IODP GeoSCAN Workshop Report

Introduction

On June 6th, 2003, a group of 30 scientists, students and members of USSAC representing the U.S. and Japanese academic geophysical community met with nine industry experts in Houston, TX for a one-day workshop to examine geophysical needs for site characterization in IODP. The goals of the meeting were to: 1) examine current seismic methods used in industry (primarily focused on 3-D seismic techniques) to investigate the site surveying needs for IODP, 2) make specific recommendations to NSF on the resources needed to support IODP as outlined in the Initial Science Plan, 3) seek advice from industry and develop a basis for further collaboration. The five-member steering committee met the following day to formulate specific recommendations to NSF based on the previous days' presentations and discussions. The outcome of both meetings is presented herein.

The transition from ODP to IODP is significant in many aspects including seismic surveying for site characterization. Although 3-D seismic surveys have been conducted and used in ODP drilling (e.g. Legs 156 and 171A near Barbados, and Leg 204 offshore Oregon), they will be a significantly larger part of IODP. Most riser drilling and some non-riser drilling will likely need 3-D surveys of some kind. This workshop was conducted to begin to understand how to address the substantially larger effort that will be required of 3-D surveying for IODP vs. the mainly 2-D surveying of ODP.

The GeoSCAN workshop was held as the academic surveying capabilities in the US are in transition. Currently there are plans to improve the R/V Ewing seismic capabilities by adding multiple streamer and seismic sources to make it possible to acquire 3-D seismic data substantially more efficiently than Ewing has so far with a single streamer. This option is being considered along with an option to replace Ewing with a retired industry seismic vessel (See Ewing Midlife Workshop report, 2002), so surveying plans were discussed considering that academic facilities are likely to be substantially improved from past capabilities of the Ewing, and potentially may approach industry capabilities if a retired industry vessel can be acquired.

The primary focus of the GeoSCAN workshop was regional or exploration surveying to meet the needs for developing science programs that will lead to IODP drilling. We identified this need as distinct from surveys designed to provide geohazards or geotechnical information for specific drill sites, which will also require 3-D seismic data, but with high-resolution and focused on 300 – 500 m below seafloor in small, localized areas around planned drill sites. The focus of the GeoSCAN workshop was on regional surveying because of the current need to develop scientific programs early in IODP; however, as discussed in the workshop and described further below these data sets can potentially overlap, and feasibility of drill sites should be considered early in the planning stages of drilling, especially riser drilling.

IODP seismic surveying needs

A clear consensus emerged at GeoSCAN that IODP will require substantial 3-D seismic surveying for supporting both non-riser and riser programs. It was generally agreed that 2-D seismic surveying may be adequate in some structurally simple settings depending on the geologic problem to be addressed, but that many geologic settings and problems will require 3-D data. In particular, complex structural setting with extensive faulting, deformation, complex hydrogeology, or variable lithologies will need 3-D seismic surveys to understand the regional geologic setting, and to design wells that have a high likelihood of success. Furthermore, high-quality 3-D seismic data will be critical in any setting in which there is a chance of encountering hydrocarbons.

It also became evident in discussions that 3-D seismic data will be needed not only for locating IODP drill holes and increasing chances for achieving target depths, but also for maximizing the total scientific return of a drilling project. Significant progress on scientific problems can be addressed with high-quality 3-D seismic data with detailed interpretation and sophisticated analysis. Associated scientific studies from 3-D seismic data will have significant add-on value to IODP drilling programs. However, this will require additional funds for science costs pre and post drilling.

It was evident from industry presentations that both acquisition and processing of higher-quality, larger sized 3-D seismic surveys are critical to future programs in IODP. The higher quality data are the results of better survey planning and design (survey designs tailored to specific geologic objectives), required acquisition specifications, state-of-the-art streamer, seismic source and navigation equipment. Furthermore, more highly trained personnel are needed for acquisition, data handling, and processing. Appropriate processing algorithms need to be implemented for imaging specific targets. Many of these objectives for improved data quality may not be feasible with academic facilities even with substantially improved facilities; however it is still uncertain what academic facilities will be.

Academic facilities vs. Industry contractors

A significant amount of the discussions and debate at GeoSCAN concerned the use of academic vs. commercial facilities for 3-D seismic acquisition and processing. This issue has been a longstanding one for seismic surveying in academia (Coffin et al., 1998) and will continue to be an issue for 3-D seismic acquisition and processing for IODP. The viewpoint of the oil industry representatives at GeoSCAN was that the seismic industry has evolved to conduct high-quality 3-D seismic surveys very efficiently and cost-effectively. Most oil companies have concluded that they can be most effective using a contractor with their own experts overseeing acquisition and processing. The primary issues for acquisition in academia are access to remote areas without the prohibitive mobilization/demobilization costs associated with industry vessels, the lower cost of running acquisition on an academic facility once it is purchased, and the opportunity to train and educate students in seismic data acquisition and processing. In many instances, however, academic facilities will not be adequate to meet survey design specifications

because of streamer length and spread necessary to effectively infill the survey volume, or inadequate source and streamer control and navigation equipment, unless academic facilities are significantly improved. Academic surveying will also not be able to meet high quality standards if data are acquired with constraints on time instead of specifications, unless a considerably longer time frame is used. Industry estimates are that acquisition by the best crews is ~ 40% efficient for the time actually shooting.

Summarized below are the main issues for academic vs. industry acquisition and processing.

Advantages with academic facilities:

1) Costs:
    i) Academic facilities have typically had lower operating costs after equipment has been acquired. In the future this may still be true depending on the survey design and academic facilities.
    ii) Mobilization (e.g. transit) costs for industry are relatively high (~$100,000/day) and many academic study areas are far from industry operating areas. Transit costs can often be minimized with academic facilities by scheduling non-seismic cruises between seismic cruises.
2) More student training and education opportunities.
3) More direct control over acquisition and processing, and ancillary science.
4) Scientific research opportunities in processing and analysis.

Advantages with industry facilities:

1) Efficient and high value data acquisition unless mobilization/demobilization costs are excessive.
2) Modern facilities resulting in consistent, high-quality data, shot to specifications rather than within fixed time frame.
3) More options for source and receiver configurations and survey design.
4) Fast turn around (6 mos. vs. 2 – 3 yrs).
5) Eliminates the service role for PIs as processors and data providers allowing more effort on specialized processing, analysis, interpretation, and integration with other data sets.
6) Long-term contracts possible to lower prices even more.
7) More experience/expertise than in the academic community.

It is evident from the GeoSCAN meeting that IODP will need to use both industry and academic facilities with consideration of the issues above as part of the planning process. It may be possible to negotiate opportunities for collaborations between seismic contractors and scientists and their students to maintain close involvement with the data and provide opportunities for students. Greatly improved academic facilities will be needed to meet desired specifications for high-quality surveys. Industry capabilities should also be used where they can be done cost effectively. Input from an advisory

panel (potentially an existing SAS panel) will be critical in using both industry and academic facilities effectively.

Data processing, management and distribution

It was apparent from the GeoSCAN presentations that along with an increase in 3-D survey data for site characterization comes a tremendous increase in the efforts of basic data processing, handling, management and distribution. Data acquisition rates are on the order of 24 Gbytes/hr and ~ 40 Terabytes for a typical survey. Current academic facilities will have difficulty processing and handling such large data volumes. Furthermore, such large data throughput puts tremendous burdens on individual PIs to conduct basic processing and data handling. An alternative scheme considered at GeoSCAN was contracting the basic processing to industry contractors to conduct the initial data processing and handling. Currently a "standard" product in the seismic industry is processing through prestack time migration. The advantage with contracting the initial processing is that it could be conducted relatively quickly, and costs are modest at 5 – 20% of acquisition costs.

In addition to initial processing and data handling, concerns over access to commercial data sets emerged from discussions at GeoSCAN. Every effort to acquire and utilize existing, available industry 3-D seismic data should be made where there is scientific interest; however, there will be significant limitations on overlapping areas between oil industry and academic interests. Access to existing data sets will need to be made through industry contacts, and is currently happening through ILP. A data management organization should be formed to help with both access and distribution of existing 3-D data sets and newly acquired 3-D data for use in IODP in coordination with SSP (Report of the iSSP Data Bank Working Group, 2003).

Using exploration/regional 3-D data for geohazard surveys

As stated above, the goal of GeoSCAN was to investigate ways to meet the needs of exploration/regional seismic surveying rather than surveying for shallow hazards and geotechnical issues. At GeoSCAN we saw presentations that illustrated how reprocessing of exploration survey data could provide 3-D data with sufficient resolution to meet the needs of a shallow hazard survey. There is a significant advantage for IODP in using exploration surveys for shallow hazards surveying. Not only can total costs be lowered by not conducting additional high-resolution surveys, but platform operation costs could be used to supplement science costs so that a survey adequate for both needs could be acquired in one 3-D survey. However, the possibility of using a 3-D survey for both exploration/regional and shallow hazards needs to be considered at the survey design stage, and it may not be feasible or desirable in all cases depending on the target objectives, mobilization/demobilization costs associated with an additional survey, geologic setting, and data quality of the initial survey.

Recommendations for 3-D seismic surveying in IODP

From discussions at GeoSCAN several suggestions emerged to facilitate acquisition and processing of 3-D data sets for IODP site surveys:

1) Establish an advisory panel of industry and academic members to advise PIs on 3-D surveying plans, design, and specifications. This panel could be part of the existing SAS structure.

2) Assemble an advisory panel of industry and academic experts to help negotiate seismic acquisition contracts with industry contractors. Contracting through JOI should be considered as a means to have a consistent party to arrange contracts for IODP.

3) Establish a data management and/or data processing facility to produce and maintain high quality, consistent data sets that can be readily distributed to scientists interested in specialized data processing, interpretation, or integration with other data sets in coordination with SSP (Report of the iSSP Data Bank Working Group, 2003).

Some of these roles might be undertaken by existing IODP panels.

Recommendations on Resources for IODP Site Survey Needs

The following is recommended to NSF by the steering sub-committee.

After discussing the various methods, costs, and resources involved, it was clear that a variety of seismic acquisition and processing strategies will be needed in IODP, in order to fulfill the goals outlined in the Initial Science Plan. These strategies will vary widely, based on the scientific goals and proposed drilling locations. To get a better idea of the types of resources that will be needed, we have defined costs based on three different "levels of complexity" of geologic settings that will be investigated in IODP. Typical costs associated with these different geologic targets are estimated as follows:

"Highly complex" targets. These areas of investigation represent the most difficult imaging targets that will be investigated in IODP. Examples pertaining to the Initial Science Plan would include studies of the seismogenic zone on continental margins, such as those currently being planned for offshore Japan and Costa Rica. For these areas, 3-D seismic surveys will be critical for successful drilling. Based on information obtained at the GeoSCAN meeting, an estimate of the cost associated with such a survey is as follows:

- Acquisition: $3,000,000-3,500,000 (assuming a 500 km^2 survey, four 4-6 km streamers, and a 50 m bin size.)
- Processing: (to pre-stack time migration) $150,000 - $700,000 (assuming industry estimate of 5-20% of acquisition costs. For most areas, especially complex areas such as Nankai, processing costs will be closer to the upper ends of that estimate).
- Mobilization/demobilization costs: highly variable, based on area of study, availability of ships, industry demand. Expected costs: $100,000/day adding at least $1,000,000 to a 3-D survey.

- Science costs $1,000,000 (e.g., prestack depth imaging, geopressure analysis, etc.)

Thus, a rough estimate for a 3-D survey adequate to characterize a "highly complex" area is $5,000,000 - $6,000,000. We envision 1-2 of these will be needed per year once IODP operations are fully implemented. The initial ramp-up phase of IODP will likely require 2 per year and later phases of IODP 1-2 per year.

"Moderately complex" targets. These areas of investigation represent a lower degree of difficulty in drilling targets, so comprehensive 3-D surveys will not be necessary in these areas. Example of such areas would be Large Igneous Provinces, submarine fans (e.g., Indus, Bengal) and potentially studies of gas hydrates. Adequate geophysical characterization can likely be obtained using the *Ewing* for multichannel seismic surveys or limited single streamer 3-D surveys. An estimate of the costs associated with such a survey is as follows:

- Acquisition: $500,000 - $750,000 (based on current month-long Ewing seismic cruises.)
- Processing: (to prestack time migration) $100,000 - $150,000 (typical of recent 2-D projects.).
- Science: $200,000 - $250,000

Our cost estimate to adequately characterize a "moderately complex" area is ~$1,000,000, similar to site surveying costs for drilling legs in ODP. We envision approximately 3 of these will be needed per year once IODP operations are fully implemented.

"Low complexity" targets will require the lowest level of site surveying resources in IODP. Examples of such legs would be paleoceanographic (especially Mesozoic) legs, addressing such problems as extreme climate change and the deep biosphere in uncomplicated geologic settings. Basic 2-D surveys should be adequate for characterization of these areas. Estimated costs are as follows:

- Acquisition: $350,000 - $500,000 (based on current month-long 2-D cruises.)
- Processing: $100,000 - $150,000 (typical currently).
- Science: $150,000 - $250,000

Our cost estimate to adequately characterize a "low complexity" area is ~$750,000, also similar to site surveying costs for drilling legs in ODP. We envision approximately 3 of these will be needed per year once IODP operations are fully implemented.

Based on the general estimated outlined above, total required seismic acquisition and processing costs for the U.S. contribution in IODP will range between $11,250,000 to $17,250,000 per year in two scenarios depending on the number of 3-D surveys.

1)

1 High Complexity survey.....$6,000,000
3 Medium Complexity surveys.....$3,000,000
3 Low Complexity surveys.....$2,250,000

$11,25,000

2)

2 High Complexity surveys.....$12,000,000
3 Medium Complexity surveys.....$3,000,000
3 Low Complexity surveys..... $2,250,000

$17,250,000

The outcome of upgrades or replacement of the Ewing will help determine the amount of 3-D and 2-D work that can be performed on an academic platform. None of the proposed academic upgrades will fully replace the 3-D commercial activities identified in this report.

The costs outlined above are estimates for site survey costs for the U.S. contribution to IODP. Additional contributions to site surveys will come from non-US members of IODP.

References

Coffin, M.F., Eldholm, O., Stoffa, P.L., and Austin, J.A., Jr., 1998. Looking ahead to the future of marine reflection seismology, Eos, Transactions American Geophysical Union 79: 614-615.

R/V Maurice Ewing Midlife Refit Workshop report, Oct 22 – 23, 2002.

Report of the iSSP Data Bank Working Group, March 13, 2003

Workshop Agenda

Rooms C306 A & B
BP Westlake Four
200 Westlake Park Blvd, Houston TX 77079

8:00 – 8:15 Sign in at Security desk (next to elevators)

8:15 – 8:30 Welcome and Logistics

8:30 – 10:30 3-D Survey Design, Acquisition, Costs, Processing – Jack Caldwell, Steve Carter & Rob Bloor (Schlumberger/WesternGeco)

10:30 – 10:45 Break

10:45 – 11:45 3-D Processing and Interpretation – Don Herron (BP)

11:45 – 12:15 Discussion

12:15 – 12:45 Lunch

Workshop will be split into two sessions to accommodate ~25 participants in the 3-D visualization HIVE (Highly Immersive Visualization Environment)

12:45 – 1:45 3D study of offshore Egypt – Craig Shipp (Shell)
3D visualization, and supplemental data integration – Jim Thomson (BP)

1:45 – 2:45 3D study of offshore Egypt – Craig Shipp (Shell)
3D visualization, and supplemental data integration – Jim Thomson (BP)

Workshop will be reconvened into one session

2:45 – 3:00 Break

3:00 – 4:15 High-resolution methods & high-resolution processing – Mike Kaluza (GEMS), Kerry Campbell (Fugro), Andy Conway (Fugro)

4:15 – 5:15 Geopressure prediction from 3-D data – Alan Huffman (Fusion)

5:15 – 6:00 Discussion

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