RECOMMENDATIONS ON FUTURE ARCTIC OCEAN SCIENCE

Summary of recommendations resulting from a panel discussion in connection with a workshop meeting on "CESAR Results and Future Arctic Ocean Science" held at the Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa, on November 12-13, 1985.

by

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SCIENTIFIC GOALS

1. Statement of Goals

The polar continental margin and the Arctic Basin constitute one of the least geologically understood regions of the world. The following is a list of high priority objectives:

1) to define the extent and character of the sedimentary basins, the crustal structure and dynamics of the continental margin
2) to determine the oceanographic and climatic evolution of the Arctic deep sea basins. It has three components to address:
   (A) timing and characteristics of initial climatic cooling and glaciation
   (B) timing, magnitude and periodicity of high amplitude late Cenozoic climatic oscillations
   (C) paleoceanographic and paleontologic responses to climatic deterioration and suspected oscillatory periods
3) to determine the origin and evolution of the Amerasia Basin, Alpha-Mendeleev Ridge, Makarov Basin and Chukchi Borderland
4) to define the relationship of Ellesmere Island to the Lomonosov Ridge, the Alpha Ridge and Greenland

2. Practical Implications

1) the investigation of the continental margins provide a framework for petroleum resource evaluation
2) the understanding of the polar influence on climatic variations in more southerly latitudes will have significant long and short term social and economic consequences ranging from the more direct effects on Arctic petroleum development to urban planning and the long-term implications of nuclear waste storage

3) the geological aspects of the relationship of the ocean ridge features to the continental margin will provide constraints for determining natural prolongations of Canadian territory as defined by the Law of the Sea Convention

4) detailed aeromagnetic and other studies in the Canada Basin from Greenland to Alaska will be useful in assessing the implications of international boundary disputes

5) the establishment and maintenance of advanced scientific facilities on the Ice Island will enable Canada to assume a leadership role in arctic research, demonstrate Canadian sovereignty, and assure Canadian presence when the island leaves Canadian water.

SCIENTIFIC PRIORITIES

Geophysical tools and methods

1) Establishment of drilling and long coring facilities on the Ice Island or an ice breaker

2) Implementation of a multichannel seismic reflection and refraction program from the Ice Island and drifting sea ice platforms. In 1986, the US will be testing new techniques for collecting seismic data in the Arctic Ocean from an ice breaker

3) completion, and in part densification, of low-level aeromagnetic coverage of the Arctic Ocean

4) Aerogravity coverage of the whole Arctic Ocean to within the distance from the USSR shoreline allowed by the Soviets. Fully tested and operational airborne gravimeters are available but their use is dependent on the GPS

world-wide navigational system and their implementaion on routine surveys has to await further expansion of the present-day satellite constellation (about 1988). With the exception of the North American polar continental shelf to the shelf break and part of the slope, part of the Alpha Ridge (CESAR), and part of the immediate polar region (LOREX), the available gravity coverage of the Arctic Ocean is very small (Figure 1).

5) Extensive sampling programs that include grabs, dredges, piston and gravity cores and heat flow measurements from the Ice Island, ice stations and properly equipped ice breakers. This information is critical for geochronological dating and interpretation of the geophysical data.

6) Magnetotelluric and magnetic induction program from the ice island and ice stations. This is particularly important for determining the relationship between Ellesmere Island, Greenland and deep ocean structures. These methods also provide information on depth and thickness of the lithosphere.

It is strongly recommended that facilities for drilling, geological sampling, geothermics and seismic programs be incorporated into the design of the proposed new Canadian ice breakers.

Scientific Plan

Because of the high cost and logistic difficulties of working in high latitudes it is important that a rigorous scientific plan be adopted

1) in order that as many scientists in a wide range of disciplines as possible can participate and review the plan's scientific objectives, operational plans should be circulated to such committees as Comité Arctique International, Arctic Ocean Sciences Board and IUGG panels. International participation in arctic studies can lower the cost to an

individual nation, increase the circulation of the knowledge and produce a higher quality product. Participation could be conducted on a cost recovery basis.

2) A detailed Ice Island program should be set up as an example of long-term, flexible, multi-disciplinary planning with international participation. A program of visiting scientists modelled after that conducted by the Naval Arctic Research Laboratory (NARL) in Point Barrow should be considered. An extensive preliminary scientific plan for the Ice Island was prepared by the authors and is available from the Earth Physics Branch.
3) Arctic Ocean studies should be co-ordinated with studies on the adjoining land masses.
4) More special sessions on the Arctic should be incorporated at geophysical and geological symposiums and meetings.

The existing geophysical data and the present state of knowledge on the nature and evolution of the Arctic Ocean on which these recommendations are based are summarised in the following pages:

STATUS OF GEOSCIENCE IN THE ARCTIC OCEAN

1. What is the present data base of the Arctic Ocean?

Bathymetry:

Bathymetric coverage of the North American polar margin from the shore line to the continental break, at a grid interval of 10 km or less, is almost complete except for a short sector off Nansen Sound. No data from the Siberian and Kara continental shelves are available. Beyond the continental slope LOREX and CESAR are the only systematic bathymetric surveys in the Arctic Ocean Basin with good positioning and relatively close station spacing. Fig. 2 shows all Canadian stations established to date. All other publicly available data are from drifting stations Alpha, T-3, Arlis II, FRAM and some 800 US airlifted stations (accuracy ± 15 km) in the Canada Basin and from early submarine data (accuracy ± 50 km). Data coverage is spotty. Contouring of Arctic Ocean bathymetric maps in areas with no data is based on 25 year old Russian maps and classified submarine data whose reliability is unknown.

Gravity:

Coverage is the same as for bathymetry without submarine data and is illustrated in Figure 1. The whole of the USSR sector from the shore line to 89° N latitude is blank. Whereas 500 m bathymetric contour lines are published, in areas with no publicly available data (albeit of unknown quality) the corresponding gravity anomaly field coverage remains blank.

Aeromagnetism:

Most of the 230° sector of the Arctic Ocean between 50°E and 180° meridians has been covered by aeromagnetics including Chukchi Sea, but excluding Chukchi Borderland, southern end of Mendeleev Ridge, Mendeleev Abyssal Plain and Barents Shelf. Flight line spacing is variable and in some areas too wide. Again, the USSR sector is blank except for the Eurasia Basin where the Soviets have released some 20 year old data.

Seismic reflection and refraction:

Industrial coverage is limited to small areas on the Beaufort Sea continental shelf between Pt. Barrow and Banks Island and consists of mostly shallow reflection seismic. Very few deep refraction surveys on continental shelves and across continent-ocean transition zones have been carried out. These are off Alaska (1966), Borden Island (1961), Morris Jesup Plateau (1979), on the Yemark Plateau (1981) and off Nansen Sound (1985 Ice Island operation). Seismic reflection data in the Arctic Basin have been collected along the drift tracks of T-3, Arlis II, LOREX, CESAR and FRAM expeditions. Penetration is of the order of one kilometre.

Seismicity:

Figure 3 shows the location of the earthquake epicentres long the North American polar margin superimposed on the free-air gravity anomaly map. These are the only known areas of significant seismicity in the Amerasia Basin. Seismicity in the Eurasia Basin has been well established and is centred along the Nansen-Gakkel Ridge.

Heat Flow:

Less than 400 heat flow measurements have been carried out throughout the Amerasia Basin mostly from T-3, LOREX and CESAR and very few in the Eurasia Basin (LOREX and Soviet expeditions, the latter of uncertain position and reliability). Although they reveal intriguing regional variations, few regions are covered with sufficient data.

Coring:

Over 700 gravity and piston cores of up to 7.6 m length have been recovered mostly from the Amerasia Basin starting with station Alpha in 1957 to CESAR in 1983. About 50 cores were also recovered from the Eurasia Basin (from LOREX, FRAM expeditions and Barents Shelf).

Magnetotelluries:

In addition to the data acquired at LOREX and CESAR, deep sounding magnetotelluric or magnetic variation data have been obtained by Soviet workers over the Chukchi Plateau, the Lomonosov Ridge, the Mendeleev Ridge, the East Siberian Shelf, the Wrangel Plain and the Nansen-Gakkel Ridge. Some of these data have extended to periods of 24 hours. American results for shorted periods (600s - 3600s) obtained from drifting ice islands Arlis II and Charlie, are also available in the vicinity of the Chuckchi Plateau.

2. <u>What do we know about nature and evolution of the Arctic Ocean</u>?

Eurasia Basin:

Origin and evolution of the Eurasia Basin and the Lomonosov Ridge are fairly well understood. The Eurasia basin is a slow spreading ocean with a thin (7 km) thick crust. The Lomonosov Ridge is a continental fragment consisting of rocks with continental type seismic velocities and densities.

Amerasia Basin:

Origin and evolution of the Amerasia Basin on the other hand are speculative at best, and the relationship of the basin to the surrounding land masses are not understood.

1. In the southern Canada Basin over the Beaufort continental rise the Moho is rising northwards from 23 km to 15 km.
2. At the eastern end of the Makarov Basin, where the basin has narrowed to 70 km, the Moho lies at a depth of 15 km.
3. The North American polar continental shelf is probably an Atlantic-type passive margin as implied by elliptically-shaped free-air gravity anomalies. Much of this northern margin is underlain by a conductive crust extending several hundred kilometres inland from the present continental slope. However, there are two anomalous, seismically active zones, off Ellef Ringnes Island and off the Mackenzie Delta.
4. There are possible magnetic lineations in the southern Canada Basin that would suggest formation of that part of the basin by ocean spreading. A suggested lineation pattern in the Makorov Basin is more speculative.
5. The Alpha Ridge crustal rocks, at least in the CESAR region, show an extraordinary homogeneity of density, seismic velocity and magnetization. The seismic velocity-depth functions on the Alpha Ridge are similar to those on Iceland, and the average crustal density at comparable depth is some 0.8 g/cm^3 greater for the Alpha Ridge than for the Lomonosov Ridge, suggesting that the Alpha Ridge may consist of a large accumulation of basaltic-type material.
6. The Alpha Ridge in the CESAR region has not undergone any significant deformation since late Cretaceous times.

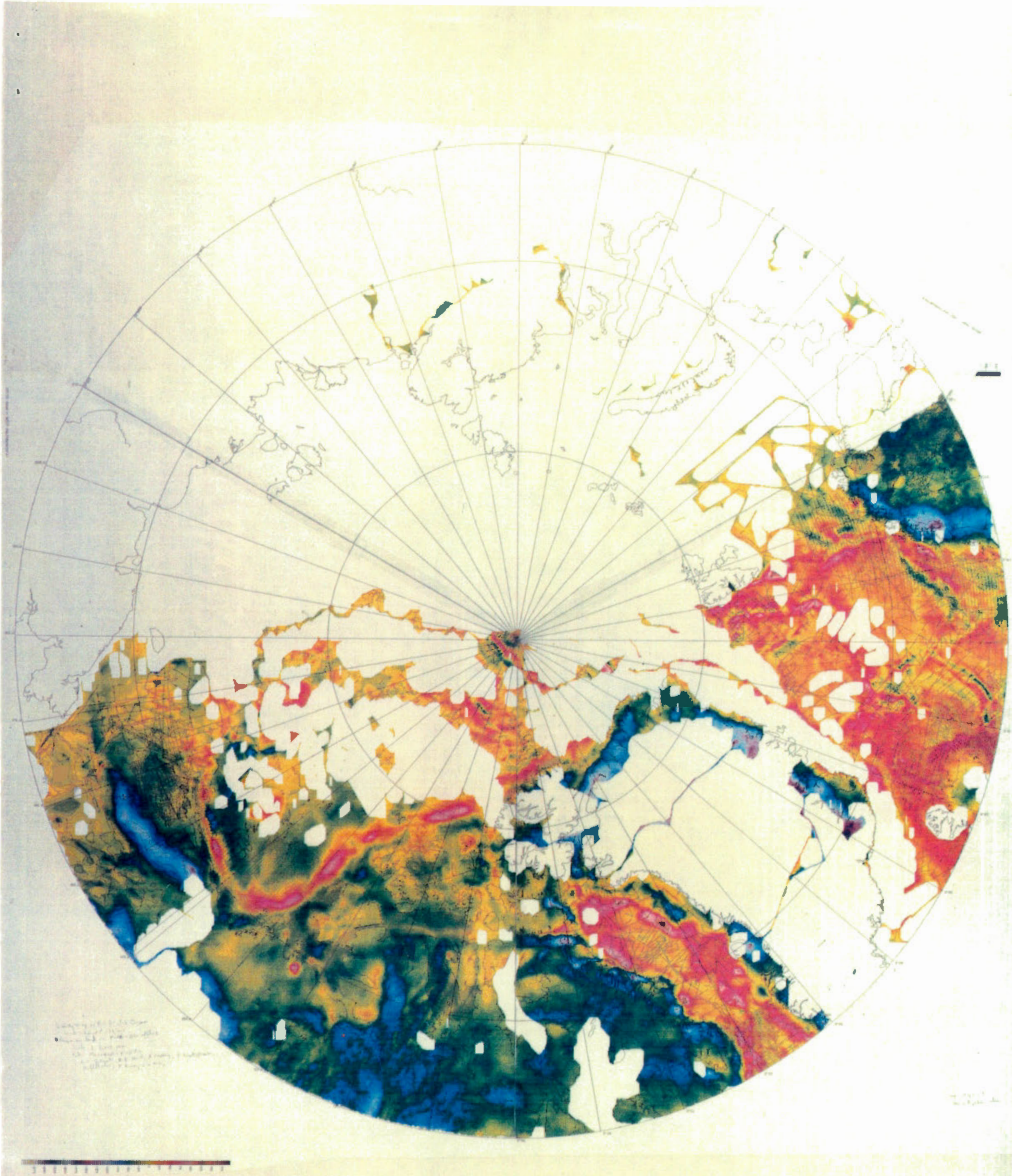

Fig. 1 Free air gravity anomalies north of 64° latitude compiled from all publicly available data by L.W. Sobczak.

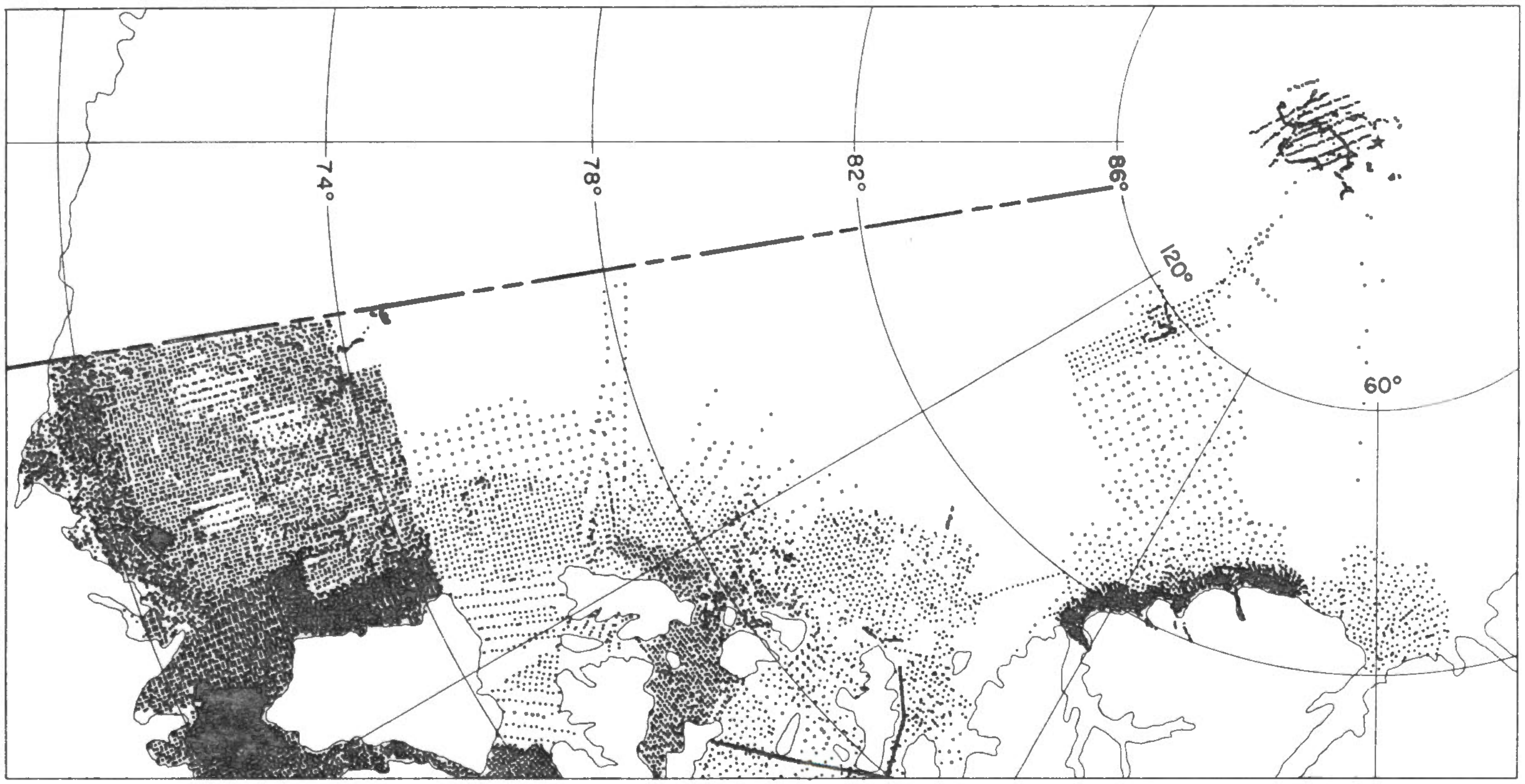

Fig. 2 Plot of Canadian bathymetric and gravity stations established on the Arctic Ocean and adjoining inter-island waters as of 1985.

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