic section can be achieved, but usually with limited penetration, resolution and signal-to-noise ratio. [SSDB: Seismic data can be submitted as image files (PDF, TIFF, JPEG) or in SEG-Y format]

Swath bathymetry. See **multibeam bathymetry**.

3D seismic data This is similar to **multichannel seismic**, except that data are acquired on a very closely spaced grid, typically with a grid spacing of only 25 m in both horizontal dimensions, so that a complete 3D volume of the sub-seafloor is virtually continuously imaged with ~25 m resolution in all three spatial dimensions, and with increased geometrical accuracy. Such surveys are expensive, and limited to relatively small areas, typically a few tens of kilometres on a side. [SSDB: Seismic data can be submitted as image files (PDF, TIFF, JPEG) or in SEG-Y format]

Visual imaging The seafloor may be directly imaged using still or video cameras lowered or towed on wires from a ship, or mounted on deep-towed, remotely operated vehicles (ROVs) or submarines near the seafloor. [SSDB: Visual imagery can be image files (PDF, TIFF, JPEG) or document files (PDF, RTF, Word Document); digital video of the immediate drilling area can be MPEG or DIVX]

References

Eakins, B.W., Miller, S.P., Helly, J., Zelt, B., and the SSDB Staff, 2006. The fully electronic IODP Site Survey Data Bank. *Scientific Drilling*, 2. Download the journal at <http://www.iodp.org/scientific-drilling/>