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and terrestrial) to provide advice concerning research the GSC will be conducting or supporting. Lake studies will begin with a preliminary coring program in February 1992, and continue in the summer with sub-bottom profiling, limnologic monitoring, and basin inventories. University-based researchers see the summer of 1993 as a practical objective for the initiation of detailed studies. The GSC plans to begin developing a process-monitoring network during summer 1992. Detailed surficial mapping (materials, slope, aspect and vegetation) will be conducted in conjunction with process monitoring.

To facilitate collaboration between individuals working in the Palliser Triangle, the GSC hopes to organize a second Palliser Triangle Global Change Observatory meeting and field trip, tentatively planned for the University of Regina in late August or early September of 1992. A traditional conference format is planned with researchers presenting results from individual projects. The recent workshop provided an important boost for the establishment of this new Global Change Observatory, and the organizers thank all participants for their efforts.

## REFERENCES

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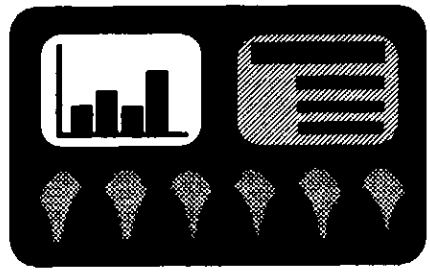

# Canadian Continental Drilling Program First 5-Year Plan Workshop

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The Canadian Continental Drilling Program (CCDP) is in the process of implementing its Pilot Project and first five-year plan of operations (Table 1). In order to brief the members of the CCDP Steering Committee and the community at large on the development of proposals, a half-day workshop was held at the Ministère de l'Énergie et des Ressources, Charlesbourg, Quebec on 27 November 1991.

The workshop was attended by 40 participants who listened to and discussed presentations on nine drilling-based proposals. The presentations were of considerable value to all concerned, dealing with areas of topical interest; most had evolved substantially since they were last presented at a National Discussion Meeting in August 1991.

The workshop was opened by a welcome to participants from Dr. Robert Lamarche, Sous-ministre adjoint, Exploration Géologique et Minérale, of the Ministère de l'Énergie et des Ressources. This was followed by presentations on individual projects.

### *Kapuskasing Pilot Project*

Robert Mereu of the University of Western Ontario described the status of this project, which is currently under consideration by the Natural Sciences and Engineering Council of Canada (NSERC) for funding. Other contributors to the project are the Geological Survey of Canada (GSC), the Ontario Geological Survey (OGS), Amoco Canada and Inco.

The principal objective of the project is to identify the source of shallowly dipping packages of seismic reflections, and coincident intervals of enhanced electrical conductivity, in mid- to lower crustal, granulite facies, mafic gneisses and tonalites in the Kapuskasing Structural Zone (KSZ) of Ontario. LITHOPROBE seismics show that reflective zones can be traced from normal crustal depths of about 20 km to 1-2 km in the KSZ, that is, to within reach of a relatively inexpensive drilling investigation using conventional technology. A single vertical continuously cored 1.8 km hole is planned, using the high-speed diamond technology with wire line core recovery. Comprehensive logging of the hole is planned. Intensive interdisciplinary study of the hole and the recovered core will delineate the source of the reflections in terms of physical properties and will demonstrate their origin in terms of structural history, crustal construction process, and the possible role of fluids in the crust. The principal investigators for the project are R. Mereu (U. of Western Ontario), J.A. Percival (GSC), M. Mareschal (École Polytechnique) and M.H. Salisbury (Atlantic Geoscience Centre (AGC)/GSC) with expertise in downhole geophysics and fluids to be provided, respectively, by P.J. Killeen and J. Mwenifumbo (GSC) and S.K. Frape (U. of Waterloo). A further 40 investigators have expressed interest in participating in the project. The project has already received wide international interest in view of the potential for application of its results to the interpretation of the thousands of kilometres of seismic profiles and electromagnetic soundings of Precambrian cratons throughout the world, and in particular to the Canadian Shield with its great mineral wealth. Should the remaining funding be secured in the near future, drilling operations will take place in spring/summer 1992 with the first results available shortly afterward.

### *The Cretaceous-Tertiary (K-T) Boundary*

Two proposals were outlined regarding the investigation of the events associated with the K-T boundary by drilling. The first of these, by Arthur Sweet (Institute of Sedimentary and Petroleum Geology (ISPG)/GSC, Calgary), aimed at work in Canada and the second, by Richard Grieve (GSC, Ottawa), concerned work in Mexico. The proposal outlined by Sweet forms the first part of the CCDP 5-Year Plan (see Table 1) and aims to sample the K-T boundary and its environs at three locations in Western Canada: the Turtle Mountain area of Manitoba, the Wood Mountain area of Saskatchewan, and the Cyprus Hills area in southeastern Alberta. This profile will enable sampling of the boundary in a number of environments, from marine conditions in Manitoba to coal swamp conditions farther west. The profile also provides a partial link between the known K-T boundary at the Manson impact structure in western Iowa and the possible K-T boundary at the buried Eagle Butte structure close to the planned Alberta hole. [The Manson impact structure is currently being sampled by drilling by the United States Interagency Coordinating Group for Continental Scientific Drilling.] Sweet summarized recent findings on the K-T boundary, including the recognition of a floral change in the middle of the boundary layer. Three continuously cored holes, each of about 250 m

depth are planned. The objectives will be to sample the boundary clay and to recover continuous, unweathered sections of the uppermost Cretaceous and lowermost Paleocene for geochemical study in an area of the poorly understood stratigraphy. The principal investigators for the project will be J.F. Lerbekmo and K. Muehlenbachs (U. of Alberta), Arthur Sweet (ISPG/GSC, Calgary) and D.R. Braman (Royal Tyrrell Museum of Palaeontology, Drumheller). A budget of close to $140,000 is envisioned, of which $65,000 has already been contributed by AMOCO Canada.

The second K-T boundary proposal, by R. Grieve, is for Canadian participation in the investigation by drilling of the Chicxulub crater in Yucatan, Mexico. Recent work suggests that the circular Chicxulub structure, which is buried beneath Tertiary sediments, is the site of the principal impact responsible for the K-T boundary extinctions. The evidence is partly from the size of the buried feature, which has a diameter of 180 km (probably appropriate for an impact by a 10 km diameter body), the thickness and type of K-T boundary deposits in nearby Haiti and Mexico, and the small amounts of core still available from wells drilled earlier by PEMEX, the Mexican state oil company. Should the dating of these samples confirm that Chicxulub marks a K-T boundary event, four holes are proposed. The first and second would be 400 m and 500 m deep, respectively, and would be located close to earlier wells to sample the known ejecta blanket. The third hole, 1700 m deep, would be located to sample ring-shaped gravity lows within the feature which are thought to originate in low-density breccia together with melt-pool products. A fourth hole, also to 1700 m, will address a number of questions regarding the boundary of the structure and the melt-pool thickness 10 km further from the center of the structure than the third hole. A strong group, under Mexican direction, is already involved in planning investigations of the Chicxulub structure and, it is suggested, a Canadian contribution in the drilling aspect of the investigations would be welcomed.

Both the advantages and difficulties of this proposal were recognized in the discussion following the presentation. While the objective is clearly of wide international interest (a CCDP criteria for project selection), there is potential for conflict with another CCDP criteria, that projects in the initial 5-year plan should be for work within Canada. It was also noted that the potential urgency associated with drilling the Chicxulub structure would, if the proposal were to be incorporated in the already agreed program, require a delay on other projects. The Steering Committee of CCDP, meeting after the workshop, passed a motion strongly supporting in principle the concept of drilling the Chicxulub structure, should a K-T age be confirmed. The Committee also agreed to investigate the possible availability of funds required for the project, estimated at $500,000, from sources in Canada that are not normally accessible for research in the earth sciences.

### *The Saguenay Fiord and New Quebec Crater Projects*

These projects together constitute the Global Change package in the early part of the CCDP 5-Year Plan. Both are designed to investigate Holocene and Pleistocene climatic history at high resolution, together with a range of other problems. The Saguenay Fiord project was presented by Jacques Locat (U. Laval). Sampling by drilling of the submarine sediment sequences of both the Saguenay Fiord and the Laurentian Trough of the Gulf of St. Lawrence is proposed. A very high resolution climatic record may be obtained from the Saguenay Fiord sequence, where reflection profiling shows from 200 m to 1400 m of presumably late Wisconsinan Quaternary sediments. Seven objectives were given, these being: 1) documentation of climatic change; 2) identification of the history of major forest fires; 3) derivation of glacial history; 4) investigation of the diagenesis of the young, but very thick, sediments; 5) search for an indication of paleoseismic history through the recognition of landslide derived sedimentary horizons; 6) investigation of sedimentary microstructures and their origin; and 7) study of the chemistry of interpore waters.

Similar objectives are envisioned for the Laurentian Trough, which is, in contrast with the Saguenay Fiord, an open basin. A large group of investigators, co-ordinated by J. Syvitski (Bedford Institute of Oceanography), has expressed interest in participation in the project, which will be ready for implementation in 1994. The possibility of the loan of drilling equipment from the Ocean Drilling Project is being investigated.

The second project in the Global Change package concerns sampling by drilling of the sediment fill in the New Quebec (Nunavik) crater, located in the Ungava area of northern Quebec. This proposal was presented by Michel Bouchard (U. de Montréal). The crater has been dated by the $^{39}Ar/^{40}Ar$ method, yielding a Pleistocene age of about 1.4 Ma. It is 3.4 km in diameter and contains a completely isolated lake, which is 267 m deep and is underlain by 100-200 m of sediments. Due to the shape of the lake and its location relative to the central areas of glaciation of North America, and according to present theories of glacial ice flow and thermal regimes, it is possible that the bottom of the crater has escaped glacial erosion from the last or all the glaciations since 1.4 Ma. If this supposition is correct, the crater may contain a well-preserved and continuous sedi-

**Table 1 First 5-Year Phase of Operations.**

| Pilot Project | 1992 | 1993 | 1994 | 1995 | 1996 | Second phase of operations |
|---|---|---|---|---|---|---|
| Kapuskasing Structural Zone Seismic Reflections | K-T Boundary | Granite-Greenstones | Granite-Greenstones | Algonquin Arch | Algonquin Arch | Possible Sudbury Basin Investigations |
| | | Steen River Structure[1] | Major faults[1] | Major faults[1] | Grenville Province | |
| | | | | ASDEW[1] | ASDEW[1] | |
| | | New Québec Crater | Saguenay/ St. Lawrence Estuary | | | |
| | | | Global Change Package | | | |

[1] Proposals not presented at the workshop:
Steen River Structure: drilling-based investigation of a buried Cretaceous impact structure in northern Alberta
Major faults: drilling of young and possibly active faults imaged by LITHOPROBE on Vancouver Island
ASDEW: Add-on drilling on industry wells in the Western Basins

mentary record of the continental Pleistocene of Canada, including a critical record of the successive continental glaciations and intervening warmer periods, from an area where such information is otherwise unavailable. Comparison with the sediment fill of the much more southerly Brent Crater would be most valuable. It is proposed to drill through the sediment sequence and the underlying brecciated rocks from an ice platform, the lake being frozen for most of the year. A large team of investigators, drawn from the Quebec universities, Quebec government agencies, the Geological Survey of Canada, the private sector, and Finland and Sweden, has expressed interest in participating in the project.

***The Granite-Greenstone Environment***

A report on the status of the Granite-Greenstone Environment proposal was given on behalf of P. Thurston (OGS) by Pierre Verpaelst (Ministère de l'Énergie et des Ressources, Rouyn-Noranda).

Archean geology is undergoing a revolution. The age of many rock units can be determined to the same precision as those in Phanerozoic sequences, allowing determinations within stratigraphic sequences and ages of discrete structural events. It is now appropriate to aid this spectacular progress with drill-based research to determine the three-dimensional architecture of parts of the Canadian Shield.

To put the revolution in context, recent changes in our understanding of the Archean should be summarized. The Superior Province is composed of granite-greenstone, sedimentary, gneissic and plutonic subprovinces. Granite-greenstone subprovinces include four newly recognized lithostratigraphic associations: platform sequences, mafic plain sequences, arc volcanics and pull-apart basins. All have modern analogues. Sedimentary subprovinces are comparable with fore-arc accretionary prisms, consisting of thrust-imbricated clastic wedges, dominated by greywackes, with fragmentary preservation of olistostromes and tectonically emplaced mafic/ultramafic bodies. Systematically across the Superior Province, the ages of calc-alkaline volcanism, post-tectonic plutonism, and deformation associated with subprovincial boundaries become younger southward from the older sialic nucleus of the Sachigo subprovince. A regime of largely vertical-style Archean tectonics has been modified by the discovery of abundant horizontal structural and geophysical features related to an earlier, horizontal-style, deformation. Whereas the plate tectonic hypothesis cannot be proven, it is the one which best explains a diversity of observations in modern and Phanerozoic geology. Likewise in the Archean, arc-accretionary tectonics is the simplest and most versatile explanation of recent observations.

Two major problems in Archean geology have been selected for investigation by drilling: a) the large-scale relationships between granite-greenstone and sedimentary subprovinces, exemplified by the relationship between the Abitibi and Pontiac subprovinces, and b) the smaller scale problem of the detailed architecture of greenstone belts.

Two 3 km holes are proposed, one for each problem. The first hole is to probe subprovincial relationships and deformation patterns by improving knowledge of the three-dimensional structure of the Pontiac subprovince. This drill hole will pierce shallowly dipping units of the central Pontiac subprovince, the part of the Abitibi-Pontiac system most amenable to a drill-based examination of the subprovince relationship problem. The results of recent field work may lead to a change in drilling needs to address this problem. The second hole is to investigate the detailed structure and stratigraphy of a greenstone segment containing relatively shallowly dipping to sub-horizontal stratigraphic units, structures and seismic reflectors. The unusually flat dip of strata and low metamorphic rank make the Abitibi subprovince the most suitable granite-greenstone area in the Superior Province for a drill-based research program.

The program includes comprehensive site surveys and multi-disciplinary logging. Results will be utilized in both scientific and mineral exploration spheres and are expected to produce measurable progress on the major problems identified.

***The Algonquin Arch Transect***

This proposal was presented on behalf of a large group of collaborators by Gail McFall (OGS). The planned transect consists of six, 1.5-2.5 km deep, continuously cored drillholes across the Algonquin Arch in the Niagara Peninsula, Georgian Bay and Windsor areas. The holes will be sited to maximize the opportunity to: 1) intersect tectonically significant basement structures; 2) provide a means for geophysical and neotectonic monitoring at depth in the area; 3) allow fluids, gases and secondary mineral phases to be sampled in order to monitor the deep hydrogeochemical regime in the area; 4) provide valuable stratigraphic information on the Paleozoic section; 5) provide geological and geochronological information on the basement rocks of the Central Metasedimentary Belt and Central Gneiss belt of the Grenville Province; and 6) provide geological information on the possible nature and position of the Grenville Front boundary and the Mid-Continent Rift System.

The update provided by McFall concentrated on geophysical and geological evidence for possibly neotectonically active structures that cross western Lake Ontario and which may be conduits for fluid transfer between shallow (surface) and deep levels. These structures were seen in the context of the general pattern of structural lineaments in Southern Ontario. Several of the planned holes, especially the one located on the Niagara Peninsula, are near one of the proposed structures and have the potential of exploring the lineament at depth, its associated fluid flow, and the underlying Grenvillian basement.

***The Sudbury Basin***

CCDP had earlier been presented with a preliminary proposal to explore the construction of the Sudbury Basin at depths of 5-10 km. The proposal was a result of the combined efforts of two groups, one with a prime interest in impact structures and the other with an interest in the constructional and economic aspects of the Sudbury Structure. Since a relatively deep hole might be needed to achieve the objectives of the proposal, CCDP had suggested that the project might form an early part of a second 5-Year Plan, with a first decision on the viability of the project to be based on the LITHOPROBE seismics to be shot over the basin in 1991. With the seismics now in hand, it was appropriate to review the proposal. The revised situation was described by Burkhard Dressler (OGS). Two new lines of evidence will have a significant effect on the form of a final proposal for drilling the structure. The first is surface structural mapping, which indicates that the basin is substantially deformed tectonically. Essentially, the original structure is thought to have been close to circular and, as such, appropriate for an impact origin. Later, the southern part of structure, the area of the present South Range, was thrust toward the northwest to give the present elliptical plan form of the basin. This line of evidence appears to be consistent with the results of the LITHOPROBE seismics, which show regularly southeasterly dipping reflectors that underlie the whole of the basin. Reflectors can be traced to outcrop on the northwestern part of the basin. A remarkably transparent interval underlies the overthrust southeastern margin of the basin. It is clear that the much revised structure of the basin will require considerable reassessment of drilling plans for the area.

The Workshop concluded with a general discussion concerning the proposals and the philosophy and state of CCDP development.

Further information on the proposals described at the meeting and on CCDP, respectively, can be obtained from the speakers or Malcolm Drury, Planning Office Coordinator, CCDP, Department of Earth Sciences, Carleton University, Ottawa, Ontario K1S 5B6, telephone 613-995-5478, FAX 613-996-9670.

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