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# THE CRUSTAL NATURE OF THE CHUKCHI CAP AND THE LORD HOWE RISE

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Determination of the nature and origin of large submarine elevations has become especially important in view of the emphasis placed on ocean ridges in Article 76 of the ICNT of the UNLOSC. It may be necessary to establish the origin of some of these features as an aid to negotiation.

Two case studies of such features are presented in this report. They are: (a) The Chukchi Cap in the southern Arctic Ocean Basin (Fig. 1); and (b) The Lord Howe Rise off the east coast of Australia (Fig. 2). Both areas have aroused interest of a commercial and political nature.

## (a) The Chukchi Cap

(1) Introduction An appraisal of the most recent literature has been made to assess the evidence for the crustal nature of the Chukchi Cap.

(2) Geography and Bathymetry The Chukchi Cap or Rise is an irregularly shaped tographic high covering approximately 5000 sq. km and lying between 170° and 160°W Long. and 76° and 79°N Lat. in the Arctic Ocean. Its upper surface is flat or sloping at angles of less than 1°, lies at 246 m depth at its shallowest point, and is indented at its margins by a number of major submarine valley features.

To the W and NW, the margin of the Cap is marked by a steep slope that deepens into a narrow and well defined trench of greater than 2000 m in depth (the Charlie Cap); further west lies the Chukchi Abyssal Plain. To the NE and E, the margin is also defined by a steeply dipping slope broken by the prominent subrectilinear Northwind Ridge, Seahigh or Escarpment. East of the Ridge lies the Canada Basin. To the S of the Cap water depths increase to 1000 m, before shoaling to approximately 500 m in outer parts of the Chukchi Shelf.

(3) Geophysical and Geological Data Geophysical data for the Cap and its environs are sparse and largely equivocal. No seismic refraction or reflection data are available except for a number of multichannel profiles which extend from the Canadian/American Shelf onto the eastern margin of the Chukchi Shelf (Grantz et al. 1975). These are discussed in detail below.

Magnetic data from the W and NW borders of the Cap reveal a well marked linear anomaly roughly co-incident with topographic break of slope (Hunkins et al. 1962). A crustal model interprets this feature as a buried basement ridge, with a scarp of approximately 8 km height facing towards the Cap, implying a minimum thickness of 11 km of sediment beneath the Cap.

Gravity profiles have been combined with the magnetic data to derive a composite section. The model is based on tentative assumptions of average crustal densities, adapted from equivalent studies. The resultant section indicates an 18 km thick crust beneath the Cap, a 32 km root beneath the marginal basement ridge, and approximately 21 km thickness beneath the abyssal plain. Despite several review papers there are no more recent geophysical data available.

The stratigraphy and sedimentary geology of the Chukchi sector of the Arctic Basin is almost entirely inferred from land-based studies in Alaska, Canada and the USSR, although literature documenting the latter is sparse. Seismic data from the N. Chukchi Basin (Grantz et al. 1975) indicate a northward deepening section, terminating in a 5-7 km thick, well defined section, interpreted as containing in excess of 2 km of Tertiary strata overlying assumed Cretaceous units. Carboniferous to Cretaceous units may underlie the NE Chukchi Shelf at depth. Data in areas closer to the Chukchi Cap and the Northwind Ridge areas are lacking.

(4) Plate tectonics Plate tectonic reconstructions for the Arctic Ocean are numerous and varied, since the lack of structural and geophysical control for the area provides much scope for unsubstantiated speculation. The majority of the refit models avoid the problem of defining the crustal studies of the Chukchi Cap by assuming a continental or quasi continental nature.

(5) Hydrocarbon prospects Between 5 and 7 km of clastic (Upper Mesozoic) rocks have been identified in the troughs bordering the Chukchi Cap. In addition, a number of structures resembling piercement diapirs have been observed on seismic records collected from the N. Chukchi Shelf. The parent horizon and composition of the features remain unknown, although magnetic and gravity data negate an igneous origin. Regional stratigraphy supports assumptions of a shale composition and a derivation from the Lower Cretaceous strata. The gross structure of the Chukchi Basin has been compared favourably with the already successfully tested Alaskan platform (Gramberg and Kulakov, 1975) and with further seismic and borehole control may reveal significant commercial prospects.

(6) Summary It is suggested that even the sparse data available indicate that an oceanic origin for the Chukchi Cap and its borderlands is not possible, and further that it is doubtful also for the Chukchi Basin and Shelf. Isolated gravity anomalies speculated by Grantz et al. (1979) to

be fossil spreading axes in the N. Chukchi Basin are inconsistent with seismic data and its stratigraphic interpretation (Grantz et al. 1975).

The most plausible model for the evolution of the area involves a crustal thinning of the Chukchi Basin and isostatic uplift of the Cap, probably tectonically controlled on its W, N and E sides. The Chukchi Shelf then appears as a natural prolongation of the Siberian platform, divorced from the Canada Basin to the east by a wide linear zone of unknown tectonic character. Included within this zone is the Northwind Ridge, about which even less definitive data is available.

(b) The Lord Howe Rise

(1) Introduction Many of the problems associated with the investigation of the crustal nature of the Chukchi Cap do not hinder comparable studies of the Lord Howe Rise. This second area of interest has been examined in detail and considerable geological and geophysical data are available. Much commercial interest has been shown in the Lord Howe Rise by the adjacent coastal states, in the light of the extensive hydrocarbon prospects found on the E. coast of Australia and west of New Zealand.

(2) Geography and Bathymetry The Lord Howe Rise is a well defined broad linear plateau orientated roughly N to S and extending for approximately 1700 km at its maximum length (Fig. 2). Water depth is approximately 1500 m on average, except for a number of local elevations, e.g. small volcanic island groups. It occupies a roughly central position in the Melanesian Sea, and along with the subparallel Norfolk Ridge and New Caledonia Basin, dominates the seafloor between the New Zealand and New Caledonia islands. It is separated from the eastern coast of Australia by the Tasman Sea Basin.

(3) Geological and Geophysical data Long seismic reflection profiles indicate a smooth rolling topography and structure with a relatively steep acoustic basement (Burns and Andrews, 1973). A single seismic refraction experiment (Schor, 1971; Fig. 3, this paper) traverses the study area from E to W and indicates a well stratified profile over the Rise. Velocities of 6.8 km/sec were recorded from the deepest levels of the profile, located at depths of between 16.5 and 29 km. The acoustic basement of folded sedimentary strata compares favourably to that of the adjacent Australian continental material. To the E, the profile is duplicated beneath the Norfolk Ridge suggesting a similar crustal identity. Between the two rises, the narrow New Caledonia Basin is floored by less than 8 km of crust closely resembling an attenuated equivalent of the Rise and Ridge profiles. A well

defined persistent unit sustaining velocities typical of those found in oceanic crustal layer 3 is observed on the profiles, but is not thought to be equivalent to subsided oceanic crust. The depths of up to 26 km and thicknesses of greater than 10 km for the layer are inconsistent with observations of oceanic crust elsewhere. In contrast, the crust beneath the Tasman Basin is unequivocally oceanic in nature.

Magnetic and gravity anomaly profiles across the Lord Howe Rise have helped to identify volcanic sites, principally on the western margins, although fissures can be identified throughout the plateau surface, and a well defined series of guyots extend beyond the N. Tasman Basin and the northern limits of the Rise. Volcanic activity is discussed in more detail below.

Patterns of linear magnetic anomalies found on the floor of the Tasman Basin confirm its crustal nature as oceanic. The anomalies have been correlated to those between 33 and 26 (76 Ma to 60 Ma). The axis of sea floor spreading subsequently shifted to beyond the Tasman Sea.

Deep sea drilling on Lord Howe Rise at sites 207 and 208, during Leg 21, yielded rhyolites and acid volcanics (Shipboard Party, DSDP), whose ages range between 93.7 My and 50 My. Upper volcanic horizons alternate with Maestrichtian (Late Cretaceous) shallow water oozes. All cored data indicate that volcanics and sediments were deposited in shallow water or subaerial conditions, and were broadly contemporaneous to the opening of the basin. Upper sections of the stratigraphic profiles are of Cainozoic age and are characterised by both local unconformities (thought to be caused by minor block faulting) and those of more regional extent (suggested to have originated through non-deposition or erosion by anomalous high current activity, Bentz 1973).

(4) Structure The Lord Howe Rise is defined to the E and W by sharp, in part fault controlled margins, and is cut by numerous tightly spaced subvertical faults. Movements on these faults may have contributed to the local unconformities and undulating topography noted above. The initiation of faulting is suggested to be co-eval with subsidence following the rifting and early spreading of the Tasman Basin. Profiles derived from seismic data, however, indicate individual faults affecting much of the Cainozoic cover.

(5) Conclusions Present data indicate that the Lord Howe Rise is composed of continental crust. Seismic refraction profiles suggest a probable continental structure, and at the time of the initiation of spreading in the Tasman

Sea the Lord Howe Rise was probably a shallow or even subaerial feature. The Lord Howe Rise is interpreted as a fragment of the E. Australia Shelf area. Seismic data suggest the possibility that the Norfolk Ridge may also be part of the continental shelf, separated from the Lord Howe Rise by a belt of thinned and subsided crust (the New Caledonia Basin).

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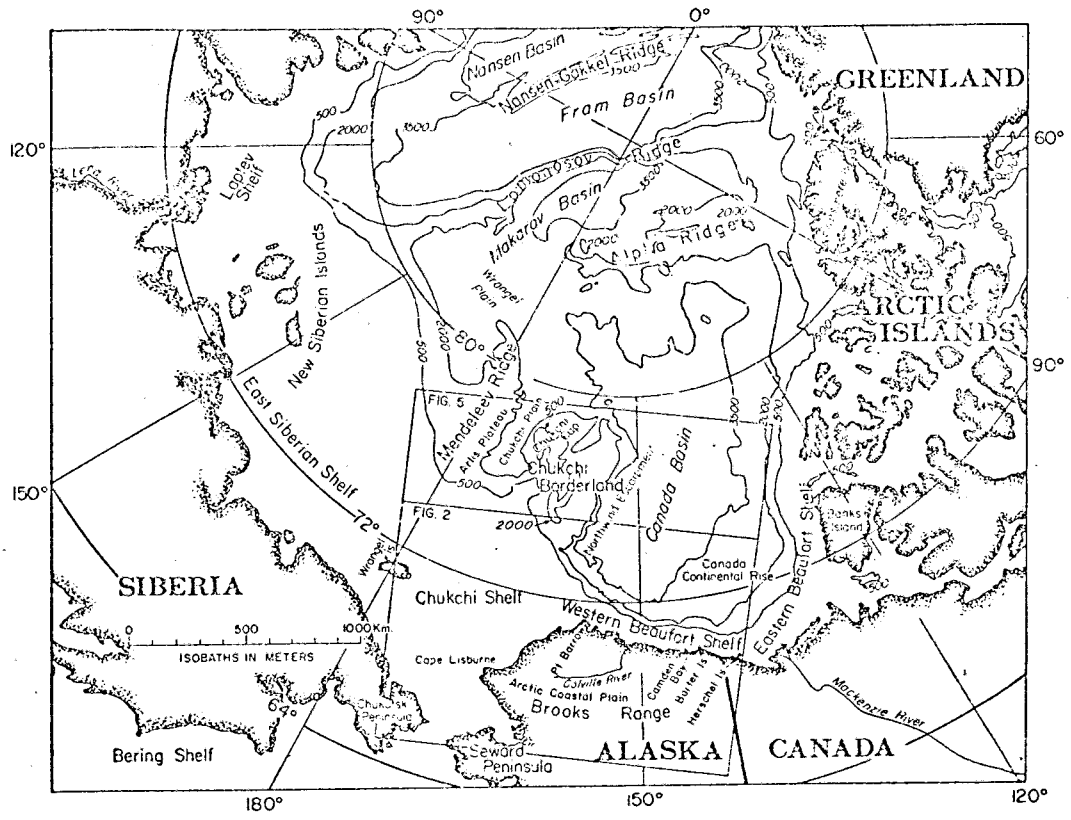


Fig. 1. Physiographic map of N. American and Siberian sectors of the Arctic, showing location of Chukchi Cap and Shelf (from Grantz et al. 1979).

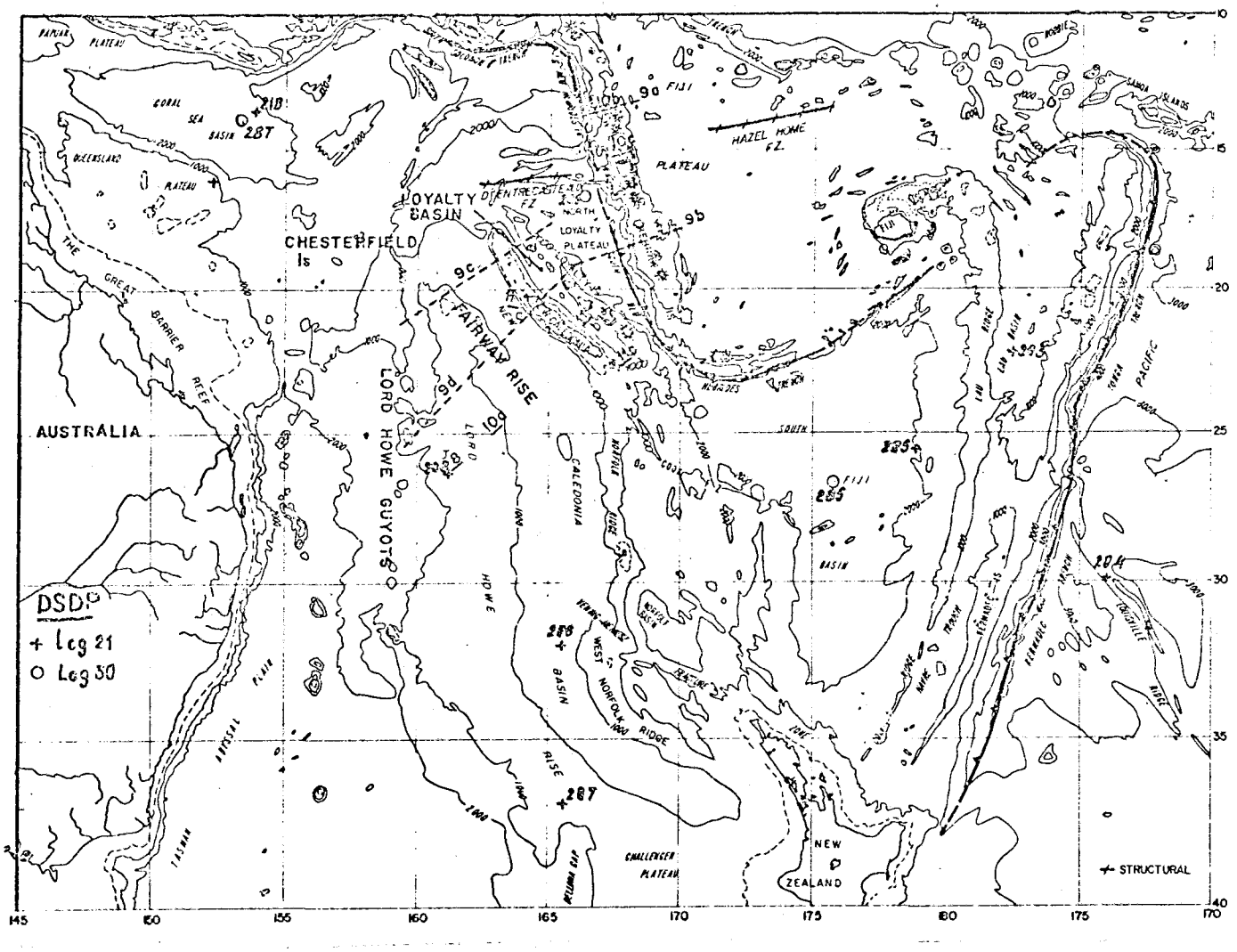


Fig. 2. Physiographic map of Melanesian Sea, showing location of Lord Howe Rise and related features (from Dubois et al. 1974).

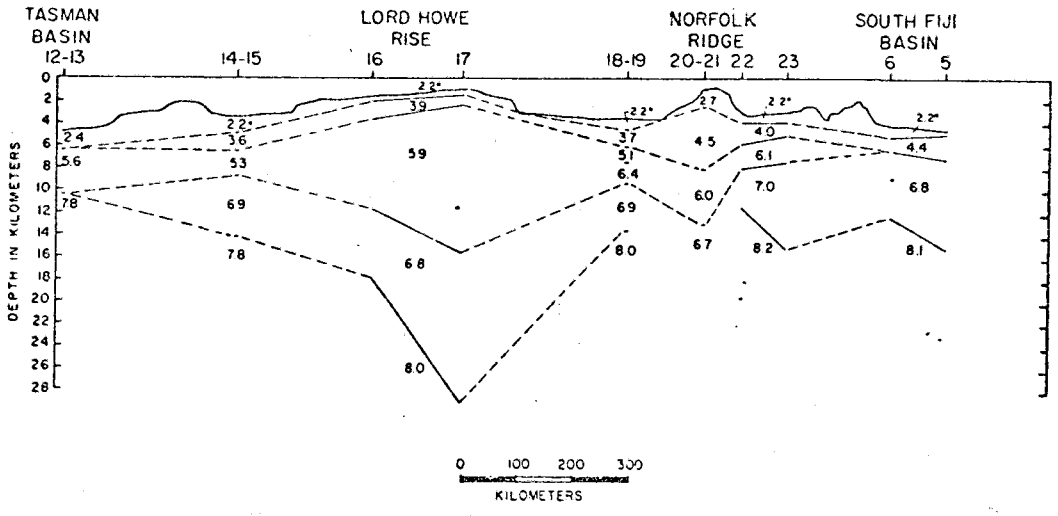


Fig. 3. W-E structural section across the Lord Howe Rise (from Schor et al. 1971).