REPORT OF JOIDES LONG-TERM OBSERVATORIES PPG

March, 1999

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EXECUTIVE SUMMARY

Long-term observatories for in-situ monitoring of geological processes are highlighted in the ODP Long-Range Plan, both as an ODP innovation and as an initiative to address ODP's principal scientific themes. Accordingly, JOIDES established the Long-Term Observatories Program Planning Group (LTO-PPG) early in 1997, with a mandate that generally includes working with international geoscience initiatives to plan the borehole components of future seafloor observatories, specifically concerning experimental design, implementation, emplacement, and oversight, hole completion requirements, and recommendations for site survey, logging, and core measurements. The LTO-PPG met three times during 1997-1998, produced a draft report reviewed by the SSEPs in late 1998, and submits this revised report to JOIDES to fulfill the LTO-PPG mandate.

The recommendations of the LTO-PPG are guided by the overall philosophy that borehole observatories are but one of a suite of drilling-related tools that can be brought to bear on a range of important scientific problems. Hence, it will be the scientific issues and objectives, not the choice of the observatory method, that should motivate responses to many of the specific issues the LTO-PPG was asked to address, e.g., experimental design, requirements for site surveys, coring, logging, and hole completion. While current types of ODP observatories, such as OSN global seismic observatories and CORK hydrogeological observatories, are well developed and documented, borehole observatory concepts for many important scientific problems remain notional and will need continuing development within appropriate scientifically-focused PPG's long beyond the lifetime of the LTO-PPG. Therefore, the LTO-PPG cannot provide definitive recommendations on these possible future borehole observatories, but we offer suggestions for several types in Appendix I.

Our most important recommendations pertain to the ODP/IODP observatory effort in general. The most significant contribution of a scientific drilling program to observatory science probably lies in drilling the "legacy holes" that remain the only means to emplace long-term monitoring instrumentation significantly into the subseafloor formations. Therefore, we strongly recommend that JOIDES continue assigning high priority and financial resources to:

- Commitment of drillship time and costs of reentry cones and casing strings at appropriate legacy sites that are well justified in JOIDES proposals.

- Continued development of hole-completion technology for difficult drilling environments often encountered in areas of active processes, where coring, logging, and long-term monitoring of these processes is of great scientific interest.

- Continued development engineering support for the installation of third-party long-term monitoring instrumentation in legacy holes.

Although we cannot specifically plan a global program of observatories to address all the scientific issues for which in-situ monitoring will make important scientific contributions, we make the following general recommendations for the proposal-driven JOIDES process to arrive at a global plan:

- Observatories are but one facet of the "cascade" of drilling-related activities that comprise the scientific ocean drilling program of the future; therefore ODP/IODP observatory proposals must be proposed in the context of an integrated package of pre- and post-drilling surveys, pre- and post-drilling seafloor monitoring networks, and ODP coring and logging results.

- The scheduling process should remain proposal- and proponent-driven, with key roles for "international geoscience initiatives" and other PPG's to be played in laying out the important scientific issues to be addressed with observatories and organizing proponent groups for JOIDES observatory proposals.

- The third-party funding model that has been followed to date for ODP observatory scientific instrumentation and post-deployment operations should be retained for the immediate future, i.e., JOIDES should not take on all these responsibilities. In a time of fiscal constraints within JOIDES, this model actually leverages additional national ODP funding for high profile observatory science of great long-term benefit to ODP.

Finally, we offer some specific JOIDES procedural recommendations for maintaining the momentum of borehole observatory science in ODP and a post-2003 IODP. These include:

- establishment of a specific early scientific and technological review process for observatory proposals,

- formation of a small oversight group for legacy holes, perhaps a subset of SciMP,

- seeding of appropriate scientifically-focused PPG's with observatory expertise, and

- establishment of a Hydrogeology PPG as the LTO-PPG disbands.

INTRODUCTION

In the current ODP Long-Range Plan (LRP), long-term observatories for in-situ monitoring of geological processes are highlighted in two important senses: as a current ODP innovation and as one of three major technological/scientific initiatives to be emphasized in addressing ODP's principal scientific research themes. The LRP emphasis on observatories and in-situ monitoring of geological processes confirms that ODP presently is at the forefront of the growing international movement toward utilizing both seafloor and ocean borehole observatories to monitor active Earth processes in the time domain and greatly enhance our tomographic image of Earth. The initiative for observatory science represents an important future direction for marine sciences; it spans all disciplines of ocean and geosciences and therefore also represents an important incentive for interdisciplinary studies. ODP is uniquely positioned to lead in this effort in three ways: in providing the "legacy holes" that will remain the only means of emplacing long-term sensors, samplers, and instruments to significant depths in the subsurface; in providing the core and log "ground-truth" for the historical record of active earth and ocean processes; and in terms of its established international programmatic organization. And any future scientific ocean drilling program post-2003 should be prepared to carry on this leadership role, as has already been confirmed by the emphasis on borehole observatories in the CONCORD Report.

Accordingly, shortly after the JOIDES Advisory Structure was reorganized in 1996-1997, the JOIDES SCICOM established a Program Planning Group (PPG) for Long-Term Observatories. (Appendix II lists the PPG membership and meeting history.) The Long-Term Observatories PPG (LTO-PPG) was one of the first two PPG's established by SCICOM. Currently, there are seven JOIDES PPG's, each charged with nurturing a particular initiative or scientific theme highlighted in the LRP. The LRP initiative for in-situ monitoring of geological processes spans a number of scientific themes centered on active Earth processes spanning a large range of time and space scales, and therefore programmatically link ODP to a range of international and national geoscience initiatives. Like the ODP drillship itself, observatories are tools that can be used to address many independent scientific objectives.

Like the other PPG's, the LTO-PPG is not a standing committee, but was set up by SCICOM with a finite lifetime and charged with producing this specific report. To fulfill its mandate, the LTO-PPG met three times and prepared a draft report for presentation at the November, 1998 meeting of the SSEPs (Appendix II). A subcommittee of the SSEPs was formed to formally review the draft report, and the report was revised in response to the reviews and suggestions from the chairmen of the SSEPs. We start by reviewing the mandate for the LTO-PPG, which has set the stage for all LTO-PPG actions as well as the organization of this report.

MANDATE, LONG-TERM OBSERVATORIES PPG

In early 1997, SCICOM set up the LTO-PPG with the following goals, mandate, and timeline, as refined after the SCICOM meetings of August, 1997 and March, 1998:

Overall Goal

To develop a plan for the integration of long-term instrumentation in boreholes with seafloor observatories planned by other global geoscience programs, with the goal of:

investigating the structure and dynamics of the Earth's interior;
quantifying the flux of heat and materials to and from the Earth's interior.

Mandate

To work with other appropriate international geoscience initiatives to:

1. Devise experiments that incorporate the use of ODP boreholes for long-term measurements at seafloor observatories.
2. Recommend mechanisms for the implementation, emplacement, and oversight of borehole-related instrumentation in the context of seafloor observatories planned by other global geoscience initiatives.
3. Organize the development of instrumentation/experimental proposals in collaboration with appropriate global geoscience initiatives.
4. Recommend ways in which instrumentation in boreholes can be serviced and maintained by, and data retrieved from, platforms other than the JOIDES Resolution.

5. Provide advice on site survey data, core measurements, logging requirements, and the completion of boreholes in preparation for instrumentation.

Timeline

The PPG will exist for a maximum of three years, during which time it will report to the appropriate SSEP on a regular basis.
SCICOM will conduct an annual evaluation of the necessity for its continuation, with advice from the SSEPs.
The PPG will produce written reports of the overall plan and the mechanisms for oversight of borehole-related instrumentation.

COMMENTS ON LTO-PPG MANDATE AND SCOPE OF REPORT

The wording of the "Overall Goal" for the LTO-PPG immediately illustrates several important aspects of the PPG's purpose. First, our charge includes "instrumentation" as well as broad scientific themes. Thus, the LTO-PPG has a more explicitly technological mandate than other PPG's. Also, the range of scientific themes to be considered by the LTO-PPG is greater and less focused than for the other PPG's. Ultimately, the scientific issues and ODP approaches to many of the scientific themes suitable for borehole observatories will be better developed in the reports of present and future PPG's with more scientifically focused mandates.

Second, the themes listed in the Overall Goal for the LTO-PPG fall within the mandates of both the Interior SSEP and the Exterior SSEP, and we have required (and been honored with) close liaison from both SSEPs as well as SCICOM. Given that our advice encompasses both technological issues and scientific themes, it is directed not only to the SSEPs and SCICOM, but in some cases to SciMP, SSP, and OPCOM. Our advice is also directed via the SSEPs to appropriate PPG's that will define scientific objectives that might be addressed in part by ODP observatories.

Third, like the other PPG's, we are charged with working with appropriate "global geoscience initiatives." In our case, observatories are a technological tool envisioned for possible use by a number of global initiatives addressing a wide range of scientific themes. The various international initiatives for which seafloor and borehole observatories are pertinent are at different stages of maturity. In some cases, there are well-developed global initiatives whose mandates overlap strongly with ours, e.g., ION and InterRidge, and national counterparts such as DEOS (Deep Earth Observatories on the Seafloor - US and UK), OSN (Ocean Seismic Network - US), OHP (Ocean Hemisphere Project - Japan), and the various national ridge-crest programs. In other cases, there are strong national initiatives with less developed international analogs (e.g., US MARGINS and the fledgling "InterMARGINS"). In still other cases, there are initiatives just barely gearing up on scientific themes of enduring interest, for which borehole observatories could be a very important tool, e.g., a new ILP initiative on "Hydrogeology of Oceanic Lithosphere." By design and some luck, our membership has included strong links to nearly all of these initiatives, but we should keep in mind that future geoscience initiatives, possibly with purposes we cannot envision now, may also have a need to utilize ODP legacy holes for future seafloor observatories.

Finally, although our timeline was initially limited to three years, we note that only some of the specific items in the Mandate above can be completed in this short time frame. Others will require ongoing effort throughout the lifetime of ODP, particularly as "global geoscience initiatives" interested in seafloor observatories develop their plans on independent timelines. In addition, the need for "oversight of borehole instrumentation" may continue beyond any end to an active drilling program. We offer some specific recommendations below as to how these continuing efforts can be achieved after the LTO-PPG has been retired.

THE "OVERALL PLAN" FOR ODP OBSERVATORIES

Considering (a) the wide range of scientific themes that can be addressed with borehole observatories and (b) the variety of geoscience initiatives and technological approaches involved, it is not possible to formulate a simple, universal "overall plan" for ODP to follow in order to achieve its LRP goals for in-situ monitoring of geological processes. Nevertheless, the LTO-PPG submits that there are a few key principles that should guide ODP in pursuing this goal. Before setting these out, a few introductory words are appropriate concerning seafloor observatories and the relevant global geoscience initiatives.

Seafloor and Borehole Observatories

As noted above, in the past decade or so there has been a growing movement on the part of many geoscience initiatives towards establishing seafloor observatories, many of which feature borehole instrumentation. The case for seafloor observatories is set out in a host of international and national workshop and committee reports dating from the late 1980's through the 1990's, including the current ODP LRP (see Table 1). The geoscience initiatives involved have separately set out the intellectual justification and technological requirements for seafloor observatories; these generally apply to borehole observatories, with special considerations for the great value and particular configurations of boreholes. We draw heavily in this section on the documents concerning observatories written by other geoscience initiatives, particularly ION (International Ocean Network) and its US national analogue, DEOS (Deep Earth Observatories on the Seafloor).

The intellectual justification for seafloor and borehole observatories stems from the premise that Earth is a dynamic system that can only be understood properly if studied in a process-oriented perspective with adequate sampling in both spatial and temporal domains. Given that the oceans cover 70% of the Earth's surface, including the locations of the most active plate boundaries, adequate spatial and temporal sampling from the seafloor and subseafloor formations is critical. Earth processes occur over a wide range of temporal and spatial scales and exhibit considerable covariation and dynamic interlinkages extending to oceanographic and atmospheric processes. While many of these processes are fairly well characterized in the static spatial domain, generally their temporal behavior is poorly understood. Investigation of the Earth as a dynamic system will require something of an intellectual reorientation, with increasing emphasis on long time-series measurements to understand processes in the time domain and complement the more traditional focus on spatial mapping and sampling.

In other words, understanding active Earth processes and their importance to society requires a new mode of ocean sciences – "observatory" science to study multiple properties, parameters, and processes over multiple time scales, and in some cases to conduct perturbation experiments. Given the range of time/space scales involved, it has been convenient (e.g., in the 1995 ION workshop report) to consider current and planned efforts on seafloor/borehole observatories in two classes:

(1) "Active Process" observatories located where the particular systems are presently most active. The most obvious examples are at plate boundaries: mid-ocean ridges, the settings of possibly the most complex interplay among tectonic, magmatic, hydrothermal and biological processes on Earth, and subduction zones, settings of tectonic and magmatic processes of great destructive impact on society. Given that these plate tectonic boundaries occur by definition almost exclusively beneath the seas, a seafloor/borehole observatory capability is imperative scientifically and societally.

(2) "Global Network" observatories (e.g., seismic, geomagnetic), sited to geometrically complete the global coverage necessary to fully image the interior of the Earth utilizing unpredictable natural sources. With 70% of the Earth's surface under the oceans, the global networks will never be complete without seafloor observatories.

This categorization is somewhat arbitrary, in that there is really a continuum of time scales of Earth processes, all of which are "active" in one sense or another. Nevertheless it may be a useful classification in terms of distinguishing observatories according to whether temporal monitoring of specific processes or better spatial resolution of Earth structure is the key requirement. In terms of the mandates of the Interior and Exterior SSEPs, the global imgaing observatories are relevant mainly to the ISSEP, whereas active process observatories may be relevant to both SSEPs, depending on the particular process.

Although various seafloor/borehole observatories may differ in their specific scientific objectives, they share many common technological needs. These are primarily related to the deployment and maintenance of long-term monitoring equipment in the remote and hostile seafloor environment. The primary issues are those of delivering long-term power to seafloor instruments, providing a link for data transmission from the seafloor to land, preferably in near real-time, providing an avenue for remote command and control of seafloor instruments, and facilitating deployment and retrieval of instruments for repair or refurbishment. The LTO-PPG mandate includes considering these issues, but it should be emphasized that they are continuing issues that apply to all seafloor observatories and are presently being extensively considered outside of JOIDES. For example, Japan has made major investments in cabled observatories, and the US DEOS program is planning both cabled and buoyed seafloor observatories; these are both viable options for linking to borehole observatories for power and data transmission and instrument control.

ODP's Unique Contributions to Observatory Science

ODP provides three unique and essential contributions that should ensure its continuing leadership role in the growing movement for observatories on and beneath the seafloor. Perhaps the most important is in providing "legacy holes," which represent the only means available for emplacing sensors and instruments deep within subseafloor formations for truly in-situ geological monitoring. This capability is critical in understanding many geological processes; monitoring from the seafloor is often not satisfactory. (It is so important that we devote a section below to a tabulation of the status of existing legacy holes and recommendations for future legacy holes.) In many cases, ODP can also provide the instrument emplacement service, although the trend is distinctly towards utilizing wireline vehicles and/or submersibles as much as possible, to minimize demands on the heavily subscribed drillship.

Second, the cores and logs recovered from ODP holes contain the record of active geological processes in the past. The combination of in-situ monitoring in the present plus the historical record in the cores and logs can be very powerful in understanding Earth processes.

Finally, in full fruition the initiative for seafloor observatories will be comparable in financial scale and international aspects to the ODP. In coordinating and administering an international seafloor observatory initiative, ODP and JOIDES will be held up as the prime model of a successful, long-term, international scientific program. More important, given its unique scientific contributions, there is a real opportunity for JOIDES, ODP and any post-2003 drilling program to flourish and play an even greater leadership role in international geosciences as seafloor observatory science grows in significance.

Current ODP Observatories

Thus, it is no surprise that ODP has been quite active in implementing borehole observatories for at least a decade. In fact, JOIDES support for observatory science can be traced back much earlier, e.g., borehole seismometer deployments during DSDP for periods of months and time-series hydrologic measurements made on multiple DSDP/ODP revisits of legacy holes like 395A and 504B. In the 1990's, ODP has provided strong support for both "global network" and "active processes" observatories mentioned above, with two prime examples: the legacy holes utilized and/or specifically drilled for the ION/OSN global seismic network and the 13 "CORK" long-term hydrologic observatories installed to date. JOIDES has now scheduled installation of a third kind of observatory designed to monitor processes at intermediate time/space scales: the strainmeter/seisomometer installations planned for the Japan Trench. Without dwelling too much on the scientific and instrumental specifics of these examples (see Appendix I), we cite them here to illustrate several of the factors our PPG is mandated to consider:

(1) The current examples are excellent illustrations of the truly unique capability ODP offers to emplace sensors deep with the formation, but with subtle differences. For the OSN holes, the great value of the legacy hole is in providing a quiet seismometer environment in basement formations away from oceanographic noise on the seafloor. For the CORKs and strainmeter installations, the great value is in emplacing sensors in the formation, as close as possible to where the active processes are occurring, again isolated from the seafloor. These differences are important, in that they result in different requirements for hole completion, illustrating that individual legacy holes are not always suitable for all observatory objectives.

(2) They are also excellent examples of the prescription for success within the JOIDES system: active proponents with clear long-term plans and a responsive JOIDES advisory structure that honors its long-range plans. In one case, the proponents are organized within the umbrella of a "global geoscience initiative" (ION/OSN), whereas in the other two cases, although links can be made to global initiatives (Table 1), the proponents have really acted as independent groups of scientists. For the global seismic network, the plans before ODP ends in 2003 involve establishing legacy reentry holes at the six highest-priority seafloor sites for the global distribution of long-term broad-band seismometers, as specified in the ION global siting plan submitted in 1996 as JOIDES Proposal 506. For the CORK observatories, the long-term plans involve development of a more capable second-generation Advanced CORK, as outlined in a recent workshop report (Becker and Davis, 1998). The LTO-PPG has consistently and strongly endorsed the long-term plans set out by both groups, and the JOIDES advisory structure has also been strongly supportive.

(3) These are also good examples of the limits on JOIDES support of instrumentation and post-drilling operations in legacy holes, along with the concomittant requirement on proponents to obtain extramural funding from national funding agencies for both the instrumentation costs and post-deployment servicing/data recovery. For the ION/OSN holes, ODP is asked only to provide the cased reentry hole; construction, deployment and servicing of seismometers will be conducted independently supported by national funding agencies. For the CORKs, ODP and JOIDES have been asked to provide the cased reentry hole, the CORK "body" which seals the hole and interfaces with scientific instrumentation, and the drillship time for initial installation of the instrumentation; costs of the scientific instrumentation and post-deployment data recovery and formation-testing have been supported by national funding agencies. The strainmeter example is similar to the CORKs, with ODP/JOIDES asked to provide the completed reentry hole and to conduct the installation/cementing of instruments built with support from national funding agencies, who will also be asked to support all necessary post-deployment operations.

Recommendations for Future ODP and IODP Observatories

The success of the current ODP observatory effort illustrates that JOIDES has experienced strong proposal pressure for observatory science, and has responded very positively in accord with the goals laid out out in the ODP LRP. As this report is written, JOIDES continues to enjoy strong proposal pressure for additional observatories of the three examples described above – proposal pressure that is probably due more to active proponents, rather than the establishment of the LTO-PPG. However, there is yet little continuing proposal pressure for new kinds of observatories to address scientific themes of global geoscience initiatives and/or PPG's. If the LTO-PPG is to have succeeded in fulfilling its mandate, it should be reflected in development of the latter type of proposals for new kinds of ODP observatory science.

With our limited membership and lifetime, we cannot possibly develop a detailed blueprint for all the observatories ODP and IODP might establish. Nevertheless, in Appendix I we outline some possibilities for several particular new kinds of ODP/IODP observatories, with the aim of stimulating more complete consideration and proposal preparation with the participation of appropriate geoscience initiatives. These examples are all essentially specialized active-process observatories: (1) ridge-crest observatories for hydrothermal and tectonic processes, (2) subduction zone observatories for seismogenic processes, (3) gas hydrates observatories, and (4) subsurface microbiological observatories. Two important general considerations should be noted here:

First, there are active geoscience initiatives and/or scientifically-focused PPG's clearly associated with each of these generic future borehole observatories as well as each of the current ODP observatory types (Table 1). As the LTO-PPG phases out, these groups must be involved in the planning for future ODP/IODP observatories; it is these groups which should set out the guidance for scientific goals, essential instrumentation, and recommended global distributions of ODP/IODP observatories. The LTO-PPG includes a strong but incomplete representation of global hydrogeological interests, and we strongly endorse the proposition that a Hydrogeology PPG should be geared up as the LTO-PPG disbands.

Second, many of the objectives of these generic future observatories are specialized fluid flow objectives that could probably be addressed with customized "Advanced CORKs" described in a recent JOI/USSSP-sponsored workshop report (Becker and Davis, 1998); that report will not be repeated or excerpted here but should be considered an essential companion to this LTO-PPG report. Most of the remaining objectives of the four example future observatories could be met by merging the fluid flow capabilities of the "Advanced CORKs" with the seismic- and strain-monitoring capabilities of the other current ODP observatories, and re-engineering as appropriate for specific site requirements. Thus, we believe that the current ODP observatory effort is laying solid engineering and scientific groundwork for future ODP/IODP observatories.

Given the considerations and examples developed above, the LTO-PPG proposes the following principles to guide the evolution of an "overall plan" for the ODP/IODP approach to observatory science:

(1) Scientific Justification of ODP/IODP Observatories

Borehole observatories should be established only when a clear case is presented for process-oriented and hypothesis-driven in-situ monitoring science. (If this seems too obvious, one important corollary is that monitoring for the sake of monitoring is not sufficient reason to devote ODP resources to establish observatories.) The prime role for international geoscience initiatives and/or thematically focused PPG's with respect to future ODP observatories lies in setting out the scientific hypotheses to be addressed with in-situ monitoring in ODP holes and any systematic approaches required (e.g., global distribution of sites). These science objectives will then define requirements for instrumentation, hole completion, coring, logging, and site surveys, which therefore cannot be specified completely and exactly by this PPG (although LTO-PPG suggestions are indeed made in Appendix I).

(2) Proposals for ODP/IODP Observatories

The proponent-driven proposal process should be retained as the device to fulfill (1). The historical record indicates that the JOIDES proposal review process, regardless of details, is for the most part a very effective filter in this regard. "Proponents" may range from individual scientists to PPG's to the "appropriate geoscience initiatives" concerned with observatories, but all proposals should be treated the same. If "geoscience initiatives" act as or appoint proponents, then that represents the second important mode of their interaction with JOIDES. In (5) below, we make recommendations for matters to be considered in review of observatory proposals, with implications for the suitable content of these proposals.

(3) Third-Party National Funding for Observatory Instrumentation and Servicing

The proponent-driven proposal process will also be the primary mechanism for obtaining the support from national funding agencies for costs of developing, deploying, and servicing long-term borehole instrumentation. For the foreseeable future, it is unrealistic to expect JOIDES to assume these responsibilities, not only because of fiscal and manpower constraints at ODP contractors and limitations inherent in the JOIDES advisory structure, but also because the interests of proponents and national funding agencies should be preserved. Thus, future observatories through the end of ODP in 2003 will probably follow a model for division of responsibilities and funding much like that employed for OSN sites, CORKs, and the strainmeters scheduled to be emplaced during Leg 186: JOIDES funds and shiptime are used to complete the appropriate reentry hole and in some cases to emplace the instrument package, whereas third-party funds are used to develop the scientific instruments, in some cases to emplace them, and to support post-emplacement servicing and data recovery.

This approach will require close contact between proponents and ODP engineers, including JOIDES support of any ODP services required to properly engineer and implement the appropriate hole completion. It will also entail some sharing of overall control and will therefore require flexibility by the JOIDES advisory structure and national funding agencies when sometimes simultaneously considering parallel proposals for (a) scheduling drillship time and (b) supporting the associated third-party costs. Achieving such flexibility may require extra work for all concerned, but it brings several important benefits: preserving interests of national funding agencies and individual proponents/PI's, minimizing fiscal and shiptime demands on a JOIDES and ODP already stretched to the limit, and, perhaps most important, leveraging additional resources for observatory science that will ultimately reflect very positively on ODP and future scientific ocean drilling programs. It might be appropriate for the IPSC to reconsider this approach when planning for a post-2003 IODP, if a new and enhanced funding model is adopted.

(4) Integration with Site Surveys, Logging, and Seafloor Monitoring Experiments

Observatories are particularly good examples of the "cascade" of activities other than drillship operations envisioned for a complete scientific ocean drilling program in reports like COMPOST-II. In most cases, the cores and logs recovered from holes intended to be instrumented will be essential in refining the scientific justification and optimal instrumental configuration for borehole observatories. In many cases, borehole observatories will be essential components of integrated seafloor/borehole observatory systems that also include monitoring of processes using seafloor instruments. Moreover, it will often be desirable to begin such seafloor monitoring prior to any drilling operations, both to help justify the case for borehole observatories and also to record background activity before any possible perturbations due to drilling. Thus, certain borehole observatories may require expanded definitions of site surveys, to include not only the spatial surveys required to select drilling sites, but also initial monitoring using seafloor instruments to set the stage for a process-oriented borehole observatory experiment. Likewise, post-drilling operations may include not only monitoring of processes using integrated borehole and seafloor instrument arrays, but also repeated and/or improved spatial surveys.

It is very difficult to make recommendations for such pre- and post-drilling surveys, logging, and seafloor monitoring except on a case-by-case basis as defined by scientific objectives of an ODP observatory; such site survey requirements should be viewed as science requirements that help to define the hypothesis-driven basis for ODP/IODP observatories. Nevertheless, in Appendix I we do offer some suggestions for generic types of future ODP/IODP observatories.

(5) Review of ODP/IODP Observatory Proposals

All of the factors discussed in (1)-(4) above should be considered in the JOIDES review process for a borehole observatory proposal. There are several important implications for the review process, as follows:

(a) Proponents of observatory proposals must include discussion of these issues in their proposals.
(b) Proponents also must be made aware very early in the review process that they, not JOIDES, must bear the responsibilities for obtaining third-party support to fulfill the long-term requirements for instrument construction, servicing and data recovery, as well as integration scientifically and technologically with seafloor monitoring systems.
(c) Early technological review by ODP engineers is very important.
(d) The science review by SSEPs, outside reviewers, and SCICOM may need to be structured in a somewhat different manner than for a straightforward coring and logging program.
(e) Finally, as a short-lived body without a proposal-reviewing mandate, the LTO-PPG cannot fulfill these review functions, which instead must fall to the SSEPs, SCICOM, and perhaps SciMP and OPCOM.

It may be useful to distinguish three alternative scenarios for an observatory proposal: (1) a JOIDES proposal built around observatory science, with the drilling proponents initially including the principal investigators for any third-party funding proposals; (2) a JOIDES proposal including an observatory component without much development, lacking participation by likely instrumental PI's; or (3) a JOIDES drilling proposal not including observatory science but for which the JOIDES advisory structure recognizes a compelling case for an observatory component. The first scenario has applied for all ODP observatories installed to date, and therefore may represent the best scenario for success. The second and third scenarios are more problematic, in that there should be a stage in the review process at which the drilling proponents are brought in contact with appropriate ODP engineers and experienced observatory scientists. The latter could possibly serve as JOIDES co-proponents and PI's in seeking the required third-party funding, although the intent of this advice is simply to share experience within JOIDES, not to perpetuate the role of established observatory scientists or discourage new approaches. The LTO-PPG did not fulfill this function, as it was not mandated to review JOIDES proposals. Therefore, this function too must fall to the SSEPs, SciMP, and/or SCICOM.

Obviously, scientific and technical review of JOIDES proposals including observatories requires that proponents include in the proposals a great deal of information not normally included in a drilling proposal. The LTO-PPG recommends that proponents of observatory proposals be as specific as possible about, and the JOIDES review focus on, the following matters:

(a) Science - How well does the existing evidence define a scientifically important problem and the proposed drilling/logging/observatory promise a solution? Hypothesis: Is there a good understanding of the problem and a carefully posed hypothesis? Test: Does the experiment promise to resolve the hypothesis? Timing: Does the monitoring experiment allow for sufficient time in establishing adequate conditions? Is pre- and post-drilling seafloor monitoring required?
(b) Technology - Will the proposed drilling provide suitable hole conditions and is suitable observatory technology available? Specifics should be provided concerning hole conditions (geology) and hole completion (open, cased, perforated); sensors and data recording (suitability and availability); power requirements, service and maintenance schedule, interfaces to and availability of appropriate servicing infrastructure (submersible, ROV, wireline control vehicle).
(c) Risks - What are the main risks to the proposed observatory science and to the future use of the site? E.g.: event occurrence and hypothesis test - probability of event occurrence within lifetime of experiment; equipment response to event occurrence (unknown magnitude of event); damage to

environment by (a) previous drilling disturbance (thus affecting proposal) or (b) the proposed experiment (thus affecting later proposals); conflicts of interest at multi-user site; decommissioning plans for experiment at legacy hole.

(d) Funding and Development Schedule - Is there sufficient lead time and proponent experience to obtain necessary third-party funding and JOIDES funding to support necessary ODP development engineering and procurement of necessary hole completion hardware?

LEGACY HOLES AND POLICIES FOR OVERSIGHT

Legacy holes are defined here as stable holes that can be reentered for deepening or for experimental use. These holes include some of those with reentry cones and casing, and could include bare rock holes that can be reentered by a Control Vehicle or ROV. The vast majority of DSDP/ODP holes are non-reenterable single-bit holes; at this time, there are only about 33 useful legacy holes, virtually all of which are traditional reentry holes (Table 2). A large majority of the best quality reentry holes have been utilized for or proposed for ODP observatories. Eleven of these holes contain CORKs, and six of the holes contain other experiments that are no longer in use. Interestingly, reentry holes established before 1991 were generally done so for deep drilling purposes, but the primary motivation for the majority of reentry holes established since 1991 has been observatory science. The LTO-PPG notes that the list of suitable legacy holes is very short, and recommends that ODP consider using a significant portion of the remaining drilling program to remediate existing reentry holes and/or drill legacy holes in locations of particular interest for future experiments and observatories. The LTO-PPG recognizes that these holes provide a valuable legacy of the drilling program, but obviously only if they are utilized. Given their small number, great value, and potential conflicts, future use of these holes will probably require coordination by an appropriate oversight group.

More Legacy Holes. New legacy holes could be suggested by appropriate JOIDES panels (SSEP's, PPG's and DPG's) and by proposals submitted by or possibly requested from the scientific community (geoscience initiatives or individuals). Such holes might include OSN sites, bare rock shallow holes for arrays, hole pairs for cross-hole studies, and other possibilities we may not be envisioning at present. Several existing holes (Table 2) that are presently blocked by experiments that are no longer operating or by other trash could be cleaned and otherwise improved at relatively little expense to make them into valuable legacy holes. The LTO-PPG requests that the ODP consider such cleaning operations whenever logistics present opportunities.

Policy for Oversight. The great majority of legacy holes are located in international waters where they cannot be legally controlled. Present JOIDES policy recognizes this, and merely requests notification of JOIDES when legacy holes are to be utilized. However, the value of these resources to the international geosciences community makes it strongly advisable that their use for experiments be monitored and even coordinated by an international group under JOIDES auspices. To date, serious conflicts have not occurred and an oversight group has not been required, but it may behoove JOIDES to consider establishing an oversight mechanism sooner than later. As the LTO-PPG reaches its retirement, it appears that this function could be delegated to a subgroup of SciMP. General guidelines for use of legacy holes should be defined, such as a provision for removing instrumentation from the hole with a standard research vessel and the capability to add ancillary experiments at a later time. This group should act as a coordinating body and as a repository for information on the availability and status of holes. Policies for hole use should be publicized by this group, including such possible guidelines as specific durations of experiments, formal contact points, and requirements for periodic status updates.

Observatory Servicing Assets. The LTO-PPG recognizes that some observatories being considered will be installed in ocean depths that are beyond the capabilities of many of the submersibles and ROVs currently in operation, and that it appears likely that the number and complexity of observatories will require a significant increase in the number and availability of full-ocean-depth vehicles for servicing both borehole and seafloor observatories. International coordination of scheduling and availabiity of these assets is highly desirable, as is the standardization of mechanical interfaces so that any of a number of assets could service many observatories. Funding agencies should be made aware of the impending demands on such assets and the impact it will likely have on the maintenance and operation of observatories.

RECOMMENDATIONS FOR JOIDES ADVISORY PROCESS

Embedded in the words above are several specific JOIDES structural recommendations for ensuring the continuing success in the ODP observatory effort after the LTO-PPG disbands. To summarize, these recommendations include:

(1) Establishment of a clear process somewhat specific to observatory proposals, including early review of technological aspects. This recommendation will fall to some combination of the JOIDES Office, SCICOM, SSEPs, ODP/TAMU, and perhaps SciMP and OPCOM, and is not intended to imply any shortcoming in the present process. In fact, the JOIDES system has dealt quite well with review of observatory proposals to date, and this recommendations reinforces the recent trend toward early review of observatory proposals by JOIDES and ODP. Nevertheless, establishing clear guidelines for early review will be especially important as new types of ODP observatories are proposed by new proponents.

(2) Establishment of some sort of oversight group for legacy holes, possibly falling to a subset of SciMP.

(3) Seeding of appropriate PPG's with scientists with observatory expertise. We re-emphasize that observatories are not scientific ends in themselves, but are part of the suite of drilling-related tools to be brought to bear on appropriate scientific problems. The LTO-PPG sees strong observatory prospects for at least three of the present PPG's (Table 1; Appendix I): the Deep Hot Biosphere PPG, the Architecture of Oceanic Lithosphere PPG, and the Gas Hydrates PPG. As the LTO-PPG disbands, JOIDES should ensure that these other PPG's retain some source of observatory expertise.

(4) Finally, we note that the LTO-PPG membership includes strong representation of hydrogeological expertise, as hydrological observatories have been a prominent ODP success since 1991. While the overall goal of the LTO-PPG mandate included "quantifying the flux of heat and materials to and from the Earth's interior," we did not feel sufficiently qualified to develop a global drilling/observatory strategy to address the wide range of hydrogeological problems still outstanding in characteristic seafloor environments. Thus, we strongly endorse the prospect that JOIDES should establish a Hydrogeology PPG as the LTO-PPG disbands, and we particularly recommend that this Hydrogeology PPG should include strong observatory representation. The first half of 1999 will be an appropriate time for this transition, not only because the LTO-PPG has now produced its mandated report, but also because of the scheduling of an ILP- and JOI-sponsored workshop on Hydrogeology of the Oceanic Lithosphere in December of 1998. This workshop represents the first major effort of a recently organized "international geoscience initiative," featured use of drilling tools and borehole observatories to address hydrogeological problems, and will provide a workshop report useful as a white paper both at the forthcoming COMPLEX meeting and for the proposed Hydrogeology PPG in developing a global strategy for ODP to address subseafloor hydrogeology.

CONCLUSIONS

In maintaining a strong commitment to borehole observatories ODP (and IODP) has a wonderful opportunity to strenthen its leadership role in the growing global initiative for seafloor observatory science. We note that the price for JOIDES to maintain its leadership role in long-term monitoring is actually quite reasonable, given that extensive third-party funds are nearly always leveraged for ODP observatory science. Several examples have followed a funding model in which non-JOIDES funds are leveraged to support scientific instrument packages emplaced in ODP observatory sites as well as post-emplacement data recovery. The total costs of these additional contributions are comparable to the contribution from JOIDES. In this sense, observatories represent a very cost-effective way to extend the visibility of ODP and the impact of ODP science in a time of level JOIDES funding.

Specifically, continuing commitments are required from JOIDES/ODP toward (1) establishing good reentry holes in appropriate locations, and (2) providing the engineering support for emplacement of third-party instruments. The first includes the commitment of costs and drillship time for standard and new types of reentry holes where appropriate. The commitment required from JOIDES also includes engineering development toward hole completion (e.g., development of hammer-in or drill-in casing systems) in difficult drilling environments where active processes are of great scientific interest. The second aspect includes engineering support at ODP for the seafloor and subseafloor hardware required for the third-party instruments. For example, in the current CORK design, ODP provides the CORK "body" which seals the reentry cone and from which third-party sensor strings are suspended. Or, for the strainmeters to be deployed during Leg 186, ODP engineered the system for deploying and cementing the instrument package in place.

To summarize, the Long-Term Observatories PPG strongly recommends that the SSEPs assign high ODP/JOIDES priority to the following:

(1) Commitment of drillship time and, in most cases, cost of standard reentry cone/casings at appropriate sites that are well justified in competitively reviewed JOIDES proposals, e.g., ION sites and other potential legacy holes.

(2) Continued development of hole-completion technology for difficult drilling environments where active processes will require long-term monitoring.

(3) Continued development engineering support for installation of third-party monitoring packages in observatory holes.

In addition, we offer some recommendations in the section above on the JOIDES review process for observatory proposals and on how the JOIDES structure can accomodate the continuing functions in the LTO-PPG mandate after the LTO-PPG disbands. Finally, in Appendix I, we offer some suggestions for possible future ODP observatories, in the spirit of stimulating appropriate PPG's and DPG's, geoscience initiatives, and individual scientists to further develop these possibilities.