REPORT

OF THE

WORKSHOP ON CARBONATE BANKS AND GUYOTS

August 6-8, 1985

sponsored by

U.S. Science Advisory Committee

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June 10, 1986

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SUMMARY

A Workshop to develop a scientific drilling program on carbonate banks and guyots, sponsored by the U.S. Science Advisory Committee, met on August 6-8, 1985, at the Scripps Institution of Oceanography.

The major thrust of our recommendations is that we seize on the special attributes of low-latitude carbonate platform buildups to address outstanding problems in paleoceanography, tectonics, sedimentology and geochemistry. Carbonate platforms are excellent monitors of relative changes in sea level, because their upward growth potential and their sensitive diagenetic response to exposure or invasion by the fresh meteoritic water. The types and frequency of turbidites derived from banks also may be used to date times of high and low stands of sea level, and propose to test hypotheses of high- and low-stand shedding from banks. The fossils in the strata provide an adequate time scale. The main contributors to upward growth cannot prosper a depth of more than a few tens of meters and some atolls do ultimately drown, to become guyots; some of our proposals are aimed directly at finding the causes for drowning. Besides the question of vertical motions (sea level and tectonic subsidence) we propose to use paleolatitude data from the volcanic foundations of guyots and from sediments in archipelagic aprons flanking them to study the horizontal motions of lithospheric plates. Reliable paleolatitude data from seamounts are prerequisites for testing the degree of fixity of hot spots and for determining true polar wander.

The proposals address such fundamental problems in diagenesis as dolomitization, cementation and the development of porosity and permeability, and should also contribute significantly to our knowledge of phosphorite genesis, and of the secular variations of $\delta^{13}C$, $\delta^{18}O$ and $^{87}Sr/^{86}Sr$.

To attack these problems, the Workshop participants recommend two legs of drilling on Western Pacific guyots, two legs on the west and east margins of the Florida-Bahamas platform, one leg on the Great Barrier Reef/Queensland Plateau, and a part of a leg in the Laccadive Basin, in the Indian Ocean.

The conferees concluded that existing drilling technology of JOIDES Resolution is adequate for the main objectives. Only if very shallow-water (lagoon) drilling is needed will another drill rig be required, and we do not herein request this drilling.

Site surveys for the two Florida/Bahama legs, for the Laccadive Basin sites and for the Great Barrier Reef/Queensland Plateau sites are in hand. The Central Pacific and Marshall Island sites are all covered by at least one single-channel seismic line and a few sites have more intensive coverage, but in both areas we recommend additional work, including swath mapping and digital single channel profiler data, to be done to specify exact site locations, and to get better estimates of sediment thicknesses.

CARBONATE BANKS AND GUYOTS WORKSHOP REPORT

INTRODUCTION

A workshop to develop a scientific drilling program on carbonate banks and guyots was held on August 6-8, 1985, at the Scripps Institution of Oceanography. The workshop originated in informal conversations among a number of people concerned with a wide spectrum of problems in the geology of shallow-water carbonate sediments, and who shared the conviction that many of these problems could be attacked most efficiently through a well-focused drilling program. During the summer of 1984, Wolf Schlager and Jerry Winterer submitted a proposal to the U.S. Science Advisory Committee for the necessary travel and administrative costs to convene a workshop; funding for the meeting was approved early in 1985. By use of thrift fares and by conferees doubling up in hotel rooms, the travel funds were stretched to allow a total of 38 scientists to attend the workshop. Their names and addresses are listed at the end of the report.

During the first day of the meeting, discussion leaders introduced the main topical themes of the workshop:

1. General overview. W. Schlager and E.L. Winterer
2. Vertical tectonics. R. Detrick.
3. Sedimentary facies. S. Schlanger
4. Biostratigraphy. W. Sliter.
5. Diagenesis. R. Matthews.
6. Plate motions. R. Gordon.
7. Basement rocks. R. Batiza.
8. Site survey design. J. Grow.

We also heard informative reports by John Grow and Bruce Wardlaw on the results of multichannel seismic reflection work and coring of a 650 m hole in the lagoon of Enewetak Atoll.

For the second day, we broke into Working Groups on:

a. Carbonate bank anatomy
b. Diagenesis
c. Tectonics
d. Technology

The Groups identified major topical problems and assessed the extent to which drilling could help in their solution. They singled out the most promising drilling targets and considered their site survey requirements. Besides the presentations of Workshop participants, the Working Groups had at hand all the written proposals submitted by people unable to come to La Jolla.

On the last day, the Working Groups reported their recommendations to the whole assembly, and after further discussion these recommendations were structured into a concrete drilling program organized into five coherent legs: three in the Western Pacific and two in the Atlantic/Gulf of Mexico. In addition, individual sites are recommended in the Indian Ocean, for inclusion in one of the legs being planned there by JOIDES panels.

One strong recommendation of the Workshop that does not fit into the present mode of JOIDES operations is that we drill holes on atolls, as well as on guyots and submerged banks. In several regions, most notably in the Marshall Islands, guyots are paired with atolls on the same pedestal; one survived, the other drowned. We believe that the drilling of atoll/guyot pairs is a powerful way to crack the very general problem of how and why platforms drown. The drilling strategies proposed in this report try to take full advantage of the few existing atoll drill holes, as parts of transects, but our formal drilling proposals do not include new atoll holes. Nonetheless, because of the scanty coring in most older atoll holes, we urge that JOIDES planners try to incorporate in their schedules and budgets very shallow-water drilling in crucial places.

The report follows the structure of the Workshop. The first part comprises the reports of the Working Groups and emphasizes topical problems in the geology of carbonate banks and guyots that can be fruitfully addressed by drilling. Then follow concrete drilling proposals.

BANK ANATOMY

Understanding the anatomy of carbonate platforms, that is, their facies patterns, the diagenetic overprints and the resulting seismic images, becomes almost by definition the centerpiece of a platform drilling program because it is both a goal in itself as well as a means to other objectives.

Carbonate platforms represent a large fraction of the Earth's carbonate deposits and provide reservoirs for about 50% of the world's reserves of oil and gas. This alone is reason enough to study platform anatomy and develop predictive models for exploration. In addition, we require a thorough understanding of platform anatomy if we are to use platforms as vertical and horizontal markers in the ocean and as recorders of ancient climate, sea level and ocean chemistry as proposed in the following sections.

Studies on land, to be sure, have contributed significantly to our knowledge in this field. Nonetheless, platforms in the modern oceans are still the best place to link process to product, and drilling, embedded in carefully planned pre- and post-cruise surveys, is still the best way to get to the bottom of it all.

Because of their peculiar organic origin, platforms are particularly sensitive to a number of environmental factors.

Light, temperature. Secreted mainly by benthic organisms as a by-product of photosynthesis, shallow-water carbonates are sensitive indicators of light and temperature. They are "fossil sunshine" and this quality makes them good proxy-indicators of water depth and latitude.

Exposure. Because carbonate production is most intensive in the surface layer of the ocean, platforms tend to maintain a flat top near sea level, thus recording even small drops in sea level as exposure horizons. Under favorable circumstances, platforms track also the low stands of the sea as a series of paleo-water tables, encoded in the geometry and isotope ratio of cements.

Rainfall, evaporation. The tendency of platforms to build to sea level often creates large tidal flats whose plant cover and evaporites provide a sensitive record of past climate (Ginsburg, 1975).

Carbonate production can be determined from sediment accumulation on, and sediment export by platforms. Aided by early cementation, the flat tops record in situ accumulation, whereas the flanks keep the books on what the factory exports. Progradation and retreat of the (mostly well-defined) margin reflect the balance between the rates of relative rise of sea level and carbonate production.

With the above characteristic of platforms in mind, one can immediately identify several important scientific problems that can be addressed by platform drilling.

Relative changes in sea level. Because of the light sensitivity of carbonate production, facies on the platform top change rapidly with water depth. This attribute, together with the ability to record sea level low stands in the form of exposure horizons, make carbonate platforms one of the most reliable dipsticks, i.e. monitors of relative sea level changes, in the geologic record. The possibility of determining not only the timing but also the amplitude of sea level falls from paleo-water tables is particularly attractive. Platforms are commonly sources for shallow-water debris in flanking basinal turbidites, and the petrology and ages of the resedimented material, e.g., contemporaneous platform aragonite ooze vs. reworked older bank debris, can be used to discriminate high-stand from low-stand events (Droxler and Schlager, in press; Schlanger and Premoli-Silva, in press). As always in the geologic record, any individual platform will record the combined effect of eustatic and tectonic sea level signals. To isolate the eustatic component, records from several regions will have to be stacked.

Horizontal displacement. Platforms can be used not only as dipsticks, but also as strip-chart recorders for horizontal motions in the ocean. They are less sensitive to horizontal than to vertical displacement, but this pattern nicely matches that of plate-tectonics where the magnitude of horizontal movements also exceeds that of vertical ones. Thus, platforms can perform a useful function as horizontal markers. A particularly drastic facies change occurs when platforms leave the low-latitude belt of coral reef growth (Grigg, 1982). Another example is the change from wet to dry tidal flats along the narrow equatorial dry belt. Finally, carbonate benthos is often dependent on shallow seas or island steppingstones for propagation, thus providing keys to paleo-geography (e.g. Premoli-Silva and Brusa, 1982).

Platform drowning. The light-dependence of carbonate production limits the growth environment of platforms to the euphotic zone, approximately the uppermost 75-100m of the water column. Submergence below this zone will kill the carbonate-secreting benthos, cause a dramatic change in sediment facies and transform the living platform into a guyot. Drowning may be related to pulses of tectonic subsidence or to changes in the environment. Particularly intriguing is a mass-extinction of platforms in the mid-Cretaceous that seems to coincide with wide-spread anoxia in the world ocean (Schlager, 1981; Arthur and Schlanger, 1979). The effect of tectonic acceleration of subsidence on platforms may be studied in areas such as the southeastern Bahamas or the Nicaragua Rise (both near Caribbean plate boundaries) or in the island arcs of the western Pacific.

Margin progradation and retreat. Darwin's model of atoll growth assumes vertical upbuilding in equilibrium with subsidence. While this situation does occur, it seems to be the exception rather than the rule. Margins and slopes of platforms have a tendency either to prograde or retreat. Particularly common are periods of progradation punctuated by episodes of rapid retreat and reorganization (e.g. Permian of West Texas, King, 1948; Bahamas, Schlager, Austin et al. 1985). At this point we do not know to what drumbeat platforms advance and retreat. Sea level is one likely control, variations in carbonate production are another; a third cause may be internal feedbacks in the depositional system that let it overshoot, slow down and rebound. One such built-in trend is the tendency of platform slopes to steepen and progradation to slow as the platform grows higher and more sediment is required to build up the flanks (Schlager and Ginsburg, 1981).

TECTONICS

The analysis of plate kinematics may well have started with Darwin's 1837 paper "On certain areas of elevation and subsidence in the Pacific and Indian Oceans, as deduced from the study of coral formations", which set forth the hypothesis that oceanic reefs rest on a subsiding foundation, and grow upward apace with the sinking. In 1842, writing in the vigorous style of the great naturalists of his era, he cut to the heart of the broader tectonic meaning of oceanic reefs:

> "Finally, when the two great types of structures, namely barrier reefs on one hand, and fringing reefs and atolls on the other, were laid down in colours on our map, a magnificent and harmonious picture of the movements, which the crust of the earth has within a late period undergone, is presented to us. We there see vast areas rising, and volcanic matter every now and then bursting forth through vents and fissures with which they are traversed. We see other wide spaces slowly sinking without any volcanic outbursts; and we may feel sure that this sinking must have been immense in amount as well as in area, thus to have buried over the broad face of the ocean every one of those mountains, above which atolls now stand like monuments, marking the place of their former existence."

Vertical motions.

Shallow-water carbonate systems develop not only on oceanic volcanoes, but in virtually every type of tectonic environment, and in all of these they furnish data on the rates, directions and amounts of both horizontal and vertical motions of their underlying substrates. It is nonetheless as recorders of vertical motions that they are most reliable. This is because they faithfully and persistently record sea level. Whenever the relative position of the sea changes at a carbonate bank, whether from a tectonic or a eustatic cause, the carbonate system responds and the response is written in the rocks for us to read. The recorder also comes with a clock: the rocks consist primarily of the skeletons of organisms that are the very basis for the biostratigraphic time scale.

The history of vertical motions that we wish to decipher from the succession of limestone layers can be very complicated, even in the simplest situations. In Table 1, the responses to the common mechanisms operating in the major tectonic environments are tabulated, in terms of timing, duration, direction, and rate. Only in the simplest of tectonic environments can we hope to estimate the rate of accumulation of carbonate by reference to a model rate of tectonic subsidence, and it is for this reason that the discrimination of eustatic from tectonic changes in local sea level is best done where tectonic complications are fewest, namely on oceanic islands and guyots and on passive margins. The myriad possible tectonic complications in the vertical trajectories of individual carbonate banks further dictate that discriminating eustatic from tectonic changes in sea level requires the stacking of many individual records from areas with different gross tectonic histories. It is not enough to have data only from the margins of the Atlantic or only from the western Pacific; each region may have its own special tectonic history. Only the global, eustatic sea level shifts will have occurred everywhere. The drilling program we recommend includes sites in the Atlantic and the Gulf of Mexico, the Caribbean, the Indian Ocean and the Pacific, and covers a stratigraphic range from Early Cretaceous to Recent. We believe it especially important to obtain data from the Mesozoic of the Pacific, since most of the inferences about eustatic sea level fluctuations during that time come from studies around the margins of the Atlantic, where broadly similar tectonic histories are indicated.

The timing and magnitude of eustatic sea level changes are variable probably over one or two orders of magnitude, and vertical tectonic movements are likewise variable. As described below in the section on the diagenesis of carbonate bodies, the record of an emergence may affect a considerable thickness of rock, and the effects of successive emergences may become superimposed, where subsidence rates are slow relative to the intervals of time between sea level fluctuations. To separate rapid fluctuations from one another, as for example in the Pleistocene, may require study of very rapidly subsiding carbonate banks: a fast "tape" speed is needed to record high-frequency events. Such banks probably exist in the island-arc complexes of the tropical regions, but we have not been able to single out one that has been studied sufficiently to qualify it for drilling.

Horizontal Motions

Darwin correctly inferred that coral atolls were the consequence of vertical subsidence, but he had no clue that the floors of the oceans had moved immense distances horizontally: continental drift and plate tectonics were yet unimagined. The horizontal movements of lithospheric plates do of course carry along the shallow-water carbonate banks, and these movements may have profound effects of the banks. The banks record these effects and hence may be used to estimate the rates and directions of plate motions, but only imperfectly. On the other hand, in some regions and for some periods of time, for example in the Pacific during the past 40Ma, the rate and direction of plate motion is described very well by the linear volcanic chains that are traces of hot spots. For these regions, the effects of changes in position, e.g., latitude, on the development of a carbonate bank can be assessed. Two special latitudes are known: the Darwin Point, where the achievable upward growth rate of a reef is just balanced by the rate of subsidence or sea-level rise (Grigg, 1982), and the equatorial dry belt, where lagoons may become evaporitic. Further details on these effects are given in the section on Anatomy, but it should be pointed out here only that the Darwin Point is controlled not only by the direct effects of latitude (insolation, temperature, etc.) but also by the tectonically- or eustatically-controlled rate of sea-level rise.

Direct evidence on the changes in position of a carbonate bank come from paleolatitudes derived from paleomagnetic data, both from sediments and from the underlying basement rocks. Carbonate bank sediments are mainly very weakly magnetized, and little useful data can be extracted from these strata; on the other hand, deeper-water sediments adjacent to the bank commonly can be used to estimate paleolatitude. Since there are many other cogent reasons to pair bank and flank holes, we expect to obtain much new data on horizontal plate motions as an added benefit.

The most reliable data on paleolatitude come from paleomagnetic measurements on basement rocks, especially the volcanic basement rocks beneath oceanic carbonate banks. These rocks are generally strongly magnetized, and if a sufficient number of flow units are sampled, say 30-50, the effects of secular variation can be averaged out and a reliable paleolatitude estimated. In some places there are likely to have been at least two discrete times of volcanic eruption, as in the Marshall Islands area, where some edifices may record both mid-Cretaceous and Eocene volcanism. The change in latitude is thus available, barring resetting of the older magnetism by the younger event.

A major question in plate tectonics that remains to be firmly settled is the fixity of hot spots (e.g., Morgan, 1981; Chase, 1985). The type example of a chain generated by a hot spot is the Hawaiian-Emperor chain, where both the faunal (bryozoan-algal community indicating a more temperate facies than modern reef communities at the latitide of Kilauea; McKenzie et al, 1980) and the magnetic (paleoaltitude of 27^{o}, +/- 4.8, for Suiko seamount, compared to 19.5^{o} for Kilauea; Kono, 1980) data suggest a southward migration of the hot spot of several degrees over the past 60my (Gordon and Cape, 1981). It is therefore desirable, where possible, to include in the program for drilling on bank-capped seamounts, volcanoes whose age and position permit further tests of the fixity question.

DIAGENESIS

The carbonate diagenesis community requires access to sequences in tectonically "simple" subsidence situations and of sufficient age to allow very slow diagenetic processes to have proceeded significantly. Guyots and atolls are especially attractive for these purposes. In order to distinguish between original carbonate components and their diagenetic products, diagenetic processes in shallow-water carbonates and rates of these processes in various tectonic regimes need to be established. Given satisfactory results concerning diagenetic processes, products and rates, we should be in a position to address outstanding problems in eustatic and subsidence histories, chemical paleoceanography, paleoclimatology, and paleohydrology.

Specific objectives of the diagenetic community are sketched in the following paragraphs:

Dolomite Formation

The long-standing problem of the origin of dolomite continues to fascinate and perplex sedimentary geologists and geochemists. A key aspect of this problem is the scarcity of modern environments where dolomite can be demonstrated to be forming *in situ*. Small quantities of young dolomite are presently forming in such varied settings as alkaline lakes, sabkhas, and tidal flats, and hydrothermal systems. Deep sea drilling has previously recovered small amounts of young dolomite from organic-rich continental margin sediments (e.g. DSDP Sites 102, 147, 467, 479, 532, 533) and from the margins of carbonate banks (e.g. ODP Leg 101). These relatively minor occurrences of young dolomite do not provide adequate analogs for the extensive platform dolomites such as the Cambro-Ordovician rocks of North America. One of the major objectives of this drilling proposal is to study the processes and products of the extensive dolomite formation on carbonate atolls and platforms.

Young dolomites have been recovered from outcrops and the subsurface of a number of atolls, islands, and carbonate platforms, for example, Yucatan, the Bahamas, Eniwetak, Kita-Iaito-Jima, Niue and Jarvis. Their origin is controversial; it has variously been proposed that these dolomites form as a result of freshwater/seawater mixing , hypersaline brine reflux and contact with normal seawater. In order to choose between these or other hypotheses it is imperative to: (1) recover carbonate sediments and porewaters demonstrably involved in present-day dolomitization, and (2) map in three dimensions, either by geophysical survey or by drilling (Schlanger, et al., 1963; Purser and Aissaoui; 1985), the extent of dolomitization, and characterize mineralogically, petrologically and chemically the various young dolomite types, e.g., those formed in the mixing water zone, and older basal hydrothermal dolomites. The burial diagenesis of these various dolomites needs to be followed; it is important to determine to what extent dolomites preserve the original fingerprints of the environment of formation.

<u>Rates of diagenesis in various environments</u>

In numerous ancient examples, it is clear that differences in rate of recrystallization from metastable aragonite and high-Mg calcite to stable low-Mg calcite and dolomite dramatically effect porosity and permeability. These relationships are extremely important in petroleum exploration and in water resources management. Preliminary data makes it clear that these processes require much longer time than is easily accessible without a significant drilling program.

Regarding the vadose diagenetic environment, we especially need access to the paleo-vadose region which accompanies each low stand of sea level. Regarding the phreatic environment, we need to see numerous paleophreatic lenses and the effects of multiple phreatic lenses. Regarding seawater/burial diagenesis, we need to look as deep and as old as there are rocks which can be reliably inferred to have escaped early recrystallization related to exposure to meteoric water.

<u>Cementation history</u>

Interaction of high-frequency glacioeustatic sea level fluctuations with a subsiding shallow-water carbonate edifice should afford an excellent chance to accumulate numerous layers of carbonate cement ranging from marine to vadose, to phreatic to mixed water to burial. These are rock types we commonly observe in the ancient carbonate build-ups. To tie similar observations to specific stands of the sea predicted by the deep sea $\delta^{18}O$ glacioeustatic record is an exciting prospect. We should learn more about diagenetic process and geometry as well as more about sea level history itself. These and above diagenetic studies are important for estimatory relationships between original carbonate mineralogy and sea level fluctuations.

Studies of atoll-guyot pairs are extremely important for some of the diagenetic objectives; these studies could alleviate biostratigraphic problems in some shallow water carbonate sections. Detailed biostratigraphy is essential for many diagenetic studies.

Porosity and permeability

Carbonate rocks are the most productive ground-water aquifer systems in the world and are also the source of about 50% of the world's petroleum production. All this despite the fact that 85% of all carbonate rocks begin in the marine environment as clay-sized (mud) particles. When these muds first become cemented into micrites, they generally have great porosity but very low permeability, which means that they are initially very poor aquifers. However, many of the early diagenetic processes and reactions that occur when micrites first interact with low-salinity groundwater have profound effects on porosity and permeability values and distribution. For example, most modern marine carbonate muds are composed of aragonite and calcite; the former generally is high in Sr and the latter may be high in Mg. During the groundwater-induced process of solution, precipitation of cement and recrystallization, aragonite dissolves, releasing Sr and calcite cements form; the initially high-Mg calcites recrystallize to low-Mg calcites. Commonly, because aragonite is more soluble than calcite, aragonite grains and even entire aragonitic skeletal remains of organisms are preferentially dissolved leaving hollow molds of the material as pores. Dolomitization may also occur early in the history of a micrite, which may either increase or decrease porosity and permeability; generally these parameters are greatly enhanced. Thus, through these processes, early freshwater diagenesis leads to the redistribution of pore space with greatly increased pore sizes and permeability. Typicallly, when fresh meteoric groundwater mixes with intruded ocean water, the resulting mixture becomes undersaturated with calcite over a wide range of mixing percentages. The end result of this undersaturation can lead to massive dissolution and the development of a megaporosity in carbonate rocks; the resulting rock can resemble Swiss cheese.

Phosphorite genesis

Recent studies in the Central and South Pacific Ocean have indicated that phosphatic rocks are common occurrences on seamounts and guyots. These rocks are quite different from the sedimentary phosphorites of continental margins. These rocks are mostly replacements of limestones, but they also occur together with volcanoclastic materials. While some occurrences may result from the submergence of a guano-derived insular phosphate deposit, such as seen in many islands in the central Pacific, most appear to be of marine origin. Since our knowledge of these occurrences is limited to samples recovered by dredging, we do not have any knowledge concerning their vertical extent (Cullen and Burnett, 1985; Burnett et al., 1985 and references therein).

It would be very profitable to study the distribution of phosphate in cores recovered on Central Pacific guyots. It would be especially valuable to drill on one of the guyot-atoll pairs so that comparisons can potentially be made between insular and marine phosphatic horizons. The Sylvania-Bikini system may be an excellent candidate for this purpose.

Should samples recovered from such a drilling program confirm that the phosphorite is marine in origin then questions concerning the origin of the phosphorus and possible relations to large-scale changing oceanographic conditions can be addressed. For example, do the phosphatic horizons represent a hardground-type of formation occurring at hiatal surfaces? Is the production of these "open-ocean" phosphorites episodic and can it be tied to known paleoceanographic parameters (oxygen-minimum zone, productivity, etc.).

How phosphoritic formation relates to other forms of diagenesis within carbonate rocks is another important aspect of this work. Phosphorite-dolomite associations are well known in continental margin regions of high productivity on islands of the Central and South Pacific Ocean (Schlanger, 1965) and have recently been found in close association on guyots of the North Fiji Plateau (Cullen and Burnett, 1985). Conceivably, a consideration of the processes involved in the formation of the phosphatic phase may place constraints on the conditions under which the associated dolomite formed, or vice versa.

Chemical paleoceanography: Secular variation of $\delta^{13}C$, $\delta^{18}O$, and $^{87}Sr/^{86}Sr$ in shallow water carbonates and associated phosphates

Numerous studies have recently demonstrated significant temporal variation in the $^{87/86}Sr$, $\sigma^{18}O$ and $\delta^{13}C$ composition of marine minerals throughout the Phanerozoic. Such shifts may represent the effects of changing surface water temperatures, oceanic circulatory patterns and basin to basin fractionation (in response to global circulatic and tectonic events) and/or changing composition of marine waters (in response to chemical cycling between lithospheric and hydrospheric reservoirs). High resolution records are available for $^{87}/^{86}Sr$ only and to some extent for $\delta^{13}C$ from pelagic micrites and pelagic skeletal components. Because of possible complications induced by diagenesis, a $CaCO_3$ record of $\delta^{13}O$ variations has been avoided except for geologically-young, non-diagenetically altered sediments.

Two major problems arise in evaluating the chemical variation of paleo-oceans. (1) Evaluation of pelagic carbonates is limited to Cretaceous or younger sediments. A carbonate record, preserved as shallow-water platform sequences is, however, available ranging in age well back into the Precambrian. (2) Variations for $\delta^{13}C$, $\delta^{18}O_{PO4}$, $\delta^{18}O_{CACO3}$, and 87/86 Sr and minor element concentrations (e.g. Sr, Mg, Mn) have not been documented in a single set of samples. Co-variation of these chemical tracers, and their relative rates of change, must be documented if the causes of chemical variation of seawater are to be determined. We need to re-evaluate the roles of both shallow-water deposition and calcite-rich pelagic deposition for discrete time intervals in order to model both the carbonate budget and the linked strontium budget in the ocean (Graham et al., 1982; Turekian, 1964; Schlanger, 1986; Brass, 1986).

Strategy

Diagenetic objectives can largely be accomplished in piggy-back fashion on other projects. Diagenetic studies will also aid in solving tectonic or oceanographic objectives. A case in point is the use of paleo-water tables (phraetic-vadose boundaries) to determine the amplitude of sea-level fluctuations (see section on Bank Anatomy). We propose to examine carbonates and phosphates in shallow water platform margins, atoll and guyot sequences of Mesozoic to Tertiary age. Paired $^{87/86}Sr$, $\delta^{13}C$, $\delta^{18}O$ and major and minor chemical compositions will be determined for co-occurring carbonate and phosphate components in both shallow water and coeval pelagic sequences. Where both inorganic (diagenetic) and organic (fish bone, teeth) phosphates are present, they will be separately analyzed to extract the most useful information possible. This strategy will allow evaluation of the fidelity of shallow water platform margin components in recording open marine chemical variation. Moreover, comparison of records obtained from co-occurring carbonate and phosphatic minerals will provide a direct test of the chemical stability of these phases during diagenesis.

Specific drill site requirements are basically similar for most holes: holes should be arranged as transects, to relate hydrology to physiography and stratigraphy. To enable downhole measurements and experiments, both short- and long-range, the holes should be reentry holes, and left open for reoccupation. Whereas in most deep-sea carbonate environments, only diffusion processes need to be considered, in shallow-water carbonates the plumbing systems are mostly much more complex and much less known. The downhole experiments will concentrate on comparative studies of environments controlled primarily by fresh water, by mixed waters and by seawater.

Wherever possible or necessary, available drilling on land will guide the choice of adjacent sub-sea drill sites.

<u>Site Requirements</u>
A) near continuous Mesozoic-Tertiary sequences with good biostratigraphic control;
B) paired Shallow-water and Pelagic sequences where lithostratigraphic and biostratigraphic correlation is possible;
C) time-equivalent passive-margin shallow-water carbonate sequences to evaluate chemical variations on a global scale.

TECHNICAL CONSIDERATIONS

The Working Group charged with examining the engineering and technical problems raised by the drilling proposals put forward at the conference recommended that:

1. ODP continue its efforts to combine the state-of-the-art mining technology with existing ODP Coring Systems to improve core recovery.

   The new generation APC and XCB being used by ODP have resulted in considerable improvement in core recovery and core quality. The experimental wire line NavaDrill shows considerable promise in improving core recovery in hard and fractured formations.

   The use of Polymer muds show considerable benefit in improving hole cleaning and satability on both the EDP and ODP.

   The Enewetak Drilling Project (EDP) used Mining Type core bits and technology, and had average core recovery of over 80%.

2. ODP should investigate the use of a hammer/percussion coring system

to improve recovery in uncemented and fractured formations. A hammer/percussion-type drill was used successfully in uncemented and fractured formations found in the atoll drilling.

3. While reverse circulation drilling may be useful in reducing hole cleaning and stability problems, it does not appear to be adaptable to wire line coring systems and should not be considered further.

4. ODP should consider use of shorted core intervals in critical sections of holes. This appears to improve recovery by reducing the chance of material jamming in the core barrel. EDP cores were taken in 0.5-1.5m lengths.

5. JOIDES should consider the use of a small jack-up or anchored drill ship as a platform for lagoon drilling.

A second option would be to use a small anchored drill ship similar to the one used for the Enewetak Drilling Project (EDP) with a 5000 ft. drilling capacity.

Cost of the EDP rig was approximately $18000/day. Cost of a small drill ship or jack-up rig with 5000 ft. drilling capability would be approximately $20000/day plus mobilization cost.

The JOIDES Resolution should not be considered for drilling in atoll lagoons or in water depths less than 500 ft. In water depths of 1500 ft. or less, drilling should not be undertaken in periods when severe weather conditions are to be expected.

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OVERVIEW OF DRILLING PROPOSALS

From the many drilling proposals considered by the Workshop, the participants narrowed the recommended list to six groups. Five of these are organized into five coherent drilling legs, three in the Western Pacific and two in the Atlantic, on either side of Florida. A sixth proposal, for the Indian Ocean, would use only part of a drilling leg. No scientific priority is implied in the ordering of the proposals.

The areas of the proposed sites are shown on Figure 1.

The proposals are:

1. Geological evolution of the northern Marshall Islands, proposed by S.O. Schlanger.

This proposal asks for coring of six sites in the Marshall Islands: three at Sylvania Guyot and three at Enewetak. At each guyot, two sites penetrate drowned Eocene carbonate banks into volcanic basement and one site penetrates the archipelagic apron.

Sylvania Guyot is a close neighbor to Bikini Atoll, and Enewetak is paired with a neighboring unnamed guyot. Both Bikini and Enewetak Atolls have been drilled, and the proposed ODP sites take full advantage of these holes by using them as end points in transects.

The objectives are:

1. to date the volcanic edifices below the Eocene(?) failed atolls (now guyots); relate dates to linear island chain models.
2. to document the stratigraphy and determine the ages of the failed atolls that characterize the Marshall Islands region, and to study the onset and failure of atoll growth.
3. to determine the subsidence history of the Northern Marshall Islands.
4. to document the diagenetic and dolomitization history of failed atolls.
5. to correlate the stratigraphy of "failed" with "successful" atolls.

2. Cretaceous guyots in the Central Pacific, proposed by E.L. Winterer, J. Natland and W. Sager.

We here present a proposal to drill the summits of five guyots in the Mid-Pacific Mountains, Wake Seamounts, and Geisha Seamounts in the central and western tropical Pacific. The drilling will address fundamental problems in the history of Cretaceous reefs on the guyots (particularly the cause[s] and timing of their extinction), the age progressions of underlying volcanic chains, the petrological character of the volcanoes and the compositions of mantle sources of the lavas, and the subsidence history of the edifices. The drilling will also provide paleomagnetic information critical to evaluation of plate motions during the Mesozoic, and the fixity of "hot spots" active then.

3. West Florida Escarpment Drilling, proposed by C. Paull, M. Kastner and A.C. Neumann.

A Florida Escarpment drilling program will elucidate the geological and geochemical processes which form and modify carbonate continental margin edges. The drilling of a three-site east-west transect across the edge western Florida Continental margin at 26°02'N is proposed. The proposed sites are FE-1 to 300 m about 100 meters away from the escarpment base, FE-2 1.5 km west of the escarpment base on the abyssal floor, and a deep reentry hole at the top of the escarpment (FE-3 to >1200 m). The objectives of the transect are to determine: 1. patterns of fluid circulation through the platform and rates of lateral exchange with seawater; 2. the diagenetic history of the platform edge as it relates to the pattern of fluid circulation; 3. the geologic record and effects of seafloor brine seepages from the platform, such as sulfide mineralization, the deposition of chemosynthetically-produced organic carbon-rich layers, and the erosion of the escarpments; 4. the stratigraphic development and facies succession across a ramping leeward carbonate margin.

4. Bahamas: Carbonate fans, escarpment erosion and the roots of carbonate banks, proposed by W. Schlager, R.E. Sheridan, J. Ladd, C. Ravenne, A.C. Neumann and J. Austin.

Based on extensive seismic survey and results of Leg 101, we propose a Bahama drilling leg to address the following questions:
1. Carbonate submarine fans at the foot of the Bahama escarpment--fan anatomy, interplay of turbidity currents and contour currents, sediment shedding of carbonate banks in relation to sea level.
2. Bench at the foot of the Blake-Bahama Escarpment--genesis and rate of retreat of eroded bank margins, search for brine seeps.
3. Exuma Sound--prograding clinoforms interpreted from seismics as buried bank margins that do not follow the present orientation of banks and basins.
4. Northwest Providence Channel--sediment shedding measured close to source; expanded record for Neogene paleoceanography; buried Cretaceous megabank.

5. Great Barrier Reef, Queensland Trough, Queensland Plateau, proposed by P.J. Davies, P. Symonds and D. Feary.

The Workshop participants did not discuss the entire contents of this integrated proposal. Dr. Davies, who was present at the Workshop, presented only the material relating directly to the major Workshop themes. The section of this proposal of most relevance to the Carbonate Workshop is a transect of five sites (10, 11A, 11B, 12, 16) across the seaward slope of the Great Barrier Reef (GBR) and onto the western margin of the Queensland Plateau (QP). The objectives are to document and compare the evolution of a mixed carbonate/siliciclastic (GBR) and a contiguous pure carbonate (QP) margin, in terms of the processes of sea-level changes, subsidence, horizontal plate motion, regional tectonics, climate and oceanographic changes. Workshop themes. We include the <u>entire</u> proposal by Davies et al. in order to place the Workshop-endorsed sites in their regional context. Some of the other proposed sites are not only worthy from a regional scientific view, but also bear on the main concerns of the Workshop; nonetheless, from our perspective we must assign them a lesser priority than the transect sites.

6. Periplatform ooze in the Indian Ocean, proposed by A.W. Droxler, P.A. Baker and D.F. Williams.

This proposal requests the coring of three HPC sites, covering a waterdepth range between 400 m and maximum 2000 m in the Laccadive basin off the Maldives Archipelago. The main objective of this coring project is to recover continuous Neogene sequences of periplatform ooze devoid of turbidite layers, and deposited as drape on highs and isolated slope terraces. These sequences should have recorded climatic-induced depth variation of the carbonate saturation level in intermediate water masses, by the preservation or dissolution of shallow carbonate banks derived aragonite and magnesian calcite. Numerous other studies will be applied to this suite of cores, i.e., variable input through time of carbonate bank derived material, variable import through time of non-carbonate (terrigenous) material, interstitial water chemistry and its implications for early diagenesis.

We are proposing to core three HPC holes (maximum penetration 200-250 m), the shallowest one between 400 and 600 m, the intermediate one between 700 and 800 m, and the deepest one between 1600 and 1800 m.

GEOLOGICAL EVOLUTION OF THE NORTHERN MARSHALL ISLANDS: A DRILLING PROGRAM ON CARBONATE BANKS WITH RELATED PALEOCEANOGRAPHIC, LITHOSPHERIC, AND TECTONIC OBJECTIVES

Proponent:

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Abstract

This proposal asks for coring of six sites in the Marshall Islands: three at Sylvania Guyot and three at Enewetak. At each guyot, two sites penetrate drowned Eocene carbonate banks into volcanic basement and one site penetrates the archipelagic apron.

Sylvania Guyot is a close neighbor to Bikini Atoll, and Enewetak is paired with a neighboring unnamed guyot. Both Bikini and Enewetak Atolls have been drilled and the proposed ODP sites take full advantage of these holes by using them as end points in transects.

The objectives are:

1. to date the volcanic edifices below the Eocene(?) failed atolls (now guyots); relate dates to linear island chain models.
2. to document the stratigraphy and determine the ages of the failed atolls that characterize the Marshall Islands region, and to study the onset and failure of atoll growth.
3. to determine the subsidence history of the Northern Marshall Islands.
4. to document the diagenetic and dolomitization history of failed atolls.
5. to correlate the stratigraphy of "failed" with "successful" atolls.

Introduction

Atolls and presently submerged failed atolls in the Marshall Islands consist of carbonate ca of shallow-water origin atop submerged and subsided volcanic edifices that erupted on the surface of the Pacific Plate. Because of the communities that built the carbonate caps flourish only at or near sea level, these caps contain a paleoceanographic record from the present day back through Eocene and, perhaps, Cretaceous time. Diagenetic alteration of the original skeletal carbonate in these caps record periods of emergence and the development of fresh-water Ghyben-Herzberg lenses which record sea level changes. The plankton-rich archipelagic aprons around atolls contain turbidites rich in shallow-water reef debris that were deposited during low sea level stands. Many of the volcanic edifices in the region grew to and above sea level; the depths to these extinct volcanoes indicate the extent of subsidence in the region. Further, the magnetic inclinations in the flows that make up the edifice record the paleoaltitude of formation of the edifice and so track the motion of the Pacific Plate.

Bikini and Enewetak atolls have been drilled; this proposal outlines a drilling campaign on their neighboring failed atolls, and their surrounding archipelagic aprons and underlying volcanic edifices which are prime targets for drilling, aimed at paleoceangraphic, lithospheric and tectonic problems. Sylvania Guyot, and similar apparent failed atolls around Enewetak Atoll are proposed as drilling sites.

Geological Background

Drilling on Bikini and Enewetak Atolls and (Figures 1,2) showed that these structures are built of Early Eocene edifices capped by Middle

Eocene to Recent reef complexes that have been subjected to several periods of subaerial emergence and consequent diagenesis and dolomitization (Figure 3). The depth to the Eocene volcanic basement at Enewetak of 1400m indicates subsidence of the region of approximately 1500m since Early Eocene time (Emery, Tracey and Ladd, 1954; Schlanger, 1963). This observation took on significance in the light of subsequent mapping of the magnetic lineations in the region which showed that the Pacific Plate in the northern Marshalls is of Jurassic age; the M22 to M28 anomalies cross the northern Marshalls (Figure 4). Crough (1978) noted that the region has subsided as if it was on approximately 25my old crust, and proposed that the area had been uplifted due to thermal rejuvenation associated with the passage of the Marshall Islands over a hot spot. Drilling at Site 462 in the Nauru Basin revealed that extensive Cretaceous volcanism, involving two major pulses--Aptian and Late Cretaceous--have taken place in the region (Larson and Schlanger, 1981). Cretaceous reef fossils and Aptian plant debris in turbidites in the Nauru Basin indicate that forested islands fringed by reefs existed in the region in Cretaceous time. Surveys of von Valtier Seamount (Figure 1) showed it to be of at least Coniacian-Santonian age. Thus the region has undergone Middle and Late Cretaceous as well as Eocene volcanic activity with the building of major seamount and island provinces--a history difficult to reconcile with the Morgan (1972) hot spot model for the evolution of the Marshall Islands.

Recent studies in the region have shown that a number of atolls (Figure 5) have as close neighbors drowned or failed atolls of Eocene age. Harrie Guyot, just south of Mili Atoll (Figures 1,5) is a counterpart of Sylvania Guyot which is attached to Bikini Atoll, and the terrace around Enewetak is also probably capped by failed reefs of Eocene age. Thus the intriguing problem of the origin of paired living and dead atolls has arisen in recent years. The internal geometry of the atoll reef complexes as deduced from the earlier deep drilling and later intensive shallow and intermediate depth drilling in connection with studies of bomb crater geometry has shown that these carbonate caps are complex and highly responsive not only to sea level changes but to latitudinal position related to plate motion. Further, detailed paleontological analysis has shown that pelagic faunas can be found in appropriate reef and associated facies, and that stratigraphic zonations can be developed which correlate local and regional shallow-water reef fossils with global planktonic faunas and floras.

Scientific Objectives

The failed atolls of Sylvania Guyot, Harrie Guyot and those around Enewetak Atoll and their surrounding archipelagic aprons and underlying volcanic edifices are sites that contain recoverable information relevant to a wide range of long-standing objectives in the western central Pacific.
1) Chronology and extent of volcanic episode; 2) Relationship of these episodes to both vertical and horizontal plate motions and local subsidence patterns; 3) Anatomy of reef and associated carbonate complexes; 4) Diagenetic processes and products in pure carbonate sequences; 5) Cenozoic and Late Cretaceous sea level history; 6) Correlation of Cenozoic shallow-water paleontological zonations with global planktonic

zonations.

Proposed Drilling Strategy and Program

The objectives listed above can be attacked by a drilling program at (a) sites on Sylvania Guyot, and guyots adjoining Enewetak Atoll, and (b) at sites on adjacent archipelagic aprons (Figures 6,9). The program utilizes the existing drill holes E1 and F1 on Enewetak Atoll and 2B on Bikini Atoll (Figures 2,6) as the base of transects that would be completed by the drilling of the failed atolls and the archipelagic aprons.

Sites and Objectives (see attached summary forms)

SYL-1 and 2. These holes will penetrate the Eocene failed atoll atop Sylvania Guyot to study the anatomy and diagenetic history of the cap and sample the basalt foundation for dating and magnetic paleoaltitude. As shown on Figures 7 and 8, high quality seismic profiles show a pelagic cap over the reef complex. The section is equivalent to the presumed deeper Eocene section under Bikini not reached by drilling to date.

SYL-3. This hole will penetrate the archipelagic apron and sample and date turbidite sequences which record low sea level stands. Drilling into volcanic basement will reveal early stages of edifice construction.

These three sites will enable us to decipher the complete history of the carbonate platform and its volcanic base.

ENE-1,2. These holes will penetrate the presumed Eocene failed carbonate banks to study their history. Penetration into the volcanic basement will allow dating and paleoaltitude determinations of thew volcanic edifice.

ENE-3. This hole has objectives similar to Site SYL-3.

HAR-1 and 2. These holes (Figures 9,10) will penetrate the drowned Eocene reef on Harrie Guyot and penetrate the volcanic edifice. Dating of the volcanic edifice is important because at the present time there is not a single dated volcanic edifice along the hotspot track proposed by Morgan.

HAR-3. This hole will penetrate the archipelagic apron on the west side of Harrie Guyot. Objectives are the same as those for SYL-3 and ENE-3.

Drilling Priorities

First Priority: SYL-1,2,3. Because of site survey data available and existing drill holes at Bikini Atoll.

Second Priority: ENE-1,2,3. Because the Enewetak drill holes reached Eocene basalt edifice. These holes are important in completion of transect.

Third Priority: HAR-1,2,3. Because of site survey data available and need to date a volcanic edifice along a presumed hotspot track.

Existing Surveys

As shown on Figures 7,8,9,10 and 11, both Sylvania Guyot and Harrie Guyot have been extensively surveyed (USGS and HIG data). Bathymetry, seismic profiles, gravity, and magnetic maps are in hand and numerous dredge hauls have been obtained. A SEARMARC survey of Harrie has been made (HIG) as shown on Figure 11.

Additional Survey Requirements

Surveys of ENE-1,2,3 will be needed including seismic, gravity, magnetic and SEAMARC or SEABEAM studies. Also surveys of archipelagic apron Sites SYL-3 and HAR-3 will be needed.

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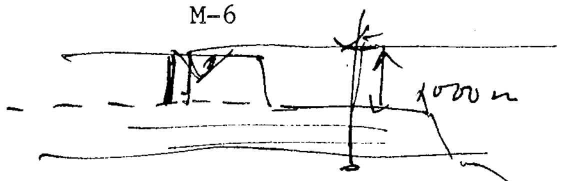

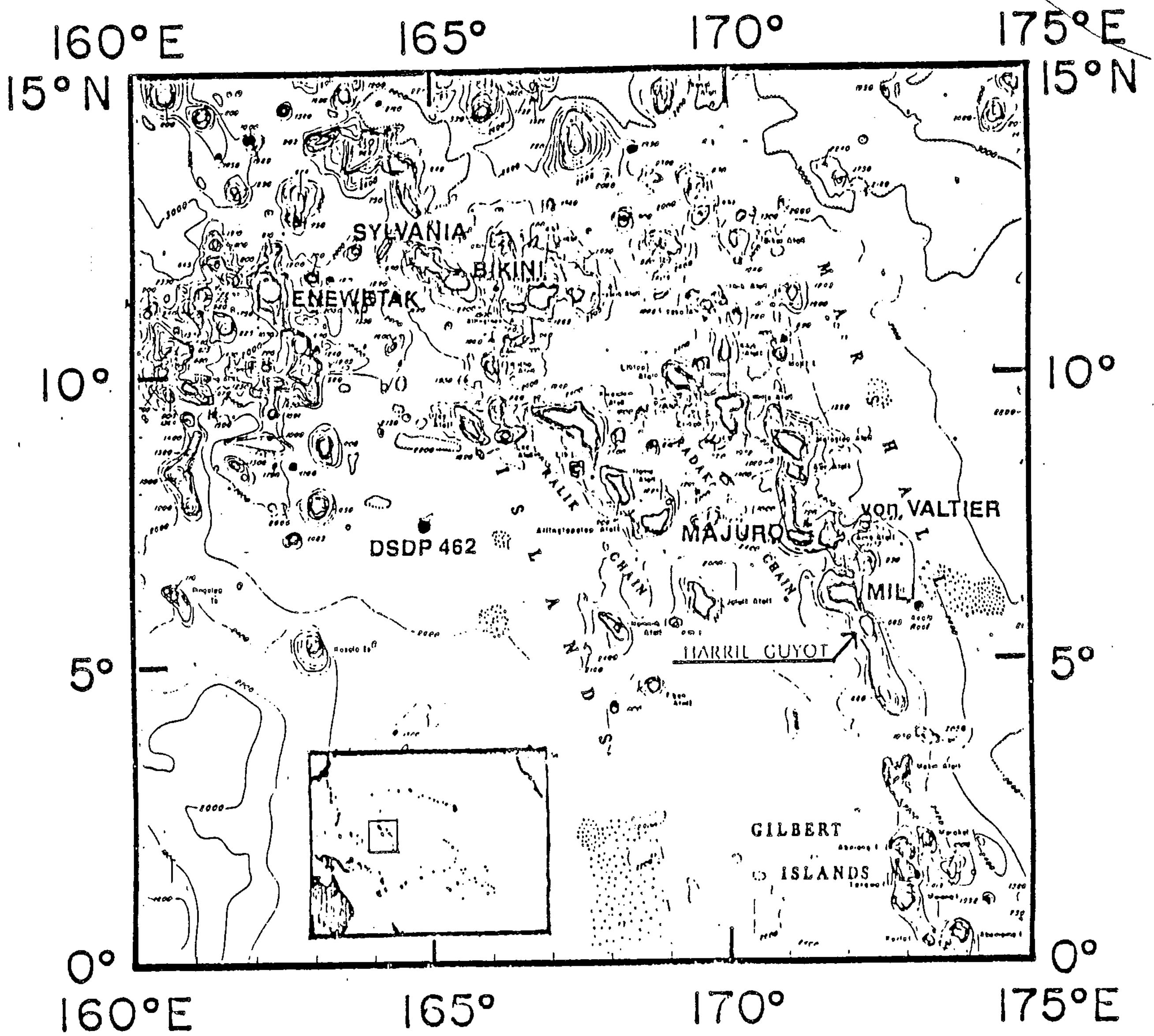

Figure 1. Map of the Marshall Islands showing location of Bikini Atoll, Sylvania Guyot, Enewetak Atoll, DSDP site 462, Majuro Atoll, Mili Atoll, von Valtier Seamount, and Harrie Guyot.

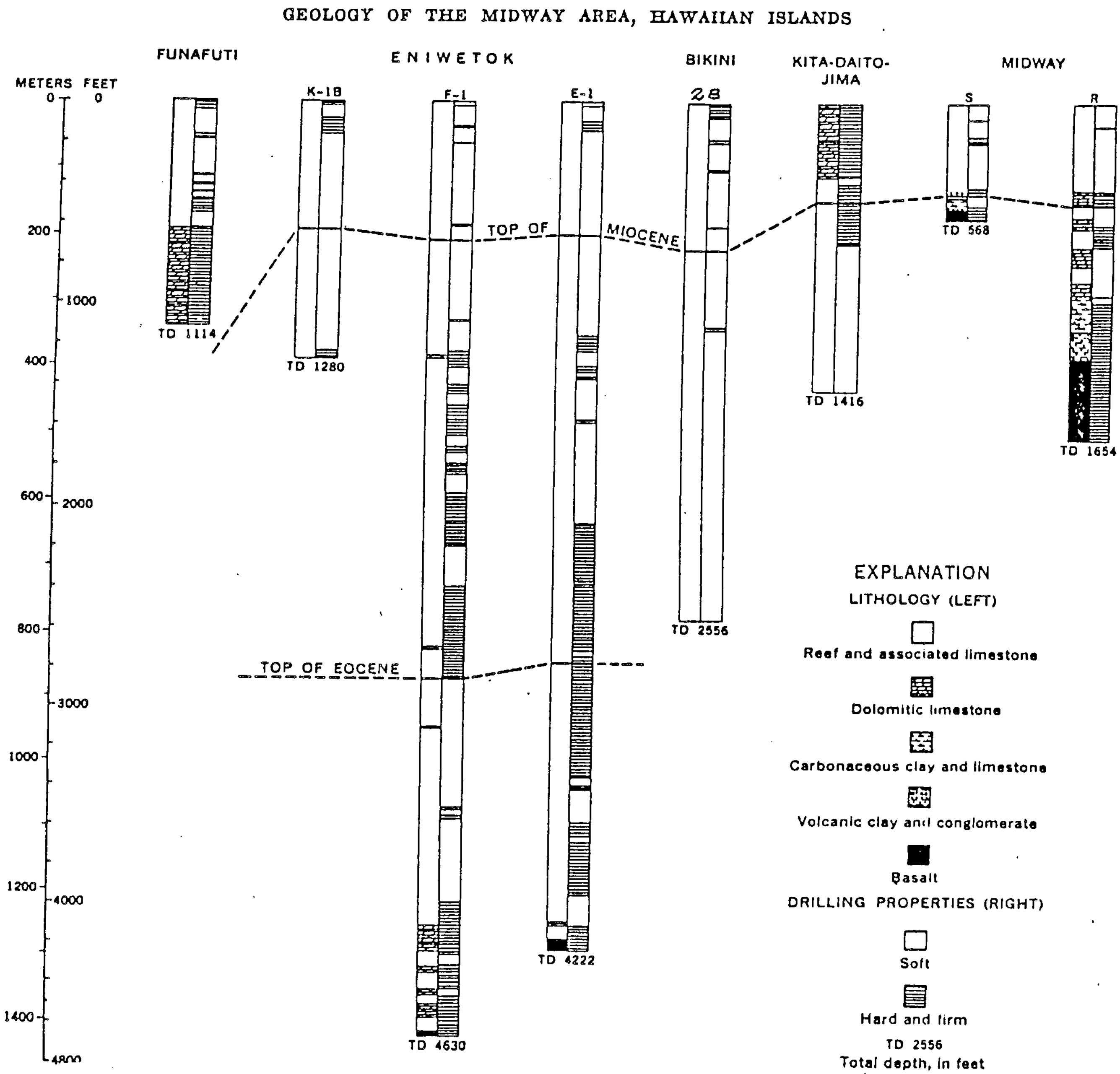

Figure 2. Summary of results of deep drilling on 5 atolls in the open Pacific Ocean.

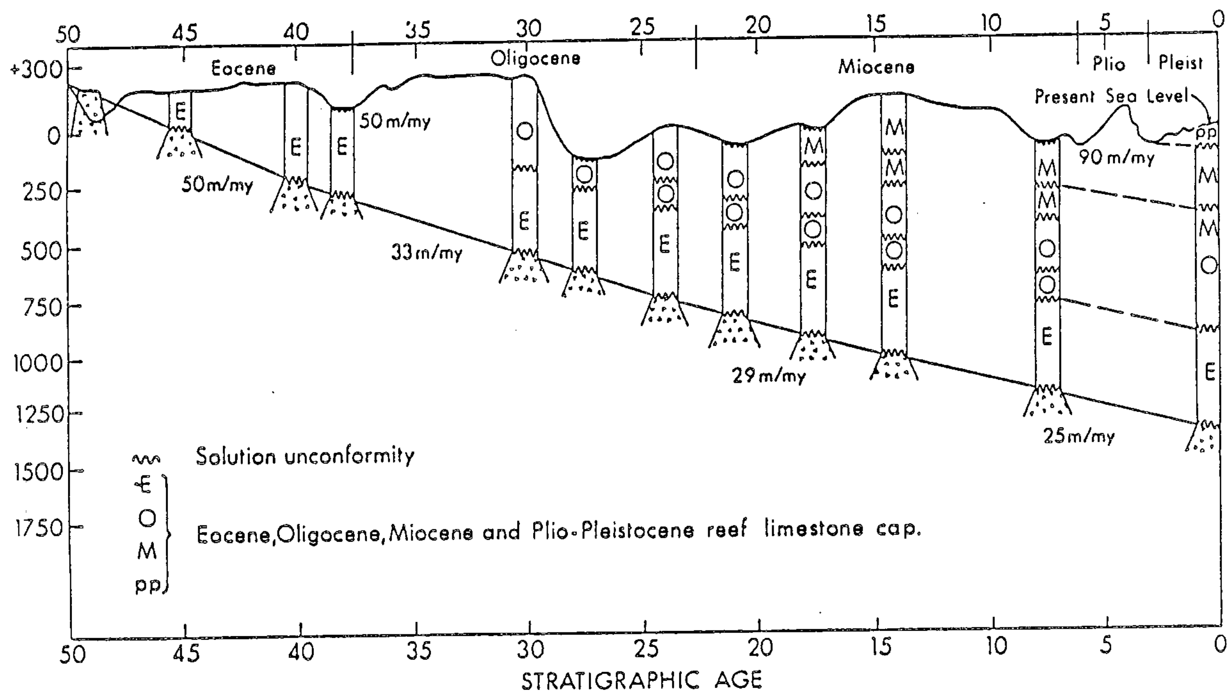

Figure 3. Subsidence of a Marshall Islands atoll (based on Enewetak drilling results) related to the growth of the reef cap and the development of solution unconformities due to subaerial exposure during low sea level stands.

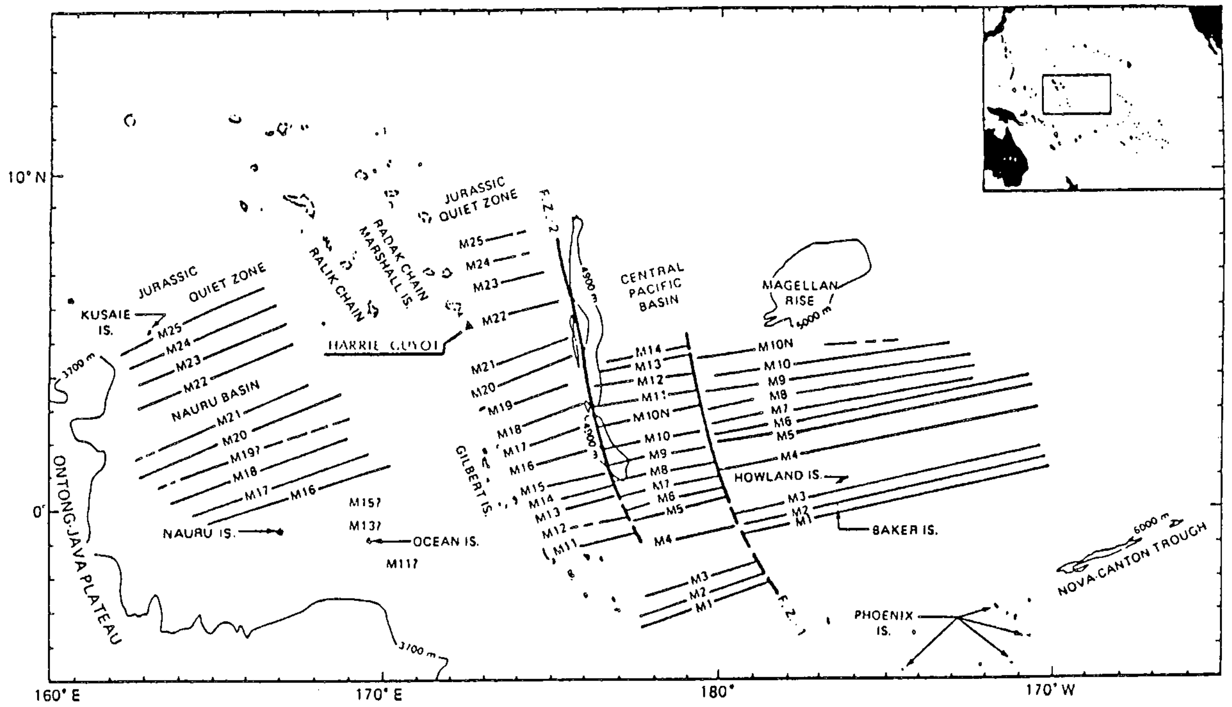

Figure 4. Magnetic anomaly patterns in the Marshall Islands region.

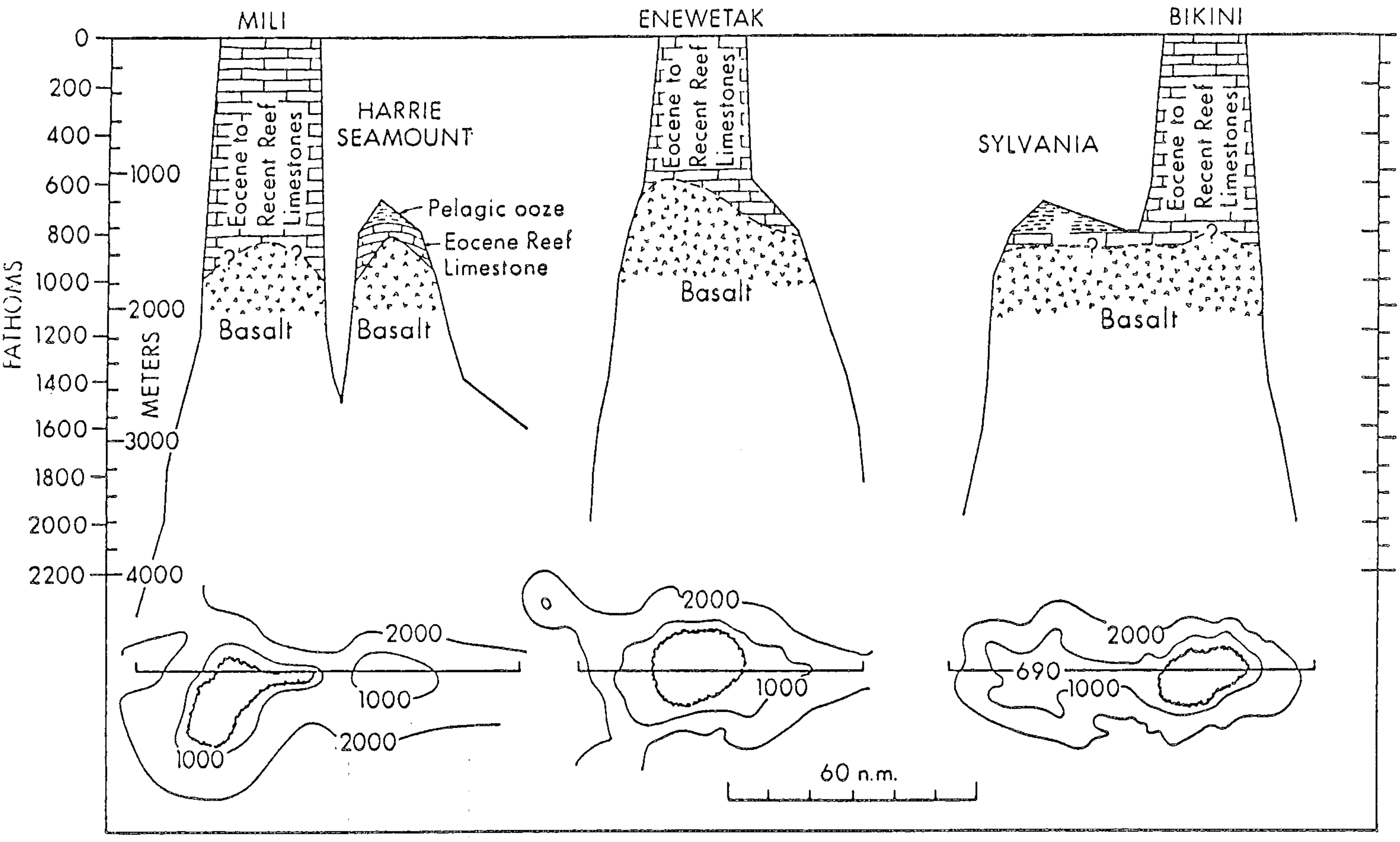

Figure 5. Paired atolls and failed atolls in the Marshall Islands. Both Sylvania and Harrie bear failed reefs of Eocene age correlative with the Eocene reefs drilled at Enewetak over edifice basalt.

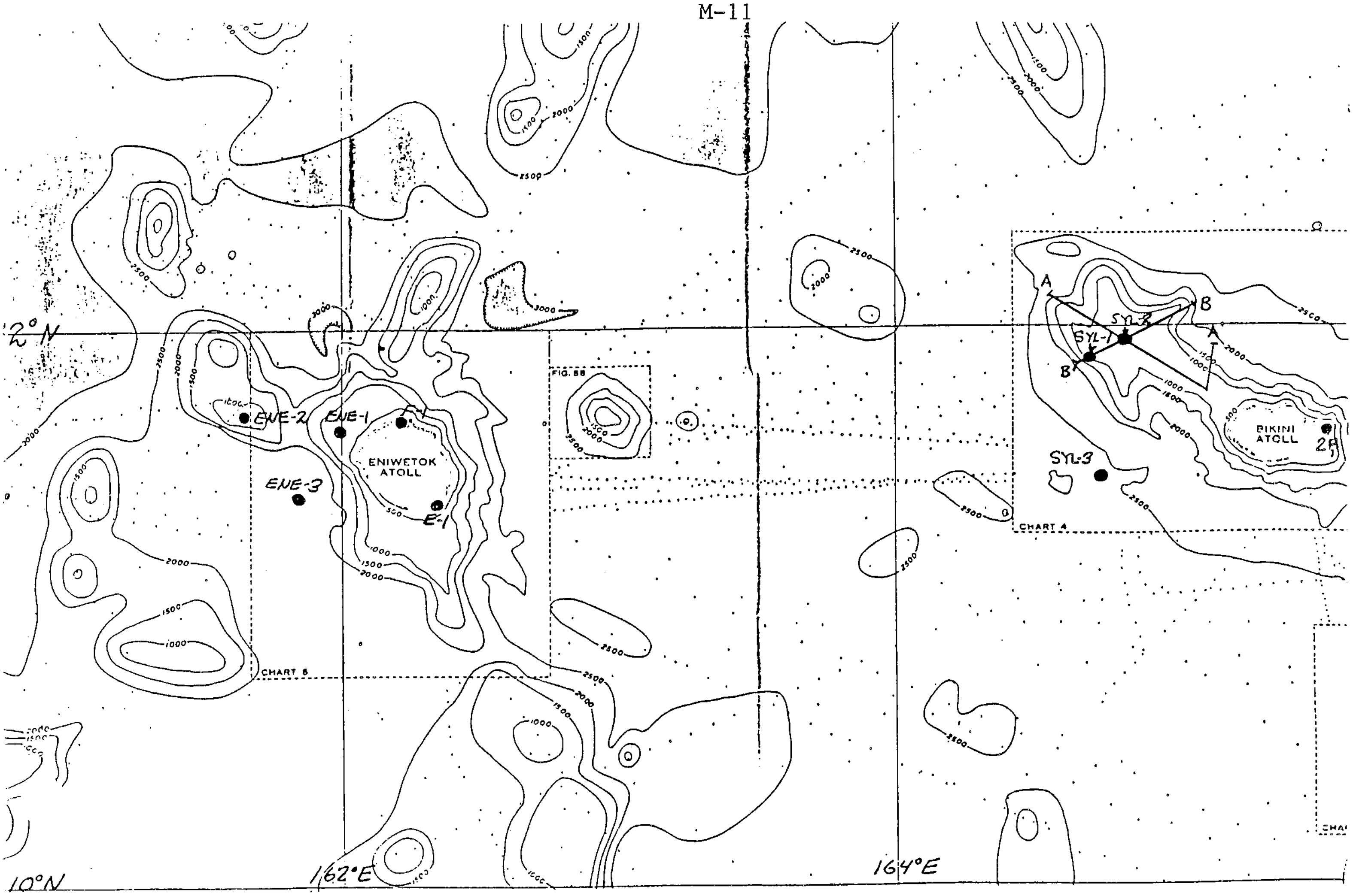

Figure 6. Chart of the northern Marshalls showing Bikini Atoll, Sylvania Guyot, Enewetak Atoll with existing drill sites, Bikini 2B, Enewetak F-1 and E-1, and proposed drill sites, SYL-1,2,3; ENE-1,2,3.

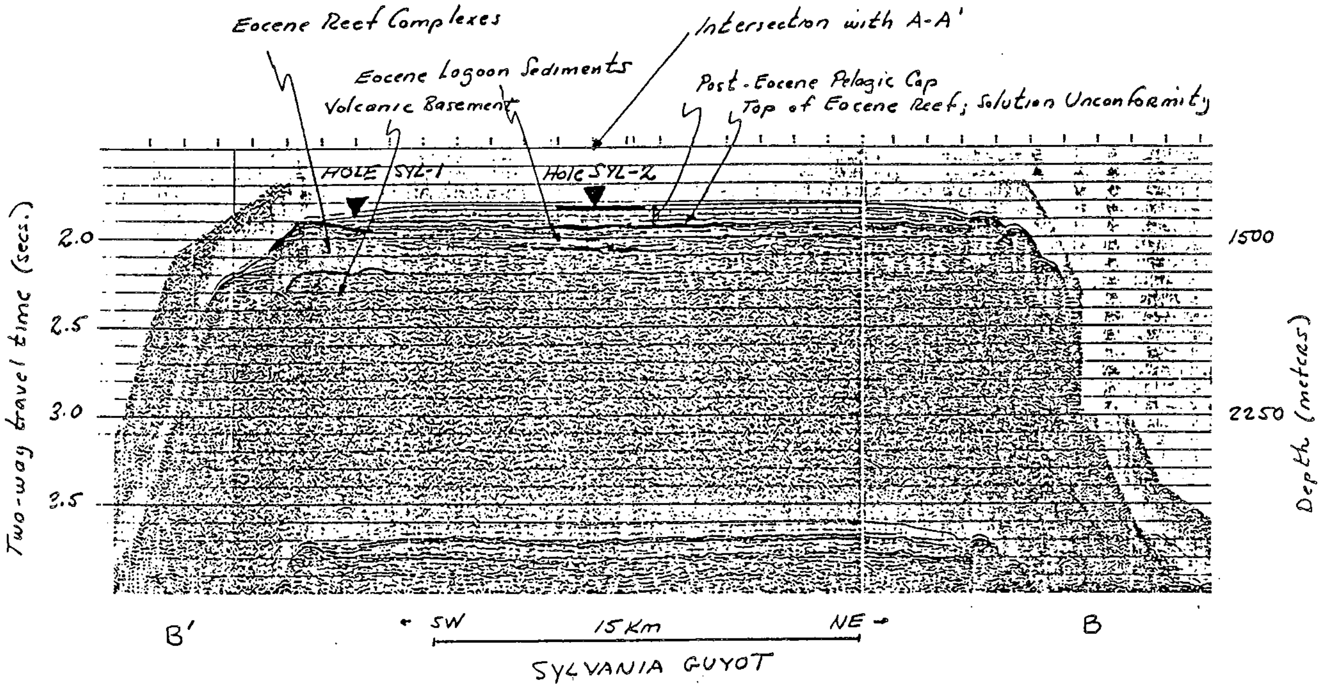

Figure 7. Seismic profile across Sylvania Guyot. Source was 80 cu in water gun processed S10 (Shipley). The line was run by Dunnebier on R/V Kona Keoki, 1981. See Figure 6 for location of seismic line. Proposed sites shown by black arrowheads.

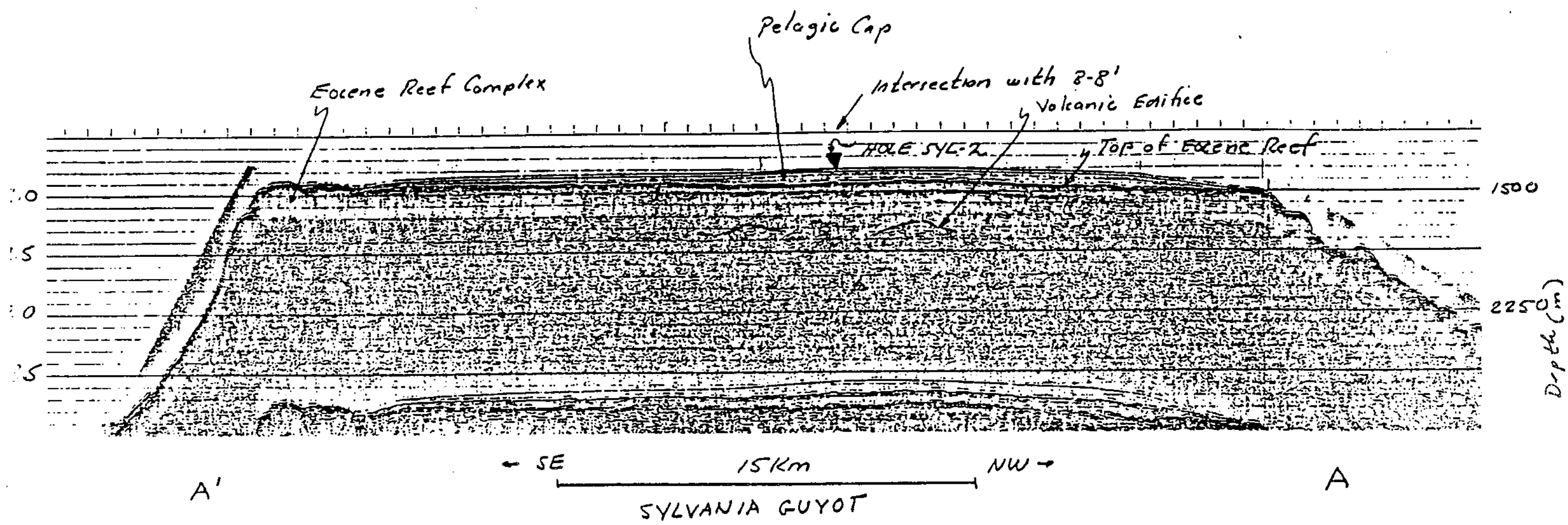

Figure 8. Seismic profile across Sylvania Guyot. This line crosses the line shown in Figure 7. Geological interpretations of sections A-A' and B-B' are based on drilling results from Enewetak, dredged specimens, and analogies with studies of other failed atolls.

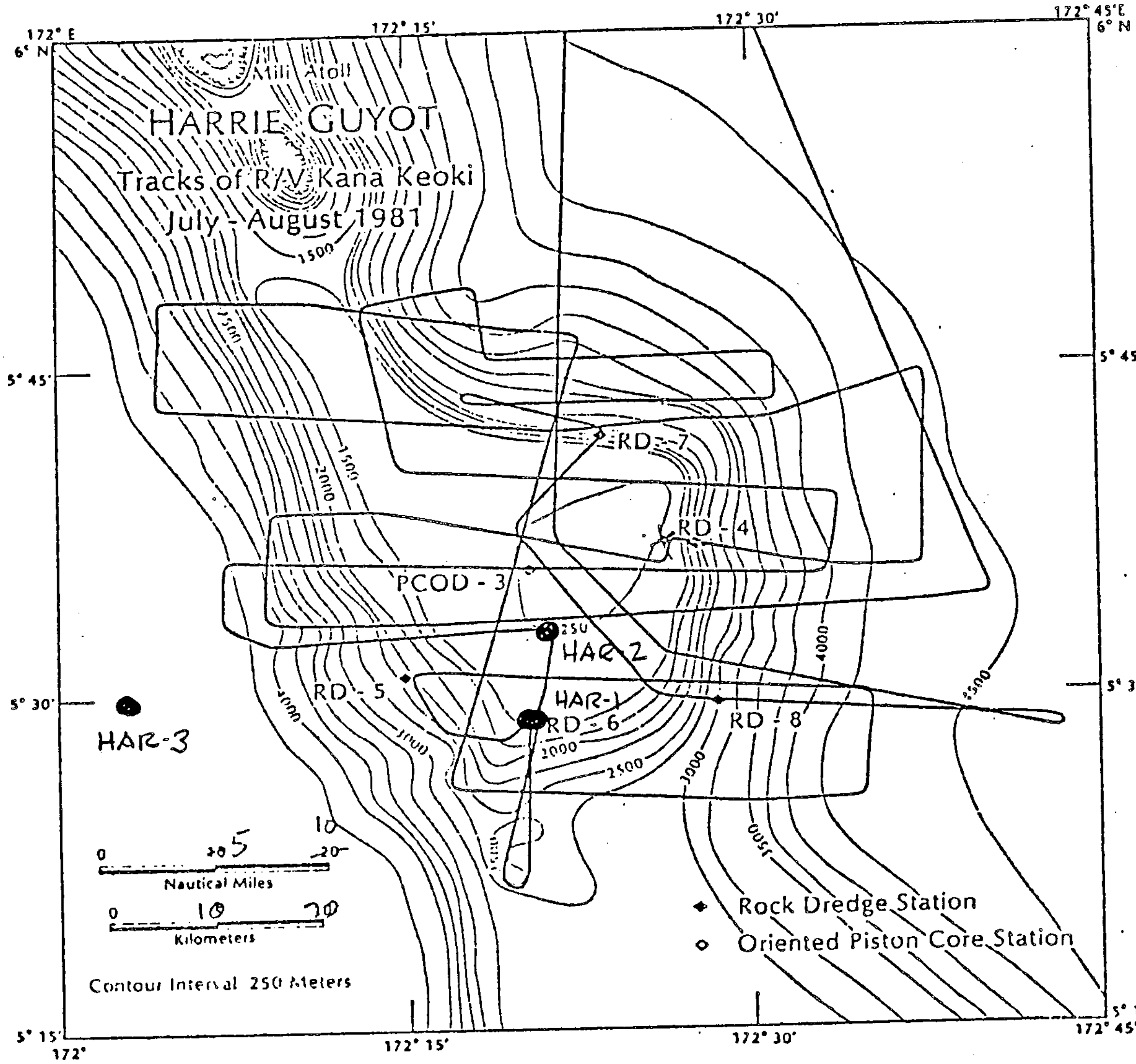

Figure 9. Bathymetric chart of Harrie Guyot showing seismic lines run by R/U Kena Keoki, dredge stations, and proposed sites HAR 1,2,3.

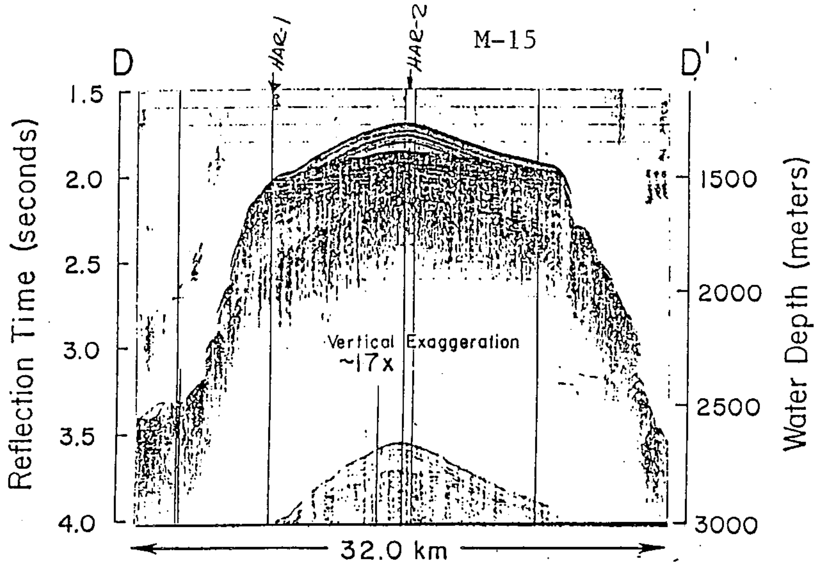

Figure 2a: Seismic profile across south end of Harrie Guyot. Geological interpretation shown on Figure 2b.

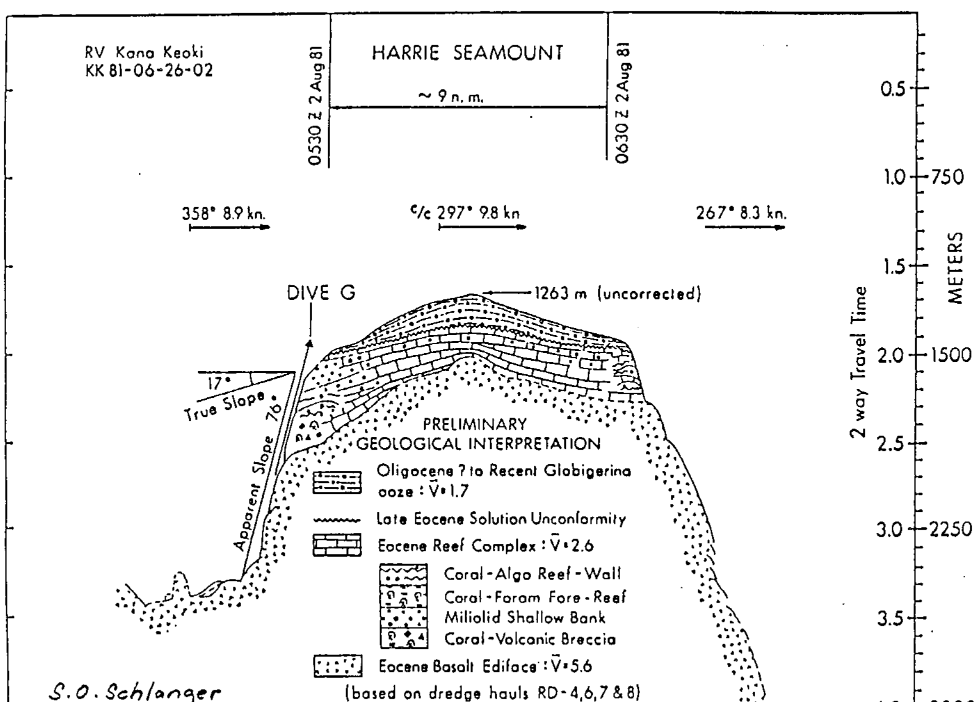

Figure 2b: Geological interpretation of seismic profile shown on Figure 2a. One of the proposed DSRV ALVIN dives is shown.

Figure 10. Seismic profile across sites HAR 1,2 (upper) and geological interpretation (lower).

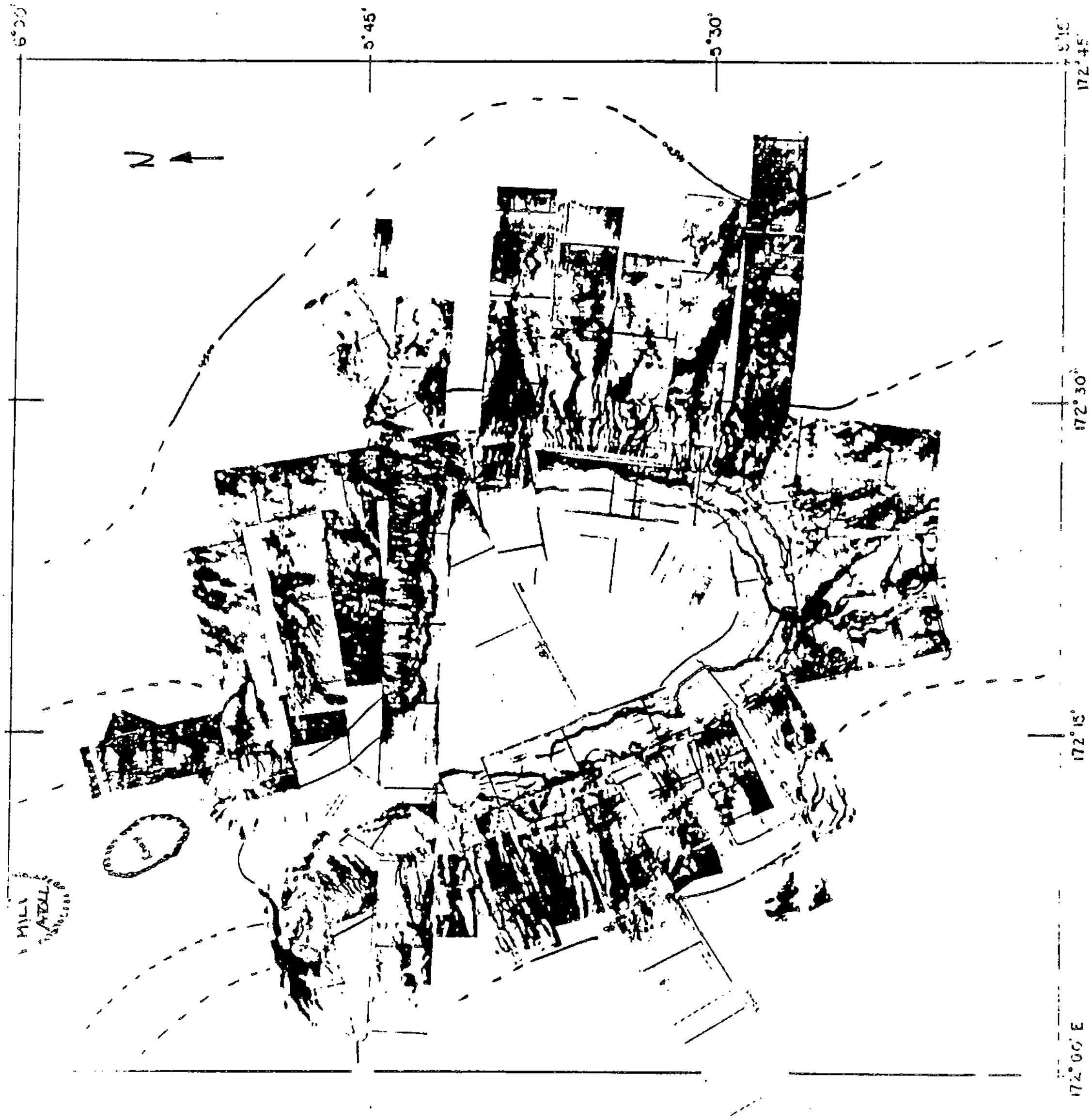

Figure 11. SEAMARC map of Harrie Guyot (HIG data, unpublished).

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:
SYL-1
(also SYL-2)

General Area: SYLVANIA GUYOT, MARSHALL IS.
Position: 11 55'N; 164 40'E
Alternate Site:

General Objective: History of volcanic edifice formation, growth and failure of atoll complexes, subsidence patterns in Marshall Is.

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives: 1. Date the volcanic edifice below the Eocene (?) failed atoll; relate dates to linear island chain models. Paleolatitude of volcanic edifice, Pacific plate motion.
2. Stratigraphy and age of the failed atoll which is characteristic of the Marshall Is. region; study the onset and failure of atoll growth.
3. Determine the subsidence history of northern Marshall Is.
4. Diagenetic and dolomitization history of failed atoll.
5. Correlation of failed atoll stratigraphy with drilled sections on Bikini Atoll.

Background Information:
Regional Data: R/V Kana Keoki, Cruise KK810626, 1981; 80 cuin water gun, processed.
Seismic profiles:

Other data: Surveys carried out during Operations Crossroads for Bikini bomb tests

Site Survey Data - Conducted by: Hawaii Institute of Geophysics (F. Dunnebier)
Date: 1981
Main results: Seismic profiles and dredging indicate 400 m of Eocene reef complex atop basaltic edifice (see attached profiles; A-A', B-B'); Gravity and magnetics mapped.

Operational Considerations

Water Depth: (m) 1350 Sed. Thickness: (m) 400 Total penetration: (m) 650

HPC ____ Double HPC ____ Rotary Drill X Single Bit ____ Reentry X

Nature of sediments/rock anticipated: Pelagic ooze and chalk cap over atoll reef complex underlain by basalt edifice foundation

Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
Seymour O. Schlanger
Department of Geological Sciences
Northwestern University
Evanston, IL 60201

Date submitted to JOIDES Office:

M-17

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: SYL-2
(see also SYL-1)

General Area: SYLVANIA GUYOT, Marchall Is.
Position: 11 55' N; 164 50 E
Alternate Site:

General Objective: History of volcanic edifice formation related to linear island chain models. growth and failure of atoll complexes, subsidenc patterns in Marshall Is.

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives:
1. Date the volcanic edifice below the Eocene (?) failed atoll; relate edifice age to linear island chain models, Paleolatitude of volcanic edifice, Pacific plate motion.
2. Stratigraphy and age of the failed atoll.
3. Determine subsidence history at the northern Marshall Islands.
4. Diagenetic and dolomitization history of failed atoll
5. Correlation of failed atoll stratigraphy with drilled sections on Bikini atoll

Background Information:
Regional Data:
Seismic profiles: R/V Kana Keoki, Cruise KK 810626, 1981: 80 cu in water gun, processed.

Other data: Surveys carried out during Operations Crossroads for Bikini bomb tests

Site Survey Data - Conducted by: Hawaii Inst. of Geophysics (F. Dunnebier)
Date: 1981
Main results: Seismic profiles and dredging indicate 400m of Eocene reef complex atop basaltic edifice (see attached profiles A-A', B-B'). Gravity and magnetics mapped.

Operational Considerations

Water Depth: (m) 1350 Sed. Thickness: (m) 400 Total penetration: (m) 650

HPC ____ Double HPC ____ Rotary Drill X Single Bit ____ Reentry X

Nature of sediments/rock anticipated: Pelagic ooze and chalk cap over atoll reef complex underlain by basalt edifice foundation
Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
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Evanston, IL 60201

Date submitted to JOIDES Office:

Rev. 0684 JOID

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: SYL-3

General Area: SW flank Sylvania Guyot,
Position: Marshall Is.
Alternate Site: 11 30'N, 165 E

General Objective: Archipelagic apron stratigraphy relevant to history of atoll development and deposition of low sea stand turbidites

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives: 1. Obtain record of archipelagic sediments with particular reference to dating of turbidites rich in shallow-water skeletal debris deposited during low sea levels. These turbidites record sea level risings and the history of growth of the adjacent atolls

2. Age and origin of volcanic basement.

Background Information:

Regional Data:

Seismic profiles:

Other data: Surveys carried out during Operations Crossroads for Bikini bomb tests

Site Survey Data - Conducted by: Needed for specific site location

Date:

Main results:

Operational Considerations

Water Depth: (m) 4600 Sed. Thickness: (m) 700 Total penetration: (m) 800 (100 m basalt)

HPC X (300m) Double HPC _____ Rotary Drill X Single Bit X Reentry _____

Nature of sediments/rock anticipated: Recent to Early Eocene and Late Cretaceous (?) ooze, chalk limestone over basalt

Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:

ymour O. Schlanger
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ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: ENE-1

General Objective: History of Enewetak Atoll and volcanic edifice

General Area: NW flank Enewetak Atoll, Marshall Is.
Position: 11 40'N, 162 E
Alternate Site:

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives:
1. Early history of Enewetak Atoll
2. Stratigraphy and facies of atoll flank deposits
3. Age, petrology, paleolatitude of volcanic basement

Background Information:
Regional Data:
Seismic profiles:

Other data: Surveys carried out during drilling operations on Enewetak Atoll
Drilling results from Enewetak Atoll (U.S.G.S. Prof. Paper 260)

Site Survey Data - Conducted by: Needed
Date:
Main results:

Operational Considerations

Water Depth: (m) 1450 Sed. Thickness: (m) 300 Total penetration: (m) 500

HPC ____ Double HPC ____ Rotary Drill __X__ Single Bit __X__ Reentry ____

Nature of sediments/rock anticipated: Eocene reef limestone over basalt edifice

Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:

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Date submitted to JOIDES Office:

M-20

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: ENE-2

General Objective: History of Enewetak Atoll and volcanic edifice complex. Subsidence history, northern Marshalls

General Area: NW extension Enewetak Atoll,
Position: 11 40'N, 161 30'E Marshall Is.
Alternate Site:

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives:
1. Stratigraphy and facies of failed atoll
2. Date volcanic edifice, petrology, paleolatitude of formation
3. Subsidence history of northern Marshalls
4. Correlation of failed atoll history with drilled sections on Enewetak Atoll

Background Information:
Regional Data:
Seismic profiles:

Other data: Surveys carried out in conjunction with drilling operations on Enewetak Atoll
Drilling results from Enewetak Atoll (U.S.G.S. Prof. Paper 260)

Site Survey Data - Conducted by: Needed
Date:
Main results:

Operational Considerations

Water Depth: (m) 1350 Sed. Thickness: (m) 300 Total penetration: (m) 500

HPC ____ Double HPC ____ Rotary Drill X Single Bit X Reentry ____

Nature of sediments/rock anticipated: Eocene reef limestone over basalt edifice

Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
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ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: ENE-3

General Objective: Archipelagic apron stratigraphy relevant to history of atoll development and deposition of low sea level stand turbidites

General Area: SW flank, Enewetak atoll, Marshall Is.
Position: 11 30'N, 161 40'E
Alternate Site:

Thematic Panel interest: SOHP
Regional Panel interest: CEPAC

Specific Objectives:

1. Obtain record of archipelagic sediments and dating of turbidites rich in shallow-water skeletal debris from nearby reefs that were deposited during low sea level stands. These record the history of atoll growth.

2. Age and origin of volcanic basement

Background Information:
Regional Data:
Seismic profiles:

Other data: Surveys carried out during drilling operations on Enewetak Atoll (U.S.G.S. Prof. Paper 260)

Site Survey Data - Conducted by: Needed
Date:
Main results:

Operational Considerations

Water Depth: (m) 4000 Sed. Thickness: (m) 700 Total penetration: (m) 800 (100 m basalt)

HPC x (300m) Double HPC ____ Rotary Drill x Single Bit x Reentry ____

Nature of sediments/rock anticipated: Recent to Early Eocene on Late Cretaceous (?) ooze chalk and limestone over basalt

Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:

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ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:
HAR-1
(see also HAR-2 and 3)

General Area: HARRIE GUYOT, MARSHALL IS.
Position: 5 29'N; 172 20'E
Alternate Site:

General Objective:
History of volcanic edifice, dating of hot spot track, growth and failure of atoll complexes, subsidence history of Marshall Is.

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives: 1. Date the volcanic edifice below the Eocene(?) failed atoll; relate dates to linear island chain models. Paleolatitude of volcanic edifice, Pacific plate motion.
2. Stratigraphy and age of the failed atoll which is characteristic of the Marshall Is. region; study the onset and failure of atoll growth.
3. Determine the subsidence history of northern Marshall Is.
4. Diagenetic and dolomitization history of failed atoll.
5. Correlation of failed atoll stratigraphy with drilled sections on Enewetak Atoll.

Background Information:
Regional Data: R/V Kana Keoki, Cruise KK810626-02, 1981,
Seismic profiles: Complete coverage with airgun profiling

Other data: Gravity, magnetic, dredge.

Site Survey Data - Conducted by: Hawaii Inst. Geophysics (S.O. Schlanger/F. Campbell),
Date: 1981 SEAMARC mapping (F. Campbell)
Main results: Seismic profiles and dredging indicates 200-400 m of Eocene reef limestone over volcanic edifice.

Operational Considerations

Water Depth: (m) 1500 Sed. Thickness: (m) 400 Total penetration: (m) 650

HPC ____ Double HPC ____ Rotary Drill X Single Bit ____ Reentry X

Nature of sediments/rock anticipated: Pelagic ooze and chalk cap over atoll reef complex and volcanic basement

Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
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ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:

HAR-2
(See also HAR 1 and 3)

General Area: W flank Harrie Guyot
Position: Marshall Is.
Alternate Site: 5 30'N; 172 05'E

General Objective:
History of volcanic edifice, dating of hot spot track, growth and failure of atoll complexes, subsidence history of Marshall Is.

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives:

1. Date the volcanic edifice below the Eocene(?) failed atoll; relate dates to linear island chain models. Paleolatitude of volcanic edifice, Pacific plate motion.
2. Stratigraphy and age of the failed atoll which is characteristic of the Marshall Is. region; study the onset and failure of atoll growth.
3. Determine the subsidence history of northern Marshall Is.
4. Diagenetic and dolomitization history of failed atoll.
5. Correlation of failed atoll stratigraphy with drilled sections on Enewetak Atoll.

Background Information:

Regional Data: R/V Kana Keoki, Cruise KK810626-02, 1981.
Seismic profiles: Complete coverage with airgun profiling

Other data: Gravity, magnetic, dredge.

Site Survey Data - Conducted by: Hawaii Inst. Geophysics (S.O. Schlanger/F. Campbell)
Date: 1981 SEAMARK mapping (F. Campbell)
Main results: Seismic profiles and dredging indicates 200-400 m of Eocene reef limestone over volcanic edifice.

Operational Considerations

Water Depth: (m) 1260 Sed. Thickness: (m) 300 m Total penetration: (m) 450 m

HPC ____ Double HPC ____ Rotary Drill ____ Single Bit _x_ Reentry ____

Nature of sediments/rock anticipated: Pelagic ooze and chalk cap over atoll reef complex and volcanic basement

Weather conditions/window:

Territorial jurisdiction: Marshall Islands

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent: S. O. Schlanger
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Date submitted to JOIDES Office:

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: HAR-3

General Area: W flank Harrie Guyot
Position: Marhsall Is.
Alternate Site: 5 30'N; 172 05'E

General Objective:
Archipelagic apron stratigraphy relevant to history of atoll development and deposition of low sea stand turbidites

Thematic Panel interest: SOHP, LITHP
Regional Panel interest: CEPAC

Specific Objectives:

1. Date the volcanic edifice below the Eocene(?) failed atoll; relate dates to linear island chain models. Paleolatitude of volcanic edifice, Pacific plate motion.
2. Stratigraphy and age of the failed atoll which is characteristic of the Marshall Is. region; study the onset and failure of atoll growth.
3. Determine the subsidence history of northern Marshall Is.
4. Diagenetic and dolomitization history of failed atoll.
5. Correlation of failed atoll stratigraphy with drilled sections on Enewetak Atoll.

Background Information:
Regional Data: R/V Kana Keoki, Cruise KK810626-02, 1981.
Seismic profiles: Complete coverage with airgun profiling

Other data: Gravity, magnetic, dredge

Site Survey Data - Conducted by: Specific site survey needed
Date:
Main results:

Operational Considerations

Water Depth: (m) 4500 Sed. Thickness: (m) 700 Total penetration: (m) 800 (100 m basalt)

HPC ____ Double HPC ____ Rotary Drill ____ Single Bit X Reentry ____

Nature of sediments/rock anticipated: Recent to Early Eocene and Late Cretaceous(?) ooze, chalk, and limestone over basalt

Weather conditions/window:

Territorial jurisdiction: Marshall Is.

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
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Date submitted to JOIDES Office:

Rev. 0684 JOIDE

PROPOSAL FOR DRILLING OF CRETACEOUS GUYOTS IN THE CENTRAL PACIFIC

Proponents

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Abstract

We here present a proposal to drill the summits of five guyots in the Mid-Pacific Mountains, Wake Seamounts, and Geisha Seamounts in the central and western tropical Pacific. The drilling will address fundamental problems in the history of Cretaceous reefs on the guyots (particularly the cause[s] and timing of their extinction), the age progessions of underlying volcanic chains, the petrological character of the volcanoes and the compositions of mantle sources of the lavas, and the subsidence history of the edifices. The drilling will also provide paleomagnetic information critical to evaluation of plate motions during the Mesozoic, and the fixity of "hot spots" active then.

Introduction

Although guyots have fascinated marine geologists ever since they were described as flat-topped seamounts beveled by erosion (Hess, 1946), the geological history of these features has been slow to unravel despite several expeditions to chart and sample them. We now understand many Western Pacific guyots to be Mesozoic volcanoes, capped with Cretaceous reefs (Hamilton, 1956; Heezen et al., 1973). The reefs were killed, possibly synchronously, during the mid-Cretaceous (Matthews, et al., 1974). After submergence, the volcanoes subsided to present summit depths of between 1000 and 1800 m. They now occupy a belt of the central Pacific reaching from the Japan and Mariana trenches nearly to Hawaii, a distance of some 5000 km (Figure 1).

The following sections summarize the range of problems that can be addressed by drilling in two principal categories: the carbonate caps, and the volcanic foundations.

The carbonate caps

Dredging (Hamilton, 1956; Ladd et al., 1974; Heezen et al., 1973) and drilling (Winterer, Ewing et al., 1973; Thiede, Vallier et al., 1983) have shown that the Lower Cretaceous reefs on many Geisha and Midpac seamounts are almost all Early Cretaceous in age; reflection profiles (Heezen et al., 1973) show some of these to be at least 700m (0.7s) thick. Barremian-age fossils occur on at least one guyot in the western part of the Midpacs (Thiede, Vallier et al., 1981) and arguments have been advanced for ages as old as Valanginian (130Ma) by Winterer and Metzler (1984). Some of the guyots have the form of atolls. Drilling into these reefs has three advantages: 1) we can sample virtually undisturbed Lower Cretaceous reefal rocks of several different facies: forereef, reef, backreef and lagoon; (2) these are covered by only a thin and incomplete cover of younger sediments, and are open to the sea on the sides; and (3) the seamount summits are essentially undisturbed by post-reef tectonics. These are virtually intact structures, offering us an unparalleled view into the oldest preserved atolls on the globe.

The implications of this state of preservation are that we can here address in a relatively uncomplicated way the problems of (1) the timing and amplitude of relative changes in sea level; (2) the timing and causes of platform drowning; (3) the history of advance and retreat of the platform margins; (4) latitude changes as reflected in latitude-sensitive facies and in the paleomagnetism of the sediments and the underlying volcanic rocks; and (5) the age of the earliest sediments on the volcanics. Each of these problems is discussed in further detail below.

Relative changes in sea level. We need to know both the history of global changes in sea level during the Early Cretaceous and the local and regional histories of subsidence and uplift. All of this information is convolved into local relative changes of sea level, and to separate them requires the drilling of several widely-spaced guyots, which share only the eustatic and the broadest regional tectonic signals. The Early Cretaceous global sea-level record is largely deduced from coastal-onlap fluctuations interpreted from seismic records across Atlantic margins, but these margins were tectonically very active during much of this time, and we need data from regions distant from the Atlantic to establish a true eustatic curve. By using the diagenetic imprint in the reefal rocks of paleo-water tables and paleo-soils, it is possible to evaluate both the magnitude and direction of relative sea-level changes.

Our quantitative knowledge of the subsidence history of seamounts (Detrick and Crough, 1978) is based on incomplete coring of only four Pacific atolls, of which two (Bikini and Enewetak) may have had very complicated subsidence paths because of renewed volcanism, 10's of millions of years after the construction of the original edifices. We need to study many more atolls and guyots with long and relatively uncomplicated histories of subsidence and reefal accumulation to establish the "normal" subsidence curve. We have identified several candidate guyots in the mid-Pacific.

Platform drowning. Two interrelated problems are at issue: (a) what caused the drowning of so many Pacific atolls in the mid-Cretaceous; and (b) were the drownings synchronous over the whole region? Carbonate banks from many other places around the world drowned in mid-Cretaceous times (Schlager, 1981), and it is important to establish the exact timing of these drownings as a constraint on models for the cause(s). The timing question can be addressed correctly on an individual guyot only by coring a continuous sequence across the drowned surface and well into the fossiliferous reefal beds. Experience shows that dredges collect mainly talus blocks or strongly altered material from the guyot top that is very difficult to date precisely. To test for synchroneity requires drilling several widely separated guyots.

Platform margins. At Eniwetak, data from drilling (Schlanger, 1963), and seismic reflection profiling (J. Grow, pers. comm.) show that the reef margin has shifted markedly, i.e., the diameter of the atoll has waxed and waned, over the past 50 Ma. Similar large advances and retreats, sometimes very rapid, are described also from ancient carbonate banks (King, 1948, Schlanger et al., 1985). Drilling several mid-Pacific Lower Cretaceous sunken atolls will allow us to discriminate among the likely mechanisms: sea level changes, carbonate production rate changes, or imperfect feedback adjustments to steady-state production and subsidence rates.

Latitude changes. Both carbonate production rates and the composition of reefal biota change as a function of latitude, especially near the so-called Darwin Point, where upward growth rates and subsidence rates are equal (Grigg, 1982). Paleomagnetic data from a hole drilled into turbidites flanking a Midpac guyot (Sayre, 1981) suggest that Midpac guyots were born and grew up in equatorial latitudes but drifted south to their Darwin Point at the time of drowning (Winterer and Metzler, 1984). Drilling should be able not only to test for changes in rates and faunas, but also provide samples for determination of changing paleomagnetic latitude. The rate of change of latitude gives an additional check on horizontal plate motions deduced from the trend and age progression along the Midpacs (Winterer and Metzler, 1984). A substantial lack of agreement among these independent measures would imply drift of the generating hot spot.

Age of seamounts. Determination of the ages of seamounts in the mid-Pacific region is essential to solving the interrelated problems of the rate of any progressive volcanism, the number of hot spots, and the horizontal motion vectors of the Pacific Plate during the Early Cretaceous. Drill cores allow paleontological determination of the age of the oldest sediments overlying volcanic basement on a guyot and put a young limit on the age of the volcano itself. This will be an important complement to radiometric-age studies on dredged and drilled lavas. Paleomagnetic reversal data from the sediments and volcanic rocks and radiometric data from the volcanics will provide supplementary data. The methods are classic, but require good seismic profiler data to place the oldest sediments in their proper context.

The volcanic foundations

Although touching into the volcanic basement beneath the carbonate caps will provide important information on the age of the seamounts and the history of the reefs, there are important reasons to proceed with drilling of basement to significant depths. These concern the compositions of mantle sources and the petrological evolution of the volcanoes, whether the volcanic chains are age-progressive, whether volcanic overprinting occurred, and whether volcanism may have attended a regional uplift, hence is intimately related to extinction of the reefs. We summarize what is known about these topics, and how drilling may improve our knowledge of them, in the following sections.

Mantle sources for lavas. The igneous substrates of the volcanoes present a considerable range of lava types, including island-type tholeiites, varieties of alkalic basalts and differentiated lavas, and strongly undersaturated olivine basanites and nephelinites (Natland, 1976; Natland and Wright, 1984, 1985, and unpublished). This range is broadly similar to the well-known sequence from shield-building to post-erosional volcanism seen in the Hawaiian Islands, but the details of the lava compositions also support comparisons to volcanic rocks of East African rifts (Natland, 1976) and to the strongly alkalic volcanic island chains of the SW Pacific, including Samoa, the Societies, and the Marquesas (Natland and Wright, 1984, 1985).

Duncan and Clague (in press) and Gordon (in press) argue that many of the volcanoes of the Mid-Pacific Mountains, Wake Seamounts, and the

Magellan Seamounts can be traced directly to present-day hot spots such as the Macdonald Seamount (Australs), Mehetia (the Societies), Easter Island, and Sala y Gomez. Natland and Wright (1984, 1985) favored an origin over the same region of mantle as the present-day Samoan, Society, Austral and Marquesas Islands. All of these island chains were supplied eruptive rocks from surpassingly radiogenic mantle sources (Hedge, 1978; Wright and White, in prep.), lately identified with a potentially hemispheric heterogeneity in the mantle, termed the Dupal anomaly by Hart (1984). Petrological and trace-element similarities of lavas from the Cretaceous seamounts to those from present-day chains in the SW Pacific suggest that the Dupal mantle sources may have persisted beneath the same general region of the Pacific for more than 120 Ma.

Are the volcanic chains age-progressive? These speculations have been made without substantial proof that the Pacific guyots and associated volcanic ridges even formed age-progressive chains during the Cretaceous. Radiometric ages on lavas are insufficient to establish that the guyots resulted from plume sources that can be traced confidently to contemporary hot spot traces. Natland (1973) and Natland and Wright (1984) suggested that the Mid-Pacific Mountains, Wake Seamounts, and Geisha Seamounts each represent a distinctive petrographic province, hence comprise apparently separate, possibly synchronously overlapping, volcanic chains. This has been confirmed by a few radiometric ages (Saito and Ozima, 1977), and drilling results (Winterer, Ewing et al., 1973; Larson, Moberly, et al., 1975; Thiede, Vallier et al., 1983), coupled with as-yet unpublished chemical analyses of Natland and Wright. A general hypothesis for the origin of the belt of volcanoes along the Marcus-Necker Ridge now seems to be that were several coeval hot spots. Motion of the Pacific plate over the hot spots was sufficient to cause the seamount chains to overlap. At about 100 Ma, plate motion changed to the NW, and separate younger trajectories imprinted on the plate as the Gilbert and Line Island chains.

This scenario is subject to a great deal of uncertainty, and some evidence suggests that other tectonic processes and volcanic events influenced this history of the seamounts. Menard (1984) recently deduced that many of the guyots are anomalously shallow, that is, they have not followed the normal subsidence patterns expected for oceanic lithosphere nor even that for seamount chains representing "reset" lithosphere (Detrick and Crough, 1978). Menard hypothesized that the seamounts passed over one or more mid-plate swells, which he grouped as the Darwin Rise. Natland and Wright (1984) related this swell to a geoidal anomaly now located in the SW Pacific (Anderson, 1982), and intrinsically to shallow, undepleted zones of asthenosphere associated with the Dupal anomaly in the same region.

Multiple episodes of volcanism. Obviously, any sort of bumpy ride over anomalous mantle might induce multiple episodes of volcanic activity over quite a number of million years. Multiple episodes (of unknown origin) have been documented for the present-day Cook-Austral chain (Turner and Jarrard, 1982). Other causes of mid-plate volcanism, e.g., rifting (cf. Natland, 1976), or flood-basalt volcanism, e.g., in the Nauru Basin (Schlanger, Larson, et al., 1982) might also have produced volcanism along portions of the Marcus-Necker Ridge. Strongly alkalic volcanism (eruption of nephelinitic lavas) occurred, for example, in much of the Line Island chain during the Late Cretaceous, but also nearly synchronously in a portion of the Mid-Pacific Mountains (DSDP Site 313; Marshall, 1975). Eocene volcanism in the Gilbert Islands, e.g., Enewetak (Emery, et al., 1954; Kulp, 1963), might have extended northward to the Wake Seamounts, where planktonic foraminifers no older than that were recovered together with volcanic rocks from several guyots (Heezen et al., 1973). Obviously, the fossils provide only minimum ages for the volcanoes, but the common occurrence of strongly undersaturated basaltic lavas in the dredge hauls suggests that late-stage (perhaps very late-stage) volcanism may have occurred.

Regional Uplift. The Cretaceous reefs in the Mid-Pacific Mountains and Geisha Seamounts (they are as yet unknown in the Wake Seamounts) are a critical element in understanding the volcanic and subsidence history of the guyots. Winterer and Metzler (1984) propose that mid-plate volcanism which produced the flood basalts in the Nauru Basin was attended by large-scale regional uplift. This raised reef summits above sea level, where they were partly dissolved and altered by fresh water. Rapid subsidence relative to sea level and with respect to coral growth rates at latitudes near the limit for coral growth (20-25^{o}S) prevented re-attachment of reefs. The rise in sea level may have been global and eustatic, it may have had to do with rapid subsidence following the uplift which effectively "reset", or thinned, the lithosphere on a regional scale, or both. Any regional thermal rejuvenation of the lithosphere could have been accompanied by renewed volcanism on many of the volcanoes (perhaps especially in the Wake Seamounts), which would necessarily have been nearly synochronous throughout the region. The common occurrence of volcanic rocks representing both subaerial and submarine lava flows (rounded cobbles and hyaloclastites) in dredge hauls from guyot summits is evidence that few of the guyots are simple drowned coral atolls.

Within this framework, the hypothesis that the reefs became extinct synchronously throughout the region (Matthews et al., 1974) takes on great significance. These authors related the extinctions to a global (eustatic) rise in sea level, occasioned by displacement of ocean waters by hot, elevated ocean crust generated by a sudden burst of rapid seafloor spreading (Larson and Pitman, 1972). Presumably a similar effect would have accompanied emplacement of flood basalts on the ocean floor. The proposal of Winterer and Metzler (1984) that there was first a regional uplift implies large-scale, mid-plate volcanism, not merely in the Nauru Basin, but so widespread as to effect the Wake, Mid-Pac and Geisha Seamounts.

The primary tasks for drilling, then, are to obtain evidence for the causes and precise timing of reef extinction across the broad tier of central and western Pacific Guyots, to document the post-extinction subsidence history of the volcanoes (whether the lithosphere may have been "reset" regionally), and to establish whether overprinting volcanism accompanied or influenced the reef extinctions. Beyond that, the drilling will address the volcanic history and age progression of the several volcanic chains embodied by the Mid-Pacific Mountains, Wake Seamounts, and Geisha Seamounts, and provide materials to evaluate the compositions of mantle sources. The fixity and duration of hot spots can be approached with paleomagnetic data, which will also provide information pertinent to true polar wander during the Mesozoic. The possibility of an initial southward component to plate motion (Winterer and Metzler, 1984) can be established by comparing magnetic inclinations stratigraphically within reefal assemblages and volcanic sequences.

The following sections document our proposal in more detail, provide justification and background information for specific drilling targets, and summarize site survey requirements. Site proposal forms are appended.

Criteria for Selection of Drill Sites

From the general considerations outlined, there are two principal criteria for the selection of drill sites.

1) There needs to be wide geographical coverage to evaluate the reef extinction problem. If reefs become extinct simultaneously (or nearly so) in the mid-Pacific Mountains, Wake Seamounts and Geisha Seamounts, then a world-wide sea-level fluctuation probably was responsible. Alternatively, if some geographical sequence of extinctions can be established, then more local causes, including tectonic uplift and rapid subsidence, would be favored. Drilling clearly has to be undertaken in all three seamount groups.

2) Within seamount groups, age progressions must be established. To some extent this can be addressed with dredged samples, but extensive alteration of dredge lavas often makes them useless for radiometric dating. Moreover, petrological sequences cannot be established with dredged rocks. Drilling through late-stage lavas into the principal shield eruptives of several of the volcanoes is necessary both to secure reliable edifice-building ages (using biostratigraphy if radiometric techniques do not work) and to understand the petrological context of the dredged samples.

Other objectives of the drilling pertaining to paleomagnetics, mantle sources, and so forth, can all be addressed using holes which meet the above two criteria. Based on these, and given some logistical restrictions, we here propose that age progressions can be established for the mid-Pacific Mountains and Geisha Seamounts by drilling two targets in each group, and that a somewhat different range of objectives should be addressed by a single target in the Wake group. We propose two sites, one in the central region and one at the western end. These can be coupled with existing data from Horizon Guyot at the eastern end of the group (DSDP Leg 17; Winterer, Ewing et al., 1973) to establish the age progression. The two sites at either end of the Geisha Seamounts trend would complement existing $^{40}Ar/^{39}Ar$ incremental-heating ages there (Ozima et al., 1977). The target in the Wake Seamounts would evaluate the possibility of Eocene volcanic overprinting at the northern end of the Marshall-Gilbert chain. This will contribute to establishing an age progression in that younger chain. The probable time needed for this single site (to penetrate Eocene volcanics if they exist and reach underlying Cretaceous lavas) makes it unlikely that a second Wake Seamount target could be drilled to establish the Cretaceous age progression in that chain.

This is all that is likely to be accomplished in a single leg. Ideally, one or more sites in the Magellan Seamounts should also be drilled. We recommend as an important complement to our proposal that the Ogasawara Plateau, which is one of the larger Magellan Seamounts, and one which impinges on the Bonins forearc at the trench there, be drilled as proposed by Japanese scientists in connection with an evaluation of collision processes at trenches and forearc regions.

Preliminary Targets

After examining existing survey, dredge and drilling data, we have selected several seamounts as likely candidates for drilling, and some alternates, with the final selection process to be made after a site-survey cruise.

In the mid-Pacific Mountains, we recommend that Allison Guyot (informally called "Navoceano" Guyot by Heezen et al., 1973) be drilled in the central portion of the chain (Figure 2), and either Menard or Ewing Guyot at the western end (Figure 3). Allison is almost certainly a drowned atoll with up to 0.7 sec of sediments trapped in a lagoonal type of structure (Figure 2). This will almost certainly require reentry. Menard and Ewing Guyots have thinner sediment caps, and altered volcanic rocks of island-type tholeiitic aspect were dredged from near the summit of Menard (Heezen et al., 1973; Natland and Wright, 1984, and unpublished; pers. comm. from Natland). These are each probably single-bit targets, one of which should be selected for drilling.

Another possibility for the western mid-Pacific Mountains is Darwin Guyot, for which good bathymetric survey data exist (Figure 4) (Ladd et al., 1974; Heezen et al., 1973) and a simple paleomagnetic history has been deduced (Harrison et al., 1975). However, the summit is tiny and may provide neither suitable spud-in characteristics nor a complete sedimentary history.

In the Wake group, we propose that Wilde Guyot (Figure 5) be drilled. Here, both mildly alkalic differentiated lavas, dated as Cretaceous by Ozima et al. (1977), and strongly under-saturated, quite fresh olivine-rich basanites were dredged. Some of the latter were embedded in Eocene pelagic chalk (Heezen et al., 1973), hence could represent a second wave of volcanism on this feature. This target we also propose for reentry. Similar petrological successions probably occur on Lamont and Miami Guyots based on the compositions of dredged rocks, and these should be surveyed as back-up targets.

Finally, we propose that Makarov (Figure 6 and 7) and Seiko Guyots (Figure 8) be drilled at either end of the Geisha Seamount chain. Multi-beam bathymetric data exist for much of this chain (Vogt and Smoot, 1984), and several of the seamounts have been dredged, yielding Cretaceous reef materials and alkalic lavas (Heezen et al., 1973). One lava from Seiko is dated at 103 Ma and another from Makarov at 94 Ma (Ozima et al., 1977). This suggests an age progression, but one too young given the more or less east-west orientation of the chain (the eastern end should be 100-110 Ma; Gordon, in press; Duncan and Clague, in press). Sites on these seamounts, which have fairly thin sediment caps, can probably be accomplished using single-bit holes.

Our general program, then, is for five principal targets, two of which require reentry drilling, the rest being single-bit holes. Our calculations indicate that this can be accomplished in 33 operational days if nothing goes wrong (Table 1). Allowing 14 and a half days for transit (Majuro-Tokyo), this would leave two and a half days (out of the nominal 51 allowed port-to-port) of contingency time for difficulties.

Site Survey Requirements

Apart from the Geisha Seamounts, none of our suggested targets or alternates has been swath mapped. None except possibly Allison ("Navoceano") has profiler coverage adequate to judge the sediment thickness on the summits of the volcanoes. The structure of the volcanoes and the distribution of reefs or late-capping volcanic rocks can only be determined using devices such as Seabeam, and modern computerized approaches to processing profiler records. The principal site survey requirements, then, are that all primary and alternate targets be properly mapped, and that digital single-channel profiler records be obtained to record sediment distributions.

The seamounts should also be dredged at different locations utilizing survey information to select dredge targets (flank rift zones, small summit knobs, cones, cratered regions, etc.). This will provide important petrological background for the drilling. Some piston coring should also be undertaken to provide surface sediments at the selected targets, and information about spud-in characteristics.

A magnometer should be towed during the bathymetric surveys to obtain data to model the magnetic fields of the volcanoes, and to determine which features should be targeted for deeper sampling of lavas. Presently, we project that the reentry targets will be Allison and Wilde Guyots, but some of the alternates may provide a better paleomagnetic record.

Recent evaluations of satellite data indicate important responses of the lithosphere to seamount loads, dependent in some measure on the age of the lithosphere when the seamounts formed. There will be a wide diversity of differences between seamount and lithospheric ages among the targets we have selected. A proper gravity survey of each should be carried out in conjunction with the bathymetric surveys, especially to evaluate the hypothesis that thermal resetting of the lithosphere may have occurred on a regional scale, and not just one around individual hot spots.

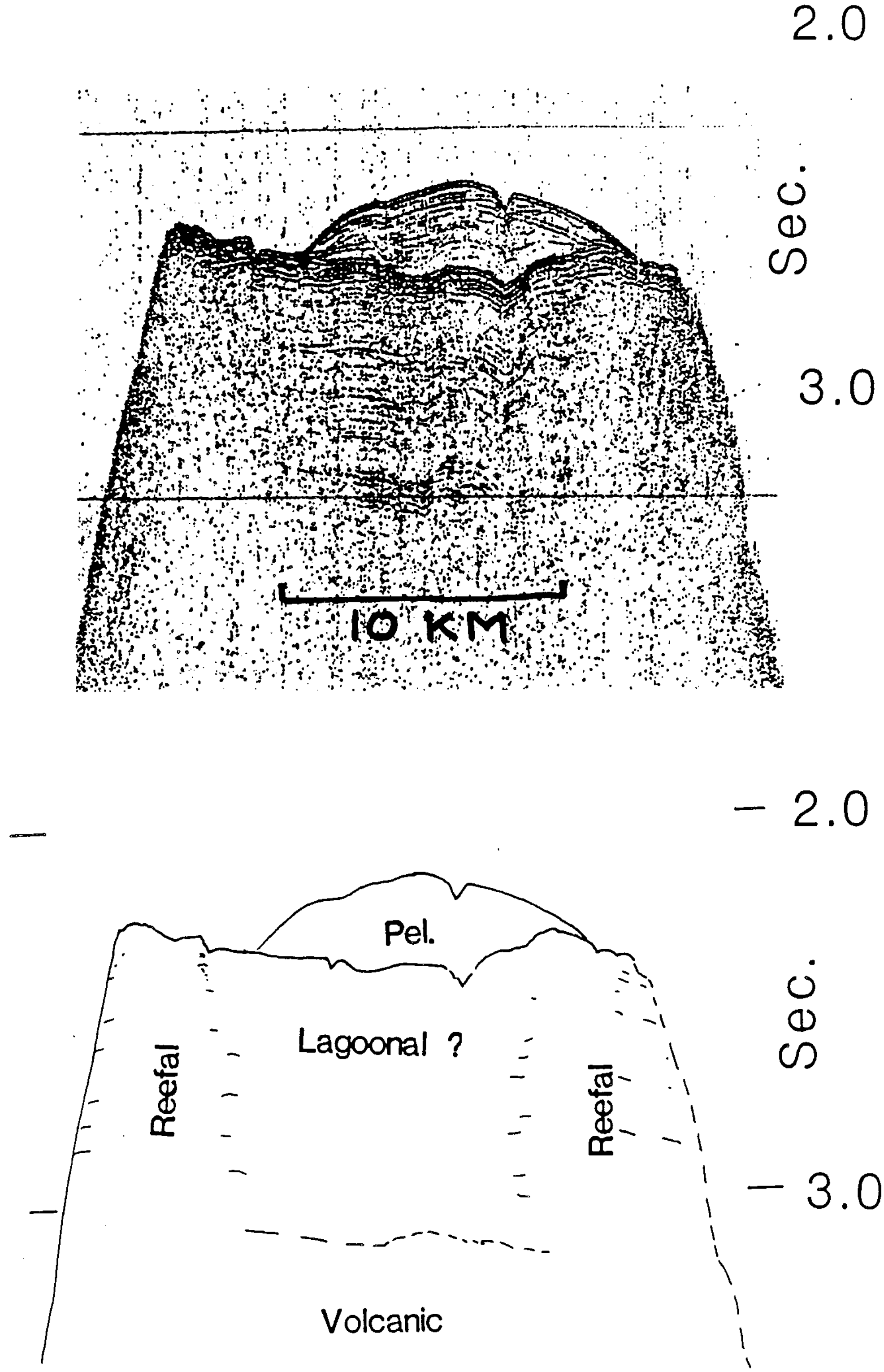

Figure 2. Seismic profile and interpretive line drawing of Allison Guyot.

TABLE 1

Time Estimates, Mid-Pacific Guyot Leg

Site	Location	Depth	Penetration	Reentry (R) or Single Bit (S)	Operations	Steaming Time	Cumulative Time
Majuro	7°10'N 171°20'E					0	0
Allison G.	18°30'N 179°25'W	1650m	∿1000m	R	10 d	3.7 days	13.7 days
Menard G.	20°45'N 173°25'E	1370m	∿700m	S	5 d	2.0 days	20.7 days
Wilde G.	21°40'N 161°55'E	1270m	∿700m	R	10 d	2.9 days	33.6 days
Makarov G.	29°30'N 153°30'E	1340m	∿300m	S	4 d	2.6 days	40.2 days
Seiko G.	34°15'N 144°10'E	1440m	∿300m	S	4 d	2.2 days	46.4 days
Tokyo	35°41'N 139°44'E					1.2 days	48.6 days
Contingency					2.4 d		51.0 days

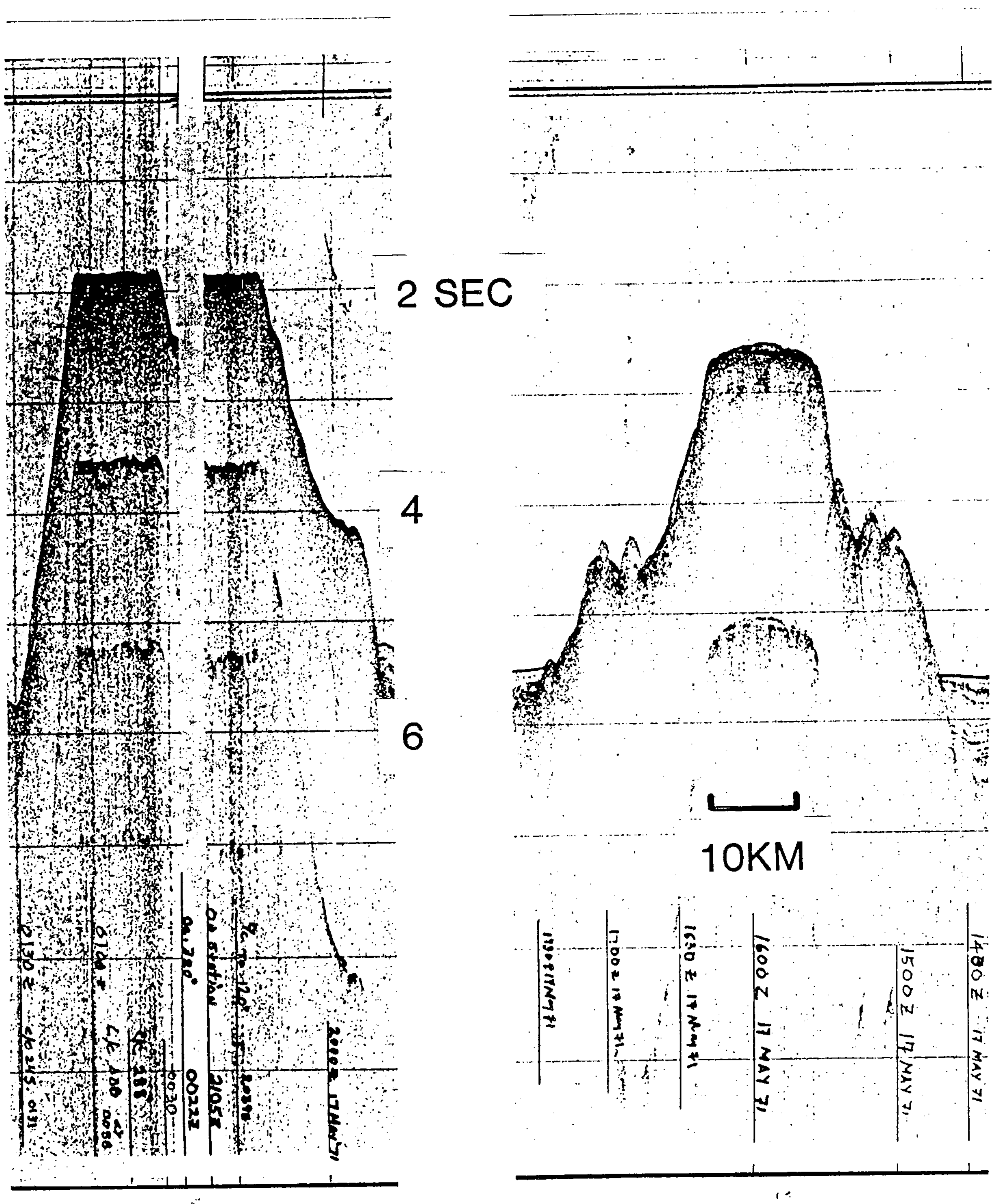

Figure 3. Seismic profiles across Menard Guyot (left) and Ewing Guyot in the western Mid-Pacific Mountains.

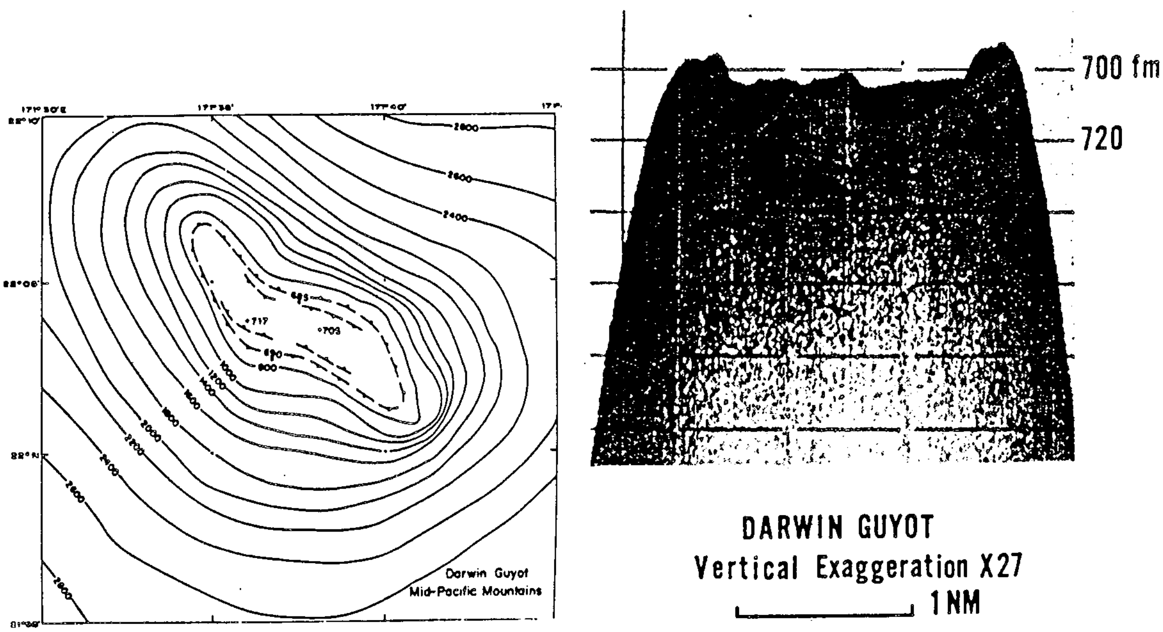

Figure 4. Bathymetric chart (left) and echo-sounding profile of Darwin Guyot. Note atoll rim. Shallow-water rudistid reef fossils were dredged from the summit (Ladd et al., 1974).

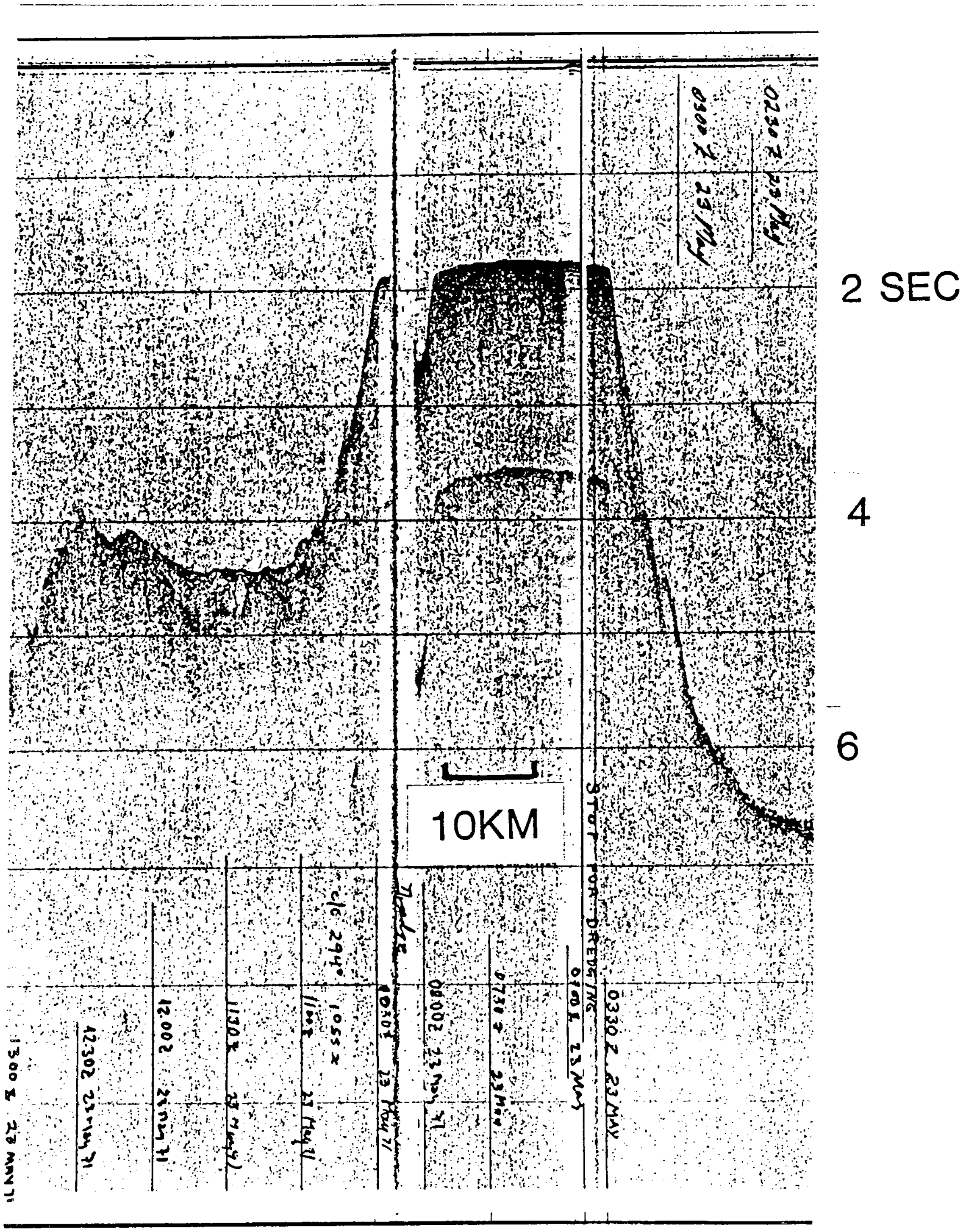

Figure 5. Wilde Guyot at the intersection of the Marcus-Wake and Marshall Seamount chains (Figure 1).

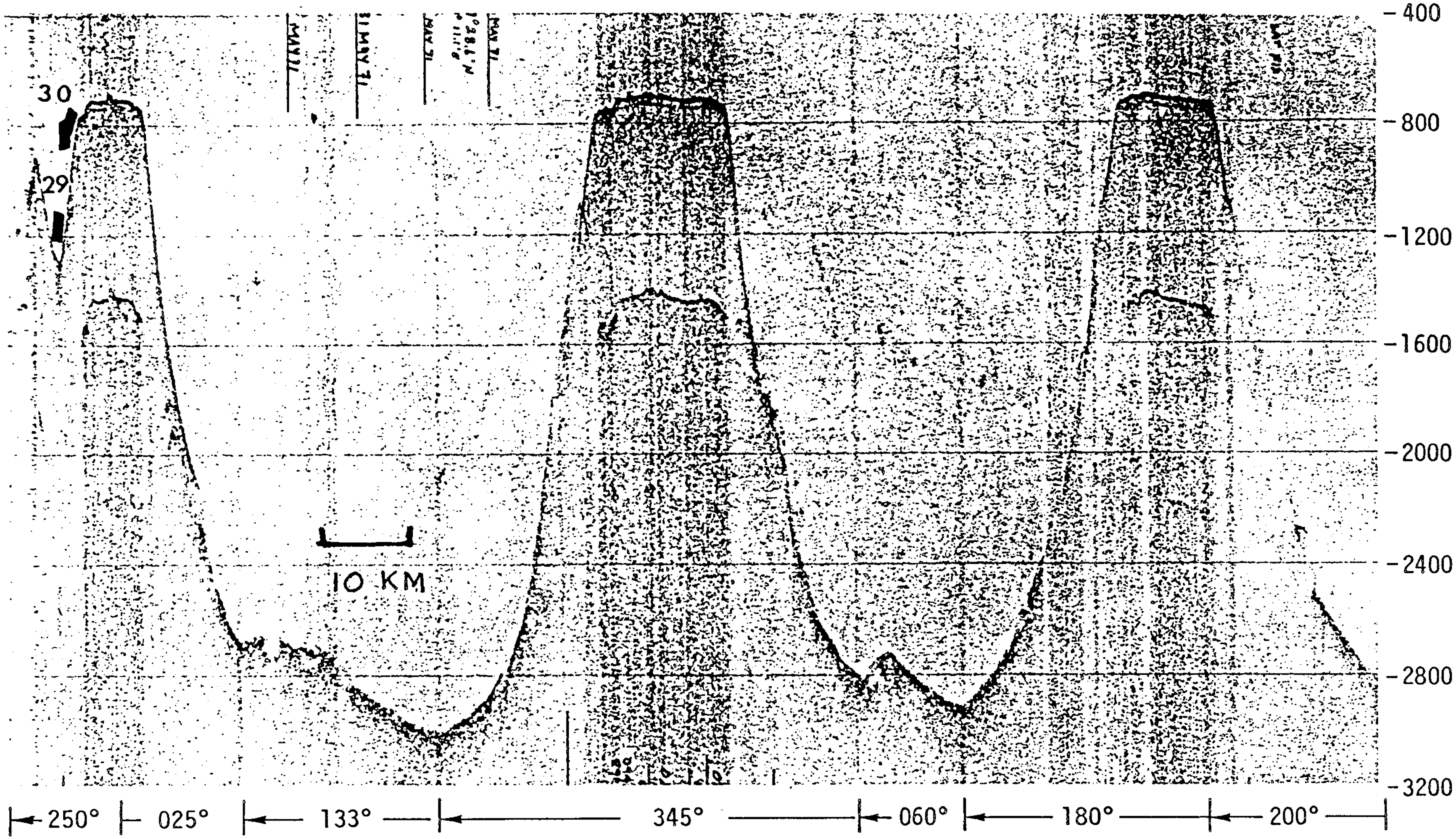

Figure 6. *Seismic reflection profiles of Makarov Guyot. Nephelene basalt was dredged at station 29 together with Upper Cretaceous phosphatized bioclastic breccias. Dredge 30 recovered Cenomanian-Senonian phosphatized bioclastic calcarenites containing molluscs.* From Heezen et al., 1973.

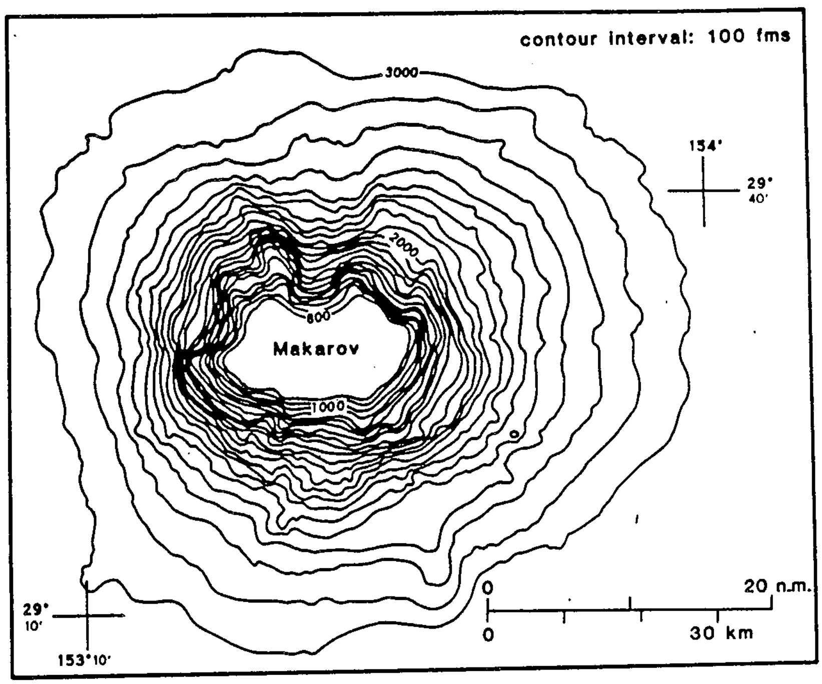

Figure 7. Seabeam bathymetric chart of Makarov Guyot. From Smoot.

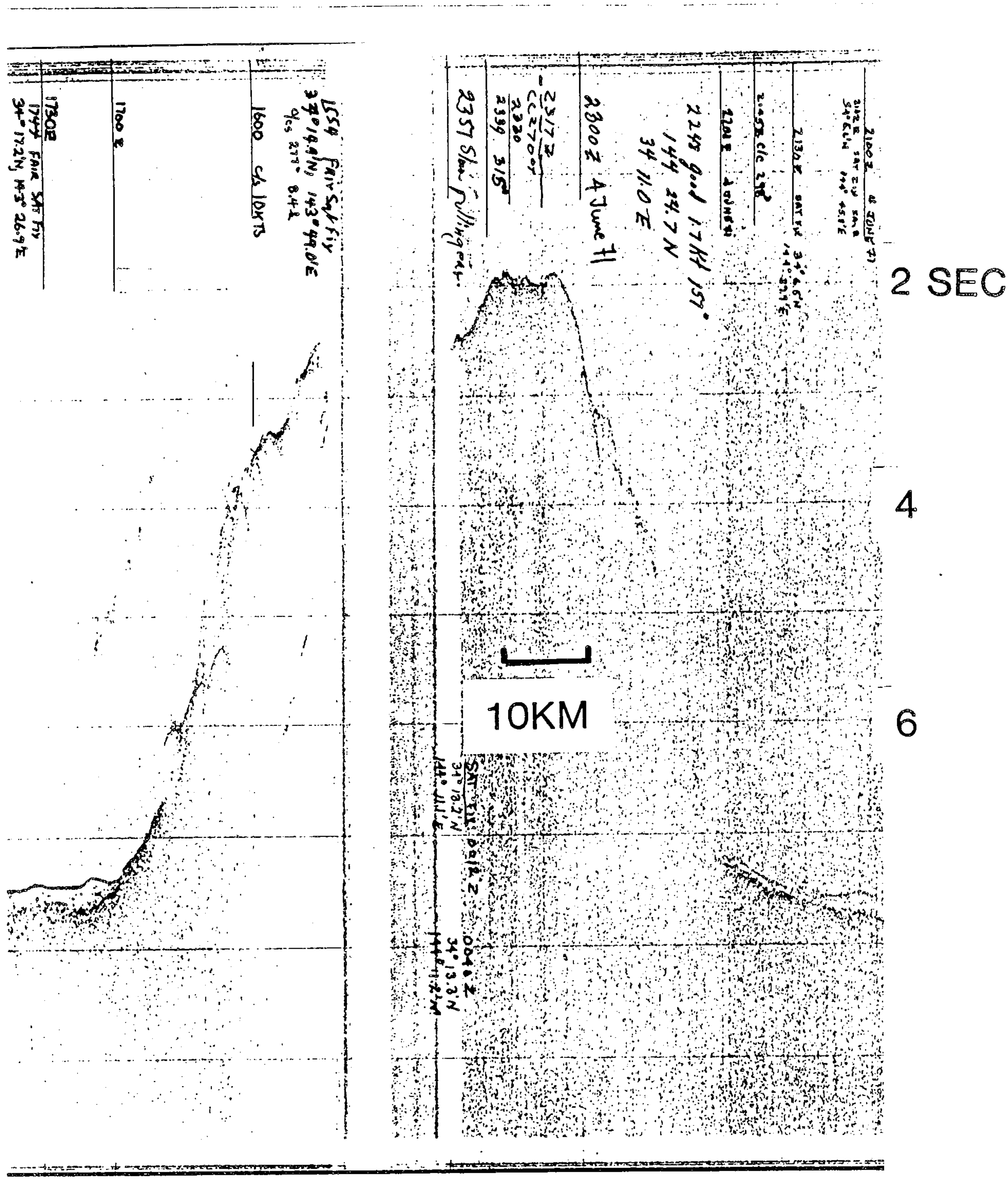

Figure 8. Seismic profile across Seiko Guyot.

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ODP SITE PROPOSAL SUMMARY FORM
(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: Allison Guyot

General Area: MidPac Mts., Cent. Pac.
Position: 18°30'N, 179°25'W
Alternate Site:

General Objective: Evolution & drowning of an Early Cretaceous atoll

Thematic Panel interest: Seds Oc. Hist.
Regional Panel interest: Cent. East Pacifi

Specific Objectives: -Date edifice-building volcanism
-Determine paleoaltitude history (horizontal trajectory) of seamount
-Determine rates of subsidence of atoll
-Determine timing and amplitude of sea level fluctuations
-Determine cause(s) of drowning

Background Information (indicate status of data as outlines in the Guidelines):
Regional Geophysical Data:
Seismic profiles: SIO Aries V (in Heezen et al, 1973)

Other data: Dating of fossils from other guyots in region in Hamilton, 1956
Ladd et al, 1974; Heezen et al, 1973; Matthews et al, 1974
Drilling: Horizon Guyot, DSDP Site 171-Winterer, Ewing et al, 1973;
Western Midpacs, DSDP Site 463-Thiede & Valher19

Site Specific Survey Data:
Seismic profiles:
SIO Aries V, 13 May 1971, 1100-2100 (in Heezen et al, 1973)

Other Data:

Operational Considerations:

Water Depth: (m) 1650 **Sed. Thickness:** (m) 900 **Tot. penetration:** (m) 1000

HPC ___ **Double HPC** ___ **Rotary Drill** X **Single Bit** ___ **Reentry** X

Nature of sediments/rock anticipated:
200m pelagic, 700m reefal, 100m basalt
Weather conditions/window:
Anytime
Territorial jurisdiction:
International waters
Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number:
E.L. Winterer, Scripps Inst. of Oceanography, A-012, La Jolla, CA 92093, (619)452-2360; James Natland, Scripps Inst. of Oceanography, A-031, La Jolla, CA 92093 (619)452-3538; William Sager, Texas A & M University, College Station, TX 77843-3469, (409)845-9828

FOR OFFICE USE:
Date received:
Classification no.:
Panel allocation:

*****ODP SITE PROPOSAL SUMMARY FORM*****
(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:	General Objective:
Menard Guyot	Evolution and drowning of an Early Cretaceous atoll
General Area: Western MidPac Mts., Cent. Pac. Position: 20°45'N, 173°25'E Alternate Site: Ewing Guyot	Thematic Panel interest: SOHP Regional Panel interest: CEP

Specific Objectives: -Determine cause(s) of drowning
-Date edifice-building volcanism
-Determine paleoaltitude history (horizontal trajectory) of seamount
-Determine rates of subsidence (& uplift) of atoll
-Determine timing & amplitude of sea level fluctuations

Background Information (indicate status of data as outlines in the Guidelines):
Regional Geophysical Data:
Seismic profiles: SIO Aries V (in Heezen et al, 1973)

Other data:

Site Specific Survey Data:
Seismic profiles: SIO Aries V, 1930/17 May 71-0130/18 May 71

Other Data: Dredges SIO Aries V, #12 & 15 from guyot flanks-takus.
Middle K reefal fossils
Upper K & Cen. planktonic fossils

Operational Considerations:

Water Depth: (m) 1370 **Sed. Thickness: (m)** ? 700m **Tot. penetration: (m)** 800

HPC ____ **Double HPC** ____ **Rotary Drill** ____ **Single Bit** X **Reentry** ____

Nature of sediments/rock anticipated: reefal limestone 0-700
basalt 700-800

Weather conditions/window: anytime

Territorial jurisdiction: International waters

Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent: Address & phone number:	FOR OFFICE USE:
E.L. Winterer, Scripps Inst. of Oceanography, La Jolla, CA 92093, (619)452-2360; James Natland, Scripps Inst. of Ocean., A-031, La Jolla, CA 92093, (619)452-3538; William Sager, Texas A & M Univ., College Station TX 77843-3469 (409)845-9828	Date received: Classification no.: Panel allocation:

ODP SITE PROPOSAL SUMMARY FORM

(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:

Miami Guyot (alternate to Wilde Guyot)

General Area: Wake Seamounts
Position: 21.7°N 161.9°E
Alternate Site: Wilde Guyot

General Objective:
History of reef growth and extinction; a...
compositions of volcanic rocks; subsidence history

Thematic Panel interest: LITHP, SOHP, Tectoni...
Regional Panel interest:

Specific Objectives: 1) Determine if Eocene (Marshall-Gilbert) alkalic volcanism covered Cretaceous reefs and lagoons; 2) core through any reef-lagoon facies; 3) core 200+ meters of Cretaceous basalts of they exist or can be reached

Background Information (indicate status of data as outlines in the Guidelines):

Regional Geophysical Data:

Seismic profiles: Aris Leg V (SIO) Survey; Figures 20B (chart) and 22C profiler record) of Heezen et al (1973)

Other data: near summit dredge haul recovered Eocene planktonic sediments and variously fresh or altered basanites

Site Specific Survey Data:

Seismic profiles: same as above

Other Data:

Operational Considerations:

Water Depth: (m) 1210 **Sed. Thickness:** (m) <100m observed in profiler record **Tot. penetration:** (m) 500+

HPC X **Double HPC** ___ **Rotary Drill** ___ **Single Bit** ___ **Reentry** X

Nature of sediments/rock anticipated: Nannofossil oozes and chalks; some cherts; limestone(?), alkalic basaltic rocks

Weather conditions/window:
good all year

Territorial jurisdiction:
International waters

Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number:
SEE SEPARATE SHEET

FOR OFFICE USE:
Date received:
Classification no.:
Panel allocation:

ODP SITE PROPOSAL SUMMARY FORM

(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: Wilde Guyot

General Area: Wake Seamounts
Position: 21°09'N 163°15'E
Alternate Site: Miami Guyot 21°43'N 161°53'E

General Objective: History of reef growth and extinction; ahes, compositions of volcanic rocks, subsidence history

Thematic Panel interest: LITHP, SOHP,
Regional Panel interest: Tectonics

Specific Objectives: 1) Determine if Eocene (Marshall-Gilbert) alkalic volcanism covered Cretaceous reefs and lagoons; 2) core through any reef-lagoon facies; 3) core 200+ meters of Cretaceous basalts, if they exist or can be reached.

Background Information (indicate status of data as outlines in the Guidelines):

Regional Geophysical Data:

Seismic profiles: Aris Leg V (SIO, 23 May 1971). Figure 21 of Heezen et al (1973).

Other data: SASS Bathymetry (unpublished; N.C. Smoot, pers. comm.). Dredges Aries V 19 & 20 recovered Eocene planktonic sediments and volcanics from near-summit flanks of seamount (>1380m). Lavas include mugearite and alkalic basalt. Mugearite (fresh) dated at 86 ± 2Ma (Ozima et al (1977).

Site Specific Survey Data:

Seismic profiles: Same as above

Other Data:

Operational Considerations:

Water Depth: (m) 1270 **Sed. Thickness:** (m) <200 observed in profile record **Tot. penetration:** (m) 500+

HPC x **Double HPC** ____ **Rotary Drill** ____ **Single Bit** ____ **Reentry** x

Nature of sediments/rock anticipated: Nannofossil oozes and chalks, some cherts, coralline limestone, alkalic basaltic lavas or differentiates

Weather conditions/window:

Territorial jurisdiction: International waters

Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number: SEE SEPARATE PAGE

FOR OFFICE USE:
Date received:
Classification no.:
Panel allocation:

ODP SITE PROPOSAL SUMMARY FORM

(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:

Makarov Guyot

General Area: Geisha Seamounts
Position: 29.5°N, 153.5°E
Alternate Site: Isakov Guyot

General Objective:
History of Createceous Reefs; date eastern end of Geishas

Thematic Panel interest: LITHP,SOHP,Tectoni
Regional Panel interest:

Specific Objectives: Core through pelagic sediment cap, through reef-lagoonal sediments and rocks, thence into igneous basement

Background Information (indicate status of data as outlines in the Guidelines):

Regional Geophysical Data:

Seismic profiles: Aries Leg V (SIO); 31 May 1971, Figure 28 of Heezen et al.

Other data: SASS Bathymetry, Vogt & Smoot (1984), Figure 3A. Alkalic olivine basalts, differentiates dredge from near-summit west flank of seamount. Dredges also brought up Createceous shallow-water facies (molluscs, echinoids, etc,) and Eocene planktonic sediments. Lava dated at 94±2 Ma; Ozima et al (1977).

Site Specific Survey Data:

Seismic profiles:
same as above

Other Data:

Operational Considerations:

Water Depth: (m) 1340 **Sed. Thickness:** (m) <100m from existing profiler records **Tot. penetration:** (m) 200-300m

HPC X **Double HPC** ___ **Rotary Drill** X **Single Bit** X **Reentry** ___

Nature of sediments/rock anticipated: Carbonate oozes, cherts(?), lagoonal carbonate sediments, mudstones; volcanic rocks

Weather conditions/window:
Good all year; possibly typhoons August-September (but a bit off track).

Territorial jurisdiction:
International waters

Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number: SEE SEPARATE SHEET

FOR OFFICE USE:
Date received:
Classification no.:
Panel allocation:

ODP SITE PROPOSAL SUMMARY FORM

(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:
Isakov Guyot (alternate to Makarov)*

General Area: Geisha Seamounts
Position: 31.3°N, 151.1°E
Alternate Site: Makarov Guyot

General Objective:
History of Cretaceous Reefs; date eastern end of Geishas

Thematic Panel interest: LITHP, SOHP, Tectoni
Regional Panel interest:

Specific Objectives:
Core through pelagic sediment cap, through reef-lagoonal sediments and rocks, thence into igneous basements
*has smaller summit than Makarov

Background Information (indicate status of data as outlines in the Guidelines):

Regional Geophysical Data:

Seismic profiles: Aries Leg V (SIO); June 1971, Figure 29 of Heezen et al (1973)

Other data: SASS bathymetry, Vogt & Smoot (1984), Figure 3B, bioclastic calcarenites (Cenomanian-Senonian) Lower Cretaceous radistad limestones & phosphorites in dredge, no volcanic rocks

Site Specific Survey Data:

Seismic profiles: same as above

Other Data:

Operational Considerations:

Water Depth: (m) 1340 **Sed. Thickness: (m)** <100m from existing profiler records **Tot. penetration: (m)** 200-300m

HPC X **Double HPC** ____ **Rotary Drill** X **Single Bit** ____ **Reentry** ____

Nature of sediments/rock anticipated:

Weather conditions/window:
Good all year; possibly typhoons August (but a bit off track)

Territorial jurisdiction:

Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number: SEE SEPARATE SHEET

FOR OFFICE USE:
Date received:
Classification no.:
Panel allocation:

*****ODP SITE PROPOSAL SUMMARY FORM*****
(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:
Seiko Guyot

General Area: Geisha Seamounts
Position: 34°15'N144°10'E
Alternate Site: Takuyo-daini Guyot

General Objective:
History of Cretaceous reefs; date western end of Geishas

Thematic Panel interest: LithP, SOHP, Tectonics
Regional Panel interest:

Specific Objectives:

Core through pelagic sediment cap, through reef-lagoonal sediments and rocks, thence into igneous basement.

Background Information (indicate status of data as outlines in the Guidelines):
Regional Geophysical Data:
Seismic profiles: Aries Leg V (SIO); 4 June 1971, Figure 34 of Heezen et al (1973)

Other data: SASS bathymetry, Vogt & Smoot (1984), Figure 3D. Dredged rocks include Cretaceous bioclastic calcarenites (molluscs, rudists, algal remain), chalks, phosphorites, trachgtic-mugearitic lavas, some volcanic sandstones-mudstones, lava dated at 104±4 Ma by Ozima et al (1977).

Site Specific Survey Data:
Seismic profiles:
Same as above

Other Data:

Operational Considerations:

Water Depth: (m) 1440 **Sed. Thickness: (m)** <100m based on present profiler records **Tot. penetration: (m)** 200-300m

HPC X **Double HPC** ____ **Rotary Drill** X **Single Bit** X **Reentry** ____

Nature of sediments/rock anticipated: Calcareous oozes, chalks, minor cherts, reefal calcarenites & limestone, basaltic basement

Weather conditions/window:
Good all year, possibly typhoons August-Sept.

Territorial jurisdiction:
International waters

Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number:
SEE SEPARATE SHEET

FOR OFFICE USE:
Date received:
Classification no.:
Panel allocation:

ODP SITE PROPOSAL SUMMARY FORM

(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site:

Takuyo-daini Guyot (alternate to Seiko)

General Area: Geisha Seamounts
Position: 34°15'N 143°50'E
Alternate Site: Seiko Guyot

General Objective:

History of Cretaceous reefs; date western end of Geishas

Thematic Panel interest: CithP,SOHP,Tectonic
Regional Panel interest:

Specific Objectives:

Core through pelagic sediment cap, through reef-lagoonal sediments and rocks, thence into igneous basement.

Background Information (indicate status of data as outlines in the Guidelines):

Regional Geophysical Data:

Seismic profiles: Aries Leg V (SIO)

Other data: SASS bathymetry Vogt and Smoot (1984)

Site Specific Survey Data:

Seismic profiles: same as above

Other Data:

Operational Considerations:

Water Depth: (m) 1450 Sed. Thickness: (m) ______ Tot. penetration: (m) 200-300

HPC X Double HPC ____ Rotary Drill X Single Bit X Reentry ____

Nature of sediments/rock anticipated: Nannofossil oozes, chalks; some cherts, reefal calcarenites & limestone, alkalic volcanic rocks

Weather conditions/window:

Possible typhoons Aug.-Sept. comparable to central Japan at other times (Jan.-Mar. can have rough seas).

Territorial jurisdiction:

International waters

Other:

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number:
SEE SEPARATE SHEET

FOR OFFICE USE:
Date received:
Classification no.:
Panel allocation:

PROPOSED WEST FLORIDA ESCARPMENT DRILLING TRANSECT

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Abstract

A Florida Escarpment drilling program will elucidate the geological and geochemical processes which form and modify carbonate continental margin edges. The drilling of a three-site east-west transect across the edge western Florida Continental margin at 26°02'N is proposed. The proposed sites are FE-1 to 300m about 100 meters away from the escarpment base, FE-2 1.5km west of the escarpment base on the abyssal floor, and a deep reentry hole at the top of the escarpment (FE-3 to >1200m). The objectives of the transect are to determine: 1) patterns of fluid circulation through the platform and rates of lateral exchange with seawater; 2) the diagenetic history of the platform edge as it relates to the patterns of fluid circulation; 3) the geologic record and effects of seafloor brine seepages from the platform, such as sulfide mineralization, the deposition of chemosynthetically-produced organic carbon-rich layers, and the erosion of the escarpments; 4) the stratigraphic development and facies succession across a ramping leeward carbonate margin.

This drilling program is recommended by the working group on Carbonate Banks and Atolls.

Introduction

Among the steepest large-scale features on the earth are the edges of carbonate continental margins, such as the Bahama, Florida and Yucatan Escarpments (Fig.1). Here average slopes are known to exceed 40° for over a kilometer of vertical extent. The overall topographical relief between bank and basin results from differential accumulation rates between the shallow carbonate platform and the adjoining deep basin. As the region subsides, the platform remains in the productive photic zone while the basin gets deeper. The early morphology of these margins and the Florida Escarpment specifically may have been influenced by the presence of reefs (Ewing et al., 1966; Antoine et al., 1967; Uchupi and Emery, 1968; Bryant et al., 1969), but the existing data suggest that their present morphology results from significant post-depositional modification by erosion and escarpment retreat. (Paull and Dillon et al., 1980; Freeman-Lynde et al., 1981; Dillon et al., 1981; Corso, 1983; Freeman-Lynde, 1983; Schlager et al., 1984; Freeman-Lynde and Ryan, 1985; Corso and Buffler, 1985). Most of these escarpments in this region appear to have undergone at least 1 to 5km of basal retreat, exposing platform interior facies on their present-day faces.

Unresolved is the question of the processes which cause the erosion of these steep carbonate margins. Chemical, physical and biological forces have affected these exposed platform edges since their initial formation over 100 million years ago. The Florida Escarpment steepens with depth and lacks a rise prism or even significant basal talus deposits (Holmes, 1984); thus, any erosional mechanisms proposed must explain why the slopes steepen with depth and why such escarpments occur only along carbonate regions.

The strata of the west Florida Slope consist of flatlying subsided water Aptian to Cenomanian carbonates which are overlain by deep water sediments. At 26°N, the face of the Florida Escarpment between 2 to 3km depth is steep (~45°) (figures 1-3) and alternates between near vertical outcrops of jointed horizontally-bedded limestones and intervening, more gently sloping sediment drapes (Maher, 1971; Mitchum, 1978; Freeman-Lynde, 1983; Paull et al., in prep.). The basal escarpment is buried by the rapidly accumulating relatively impermeable hemipelagic sediments of the distal Mississippi fan. Above 1.5km depth, the scarp's face becomes less steep and the Cretaceous strata are capped by prograded Tertiary shelf sediments. Free exchange and circulation may occur between seawater and the platform pore fluids along the exposed escarpment face between 1.5 and 3.2km depth.

Ground Water Circulation in the Florida Platform

The patterns of fluid circulation within the Florida Platform are known to involve considerable lateral advective flow and horizontal exchange with seawater at the edge of the platform (Kohout, 1967; Fanning et al., 1981). In the upper kilometer of the platform there is a thermohaline circulation system where the circulating fluids consist of mixtures of meteoritic water and seawater which are being driven by recharge and geothermal heat. The circulation patterns at greater depths are not well understood; however, the Florida Platform is filled at depths of >2km with a dense brine (Manheim and Horn, 1968), and brines are known to be discharging from the platform at the base of the Florida Escarpment (Paull et al., 1984). The brines within the platform are denser than the seawater at the edge of the platform, and a later hydraulic head exists between the platform interior brines and the Gulf bottom waters which will drive brine out of the platform. Presumably, seawater must enter the platform at higher levels to replace the exiting fluids. Thus a two-cell circulation system is envisioned at the edge of the platform where seawater enters along the face of the exposed escarpment and either mixes with brines and sinks, or mixes with fresh waters and is heated and rises.

Seeps and Brine Corrosion Along Carbonate Escarpments

Origin. Communities of abundant organisms similar to those that surround the hydrothermal vents of the East Pacific Rise were recently discovered via the submersible ALVIN at the base of the Florida Escarpment in the abyssal Gulf of Mexico (Spiess et al., 1980; Hessler and Smithey, 1984; Paull et al., 1984; Hecker, 1985). They occur at a depth of 3266m directly at the contact between the flatlying, relatively impermeable, clay-rich sediments of the distal Mississippi fan, which fills the abyssal Gulf of Mexico, and the jointed, potentially impermeable limestone at the basal escarpme (Figure 1b). These organisms are nourished by a chemosynthetic food chain that starts with the bacterially-mediated oxidation of reduced inorganic compounds. Relative to seawater, the pore waters collected from the upper few cm of these sediments show a 33% enrichment in Cl^-, lower SO_4^{-2}, and significant concentrations of NH_4^+, and have the distinct smell of H_2S when fresh (Paull et al., 1984). Both H_2S and NH_4^+ are chemosynthetic compounds (Jannasch, 1984).

The elevated salinities and sharp geochemical gradients in the pore waters suggest that the fluid is seeping from the adjacent carbonate platform. Formation waters sampled in bore holes at a similar depth within the platform under Florida contain fluids with up to 250 gm/kg dissolved solids, temperatures up to 115°C, and high concentrations of H_2S (Kohout, 1967; Manheim and Horn, 1968). The host limestone, dolomite and anhydrite are similar in age and lithology to the rocks exposed on the face of the Florida Escarpment as well as the Blake-Bahama Escarpment (Maher, 1971; Sheridan et al., 1979; Dillon et al., 1979; Dillon et al., 1981; Freeman-Lynde et al., 1981; and Freeman-Lynde et al., 1983). A highly saline aquifer, charged with reduced inorganic compounds, underlies the northern Florida-Bahama Platform (Manheim and Horn, 1968; Manheim and Paull, 1981) and may extend beneath the entire platform. The chlorinity of pore fluid collected at the seeps indicate a mixture of 6% formation brines and 94% seawater, and is denser than seawater.

Elemental, pyrite and organic sulfur $\delta^{34}S$ values from the black seep sediments were measured to determine the source of the seep sulfur; they range from 4.5 to $11.2^0/00$. Mesozoic anhydrite deposits within the Florida-Bahama Platform have $\delta^{34}S$ values ranging from 12.8 to $16.4^0/00$ (Claypool et al., 1980). Dissolution of the anhydrite could provide a continuous supply of sulfate to the platform pore fluids, which is then available for sulfate reduction. The similarity in the $\delta^{34}S$ values of the sulfur in the deep sea sediments and in the platform anhydrites suggests that the anhydrite may be the ultimate source of the seep sulfide.

Erosive Effects

Acidic conditions may exist locally wherever pore fluids that contain sulfides seep from the platform. In the presence of oxygenated seawater, the hydrogen sulfide carried in the seeping fluids is rapidly oxidized,

$$HS^- + 2O_2 // SO_4^{-2} + H^+$$

producing acid which is available to react with the escarpment limestones.

The effects of active strong corrosion at the known seeps are clear. The rocks in the vicinity of the seeps, unlike all other strata from the escarpment, are not MnFe coated but rather have extensively pitted and corroded surfaces. Only at the seep sites do undercut ledges and open vertical fissures occur. The drape of fine sediment which covers the escarpment elsewhere is missing at the seep sites. Smear slide analysis shows that the seep black sediments contain essentially no calcareous nannofossils, and only rare heavily etched and pyritized foraminifers. Here the carbonate material is >95% locally derived mussel shell hash which is also heavily corroded and pyritized.

The amount of escarpment corrosion associated with brine seepage is related to the flux of hydrogen sulfide carried in brines to the oxygenated seafloor from the adjacent platform. One molecule of carbonate could be dissolved for every molecule of hydrogen sulfide that arrives at the oxygenated interface, but chemosynthetic organisms and sulfide mineralization also compete for the sulfide and can, in the process, produce acid as well. Because the production of acid is confined to the interface between rock and oxygenated seawater, the erosive efficiency of the seeps may be high. Although seeps may occur wherever permeability conduits emerge at the escarpment face, observations from ALVIN indicate that they are concentrated in the first two meters above the base of the escarpment.

Temperature profiles measured in deep bore holes (>1km) in Florida show temperature reversals and values well below the normal geothermal gradient as a result of advection and horizontal exchange with abyssal Gulf of Mexico seawater (Kohout, 1967). In places, this carbonate platform is known to have cavernous porosity and enormous bulk permeability (Kohout, 1971), which may allow significal amounts of advective flow deep within the platform.

The sulfide concentrations in these brines is not known and may be quite variable. A range from 2 to 200 mg/liter is typical for sulfide concentrations in the subsurface carbonates which rim the Gulf of Mexico but much higher concentrations and even sulfide-gas fields occur in some areas (Beebe, 1968; Back and Hanshaw, 1970; Orr, 1975; Rye et al., 1981). If significant amount of HS^- exit the edges of the platform, large amounts of limestone could be dissolved. Corrosive effects concentrated at the base of the slope can certainly be perceived to exert a significant control upon the morphology of the entire margin. However, to evaluate the actual effects, we need to determine the present flux of sulfides from the platform.

Potential Model for Chemosynthetic Hydrocarbons

The seep sediments contain up to 8% organic carbon which is extremely high for your abyssal sediment. Presumably, most of this organic matter is not derived from surface photosynthesis, but is locally produced through chemosynthesis. Reduced inorganic compounds (such as HS^- and NH_4^+), which are advected to the oxygenated seafloor, are used by bacteria as an enewrgy source for the production of organic carbon (Jannasch, 1984). The amounts of organic material buried at seep sites can be estimated assuming the observed geometry of the known seep deposits (~10m wide and occurring along ~1/3 of the escarpment base for 1km of escarpment face), organic carbon content of 5%, bulk sediment density of 2 gms/cm^3, and a sedimentation rate of >1m/10^3 years (Leg 96 Scientific Party, 1984). Thus 6.6 x 10^3 metric tons of organic carbon will be buried per km of escarpment face in 10^3 years. If the seeps have been active for 50 million years, then 1.7 x 10^{7}m^3 of organic carbon will line the unconformity between the platform limestones and the abyssal sedimewnts along this km of escarpment face. The potential existence of chemsynthetically generated hydrocarbon deposits merits examining the geological record of these immature deposits to evaluate and refine this model.

Potential Model for Sediment Hosted Sulfide Deposits

The black sediments at the known seeps contain 38% iron sulfide minerals and have an outcrop pattern (Paull et al., 1984) which suggests that a blanket of sulfide minerals is being deposited directly at the contact between the buried escarpment limestones and the accomulating abyssal sediments. Similar brines are believed to be the ore-forming solutions for some sediment-hosted sulfide deposits (Sverjensky, 1984). Although the sulfide minerals at the known seep sites do not contain economically important metals, the seeps remain a viable model to explain the origin of some ancient deposits which do have economically important metals (Gustafson and Williams, 1981; Hanor, 1979; and White, 1981). The source of the Fe is not clear; it may originate from clay diagenesis in the hemipelagic sediments, from dissoultion of carbonates in the platform, or both.

Seep Biochemistry

Isotopic ratios in tissues of organisms and in the organic fraction of the underlying sediments were measured to determine the origin of the local food chain (Rau and Hedges, 1979). The tissues have extremely negative δ13C (-42 to -77 0/00 PDB) and δ15N (-2.72 to -9.34 0/00 air) values. Such highly fractionated carbon and nitrogen isotopes are unknown in food chains based on photosynthesis, suggesting that these communities are chemosynthetic (Paull et al., in press). The reactions responsible for this extreme fractionation are unknown. More than one type of chemsynthetic process may be occurring because the average tissue $\delta^{13}C$ values vary by 21.6 0/00 between the mytilids and vestimentiferans. The tissues of these animals contain significant amounts of ^{14}C (~60% modern), so the source of this fractionated carbon is not predominatly fossil methane.

The following model is proposed to explain both the ^{14}C and the $\delta^{13}C$ values. First, ambient DIOC is fixed as the tissue carbon of chemosynthetic bacteria which utilize either the sulfide or ammonium in the seeping pore fluids as an energy source. Some of this organic carbon is incorporated in the sediments which are bathed in the advecting pore fluids. In the reducing environment of the shallow subsurface methanogenic bacteria may actively reduce organic matter to biogenic methane. The resulting methane would contain ^{14}C concentrations approximately equal to those of seawater DIOC, $\delta^{13}C$ values of -60 to -90 0/00 PDB, and would be available for methylotrophic assimilation (Large, 1984). This scenario requires efficient recycling of organic carbon within the seep environment, active methanogenesis in the organically-rich reduced black sediments, and a succession in the types of reduced compounds being used as energy sources by chemosynthetic bacteria at the seeps. To clarify these problems we need to measure the isotopic composition of the available CO_2, CH_4, NH_4^+, and HS^- in the platform waters and determine the flux of these fluids.

Diagenesis

The rates and processes of carbonate diagenesis are clearly effected by the types of fluids and by its circulation patterns. The various ocean drilling projects have supplied valuable data and samples of deep-sea carbonates which have vastly increased the understanding of deep-sea diagenetic processes (Manheim and Sayles, 1974; Baker et al., 1982; Stout, 1985). To date, the sites which have been studied come from deep-sea environments where fluid migration can be simplified to a one-dimensional effect which occurs at diffusive rates. However, a significant proportion of the world's carbonates (particularly those which are of economic importance because of their frequent association with petroleum), were deposited in shallow-water environments and have experienced the ewffects of considerable advective circulation of pore-waters which vary in composition from fresh water to brines. At present, little is known about the rates and types of fluids which circulate within carbonate platforms, and the effects of these fluids on the rates and processes of diagenesis (Runnels, 1969; Halley et al., 1983) of the rocks and the generation of porosity and permeability of the platform (Schmoker and Halley, 1982).

The edge of the Florida Escarpment is a natural laboratory to study the "plumbing" of a carbonate bank. Here over a kilometer of shallow water carbonate sediments are exposed by erosion along the face of a ~45° cliff and effected by two distinct circulation systems occurring. By drilling a single deep hole through the entire Cretaceous sequence which is windowing at the edge of the platform, the circulation within the platform and its effects on the strata can be determined.

Proposed Leg

Three sites are proposed (Figs. 1 and 3) as an Ocean Margin Drilling Program Leg. The objectives of this leg form a geographically and scientifically coherent package, which addresses the problem of the "plumbing" systems of carbonate continental margins and their influence on diagenesis of carbonates, the formation of chemosynthetic organic carbon deposits and the formation of sedimentary metal sulfide ore deposits. If necessary, the proposed leg could be split into two sublegs; in each of which many of the scientific objectives could be fulfilled.

Proposed Site FE-1 (26°02'N84°55'W). FE-1 will be located in 3120 meters of water approximately ~100 meters from the base of the escarpment (Figs. 1-3), in the area where active brine seepages are known. In this hole we expect to encounter up to 100 meters of rapidly accumulating hemipelagic sediments of the distal Mississippi Fan before penetrating ~100 meters into the Cretaceous limestones of the buried escarpment. The objectives of this hole are: 1) To sample the pore-fluids in the limestones as they should be representative of those which exit the platform at the escarpment base, and 2) to determine the nature of the sulfide-rich sediments which overlie the unconformity.

We estimate that FE-1 will take ~4.5 days (105 hours) to drill a 300 meter TD; based on it being a single-bit hole 3200 meters of water (1 trip ~ 15 hours), a drilling rate of 5 meters per hour (60 hours) and a wire time per core of one hour (30 hours).

Proposed Site FE-2 (26°02'N84°56'W). FE-2 will be located in 3150 meters of water about 1.5 kilometers west of the base of the Florida Escarpment (Figs. 1-3). Seismic profiles (Fig. 3) indicate about .5 seconds of hemipelagic sediments (~450 meters) overlie the former escarpment face at this site. Here the objectives are: 1) to determine the facies of the strata beneath the unconformity, 2) to sample the pristine pore fluids of the platform, and 3) to sample the sediments and rocks of the unconformity itself.

Drilling into the Mesozoic sediments which are 1.5km seaward of the escarpment base will enable assessment of the amount of erosion which has occurred to the escarpment. Seismic reflections (Fig. ?) from beneath the onlapping abyssal sediments are complicated and reveal crosscutting reflectors (too deep for gas-hydrates) which may result from either Mesozoic fore-reef or rise prism sediments, or from a very irregular face of the buried former escarpment face. If they are fore-reef sediments, then the amount of basal erosion which could have occurred to the escarpment would be constrained to less than 1.5km. These units may be platform interior sediments which would be the oldest sampled locally and would indicate that considerable erosion has occurred and the toe of the former platform is further seaward.

The pore fluids in the Mesozoic strata beneath the relatively impermeable hemipelagic sediments of the distal Mississippi Fan have been isolated from advective exchange with Gulf of Mexico seawater for long enough to have come to equilibrium with the pristine platform interior fluids at that depth. Sampling of these fluids will give the compositional end limits for the fluid circulating within the platform.

If seepages of brines from the platform have been occurring at this site for geologically-long periods of time, the sediments which line this passive margin unconformity may document the history of the seeps and establish the potential importance of continental margin seep sites as models for sulfide mineralization and chemosynthetic hydrocarbon accumulation.

We estimate that FE-2 will take ~ 7.5 days (168 hours) to drill to a 500 meter TD; based on it being a double-bit hole 3200 meters of water (2 trips = 30 hours), a drilling rate of 5 meters per hour (100 hours) and a wire time per core of one hour (50 hours).

<u>Proposed Site FE-3</u> (<u>26°02'N84°54'W</u>). FE-3 is located in 1700 meters of water immediately east of the break in slope which corresponds with the junction between the erosionally exposed Cretaceous shallow-water limestones and the prograded Tertiary slope sediments. Except for a 10 to 100 meter thick drape of Tertiary sediments, the entire well will be in limestones of shallow-water facies. The objective is to drill through the entire section which windows at the face of the escarpment (>100 meters) to determine: 1) the circulation patterns of fluids in and out of the platform, 2) the total fluxes of the circulating fluids, 3) the geological controls on the paths of the circulation, 4) the diagenetic effects of the different types of circulation on the strata, and 5) to determine the stratigraphy and facies of the platform.

We estimate that FE-3 will take ~ 23.4 days (561 hours) to drill to a 1200 meter TD; based on it being a single-bit hole 1800 meters of water; 7 bits at 15 hours per trip (105 hours), six reentries at 6 hours each (36 hours), a drilling rate of 4 meters per hour based on the the results of drilling in similar limestones on Leg 77 (300 hours) and a wire time per core of one hour (120 hours). We would require some additional time (2.5 days) for downhole logging.

<u>Logistics</u>

FE Sites 1, 2, and 3 are all close together and lie only ~ 120 nautical miles from the Tampa Harbor entrance. The total transit time for a Tampa to Tampa leg would be less than two days. This would require a full 40-day leg.

Site Surveys

The USGS has several 20 kilijoule sparker profiles in this area. Deep-Tow Survey will be conducted in 1986 which will further clarify the exact sites and identify a terrace on which to drill FE-3.

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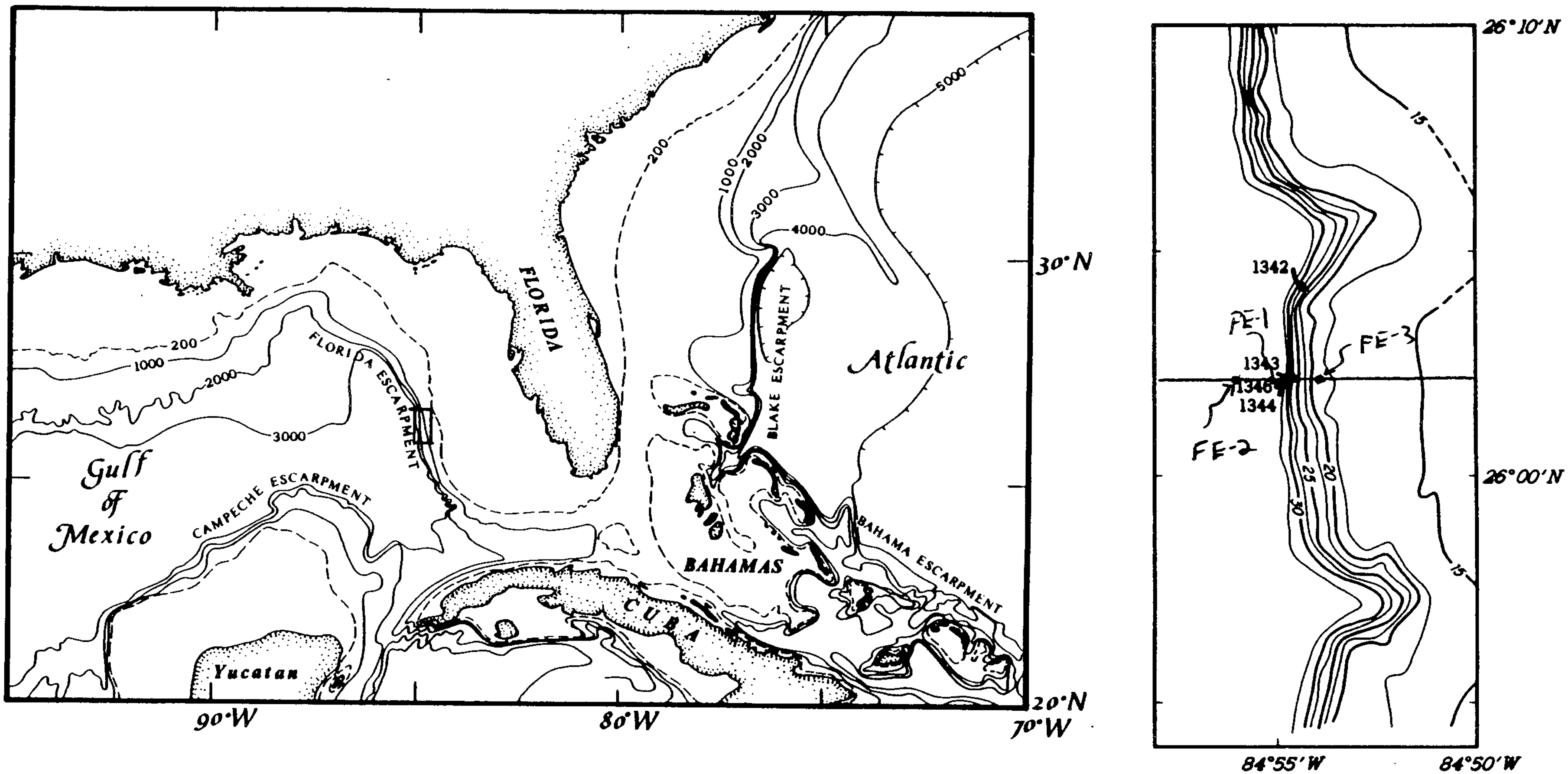

Figure 1A Bathymetry of carbonate provinces off S. E. North America indicating the location of major carbonate escarpments. Area of Florida Escarpment covered in Figure 1B is indicated. Figure 1B Detailed bathymetry of the Florida Escarpment showing the location of proposed drill sites, ALVIN dive sites in which seeps were encountered, and location of seismic profile shown in figure 3.

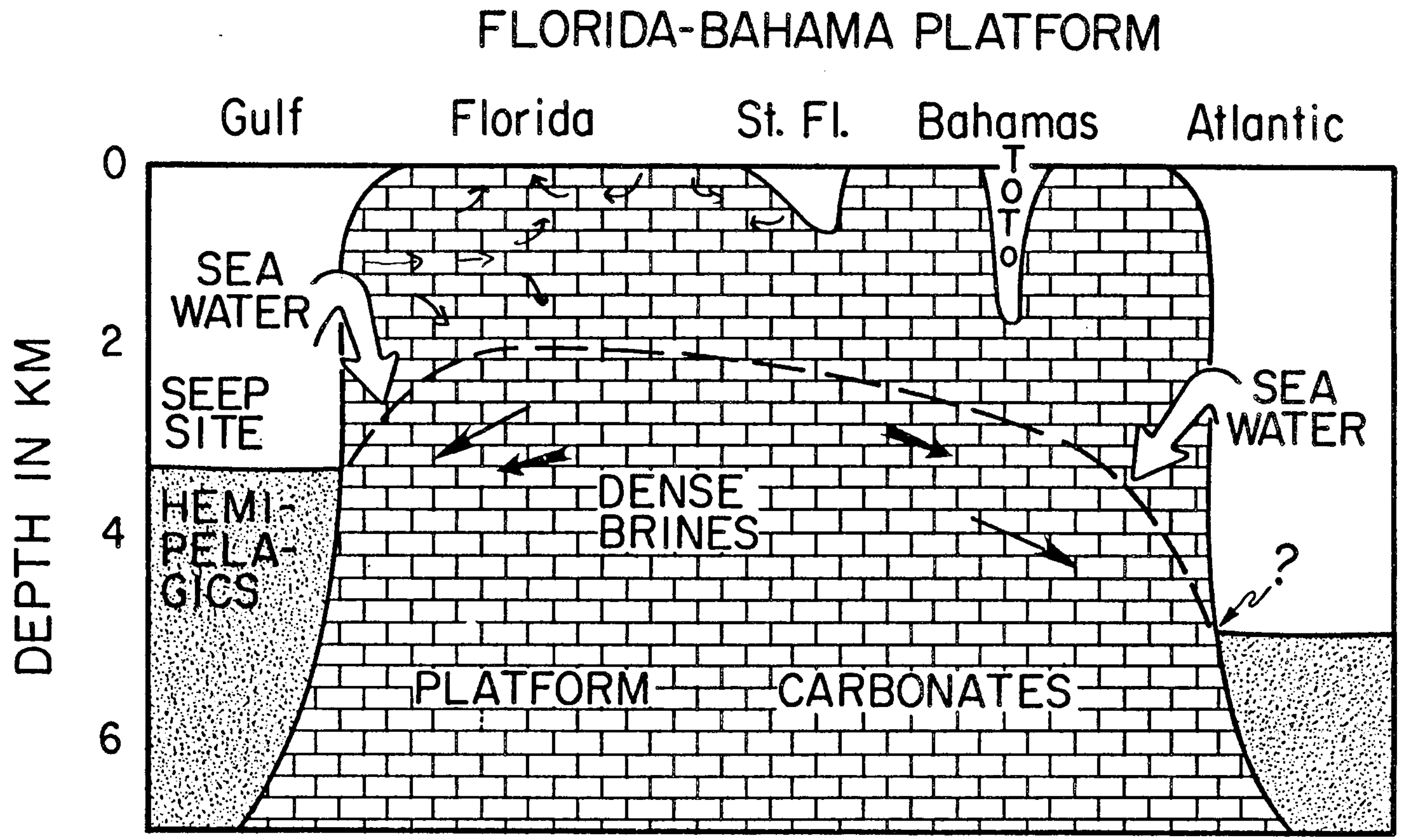

Figure 2 Cartoon of the circulation of fluids which is envisioned to occur deep within the Florida-Bahama platform. Section is East-West at ~ 26^0 N. The level of the brines is known in bore holes under Florida (Manheim and Horn, 1967). At shallower levels within the platform (>1 km) there is another circulation system involving exchange and mixing between fresh and seawaters (Kohout, 1967; Fanning et al., 1981).

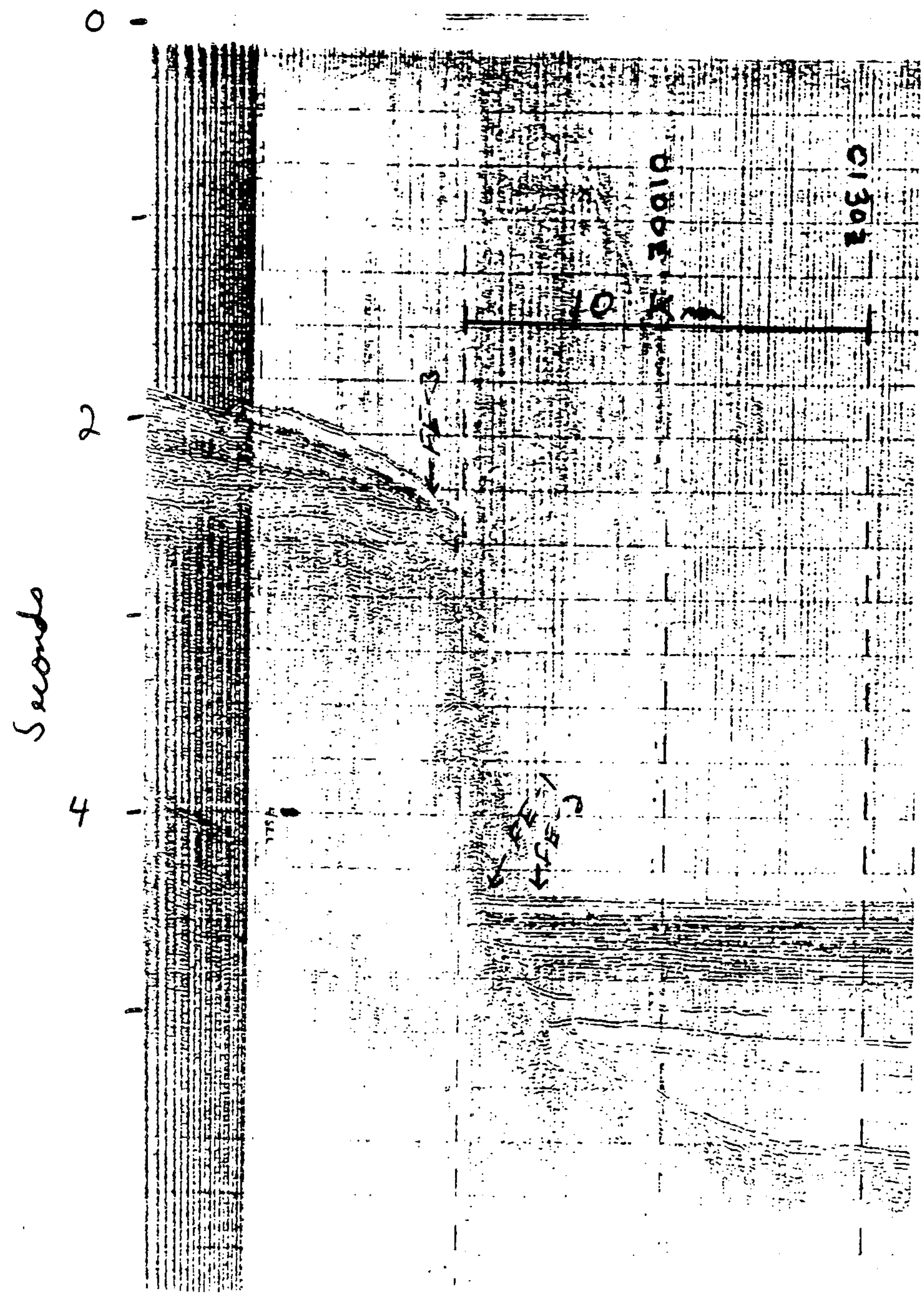

Figure 3 Seismic reflection profile across the Florida Escarpment. The face of the scarp is seen to continue beneath the hemipelagic sediment. Proposed drill sites are indicated. Profile was collected with a 30 KJ sparker by the USGS with the NORDA system on the RV/ Lynch.

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: FE-1 (Florida Escarpment 1)

General Area: Gulf of Mexico
Position: 26° 02' N 84° 55' W
Alternate Site: 26° 04' N 84° 55' W

General Objective:

Sample saline seeps and their associated chemosynthetic organic carbon and sulfide mineral rich sediments.

Thematic Panel interest:
Regional Panel interest:

Specific Objectives:

Sample the fluids, basal organic matter-rich and sulfide mineral-rich sediments, and the buried limestones at the base of the Florida Escarpment in an area of active continental margin brine seepage and chemosynthetic communities occur.

Background Information:
Regional Data:
Seismic profiles: Regional multichannel seismic reflection coverage collected by the University of Texas. Sparker profiler survey of this area by the USGS (figure 3).

Other data: 1984 ALVIN diving at the site (figure 1B). GLORIA data.

Site Survey Data - Conducted by:
Date:
Main results: The sites will be surveyed in 1986 with the SIO Deep-Tow. Additional seafloor sampling will be done with ALVIN in 1986.

Operational Considerations

Water Depth: (m) 3200 m Sed. Thickness: (m) 300 m Total penetration: (m) 300 m

HPC ____ Double HPC X Rotary Drill X Single Bit X Reentry ~~no~~

Nature of sediments/rock anticipated: Holocene hemipelagic clays (50 to 100 m), seep deposits at unconformity (10 m), and unconformity into Lower Cretaceous limestones.

Weather conditions/window:

Territorial jurisdiction: United States waters.

Other:

Special requirements (Staffing, instrumentation, etc.)

Sampling and analyzing anoxic pore waters to preserve samples for organic geochemistry. Logging.

Proponent: C. Paull
M. Kastner
A. C. Neumann

Date submitted to JOIDES Office:

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

r posed Site: FE-2 (Florida Escarpment 2)

General Area: Gulf of Mexico
Position: 26° 02' N 84°56' W
Alternate Site: 26° 04' N 84°56' W

General Objective:
Drill through the buried unconformity at the the base of the Florida Escarpment and sample fluids and strata.

Thematic Panel interest:
Regional Panel interest:

Specific Objectives:

1. Sample the geological record of sulfide seepages and the associated chemosynthetically produced organic matter rich sediments.
2. Establish the facies of the units in the buried lower escarpment to asses the amount of erosional retreat that the escarpment has undergone.
3. Sample the pore fluids in the sediment sealed escarpment.

Background Information:
Regional Data:
Seismic profiles: Regional multichannel seismic reflection coverage by the University of Texas. Sparker surveys of the USGS (figure 3).

Other data: The sites will be survey with the SIO Deep-Tow in 1986.

Site Survey Data - Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 3225 m   Sed. Thickness: (m) 600 m   Total penetration: (m) 600 m

HPC _____   Double HPC _____   Rotary Drill _____   Single Bit _____   Reentry _____

Nature of sediments/rock anticipated: Holocene and Pleistocene hemipelagic silts and clays (400 to 500 m), unconformity sediments (10 m), and limestones (100 to 200 m).

Weather conditions/window:

Territorial jurisdiction: United States waters.

Other:

Special requirements (Staffing, instrumentation, etc.)
Sampling and analyzing anoxic pore waters to preserve samples for organic geochemistry. Logging.

Proponent: C. Paull
M. Kastner
A. C. Neumann

Date submitted to JOIDES Office:

ODP SITE PROPOSAL SUMMARY FORM
(Submit **5 copies** of mature proposals, **3 copies** of preliminary proposals)

Proposed Site: FE-3 (Florida Escarpment 3)

General Area: Gulf of Mexico
Position: 26° 02' N 84° 54' W
Alternate Site: 26° 04' N 84° 54' W

General Objective:
Determine the patterns and rates of fluid circulation into and out of a major carbonate platform, and its effect on the diagenesis of shallow water carbonates.

Thematic Panel interest:
Regional Panel interest:

Specific Objectives:

The objective is to drill through the entire section which windows at the face of the escarpment to determine: 1. The circulation patterns of fluids in and out of the platform. 2. The chemistry and total flux's of the circulating fluids. 3. The geological controls on the paths of circulation. 4. The effects of the differant types of circulation on the diagenesis of the strata. 5. To establish the original depositional environment of this leeward margin.

Background Information:
Regional Data:
Seismic profiles: Regional multichannel seismic reflection coverage by the University of Texas. Sparker profiler survey of this area by the USGS (figure 3).

Other data: 1984 ALVIN dives at the site (figure 3). GLORIA data of the USGS.

Site Survey Data - Conducted by:
Date: The site will be surveyed in 1986 with the SIO Deep-Tow.
Main results: Site will also be seabeamed in 1986.

Operational Considerations

Water Depth: (m) 1700 m Sed. Thickness: (m) 1200 m Total penetration: (m) 1200

HPC ____ Double HPC ____ Rotary Drill ____ Single Bit ____ Reentry ____

Nature of sediments/rock anticipated: Drape of slope carbonates (up to 100 m), platform limestone (1150 m).

Weather conditions/window:

Territorial jurisdiction: United States waters.

Other:

Special requirements (Staffing, instrumentation, etc.)

Pore water sampling with a packer. Logging. Reentry experiments at a latter date.

Proponent: C. Paull
M. Kastner
A. C. Neumann

Date submitted to JOIDES Office:

PROPOSAL FOR ODP DRILLING IN THE BAHAMAS- CARBONATE FANS, ESCARPMENT EROSION AND THE ROOTS OF CARBONATE BANKS

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Abstract

Based on extensive seismic surveys and results of Leg 101, we propose a Bahama drilling leg to address the following questions:
1) Carbonate submarine fans at the foot of the Bahama escarpment--fan anatomy, interplay of turbidity currents and contour currents, sediment shedding of carbonate banks in relation to sea level.
2) Bench at the foot of the Blake-Bahama Escarpment--genesis and rate of retreat of eroded bank margins, search for brine seeps.
3) Exuma Sound--prograding clinoforms interpreted from seismics as buried bank margins that do not follow the present orientation of banks and basins.
4) Northwest Providence Channel--sediment shedding measured close to source; expanded record for Neogene paleoceanography; buried Cretaceous megabank.

Scientific Rationale

For several decades, the recent sediments of Florida and the Bahamas have served as a model and standard for the interpretation of carbonate deposits in the geologic record. More recently, sediments in Florida and the Bahamas have been used as a key to their own past. These comparative studies, along with classical bore hole stratigraphy and seismic surveys have shed much light on the history of the archipelago (Tator and Hatfield, 1975; Mullins and Lynts, 1977; Beach and Ginsburg, 1980, Austin, Schlager et al., 1985). In this way, the Florida-Bahama platforms have become not only a standard for the interpretation of sedimentary structures and textures but also a well-documented case history in platform evolution (Fig. 1). Much like biological researchers keep returning to the coli bacterium as their best-known object, carbonate sedimentologists will return to the Bahamas as one of the best-documented case histories, where new experiments can be planned with more precise problem definition than elsewhere.

A most promising area for new experiments is the eastern margin of the Bahamas, where some of the world's largest canyons "drain" the Bahamas and discharge their sediment into the Western Boundary Undercurrent, one of the strongest deep sea currents in the world. This area was a target of Leg 101, but could not be drilled because of time constraints. Ongoing studies in NW Providence Channel (Boardman and Neumann, 1984) will complement the picture with data on the upstream end of the canyon system.

The French-American team BACAR has described a complex system of <u>submarine fans and contourites</u> around the mouths of two of these canyons. These features are well-documented with Seabeam maps, dense-grid seismics and precisely-positioned piston cores (Fig. 2-9; Schlager et al., in prep.; Ravenne et al., in prep.). Drilling these fans provides a special opportunity to tackle basic questions on sediment discharge by carbonate platforms, erosion and deposition by turbidity currents and contour currents, and on the modulating effect of sea level on all these processes.

<u>High-stand shedding</u> of carbonate platforms is one of the concepts to

be tested by drilling in the fans. Pleistocene piston cores and ODP drilling clearly indicate that the slopes and interplatform basins receive most sediment during high stands when the banks are flooded and produce sediment (Fig. 4; Droxler and Schlager, in press; Schlager and Austin, et al., 1975). This puts the banks out of step with siliciclastic systems where sedimentation on slope and rise reaches a peak during low stands of sea level.

However, the concept of high-stand shedding did not go unchallenged. For instance, there is some evidence that the sediment aprons around the Pacific platforms receive significant amounts of erosional, lithoclastic debris during low stands of sea level (Thiede, 1981, Schlanger, in press). In the Bahamian fans, deposition is particularly rapid because of the joint contribution of turbidity currents and contour currents. This will furnish an opportunity to clearly identify carbonate and clastic input during high and low stands and to separate the lithoclastic debris of platform erosion from coeval loose sediment shed by the platforms.

Another topic is the interplay between contour currents and turbidity currents and the influence of this balance on fan anatomy. In the Bahamas, the original contributions of terrigenous contour currents and of carbonate-rich turbidity currents are clearly identifiable. Pleistocene core studies suggest, however, that both current systems rework each other's deposits, and the balance between turbidite and contourite deposition varies regionally with distance from the canyon mouth and with the pathway of the Undercurrent. Only drilling will show if and how this balance has shifted with time, and how erosion and deposition have succeeded each other in shaping the Bahama Escarpment.

Amount and timing of erosion of the Bahama Escarpment is a controversial topic that is intimately tied to the history of the fans. Paull and Dillon (1980) and Sheridan (1981) arrived at vastly different estimates of escarpment retreat. The dispute centers on the origin of a seismically identifiable bench at the foot of the escarpment (Fig. 10). We suggest to drill this bench either in one of the fan areas where the stratigraphy is already well-constrained (Fig. 11, Sheridan et al., 1981; Schlager et al., 1984) or on the Blake Nose as proposed by Paull, this report. The bench site will be in a position analogous to the brine-seep sites proposed at the foot of the Florida Escarpment (Paull and Neumann, this report). Thus, the bench site is also a suitable test for brine seeps along the Blake-Bahama Escarpment and their possible role in escarpment erosion.

Within the Bahama archipelago, a number of problems have been solved recently through a combination of seismic surveys, bottom sampling and drilling. Specifically, these results have strengthened the idea that the present pattern of platforms and basins is underlain by a large continuous platform ("megabank hypothesis"). We have learned, furthermore, that platform margins were generally not stationary through time, but have migrated laterally by tens of kilometers (Schlager, Austin et al., 1985). With regard to platform migration, seismic surveys by Ladd and Sheridan, in prep., point to a particularly interesting drilling target: a series of flat-topped, prograding clinoforms of Latest Cretaceous or Early Tertiary age whose orientation shows no resemblance with today's platform margins (Fig. 12). There exists the distinct possibility that after drowning of the megabank, a first generation of platforms and basins was established, and later modified to the present configuration. Exuma Sound provides an excellent opportunity to drill these prograding units, document and date the rhythm of progradation, and retreat and determine if (and how) these sequences can be tied to the seismic stratigraphic framework of Vail et al. (1977).

Basin sedimentation and basin origin are the objectives of Site BAH-2a, also located within the Bahama archipelago (Fig. 13, Boardman and Neumann, 1984). This site has the potential to continue and greatly expand the work by ODP Leg 101. Located in Northwest Providence Channel on the interfluve between two submarine valleys, the site was out of reach of most turbidity currents at least since the Miocene. Thus, it provides an excellent record of periplatform ooze, a peculiar mixture of planktonic and bank-derived carbonate and a sensitive indicator of sediment export by the banks that compliments the turbidite-dominated record of the abyssal fans. Piston cores in the area also demonstrate the potential of this site as a paleoceanographic record with interglacial intervals expanded by bank input. When deepened to 1200m, this site has the potential to sample again (as did Site 627) the prominent reflector interpreted as the top of the drowned Cretaceous platform thought to underlie most Bahamian basins. In this way, Site BAH-2A will provide another test of the megabank vs. graben controversy in the Bahamas.

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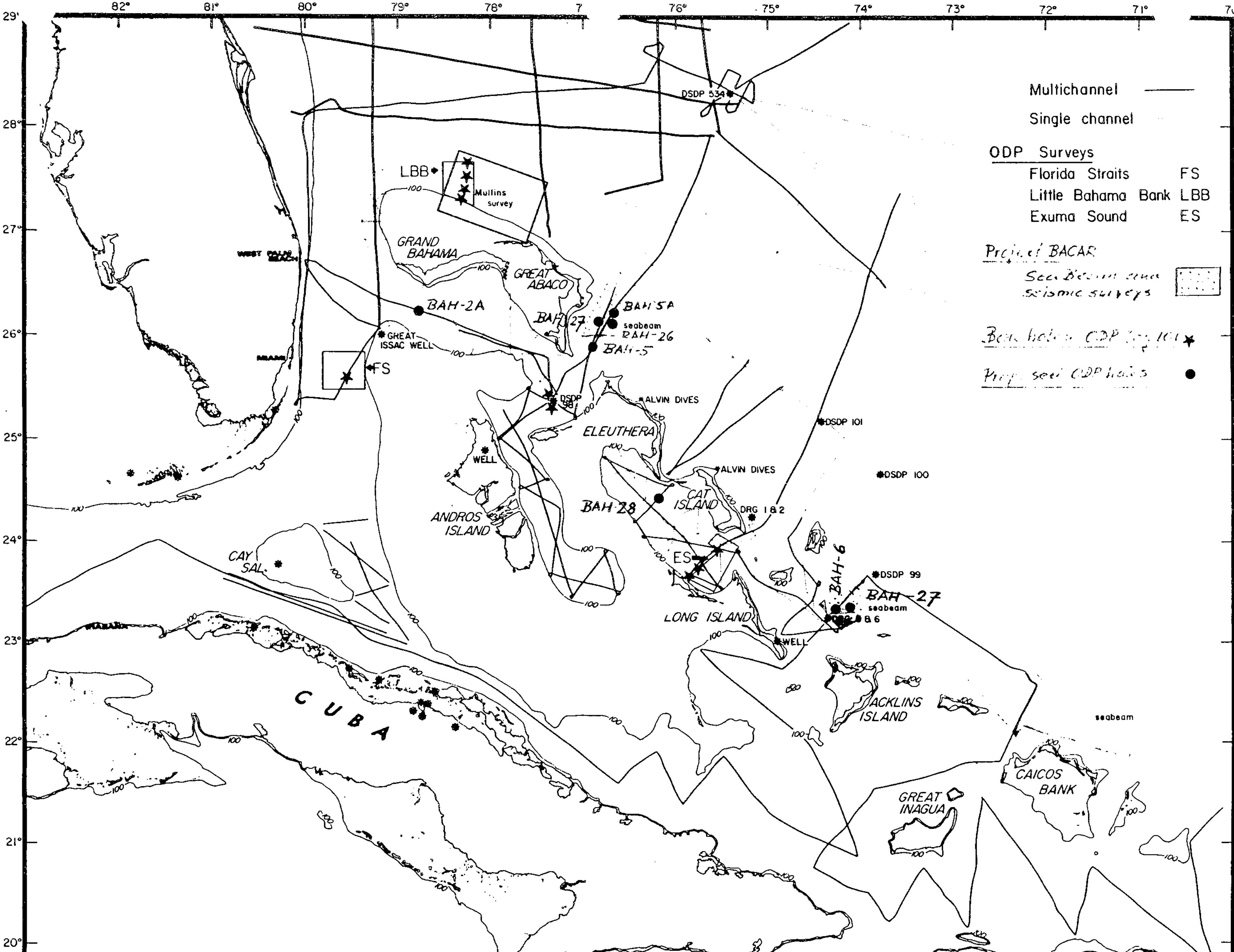


FIG. 1 Existing seismic surveys, sea beam surveys and bore holes in the Bahamas. Sites proposed in this report indicated by full circles and site number.

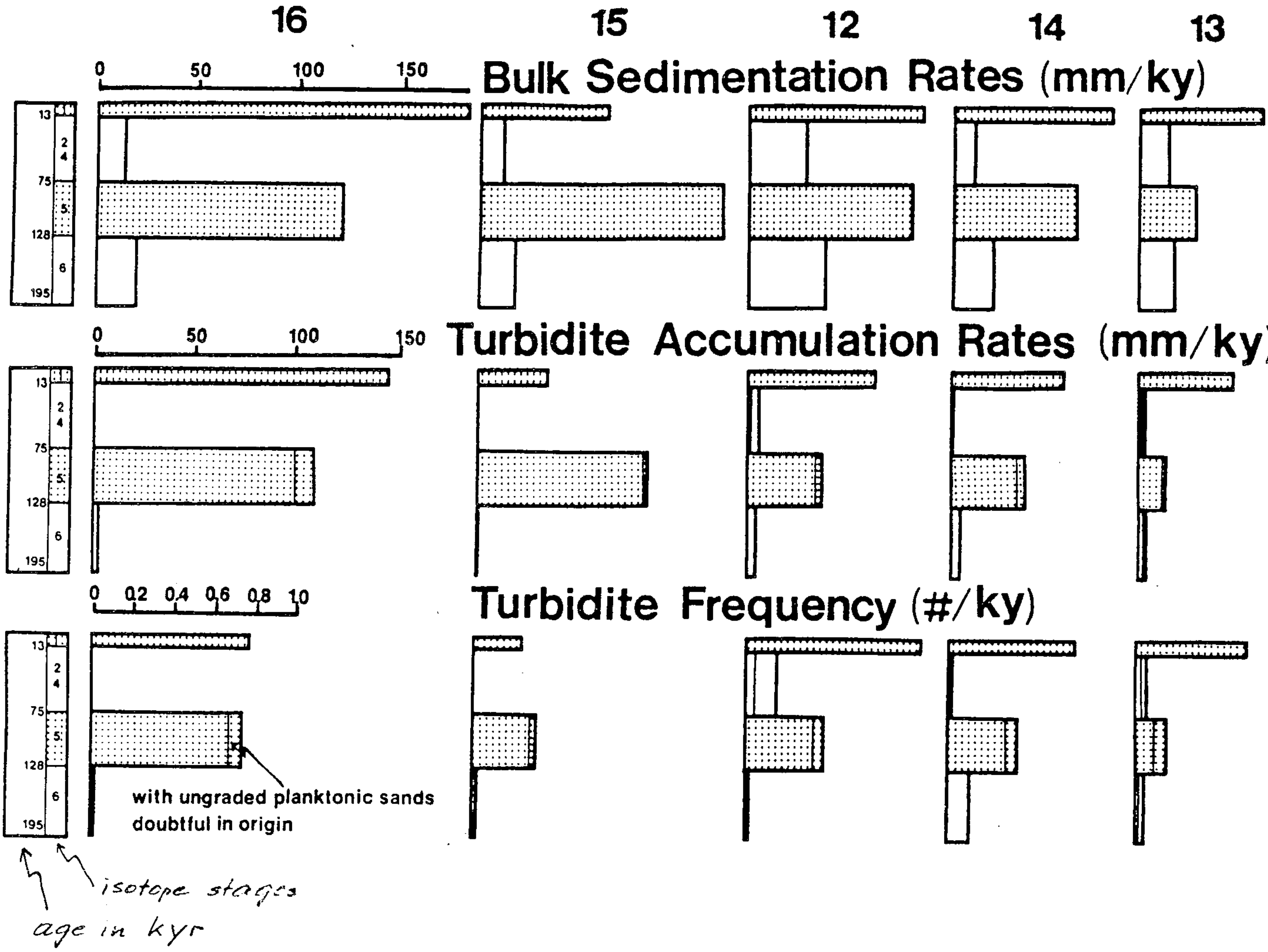


FIG. 2 Quaternary high-stand shedding in the Tongue of the Ocean, one of the basins surrounded by active platforms. Bulk sedimentation rates, turbidite accumulation rate and turbidite frequency in the basin all are significantly higher during interglacial periods. (After Droxler and Schlager, in press).

FIG. 3 Eleuthera Fan. Simplified Sea Beam map and seismic surveys plus proposed drill sites (data from project BACAR, Ravenne et al., in prep. and Schlager et al. in prep.)

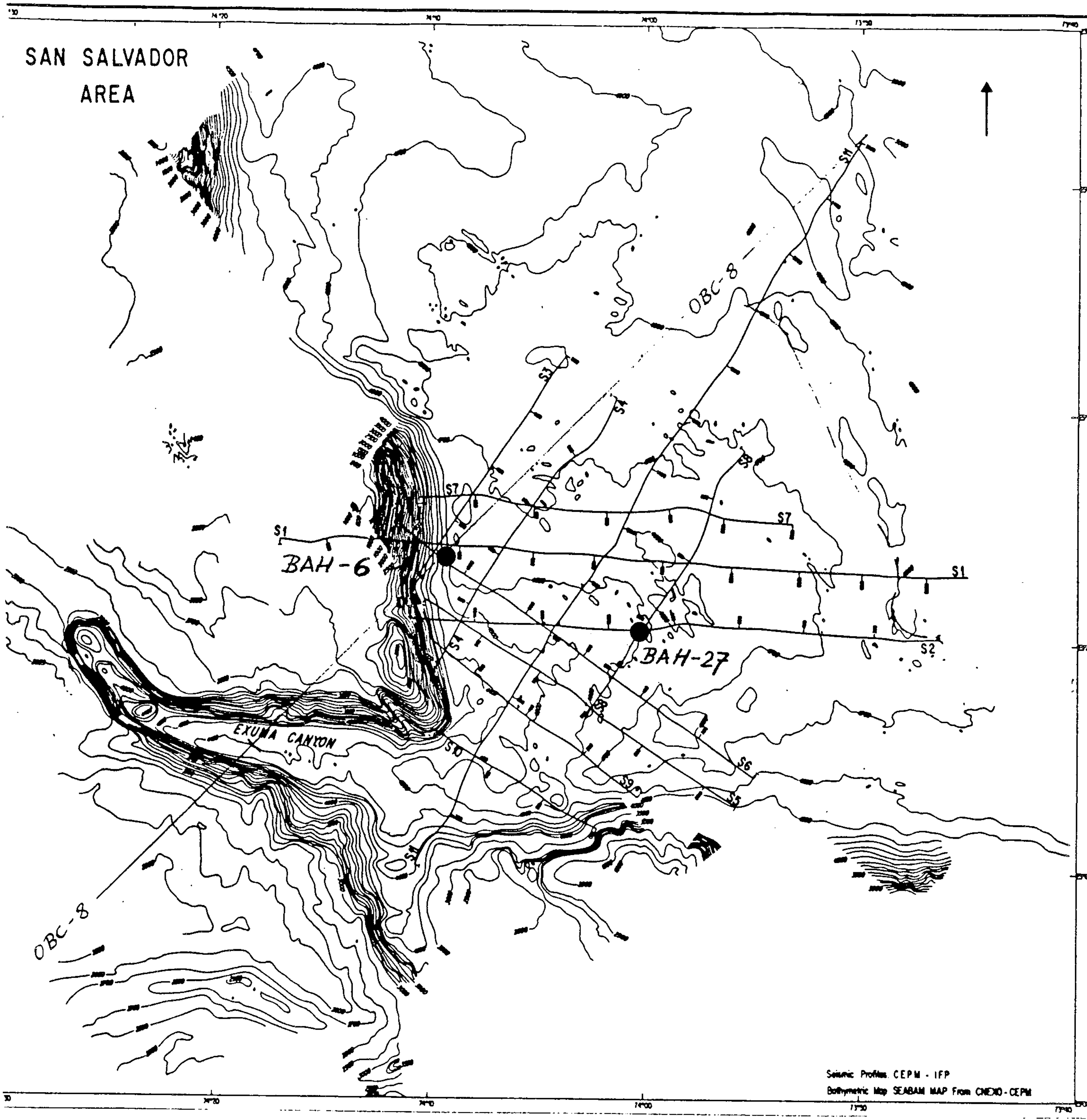


FIG. 4 Salvador Fan. Simplified Sea Beam map and seismic surveys plus proposed drill sites (data from projact BACAR, Ravenne et al., in prep. and Schlager et al., in prep.)

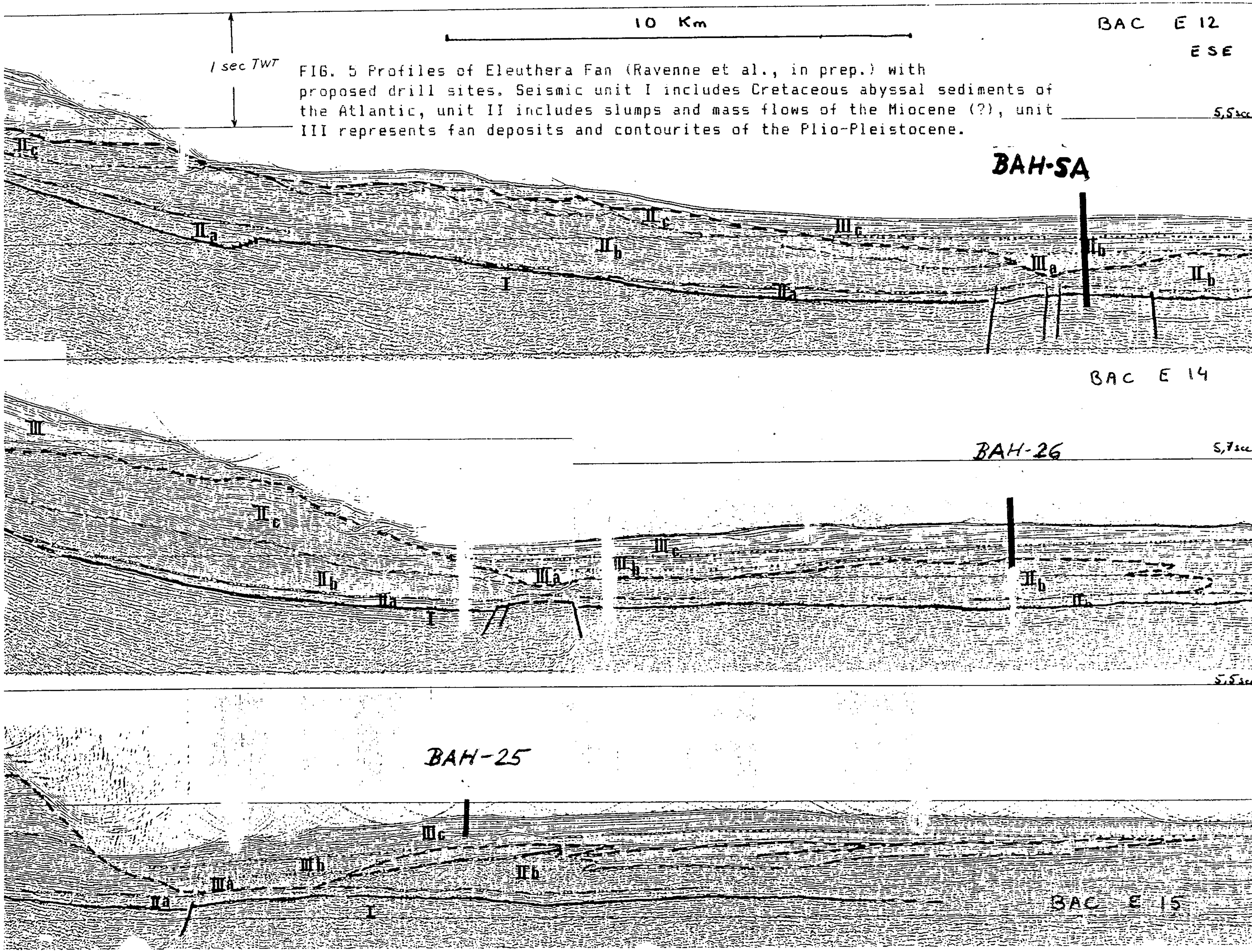


FIG. 5 Profiles of Eleuthera Fan (Ravenne et al., in prep.) with proposed drill sites. Seismic unit I includes Cretaceous abyssal sediments of the Atlantic, unit II includes slumps and mass flows of the Miocene (?), unit III represents fan deposits and contourites of the Plio-Pleistocene.

FIG 2

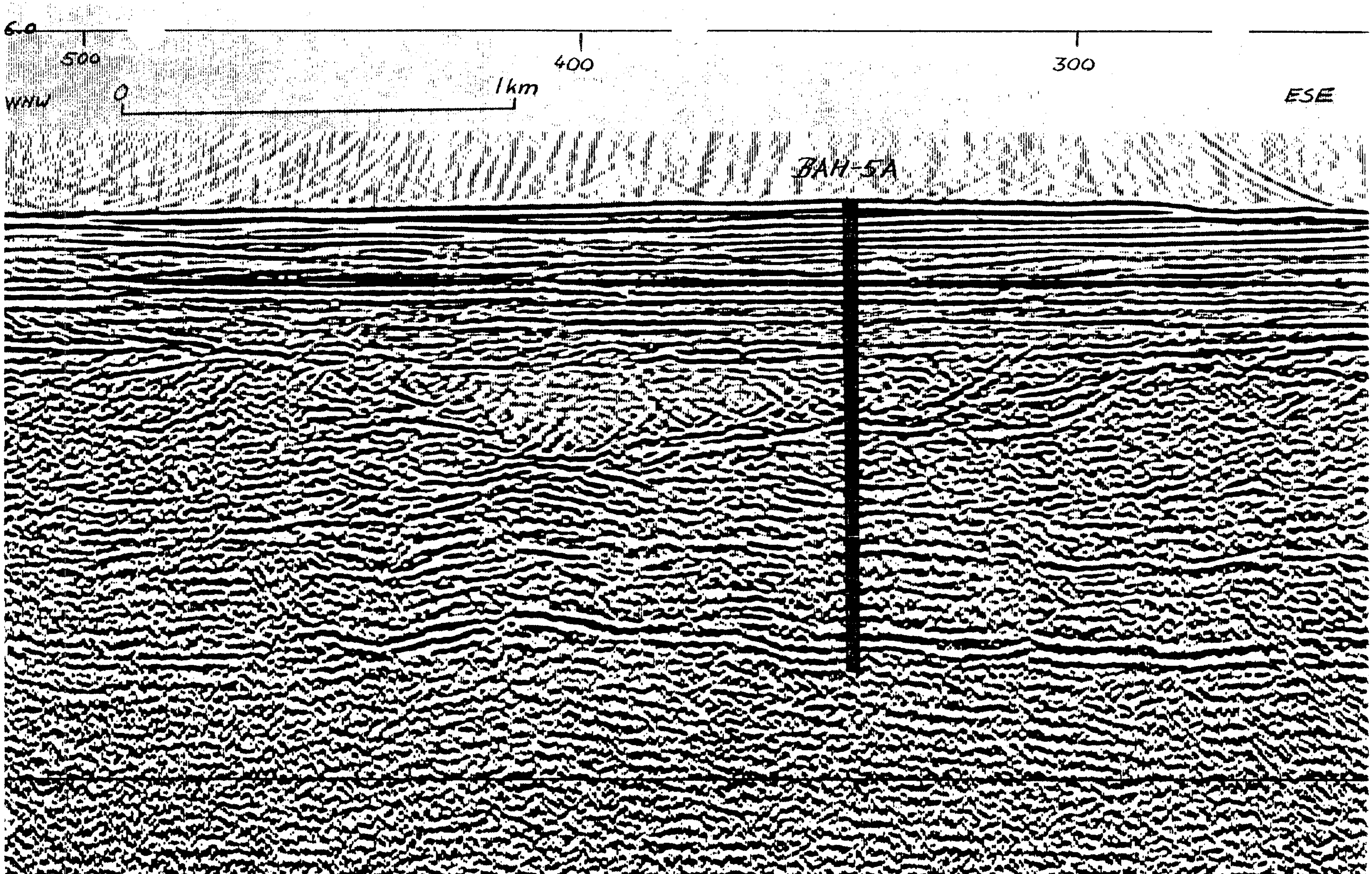


FIG. 6 Site BAH-5A in the mid-fan area of Eleuthera Fan. Flexichoc profile E-12.

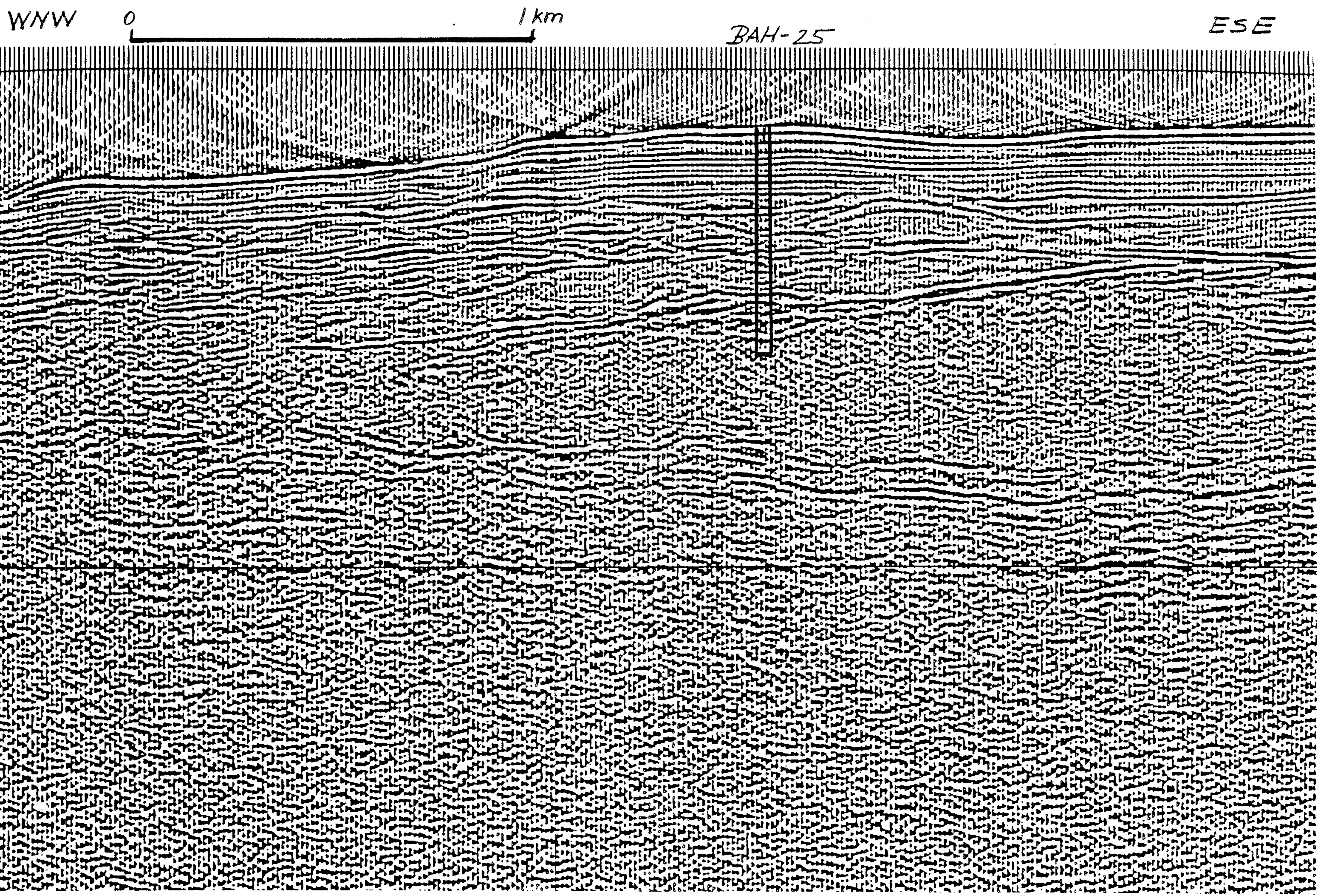


FIG. 7 Site BAH-25 on a fan levee of Eleuthera Fan.. Profile E-15.

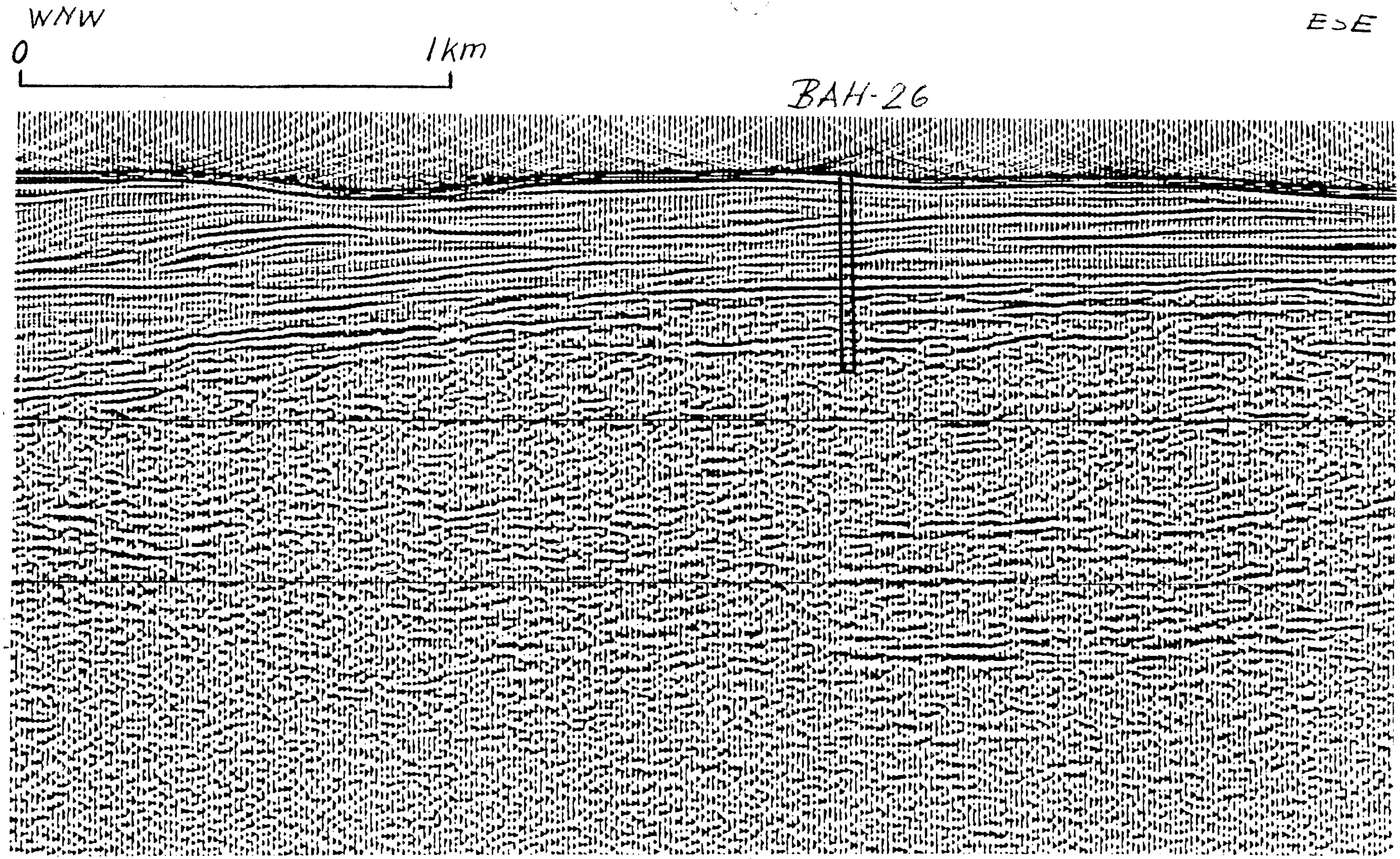


FIG. 8 Site BAH-26 in area of (mid-fan ?) sand lobes of Eleuthera Fan.
Profile E-14.

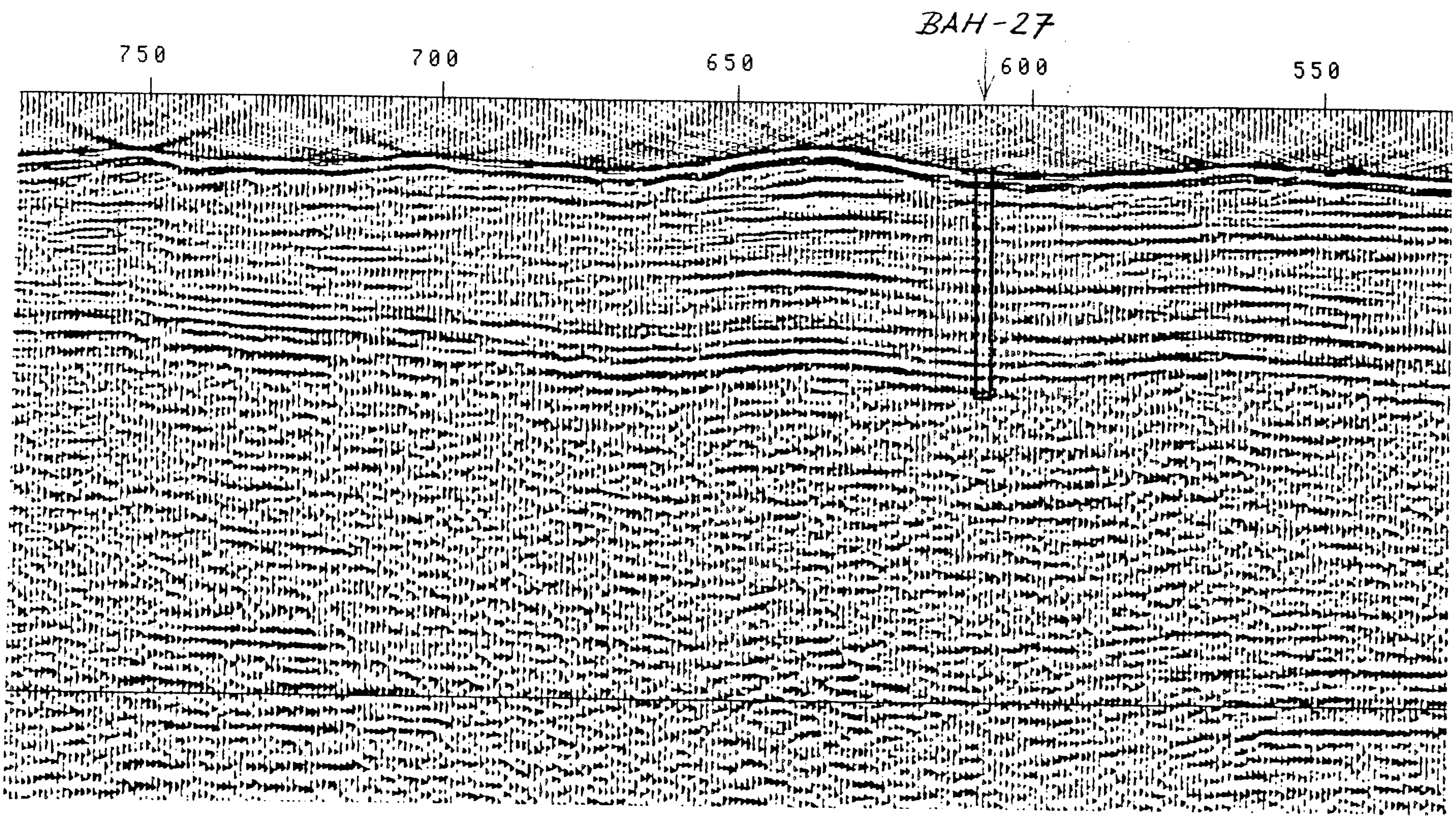


FIG. 9 Site BAH-27 on levee of Salvador Fan. Flexichoc profile S-8.

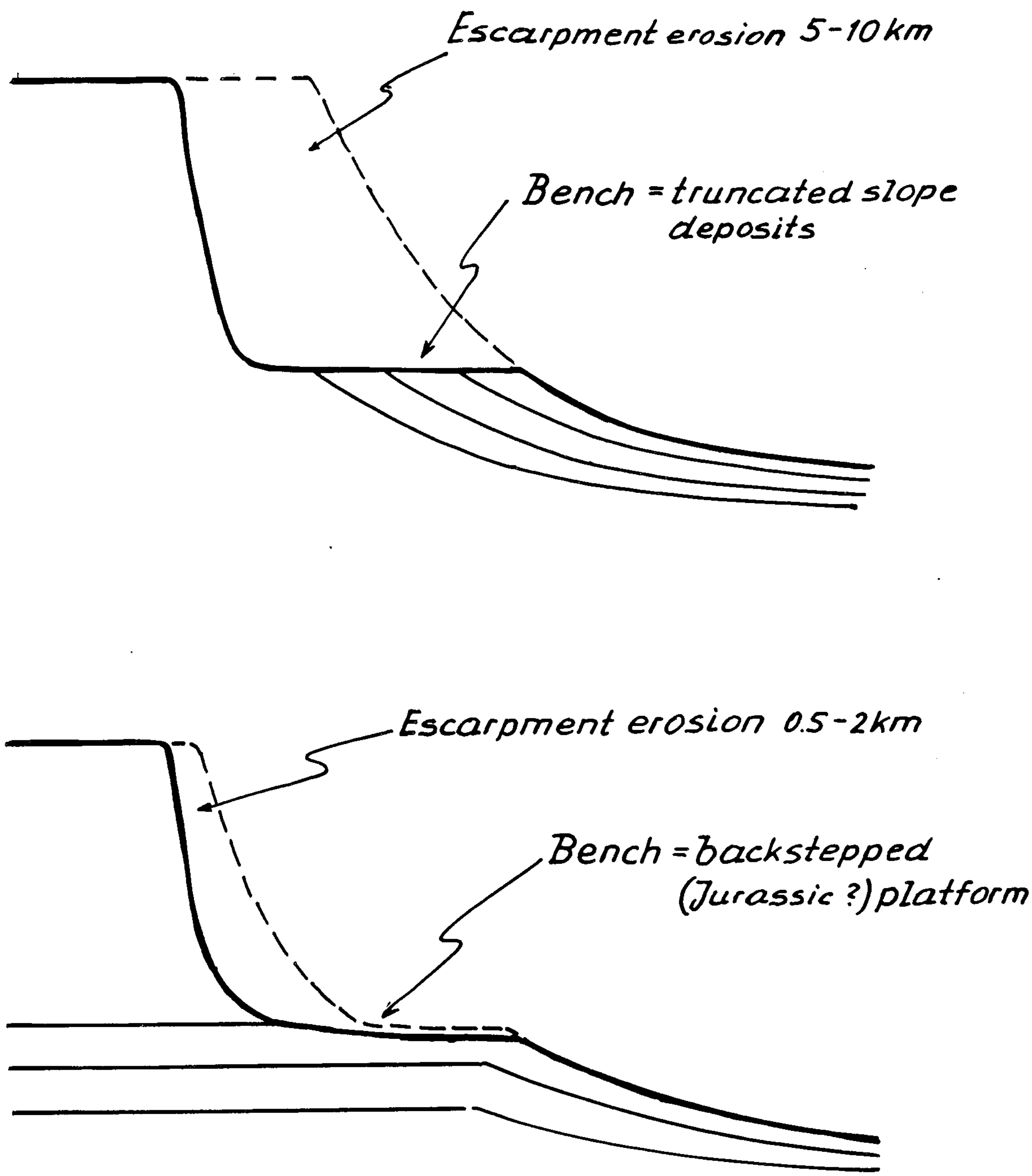


FIG. 10 Two contrasting interpretations of bench to be drilled at foot of Blake-Bahama Escarpment.

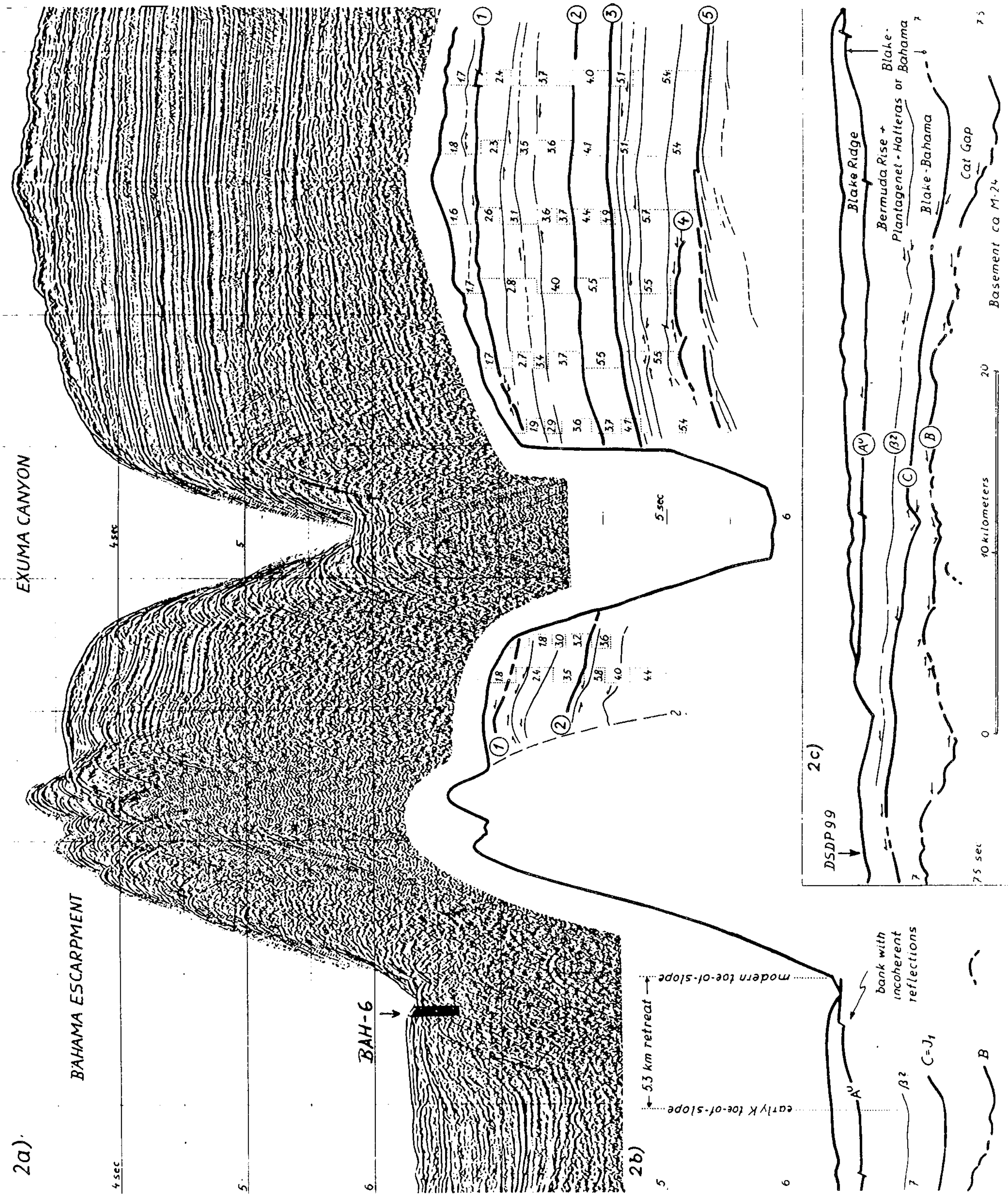


FIG. 11a Bench at foot of Bahama Escarpment in area of Salvador Fan (Site BAH-6). MCS line by UTIG, interpretation after Schlager et al. 1984.

Blake - Bahama

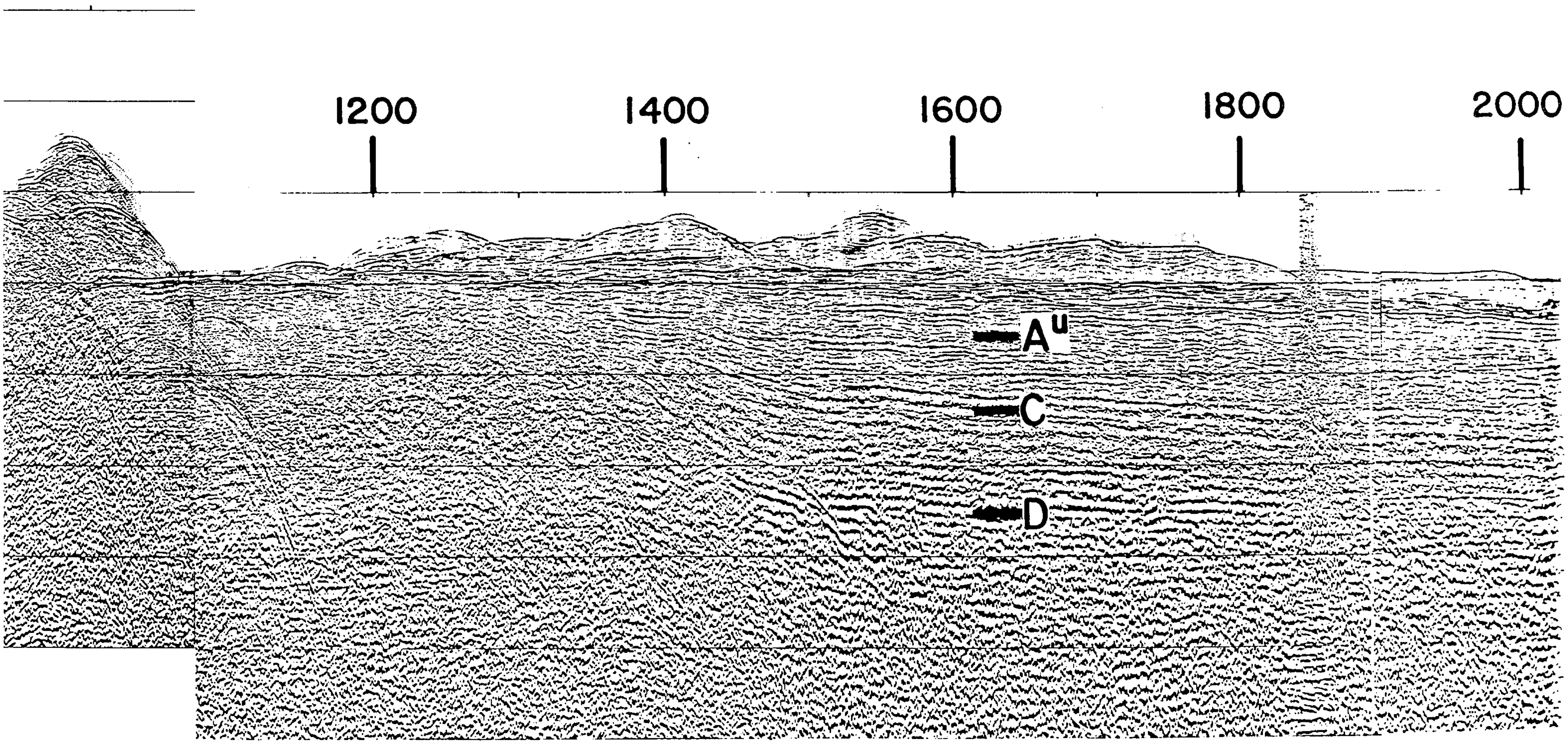


FIG. 11b Bench at foot of Bahama Excarpment off Eleuthera Island in area of upper Eleuthera Fan (Sheridan et al. 1981)

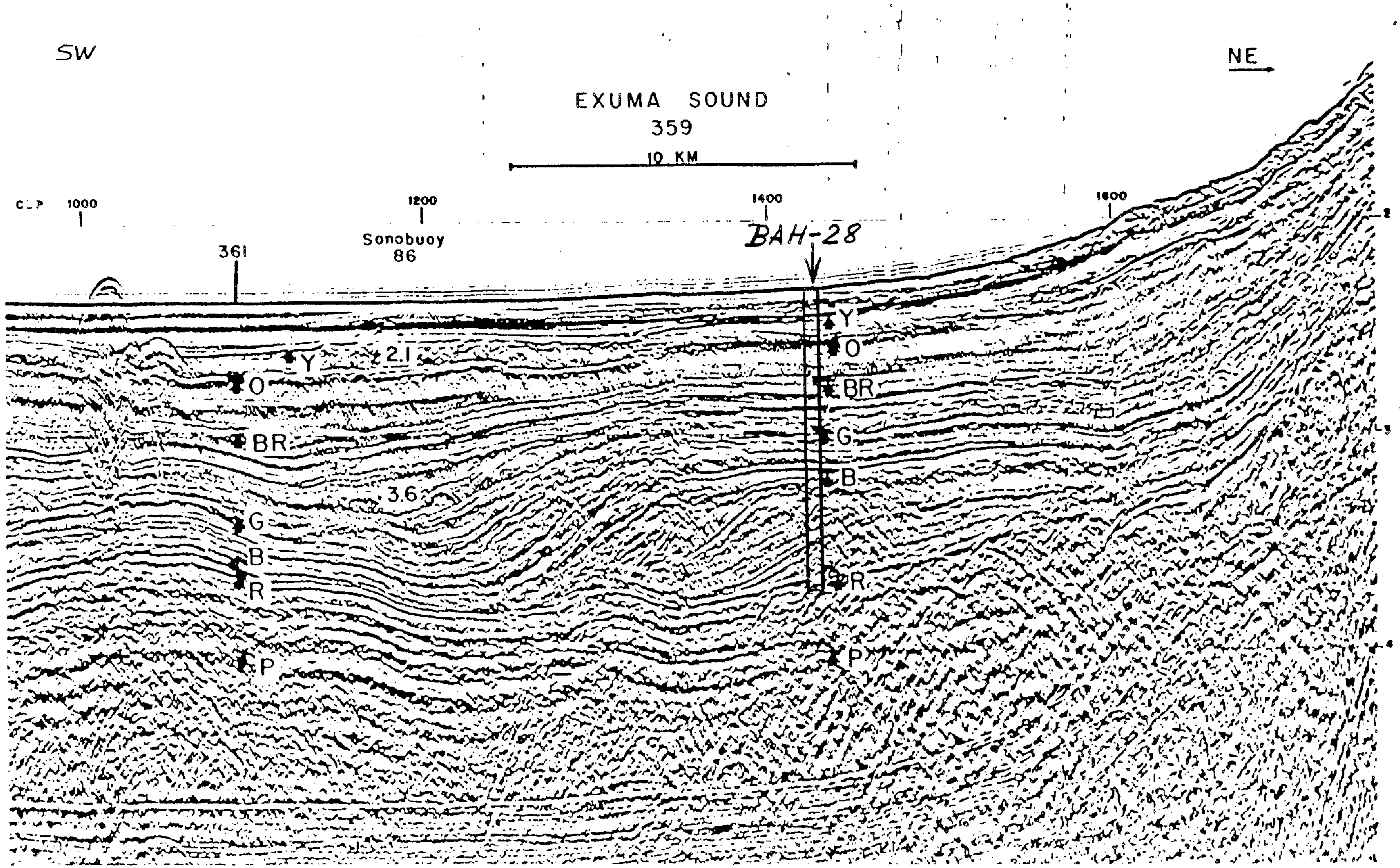


FIG. 12 Site BAH-28 in Exuma Sound on MCS line Conrad 359 (Ladd and Sheridan, in prep.). Target is flat-topped, prograding sequence between reflectors B and R. This unit is interpreted as part af a first generation of banks and basins established after drowning of the Cretaceous megabank, whose top is presumably reflector P. These buried prograding units cut present-day bank margins almost at right angles.

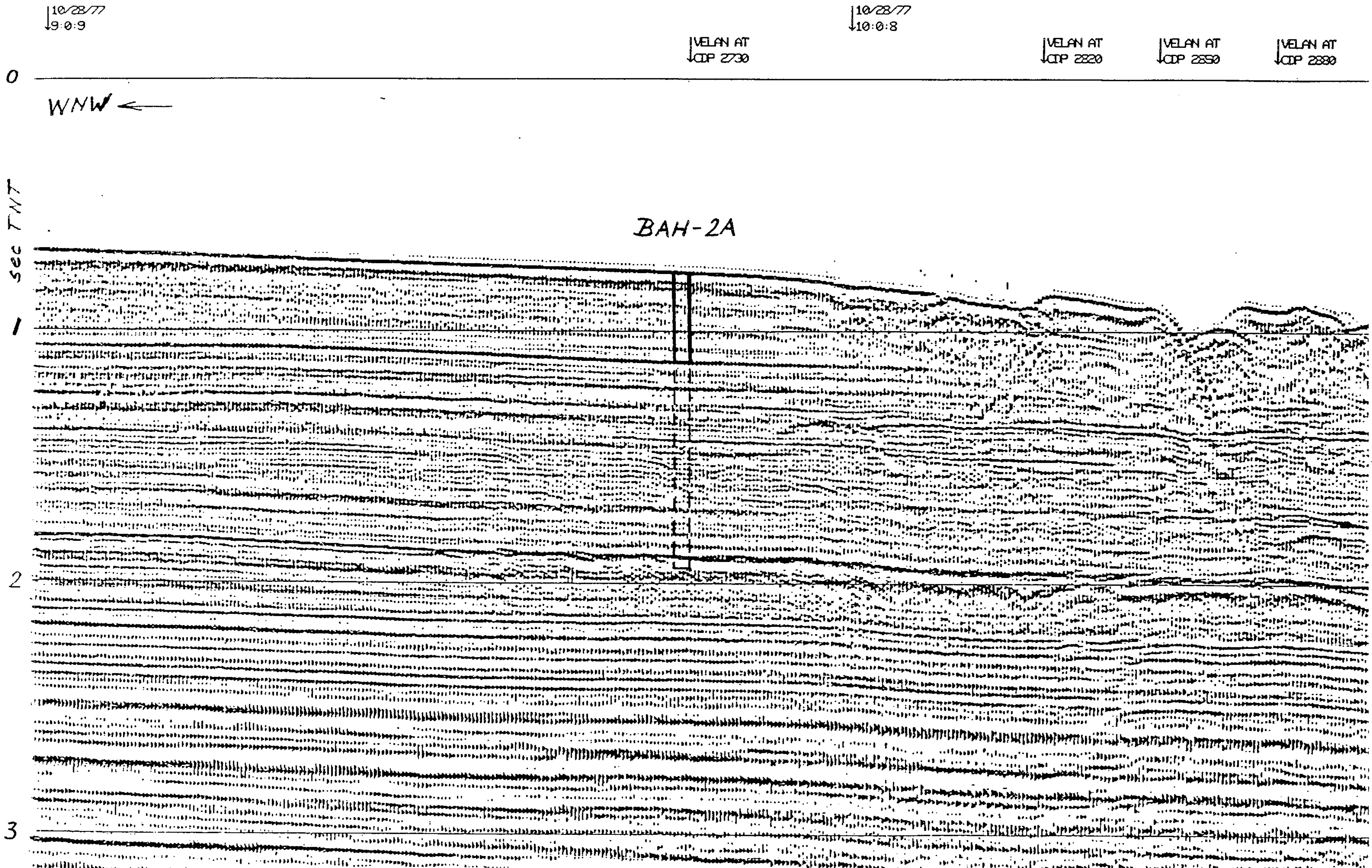


FIG. 13a Site BAH-2A in Northwest Providence Channel (at CDP 2730 on MCS line Conrad 94, Sheridan et al. 1981). Site can be drilled as HPC hole for high-resolution stratigraphy in peri-platform ooze and/or as deep penetration rotary hole to test megabank hypothesis.

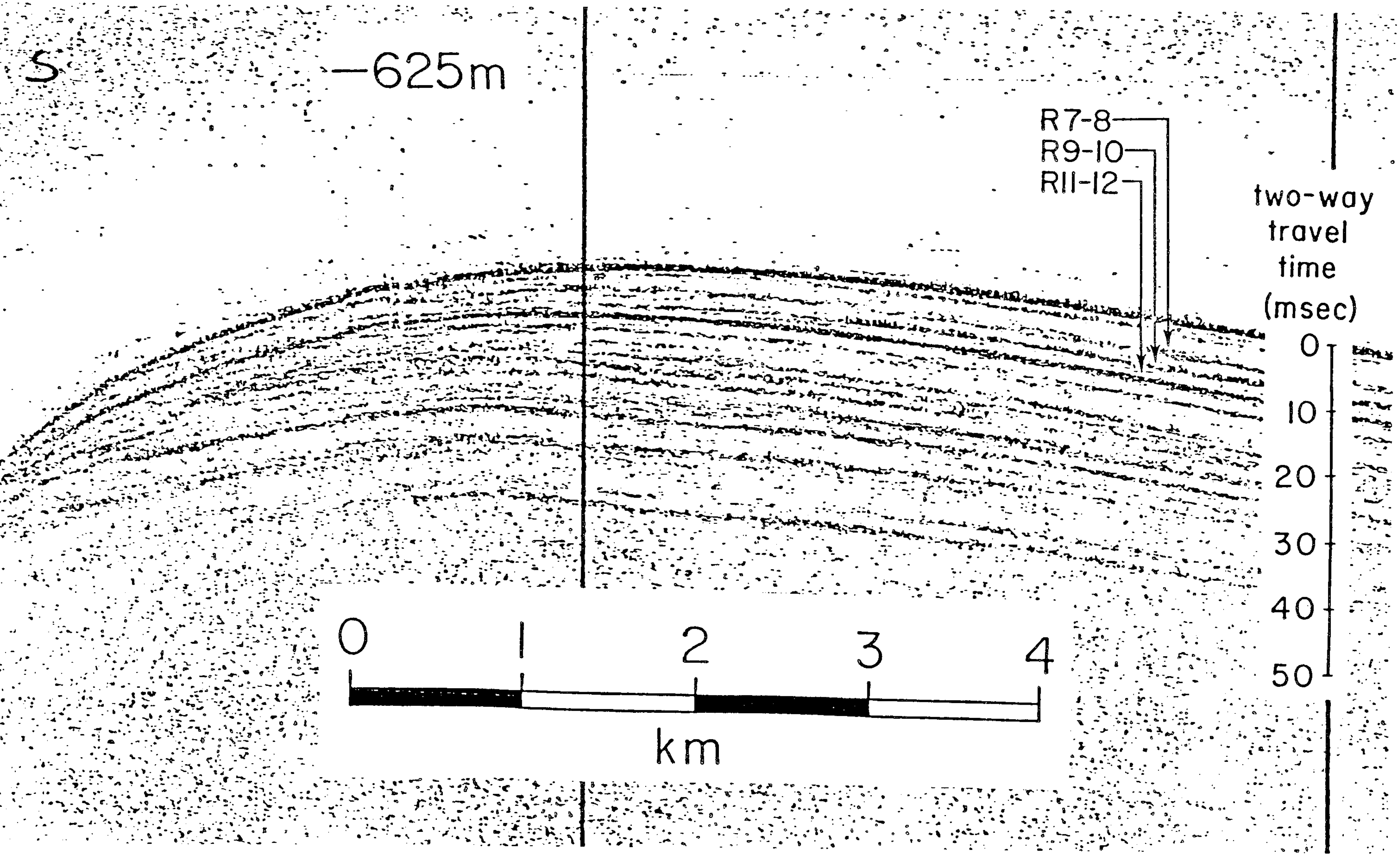


FIG. 13b 3.5 kHz record near site BAH-2A. The uppermost reflectors have been sampled and can be correlated with glacial-interglacial boundaries in oxygen-isotope records (Slowey and Neumann 1984). Reflector numbers indicate boundaries of Quaternary isotopic stages.

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH-2A

General Area: NW Providence Channel, Bahamas
Position: ca 26° 14'N 78° 43'W
Alternate Site: (CDP 2730 on Robert Conrad line 94)

General Objective: History of interplatform basin

Thematic Panel interest: SOHP
Regional Panel interest: ARP

Specific Objectives: Site will expand and continue work by leg 101.
1) Rate, composition and timing of sediment input from the shallow banks, correlation with sea level and other environmental factors
2) Nature of prominent reflector at 1.9 sec on line Conrad 94, currently interpreted as top of Cretaceous platform underlying the deepwater sediments
Objective 1) requires 200-300m penetration;
Objective 2) requires ca. 1200 m

Background Information:
Regional Data:
Seismic profiles: Conrad line 94 (Sheridan et al. 1981)

Other data: cores, bathymetry, single-channel seismics in MULLINS and NEUMANN 1979, BOARDMANN and NEUMANN 1984

Site Survey Data - Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 560 m Sed. Thickness: (m) Total penetration: (m) 300m
1200m for objective 2)

HPC ____ Double HPC X Rotary Drill (X) Single Bit (X) Reentry ____

Nature of sediments/rock anticipated: carbonate ooze and sand, chalk, limestone

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other: Leg 101 obtained safety clearence for Site at CDP 2730 on line Conrad 94 to target 2) at 1.89 sec

Special requirements (Staffing, instrumentation, etc.)

roponent:
C. Neumann,

Date submitted to JOIDES Office:

Rev. 06S

ODP SITE PROPOSAL SUMMARY FORM

(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH-5

General Area: Eleuthera Fan, Bahamas
Position: 25° 58'N 76° 55'W
Alternate Site:

General Objective: Stratigraphy Late Jurassic to Recent, in particular Neogene levee deposit possible shallow water limestone of Late Jurassic age beneath bench surface

Thematic Panel interest: SOHP
Regional Panel interest: ARP

Specific Objectives: Calibrate seismic stratigraphy of Jurassic to Holocene age. Recover Neogene fan and levee deposits of Eleuthera fan complex. Penetrate possibl Cretaceous and Late Jurassic shallow water limestone beneath reflector-free hummocky "bench" beneath erosional unconformity A^u.

Background Information:

Regional Data: Conrad lines 95 and 348,1982;
Seismic profiles:

Other data: (Sheridan et al, 1981; Ladd and Sheridan, in prep.)

Site Survey Data - Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 4125m Sed. Thickness: (m) Total penetration: (m) 1000m.

HPC X Double HPC ___ Rotary Drill X Single Bit X Reentry ___

Nature of sediments/rock anticipated: Carb. ooze, mud, lst. rubble, chalk, shale, hard limestone

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
R.E. Sheridan

Date submitted to JOIDES Office:

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH-5A

General Area: Eleuthera Fan, Bahamas
Position: 26° 21 'N 76° 34 'W
Alternate Site:

General Objective: Stratigraphy Late Cretaceous to Recent, in particular Neogene turbidites and slumps

Thematic Panel interest: SOHP
Regional Panel interest: ARP

Specific Objectives: Calibrate seismic stratigraphy developed from high-resolution grid surveys (Project BACAR). Anticipated units include carbonate fan and contourites (Plio-Pleistocene) slumps (Miocene) and Hatteras shale (Late Cretaceous). Site will provide stratigraphic basis for Eleuthera Fan study and document fan deposits in mid-fan province.

Background Information:
Regional Data:
Seismic profiles: Grid survey with Mini-Flexichoc, Inst. Français du Petrole, 1982; on line E-12, near intersection w. line E-10
Other data:

Site Survey Data - Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 4770 Sed. Thickness: (m) Total penetration: (m) 1200 m.

HPC X Double HPC ____ Rotary Drill X Single Bit X Reentry ____

Nature of sediments/rock anticipated: Carb. ooze, mud, lst. rubble, chalk, shale

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
C. Ravenne, P. Le Quellec

Date submitted to JOIDES Office:

Rev. 0684

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH – 6

General Area: Bahama Escarpment
Position: 23°23'N 74°10'W
Alternate Site:

General Objective: Cause and amount of erosion along Blake-Bahama Escarpment

Thematic Panel interest: SOPH
Regional Panel interest: ARP

Specific Objectives: Drill buried bench at the foot of the Bahama Escarpment to determine if it is cut entirely into slope deposits or if it represents the top of a drowned platform (Fig. 10, this proposal). If bench is cut into slope deposits, then the geometry of seismic reflections below the bench dictates that the erosional retreat of the escarpment must equal or exceed the entire width of the bench, ca. 5 km. If bench represents a drowned platform, then the amount of escarpment erosion could be as little as 500 m, just enough to account for the lack of bank-margin facies.

Background Information:
Regional Data:
Seismic profiles: OBC-8 (Univ. Texas, Inst. for Geophysics); 48-channel, large airguns; 1981.

Other data: Mini-Flexichoc grid survey, Inst. Francais du Petrole, 1982

Site Survey Data – Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 4690 Sed. Thickness: (m) Total penetration: (m) 400 m.

HPC X Double HPC ___ Rotary Drill X Single Bit X Reentry ___

Nature of sediments/rock anticipated: Carb. ooze, terrig. mud, lst. rubble, limestone

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
W. Schlager, J. Austin

Date submitted to JOIDES Office:

Rev. 0684 JC

SITE PROPOSAL SUMMARY FORM

(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH-25

General Area: Eleuthera Fan, Bahamas
Position: 26° 10'N 76° 44'W
Alternate Site:

General Objective:
Levee deposits and contourites of Eleuthera Fan

Thematic Panel interest: SOHP
Regional Panel interest: ARP

Specific Objectives: Site is located near crest of levee (as opposed to BAH-5A which is in mid-fan sand lobes); designed to penetrate entire fan sequence (Plio-Pleistocene) and recover top of underlying (Miocene) slumps and landslides derived from escarpment. Site will document deposits of high-stands and low-stands of sea level and record the interplay of deposition from turbidity currents and contour currents and their variation through time.

Background Information:

Regional Data:

Seismic profiles: Grid-survey with Mini-Flexichoc Inst. Français du Petrole, 1982; on lines E-2 and E-15

Other data:

Site Survey Data - Conducted by:

Date:

Main results:

Operational Considerations

Water Depth: (m) 4600 Sed. Thickness: (m) Total penetration: (m) 500m

HPC ____ Double HPC X Rotary Drill X Single Bit X Reentry ____

Nature of sediments/rock anticipated: Mud, carbonate, ooze, chalk, lst. rubble

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
Ravenne, P. Le Quellec

Date submitted to JOIDES Office:

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH-26

General Area: Eleuthera Fan Bahamas
Position: 26° 14 'N 76°36 'W
Alternate Site:

General Objective:
Levee backslope with turbidites and contourit
Eleuthera Fan

Thematic Panel interest: SOHP
Regional Panel interest: ARP

Specific Objectives: Record of carbonate turbidite deposition and contourites deposition (and erosion), and their relation to seismic stratigraphy and sea level.

Background Information:
Regional Data:
Seismic profiles: Grid survey with Mini-Flexichoc, Inst. Français du Petrole, 1982 on line E-14

Other data:

Site Survey Data - Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 4750 Sed. Thickness: (m) Total penetration: (m) 300m

HPC X Double HPC ____ Rotary Drill X Single Bit X Reentry ____

Nature of sediments/rock anticipated: Mud, carbonate ooze and sand

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
C. Ravenne, P. Le Quellec

Date submitted to JOIDES Office:

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH - 27

General Area: Salvador Fan., Bahamas
Position:
Alternate Site:

General Objective:
Stratigraphy of Salvador Fan
(Neogene, possibly Cretaceous)

Thematic Panel interest:
Regional Panel interest:

Specific Objectives: Site is located in center of fan area and addresses several objectives:
a) Calibrate seismic stratigraphy of Salvador Fan above A^u unconformity
b) Determine age of channeled carbonate fan complex below A^u (Early Cretaceous vs. Tertiary)
c) Compare record of Neogene carbonate turbidites and contourites with sea level history.

Background Information:
Regional Data:
Seismic profiles: Grid survey with Mini-Flexichoc, Inst. Français du Petrole, 1982 on line S-8, near intersections w. line s-2
Other data:

Site Survey Data - Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 4590 Sed. Thickness: (m) Total penetration: (m) 400m

HPC ____ Double HPC X Rotary Drill X Single Bit X Reentry ____

Nature of sediments/rock anticipated: carbonate ooze, mud, lst. rubble, limestone

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:

w. Schlager

Date submitted to JOIDES Office:

Rev. 0684 JC

ODP SITE PROPOSAL SUMMARY FORM
(Submit 5 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: BAH-28

General Area: Exuma Sound, Bahamas
Position: 24° 30' N 76° 08' W
Alternate Site:

General Objective:
Late Cret. and Tertiary history of interplatform basin

Thematic Panel interest:
Regional Panel interest:

Specific Objectives:
a) Calibration of seismic stratigraphy in Exuma Sound
b) Variations of sediment input and correlation with Tertiary sea level
c) age and nature of prograding, flat-topped unit at 3.1-3.7 sec tentatively interpreted as carbonate bank margin, oriented almost at right angle to present day features

Background Information:
Regional Data:
Seismic profiles: 48-channel airgun surveys (Ladd & Sheridan in prep.)
48-channel watergun site surveys ODP leg 101 (Austin et al. unpubl.

Other data: DSDP sites 631, 632 and 633 in southeastern Exuma Sound (Austin, Schlager et al. 1985)

Site Survey Data - Conducted by:
Date:
Main results:

Operational Considerations

Water Depth: (m) 1750 Sed. Thickness: (m) Total penetration: (m) 1200 m

HPC X Double HPC ___ Rotary Drill X Single Bit X Reentry ___

Nature of sediments/rock anticipated: carb. ooze, chalk, limestone

Weather conditions/window: all year

Territorial jurisdiction: Bahamas

Other:

Special requirements (Staffing, instrumentation, etc.)

Proponent:
R.E. Sheridan, J. Ladd

Date submitted to JOIDES Office:

Rev. 0684 JC

AN OCEAN DRILLING PROPOSAL FOR THE GREAT BARRIER REEF QUEENSLAND TROUGH QUEENSLAND PLATEAU

Proponents:

Peter J. Davies
David Feary
Phillip Symonds

Division of Marine Sciences
Bureau of Mineral Resources
Canberra, Australia

PROJECT TITLE: THE EFFECTS OF MARGINAL SUBSIDENCE, PLATE MOTION AND SEA LEVEL ON THE EVOLUTION OF CARBONATE PLATFORMS.

OVERALL OBJECTIVE: TO DEFINE THE EVOLUTION OF MIXED CARBONATE/SILICICLASTIC MARGINS IN TERMS OF THE MEGAPROCESSES EFFECTING THEIR FORMATION. SUCH PROCESSES INCLUDE SEA LEVEL CHANGE, HORIZONTAL PLATE MOTION, SUBSIDENCE, REGIONAL TECTONICS, PHYSICAL AND CHEMICAL OCEANOGRAPHY AND CLIMATE.

INTRODUCTION

Our current knowledge of carbonate platforms is based almost exclusively on studies of the Bahamas and the Caribbean (Hollister et al, 1972; Austin, Schlager and Palmer, 1985). Such studies represent one model of carbonate margin evolution; the time is ripe to augment this knowledge with studies of other margins so that a comprehensive understanding of margin accrection will lead to different models and different analogues. The Bahamas and the Caribbean clearly do not provide adequate models for the interpretation of all ancient sequences; discovering and studying other modern examples of more direct application should be accorded high priority. Many ancient sequences are carbonate/siliciclastic mixtures and some thought and priority should therefore be given to the study of modern analogues. The following objectives should be addressed by ODP in extending knowledge in this direction:

1. To determine the response of shallow and deep marine sedimentation to fluctuations in sea level. As reefal platforms are formed close to sea level (Davies and Montaggioni, 1985), they provide a base level for determining the paleo-water depths of adjacent facies particularly through the study of the sedimentological and diagenetic processes.

2. To determine the response of ocean circulation to changing conditions of plate boundary configuration and climate. The positions and fluctuations of ACD, lysocline and CCD are imprinted in the sediments.

3. To determine the sedimentologic nature of submarine fan and slump deposits and their relation to sea level and tectonics.

4. To determine the influence of passive margin tectonics on depositional setting. The subsidence history of some passive margins is not the simple post-breakup cooling path exemplified by Atlantic situations and as seen in the northern Caribbean.

REGIONAL TARGETS:

NORTHEAST AUSTRALIA - THE GREAT BARRIER REEF AND THE QUEENSLAND PLATEAU. The advantages of studies in this area are that they allow simultaneous and contiguous research into both mixed carbonate/clastic (Great Barrier Reef) and pure carbonate margins (Queensland Plateau).

STRATEGY

We propose a series of double-entry piston cores and rotary drill cores through the margin of the Great Barrier Reef, down the slope, across the Queensland Trough, and up onto the western margin of the Queensland Plateau.

The Great Barrier Reef is the largest epicontinental reef system on earth and the Queensland Plateau one of the largest marginal plateaus. They are separated by a major deep rift basin. This enrvironmental juxtaposition is a recurrent theme throughout geological history.

Throughout most of its history the shelf has been dominated by terrigenous sedimentation controlled through sea level changes. Alluvial, fluvial and wave-dominated deltaic processes characterize low sea level periods; coastal deltaic progradation and continental slope onlap by fans dominate the high sea level periods. The Great Barrier Reef appears throughout much of the central province as a relatively thin Pleistocene feature built upon a fluvio-clastic base but thickens to the north. This northward thickening reflects the northward drift of Australia into the tropics, the sedimentological and environmental imprint of which is locked in the reef and slope sequences.

The Queensland Plateau has been a carbonate-dominated province since the early Tertiary. The earliest reef growth may have started in the Eocene along the western margin of the plateau; it is likely that reef growth was well established by the Oligocene or Miocene. Currently, reef growth occupies one quarter of the surface of the platform although seismic sections indicate that reef growth may have been more extensive in the past.

The Queensland Trough is a post late Cretaceous graben containing 1-4 kms of sediment bounded in the west by the mixed carbonate/clastic slope of the Great Barrier Reef and in the east by the totally carbonate dominated western Queensland Plateau. It is currently a major bathymetric feature.

The sedimentological and structural association represented by the Reef/basinal Trough/marginal Plateau are common geological features. Northeast Australia provides an opportunity to study the most complete example on earth today and to produce a directly applicable analogue. Further, it is a unique area to study carbonate/clastic interactions on tropical passive margins in addition to containing a superb record of ocean history.

AN OCEAN DRILLING PROGRAM FOR NORTHEAST AUSTRALIA

1. INTRODUCTION

Offshore northeast Australia is an extremely complex product of rifting, seafloor spreading and margin accretion. The Great Barrier Reef is the largest epicontinental reef system on earth and is bounded oceanwards by the Queensland Trough and the Queensland Plateau, the largest marginal plateau offshore in the Australian region and one of the largest of its type in the world. The geological development of northeast Australia has juxtaposed rift sequences, thick fluvio-deltaic sediments and coral reefs. It must therefore be considered of immense global scientific interest, both in itself and as an analogue for comparable associations throughout the world. Recent cruises by the Bureau of Mineral Resources have augmented an already large data base and refined potential research objectives in the region.

2. PHYSIOGRAPHY

Figure 1 shows the main physiographic elements, which are the Great

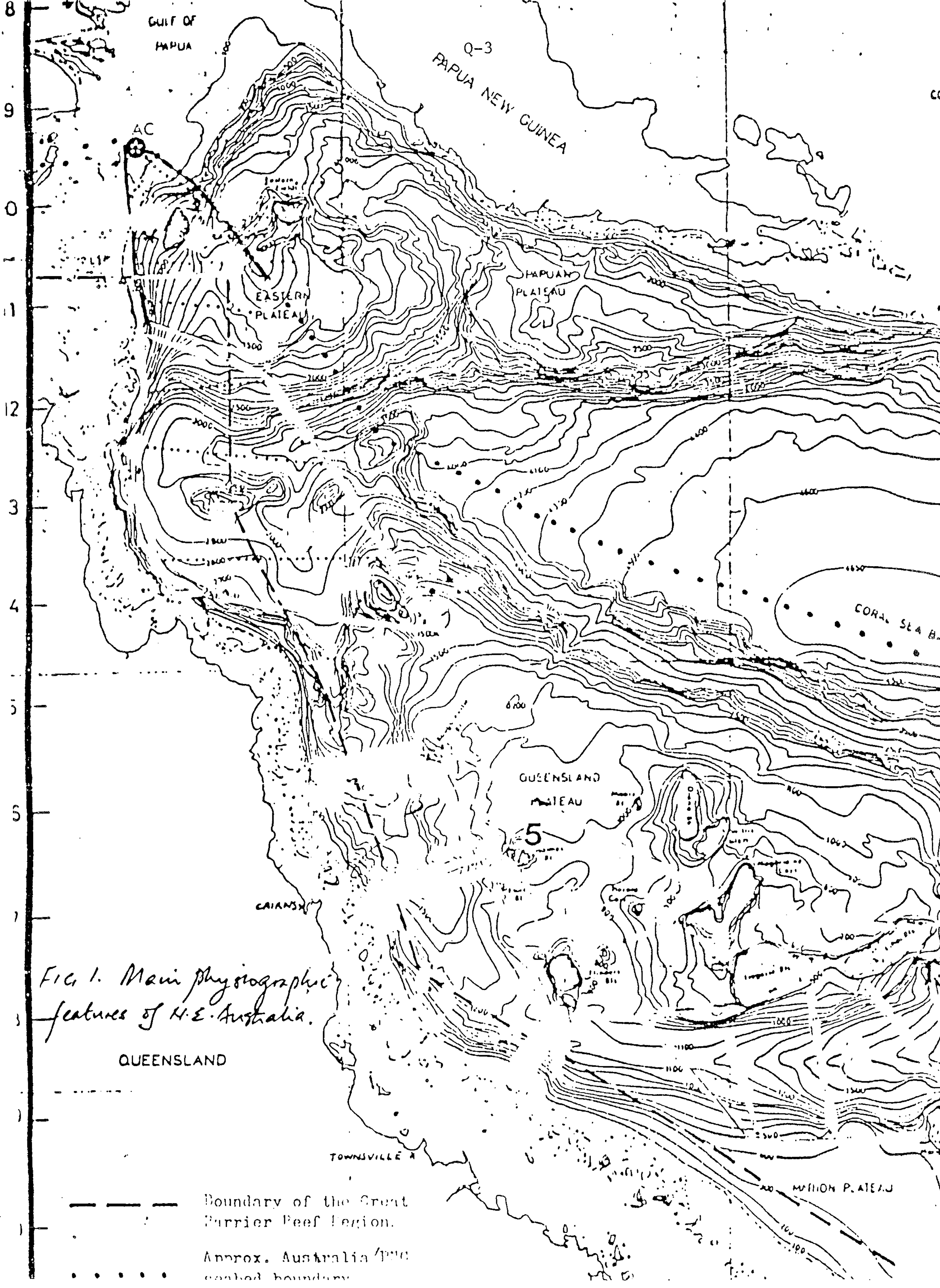


FIG. 1. Main physiographic features of N.E. Australia.

Barrier Reef slope, the Queensland Plateau, the Queensland and Townsville Troughs, the Osprey Embayment and the Eastern Plateau with the adjacent Pandora, Bligh (Portlock) and Moresby Troughs. The slope of the Great Barrier Reef is steeply dipping and canyoned throughout most of the region, particularly adjacent to the Ribbon Reefs; in the proximity of Townsville the slope is much gentler.

The Queensland Plateau is the largest marginal plateau of the Australian continental margin, being nearly twice as large as the Exmouth Plateau. As such it is one of the largest features of its type in the world. The Plateau is roughly triangular with its western margin striking north-northwest, its northeastern margin facing the Coral Sea Basin striking northwest, and its southern margin striking east-west. The western and southern margins are both bounded by linear troughs. Many valleys and canyons lead from the Plateau surface into the troughs and the Coral Sea Basin.

The Plateau surface lies at a medium depth of 1100 m and away from reef areas is generally very smooth and flat. It exhibits a very gentle northwest tilt, its surface being most deeply submerged around Osprey by tectonic rather than sedimentary processes. Fairbridge further observed that the Plateau reefs grow from as much as 1500 m below sea level, well beyond the normal ecological limit of reef growth, and this led him to suggest that the Plateau had subsided to its present depth from an initial elevation close to sea level, with reef growth keeping pace with subsidence.

The northeastern margin of the Queensland Plateau is linear for more than 600 km between 13 30 S and 16 00 S with a slight change in trend at about 14 20 S, suggesting that tectonic influences have shaped the Plateau. This margin forms the lower continental slope leading down to the Coral Sea Basin. Slopes are relatively steep, ranging from 1:25 to 1:35; by comparison a normal continental slope is about 1:40 (Shepard, 1948). The profile of this margin shows a convex shape whereas a continental margin formed by the process of seaward accretion of sediment normally has a concave profile. This may also point to a tectonic influence on plateau formation. Profiles of the northern part of the Plateau show that extensive canyoning has modified the shape of the outer margin of the Plateau.

Immediately east of Lihou Reefs the plateau surface deepens in two steps; one adjacent to the reefs and one along longitude 153 15 E. Two small terraces have formed as a result-one at a depth of 1400 to 1600m, and the other at 2200m. The latter has a shallow trough on its western edge. No similar structures occur on the boundary between the Plateau and the Coral Sea Basin and this may point to a different genetic influence on these two areas.

The Queensland Trough occupies the region between the continental shelf of Queensland and the Queensland Plateau between 14 S and 17 30 S, adjacent to the Great Barrier Reef. Its western margin is much steeper than its eastern margin, with gradients up to 1:3 (at 15 S). The steepness of this slope implies a tectonic origin for its western margin. The Trough has a smooth, flat floor which gently steepens to the north-northwest from about 1100m. It joins the Osprey Embayment region at a depth of about 3000m between the Queensland and Eastern Plateaus. The Queensland Trough is probably fed from both sides by canyons (Falvey, 1972).

In the southern part of the Trough, between Flinders and Bougainville Reefs, the west to east profile is simple, but north of Bougainville Reef the profile becomes more complex. The eastern wall of the trough appears to rise in two steps; one along about 146 15 E where there is a relatively steep rise through about 500m, and the second adjacent to the Flinders/Osprey Reef trend. Gardner (1970) noted an abrupt constriction in the trough, behind which sediment has ponded at 15 S, between Osprey and Bougainville Reefs. He suggested that differential down-faulting along a lineament between these two reefs was responsible for forming the trough margin in this region. As a result, a small terrace at a depth of about 2000m has formed south-southwest of Osprey Reef.

The strike of the Trough is that of the dominant structural grain of the Tasman Fold Belt in northern Queensland (Hill and Denmead, 1960). It mirrors the trend of, and has approximately the same strike extent as, the North Coast Structural High (Fig. 2). West of this high, structural depressions form the site of the Laura and Hodgkinson Basins. Such a structural framework onshore immediately west of the QQueensland Trough led Mutter (1977) to speculate that the Queensland Trough lies along a structural "low" of the Tasman Fold Belt.

3. PREVIOUS WORK

Geological sampling and drilling. Taylor (1977) listed over 120 core and bottom sample stations from the Coral Sea region, while Krause (1967) and Gardner (1970) have described smaller sets of samples from the same area. The cores and bottom samples were taken by several overseas institutes and also from Australian navy vessels. They give an overall description of the surface sediment type for much of the margin although sites are sparse in the deeper, eastern parts of the Queensland Plateau and in the Townville Trough. They show that the margin is at present receiving calcareous pelagic sedimentation. Some areas near to the Great Barrier Reef, and near to large reefs on the Queensland Plateau, have reef-derived detritus (Taylor, 1977). Mutter (1977) described evidence on seismic reflection profiles for zones of reef detritus around the Queensland Plateau reefs and he mapped their distribution. The Coral Sea Basin, the Moresby Trough and the Papuan Plateau receive terrigenous sediment at present, largely deposited as turbidites. Taylor (1977) has shown from mineralogical evidence that the provenance of the terrigenous sediment is from southeastern Papua rather than the Fly River delta as had previously been assumed.

In 1980/81 a joint BGR/BMR sampling cruise using the R.V. Sonne collected core and dredge samples from the Eastern Plateau, Osprey Embayment, northwestern and northeastern slopes of the Queensland Plateau, and the Moresby Canyon. Some of the paleontological results of this cruise are discussed by Chaproniere (1983).

On the shelf in the central Great Barrier Reef area about 50 vibrocores have been obtained using an Amos McLean Vibrocorer. The cores sampled to a maximum of 4.5m in water up to 70m deep. In addition, teen reefs have been studied in detail, with about 400m of core being obtained from 30 drill holes. The mechanisms of modern reef growth (Davies and Hopley, 1983) and the deposition of the near-surface inter-reef sediment (Davies and others, 1983) are relatively well understood in this area.

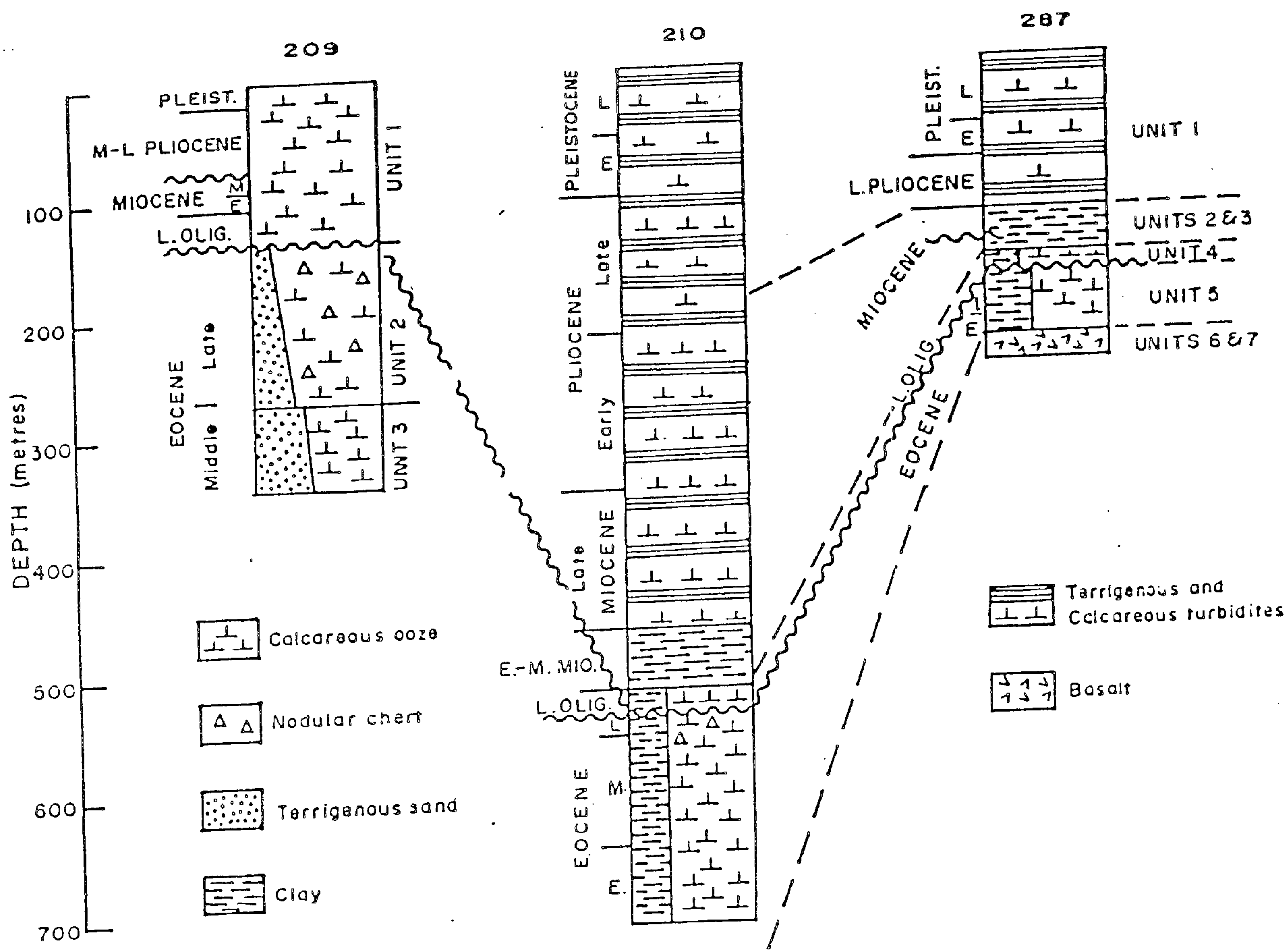


Figure 2. Stratigraphy of DSDP sites in the Coral Sea. Locations shown in Figures 1 and 2. Data sources: Burns, Andrews & others, 1973; Andrews, Packham & others, 1975. (After Taylor, 1977)

The most important sources of geological data are the Anchor Cay well, and the three drill sites of the JOIDES Deep Sea Drilling Project (Fig. 1). Sites 209 and 210 were drilled during Leg 21 of the project (Burns and others, 1973), and Site 287 was drilled during Leg 30, with the object of reaching basement in the Coral Sea Basin (Andrews and others, 1975). These sites are described below. Other wells in some of the adjacent onshore basins and, particularly on the shelf to the south in the Capricorn Basin (Aquarius -1 and Capricorn 1-A), contain information relevant to the study area (Table 1).

Anchor Cay No. 1, drilled by Tenneco in 1969, revealed Eocene to Pliocene (?) reef and associated carbonates unconformably overlying paralic Mesozoic sandstones. A summary of the salient points from the well completion report (Oppel, 1969) is included in Appendix A.

The most important deep sea geological data are the three drill sites of the Deep Sea Drilling Project, drilled during Legs 21 and 30.

DSDP Site 209 was drilled on the eastern Queensland Plateau in 1428 m of water and penetrated three lithologic units. It bottomed in late mid-Eocene glauconite-bearing bioclastics and foraminifera-rich sediment thought to have been deposited in upper bathyal to neritic depths, probably on the continental margin (Unit 1). The overlying Unit 2, which is of the latest middle Eocene to late Eocene age, is comprised of detritus and foraminiferal ooze indicating subsidence of the margin. A major hiatus separates Units 1 and 2, extending from late Eocene to late Oligocene and is probably the result of non-deposition and/or slight submarine erosion. This was followed by further subsidence to the present mid-bathyal depths and the deposition of almost pure foraminiferal and nannofossil ooze from the late Oligocene to the present. This stage of sedimentation was interrupted by a period of non-deposition or erosion during the middle Eocene.

The most important points to emerge from the data are (Fig. 2):

* The site clearly records the history of subsidence of the Queensland Plateau from shallow water (neritic) in the late middle Eocene, to the present depth at the site of 1428 m (mid-bathyal).

* Sediments are dominantly foraminiferal ooze throughout with terrigenous content in the cores reducing in the upper units, particularly from middle to upper Eocene.

* A major period of non-deposition or submarine erosion spans most of the Oligocene. After this hiatus the sedimentary regime is almost purely pelagic carbonate ooze.

* The effects of submarine current activity are well recorded.

The Eocene/Oligocene hiatus has been attributed to submarine erosion caused by either a major chamge in circulation patterns following the final separation of Australia from Antarctica in the early Eocene (Kennett and others, 1972), or by the commencement of a significant equatorial circulation pattern (Taylor and Falvey, 1977). Winnowing is evident in the post-hiatus sediments, suggesting bottom current activity. Depositional patterns (Mutter, 1977; Taylor and Falvey, 1977) also suggest the influence of currents on

TABLE 1 - Exploration wells - offshore and onshore Queensland

ll	No.	Title	Rig	Rig Release	K.B./S.L.	Basin	T.D.	Reached basement	Deepest Sed. horizon penetrated	Cost MM$	
ay No. 1	69/2000	Q/1P	Conception	6.5.69	10m/63m 34'/206'	Papuan	3623 m 11,888'	No	Mesozoic undiff.	1.73	p/a p/a
No. 1	67/4276	Q/4P	EW Thornton	27.3.68	10m/65m 32'/213'	Capricorn	2650 m 86095'	Yes	Early Cret. (Aptian)	1.101	"apparent drape over [illegible] after drilling no structur Recent reef in sea floor.
n No. 1A	67/4269	Q/5P	EW Thornton	15.1.68	10m/106m 32'/347'	Capricorn	1710 m	Yes	Aptian	.99	p/a closed anticline.
. 1	62/1214	onshore	-	12.8.62	24m RT + 80'	Laura	1166 m 3829'	No	Permian (basalt)	.196	p/a Stratigraphic test - or [illegible] positive gravity anom[illegible]
ains No. 1	70/650	onshore	-	14.8.70	19m KB + 61.8'	Laura	987 m 3238'	Yes	Permian	.288	p/a East flank of ar[illegible]iclin[illegible].
No. 1	70/650	onshore	-	29.8.70	32m KB +105.4'	Laura	930 m 3052'	Yes	Jurassic		p/a East flank of a[illegible]iclin[illegible].
land No. 1	62/1021	onshore	-	14.6.59	7m RT + 22'	Maryborough	579 m 1898'	Yes	Miocene	.169	p/a Gravity high.
e No. 1	65/4149	onshore	-	28.7.65	7m RT + 23'	Proserpine	1295 m 4250'	Yes	L. Carb(?)	.108	p/a
o. 1	69/2022	Q/12P	Navigator	Proposed spud 1.3.1970. Est. duration 40 days	23 m RT + 77'	Proserpine	6600'	?	?	.82	Proposed well - never drill located in inland waters 162P of Q/12P. Anticl[illegible].

(After McAvoy & Temple, 1978)

offshore well

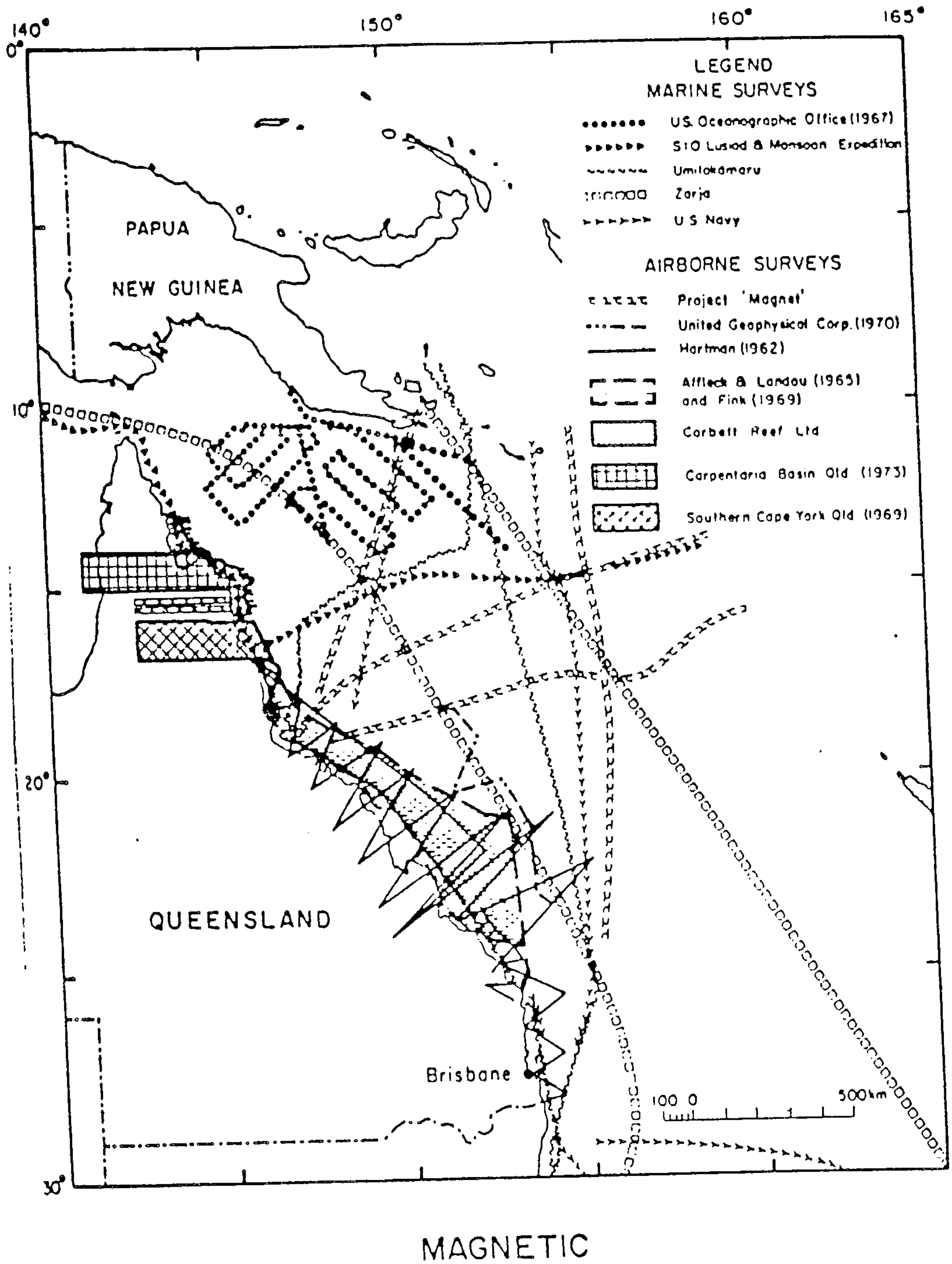


Figure3 Magnetic surveys in northeastern Australia and the western Coral Sea (after Mutter, 1977).

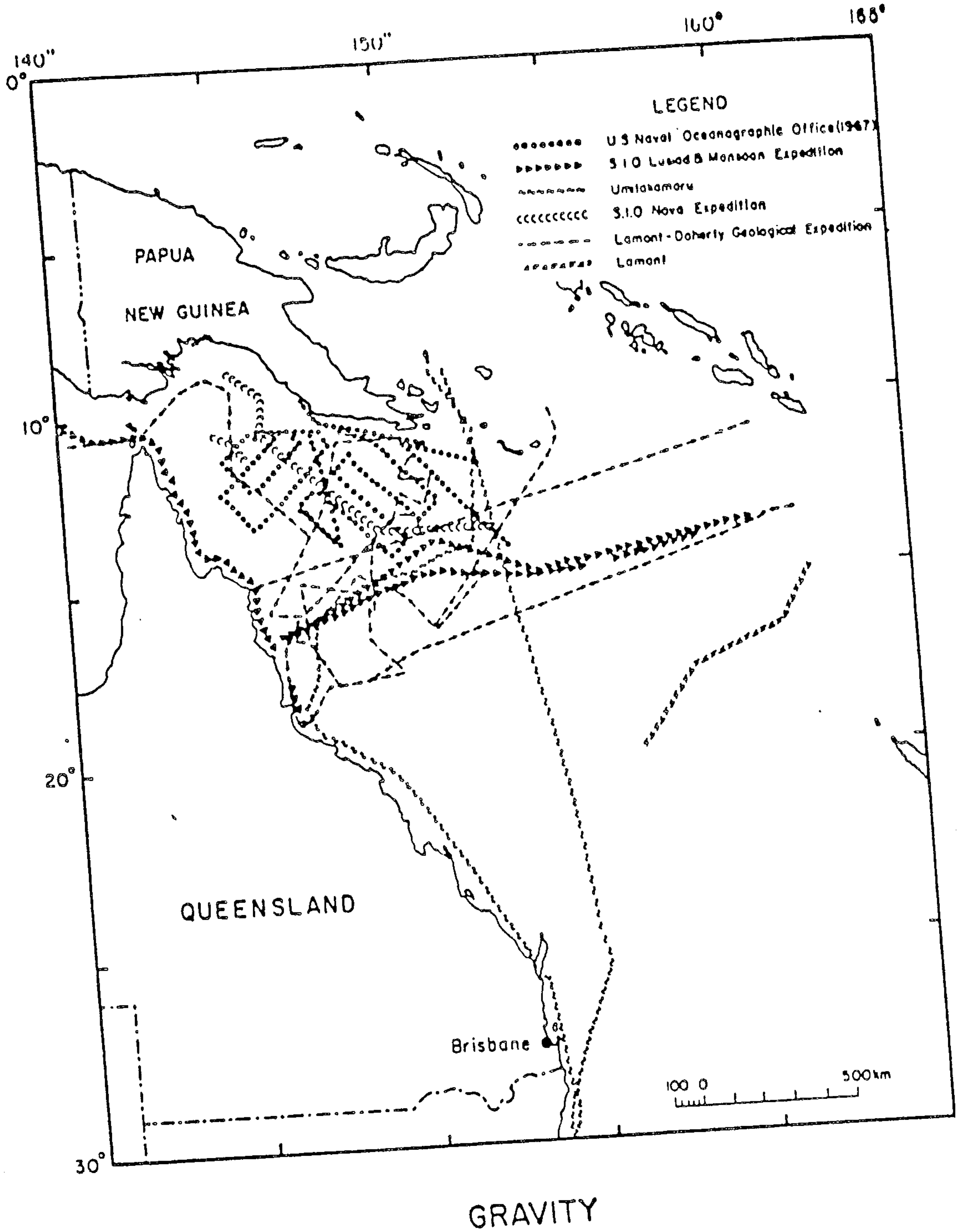


Figure 4 Gravity surveys in the western Coral Sea, pre-1970 (after Mutter,1977).

TABLE 3 — PERMIAN AND MESOZOIC STRATIGRAPHY

	AGE	UNIT	MAXIMUM THICKNESS (m)	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	HYDROCARBON SHOWS	REFERENCES
LAURA BASIN	Early Cretaceous	Rolling Downs Group	200 to 300	mudstone with minor glauconitic sandstone and siltstone	shallow marine	nil	de Keyser & Lucas (1968) Powell & others (1976)
	?Late Jurassic to Early Cretaceous	Albany Pass Beds	?20	quartzose clayey sandstone, pebble and granule conglomerate, claystone beds	fluvial; upper part paralic	nil	Powell & others (1976)
	?Late Jurassic to Early Cretaceous	Gilbert River Formation	200	quartzose sandstone, with siltstone and shale, locally glauconitic; rare coal	paralic, ?fluviatile in part	rare fluorescence	de Keyser & Lucas (1968), Smart & others (1971) Powell & others (1976)
	Middle to Late Jurassic	Dalrymple Sandstone	550	quartzose sandstone conglomerate, minor siltstone, shale and coal, glauconitic in part	fluviatile, paralic	slight stain and fluorescence	de Keyser & Lucas (1968) Powell & others (1976)
TORRES SHELF	mainly Jurassic	Helby Beds	500	quartzose sandstone, granule conglomerate micaceous calcareous siltstone minor glauconite and pyrite, tuff and tuffaceous sandstone in lower part	estuarine-paralic	none reported	Gibson & others (1974) Powell & others (1976)
TAI ANCHOR CAY 1	Jurassic to Early Cretaceous	Undifferentiated Mesozoic	2200	upper — quartzose sandstone, some siltstone and shale middle — black pyritic shales volcanic detritus lower — conglomerate, sandstone	deltaic lagoonal-deltaic	dead oil stains	Oppel (1969 1970)
				U N C O N F O R M I T Y			
OLIVE RIVER AREA and under LAURA BASIN	Late Permian to Early Triassic	undifferentiated		carbonaceous shale, sandstone, minor coal	?continental, deltaic	none reported	de Keyser & Lucas (1968); Minad (1962)

(After Smart & Rasidi, 1979)

TABLE 4 — CAINOZOIC STRATIGRAPHY

AGE	LAURA BASIN: Thickness (m) Depositional Environment	LAURA BASIN: Lithology	TORRES SHELF: Thickness (m) Depositional Environment	TORRES SHELF: Lithology	PAPUAN BASIN — TAI ANCHOR CAY 1: Thickness (m) Depositional Environment	TAI ANCHOR CAY 1: Lithology	TAI ANCHOR CAY 1: Hydrocarbon	PPC PASCA 1: Thickness (m) Depositional Environment	PPC PASCA 1: Lithology	PPC PASCA 1: Hydrocarbon shows
Holocene	25 Fluvial & coastal	quartzose sand, silt, clay		reef limestone	25 Shallow shelf	coral biocalcarenite, black volcanic sandstone	Nil	360	mudstone and interbedded sandstone grading to calcarenite	Nil
Pleistocene	20 Fluvial & coastal	sand, silt, clay, quartzose sand, clayey sand		calcareous muds	200 Shallow shelf & shallow neritic	coral debris; mudstone with coal & volcanic debris	Nil	300 Shallow shelf	mudstone, some interbedded sandstone and calcarenite	minor gas
Pliocene	15 Colluvial	weathered bedrock (sandy & clayey)		minor	300 Shallow shelf (reef)	coral debris; mudstone with volcanics in upper part, decreasing with depth; limestone-biomicrite, with argillaceous mudstone and marl	Nil	1550 Shallow shelf	mudstone with interbedded sandstone as above	gas
	70 Continental	clayey quartzose sand, sandy clay, granules, locally pebbly Lilyvale Beds	? up to 300	terrigenous						
									calcareous mudstone, some interbeds of marl and minor limestone	
					U N C O N F O R M I T Y					
Miocene					950 Shallow shelf & shallow neritic (reef in upper part)	limestone as above, limestone with some marl,		250 Shallow shelf (reef)	coralline limestone, porous	
						calcarenite, some some calcirudite; dolomite; mudstone & marl, cherty, marl & limestone interbedded, dense	Nil	130+ Shallow shelf	lowest part shaley limestone or ? shale	
					U N C O N F O R M I T Y					
Oligocene Eocene		? Absent	?	? ?	330 Shallow neritic & shallow shelf	Argillaceous limestone, some dolomite, variegated shale in lower part			?	
References	da Keyser & Lucas (1968) Whitaker & Gibson (1977)				Oppel (1969, 1970)			Patterson (1960) Wise (1976) Brown & others (in press)		
Remarks					Lithologies after Oppel (1969) Environments from Rainwater, in: Oppel (1970)			Lithologies after Patterson (1969) Thicknesses from Patterson (1969) and seismic interpretation		

(After Smart & Rasidi, 1979)

TABLE 5 - SEISMIC STRATIGRAPHIC FRAMEWORK OF THE WESTERN CORAL SEA

Inferred Max. Age Range	Bathymetric Province	Sequence Boundary Geometry	External Form	Internal Reflection Properties: Configuration	Internal Reflection Properties: Continuity	Internal Reflection Properties: Amplitude	Interval Velocity	Palaeoenvironmental Facies Interpretation
A Pliocene and younger	plateaus	concordant to onlapping at base	sheet, channel, & trough fill	subparallel wavy parallel to hummocky clinoform in places	moderate, low in places	moderate to low	Range (Average)	open marine mid-lower bathyal pelagic ooze, N & NW terrigenous low-energy turbidity currents, and slump deposits
	deeps	concordant to onlapping at base, some downlap	basin & slope front fill	subparallel to hummocky, migrating waves in places	moderate to low	moderate to low	1.56-2.41 (1.8)	deep water low energy turbidity current deposits with some pelagic ooze, strong bottom current activity in places
B Late Miocene	plateaus	erosional truncation, concordant at top, concordant, gentle onlap at base	sheet, channel, & trough fill in places	parallel to sub-parallel, hummocky	moderate to high, low in places	moderate to low	1.65-2.62	deep water open marine pelagic ooze, N & NW low-energy turbidity current deposits
	deeps	concordant at top, concordant, gentle onlap at base	basin & slope front fill, some mounded fill	subparallel to parallel	moderate to high	moderate to low	(2.0)	deep-water, low-energy turbidity current deposits with more pelagic ooze than seq. A, some turbidite fans
C Middle Miocene to early Oligocene	plateaus	concordant or gentle truncation at top, onlap at base	sheet, channel, & trough fill	parallel wavy parallel and sub-parallel	high to moderate	moderate to low	2.0-2.94	open marine upper bathyal pelagic ooze, N & NW low-energy turbidity current deposits, shelf limestones, reef debris, & calcarenites in shallower areas
	deeps	concordant or erosional truncation at top, onlap or concordant at base	basin & slope front fill	parallel, sub-parallel	moderate to high	high to moderate	(2.2)	pelagic ooze & abyssal clay, turbidite deposits close to source areas often in restricted marine environment
D Late to early Eocene (& late Paleocene?)	plateaus	concordant or erosional truncation at top, concordant or onlap at base	channel, trough, basin fill, sheet	parallel, subparallel, & even, slightly divergent, some areas of oblique prograding	high to moderate	variable, high to moderate	2.07-3.87	neritic, open shelf marine, high & low energy deposits & uniform energy deposits, bioclasts
	deeps	concordant or gentle truncation at top, concordant, onlap & downlap at base	slope front fill, trough fill, sheet	parallel, subparallel, & even, slightly divergent in placus	high to moderate	variable, often moderate, very high in places	(2.6)	pelagic ooze & terrigenous detritus, low energy turbidity currents in restricted marine environments
E Early Paleocene to Late Cretaceous	plateaus	concordant or gentle truncation at top, concordant, onlap, & dwnlap at base	sheet, channel, trough, & basin fill	even parallel & sub-parallel to slightly divergent in places, some oblique prograding locally	high to moderate	variable, generally high but very low in a few areas	2.35-4.75	paralic to shallow shelf clastics with some fluviatile & deltaic deposits
	deeps	generally concordant at top, onlap and downlap at base	slope front, trough & basin fill	subparallel, slightly divergent, hummocky & reflection free in places	low to moderate	generally very low, also moderate	(3.5-4.0)	continental, marginal marine & shallow marine clastics, alluvial & submarine fan deposits in restricted environments
F Early Cretaceous and older Mesozoic?	plateaus & deeps	strong erosional truncation at top; downlap, onlap, or concordant at base	variable wedge, sheet, & basin fill	variable parallel, subparallel, divergent, hummocky, & often disrupted	variable but often high to moderate	variable, often high	3.25-4.68 (4.2)	a variety of environments, mostly non-marine to inner neritic, fluviatile & deltaic deposits

(After Symonds & others, 1984)

sedimentation.

DSDP Sites 210 and 287 in the central Coral Sea Basin penetrated essentially the same lithologic sequences. The more complete section was intersected at Site 210. The bottom part of the section is comprised of early to late Eocene detrital clays and biogenic pelagic sediment which accumulated above the foram solution depth. The clays are thought to have been derived from high grade metamorphics and volcanics to the west (Burns and others, 1973). Deposition was interrupted in the late Eocene to early Oligocene by an erosional and non-depositional hiatus which is of regional extent and was caused by a marine bottom water current (Kennett and others, 1972; Edwards, 1975) middle Oligocene nanno-oozes deposited near the carbonate compensation depth overlie the unconformity, and are followed by a late Oligocene to early Miocene period of non-deposition and/or erosion. Overlying this conformity is an early-mid Miocene abyssal clay indicating deepening of the sea floor to below the compensation depth. The clays are though to have been derived from the Papuan area to the northwest (Burns and others, 1973). During the late Miocene to late Pleistocene, turbidity currents deposited graded cycles of silt and clays with the sediment again being derived from sources in Papua New Guinea.

Smart and Rasidi (1979) tabulated the stratigraphy of the northern part of the region from the limited well data available (Table 3 and 4). Symonds and others (1984) have set up a seismic stratigraphic framework for the region mainly based on the interpretation of processed SONNE seismic data tied to the three DSDP sites (Table 5).

Geophysical data.

Gravity and magnetic measurements, seismic reflection profiling, single-ship (sonobuoy) and two-ship seismic refraction profiling, and heat flow measurements have been recorded fairly extensively throughout the Coral Sea region (Figs. 3). The data collection agencies fall into three fairly distinct groups which appear to have had rather different objectives - BMR, oil exploration companies and academic institutes.

BMR collected gravity, magnetic and seismic reflection profiling over the continental margin area during 1970/71 as part of the continental margin survey. It is the only agency which has collected regional data on a systematic survey grid (Fig. 4). Seismic reflection profiling was made with a 120 kJ sparker and six-channel hydrophone streamer. Magnetic measurements were made with a proton precession magnetometer, and gravity measurements with a LaCoste and Romberg stabilized platform gravimeter. Navigation control was available from the U.S. Navy Transit satellite system. Sonar doppler, electro-magnetic and ship's pressure logs were used for dead-reckoning between satellite fixes. All data, except some reflection profiling and gravity data collected in moderate to rough weather conditions, are of reasonable quality.

BMR has also made gravity measurements in the Great Barrier Reef, and with the use of underwater instruments, on the continental shelf. (Dooley, 1965).

As well as this regional data (Fig. 5) set BMR has collected intermediate penetration seismic and magnetic data in the central Great Barrier Reef area

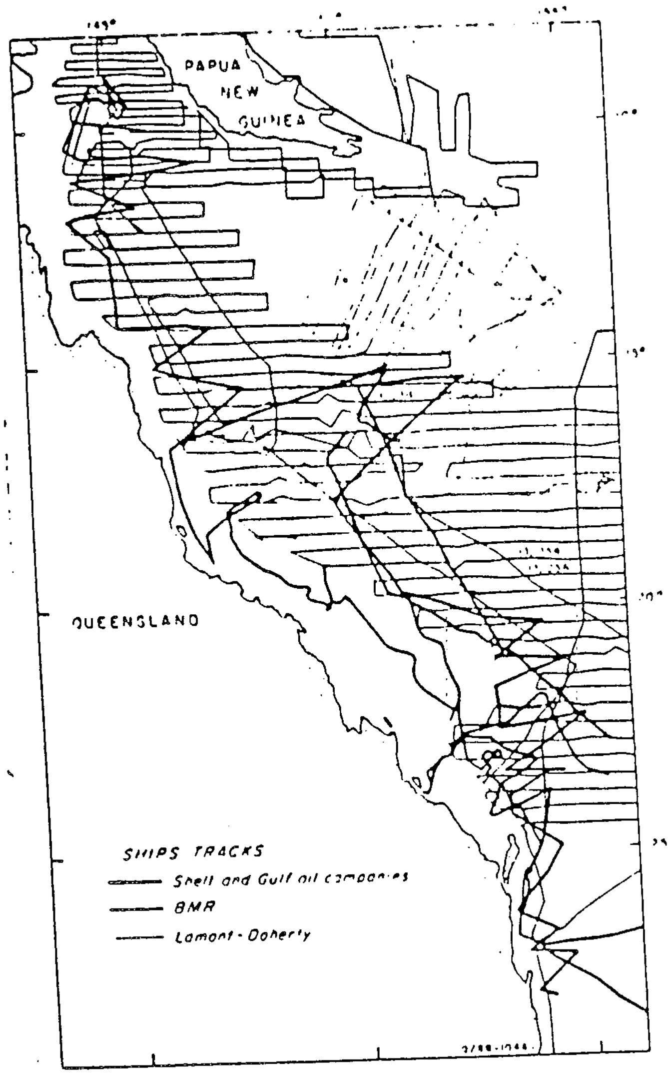


Figure 5 Post-1970 seismic data in the western Coral Sea - Shell, Gulf, BMR and Lamont-Doherty (after Mutter & Karner,1980).

between Cairns and Bowen (Fig. 6). This program generated 1000km of single channel digital data (1981), 8000km of 24 channel digital data (1982/83), and 3000km of high-resolution boomer profiles (1982/83). The sparker data was variously shot at 6, 12 and 18 fold on closely spaced (2km apart) lines in two areas on the shelf and on more widely spaced lines across the outer shelf/upper slope into the Queensland Trough. The data was recorded using a 9 kilojoule, 9-electrode sparker and a decca Hifix 6 and Motorola miniranger navigation system.

While BMR's surveys aimed at obtaining a systematic coverage of the margin as a whole using a variety of geophysical techniques, exploration companies have collected data largely from those areas where sediment thicknesses are fairly large, and oil prospectivity therefore high, and have mainly concentrated on obtaining high quality reflection profiles (Tables 2A and 2B).

Exploration companies have also flown airborne magnetometer surveys throughout most of the continental shelf area, including the Capricorn Channel in the extreme south. The northeastern sheet of BMR's magnetic map of Australia (Bureau of Mineral Resources, 1976b) is a contoured compilation of existing magnetic data and shows exploration company information on the continental shelf and BMR information in deeper water.

Shell Development Australia and Australian Gulf Oil have also conducted extensive regional work and have obtained high quality reflection profiles using powerful energy sources and multi-channel streamers (Fig. 5). Digital processing has also been applied to the data to enhance record quality. High precision navigational equipment was used on the vessels working for both companies. Gravity and magnetic measurements were also made.

A number of vessels from overseas oceanographic and/or geological institutions have recorded geophysical information in the region, and some specific studies of the continental margin have been made. The most important of these is the two-ship seismic refraction program conducted cooperatively between the Lamont-Doherty Geological Observatory and the University of New South Wales in 1967. Analyses of the reflection and refraction data were published by J. Ewing and others (1970) and M. Ewing and others (1970) and have subsequently been used by Gardner (1970), Falvey (1972), and Taylor and Falvey (1977). Lamont-Doherty, working with BMR, conducted a very comprehensive survey over the Coral Sea Basin in 1977, collecting bathymetric, gravity, magnetic and reflection seismic information.

Several expeditions of the Scripps Institution of Oceanography have entered the area as part of more wide-ranging programs, and collected geophysical data including seismic reflection and refraction profiles (Shor, 1967; Winterer, 1970). Gravity data from these expeditions and those of other institutions have been incorporated into the BMR Gravity Map of Melanesia (Connolly and Murray, 1978), which includes the northern part of the continental margin of northeastern Australia. Falvey (1972) compiled a free-air gravity map of the Coral Sea region from data obtained by Scripps and other institutions, but was unable to include BMR data at the time. The gravity map of Australia (Bureau of Mineral Resources, 1976a) incorporates all available onshore gravity data with BMR offshore data.

In 1978 and in 1980/81, 6500 km of 24-fold seismic reflection data were

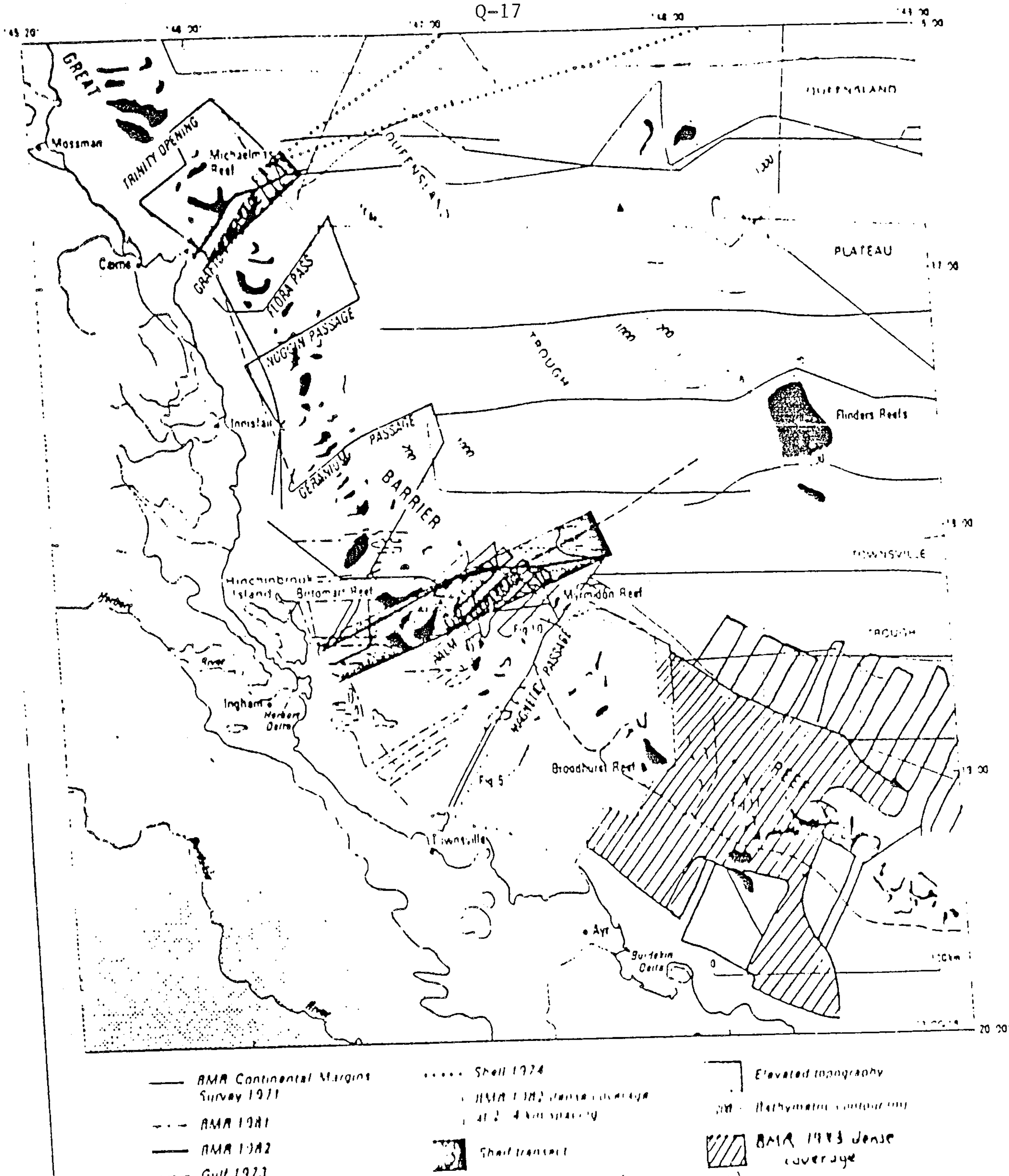


Figure 6 Distribution of seismic lines in the central Great Barrier Reef region. (post-1970).
The positions of the Grafton Passage and Palm Passage shelf transects are also shown. The reefs are shown in black.

collected by the RV. Sonne in joint BGR/BMR programs. The location of these data is shown in Figure 7.

Heat flow measurements have been made fairly extensively in the Coral Sea region. Most have been measured with shallow probes attached to conventional sediment coring devices, but values have also been obtained from the Deep Sea Drilling Project on Leg 21 (Von Herzen, 1973).

4. MARGIN EVOLUTION

Stratigraphic and Tectonic Development

The continental margin of northeast Australia consists of a submerged and dissected northeastern extension of the Tasman Fold Belt. The margin formed during a period of rift tectonism which culminated in the opening of the Coral Sea Basin. The margin is comprised of a series of plateaus separated by rift troughs (Fig. 8); its development followed the following broad course.

Pre-Breakup Development - Jurassic to Early Cretaceous

In the Jurassic to Early Cretaceous the northeast Australian continental margin, incorporating the present marginal plateaus and parts of Papua New Guinea, lay adjacent to the Pacific Plate. Dominantly left-lateral transform movement between the plates (Taylor and Falvey, 1977) may have activated an oblique wrench zone on the Australian continent (Symonds and others, 1984) and formed an elongate trough or "infrarift" basin, which became a site of future rifting.

Continental Breakup - Late Cretaceous to Paleocene

Uplift, rifting and volcanism in the Late Cretaceous formed the Bligh Trough, Osprey Embayment and Queensland Trough as part of a complex rift basin system that developed off northeastern Australia. The Townsville Trough, and a less well developed arm along the site of incipient Coral Sea Basin breakup, form other parts of the rift basin system. This westernmost rift basin controlled the location and form of the present-day continental shelf. Continental breakup through seafloor spreading in the Coral Sea Basin began at the very end of the Cretaceous and was complete by the late Paleocene. During this phase anti-clockwise rotation of the Eastern and Papuan Plateaus produced the northeast-trending ridges flanking the Pandora Trough by thrusting, folding and uplift (Symonds and others, 1984).

The Late Cretaceous to Paleocene interval was one of rift basin infill by alluvial fans along the scarps, and alluvial stream sedimentation in the center of the troughs (Fig. 9a).

Recent seismic studies on the western flank of the Queensland Plateau and in the Queensland Trough have confirmed the presence of a very thick rift fill sequence of Mesozoic age with at least six places having total sediment thicknesses greater than 6 km, and one section in the northwest where it is greater than 7.5 km.

Post-Breakup Subsidence - Paleocene to Recent

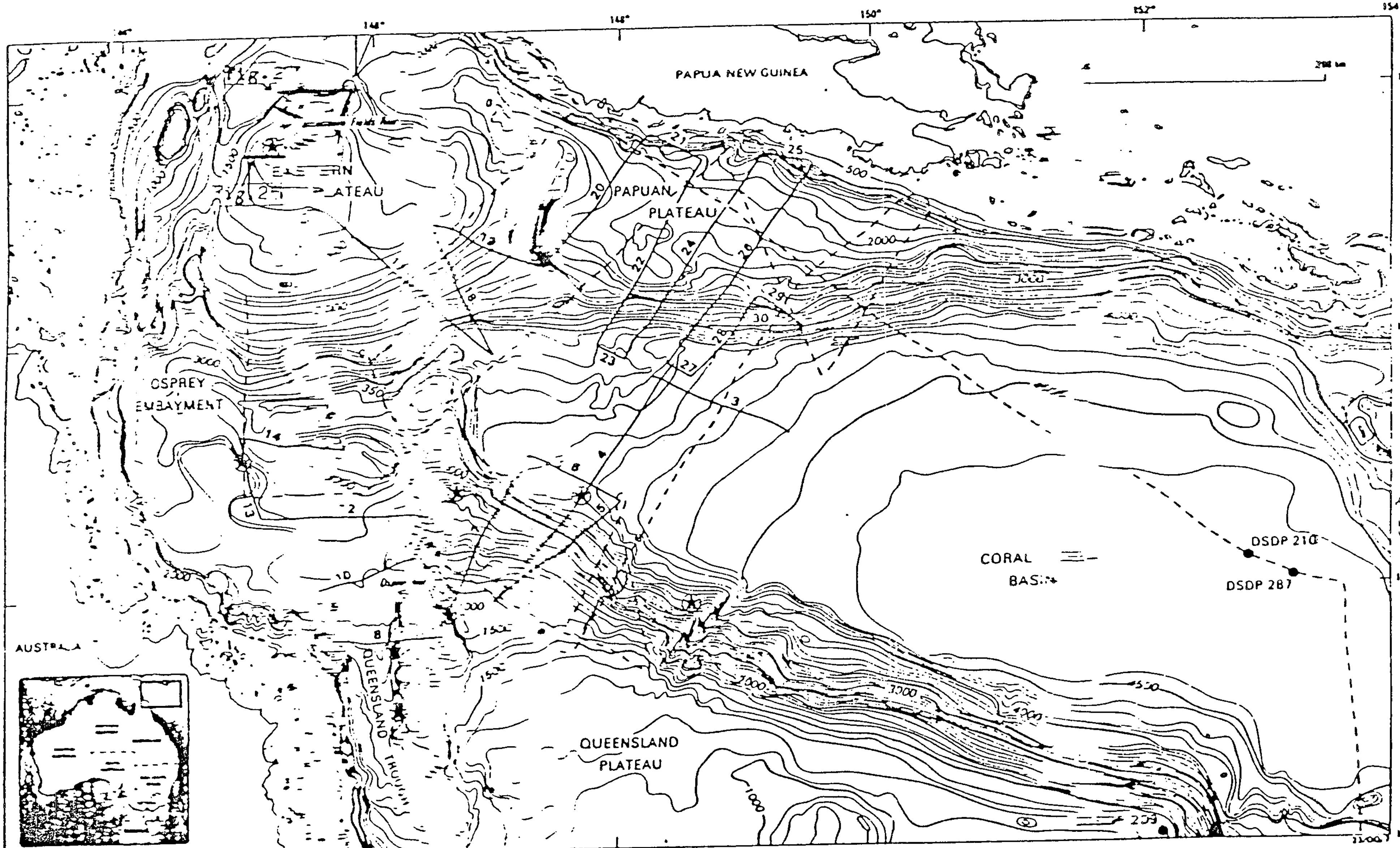


Figure 7 [illegible] 1978 and 1980 [illegible] seismic lines in the western Coral Sea. Bathymetric contours in metres. 1978 seismic data shown by [illegible] lines and 1980/81 seismic data by continuous lines, with line numbers. DSDP sites [illegible] 210 and 287 are also shown (after Symonds & others, 1984). ⊛ — [illegible] 1980/81 sampling sites.

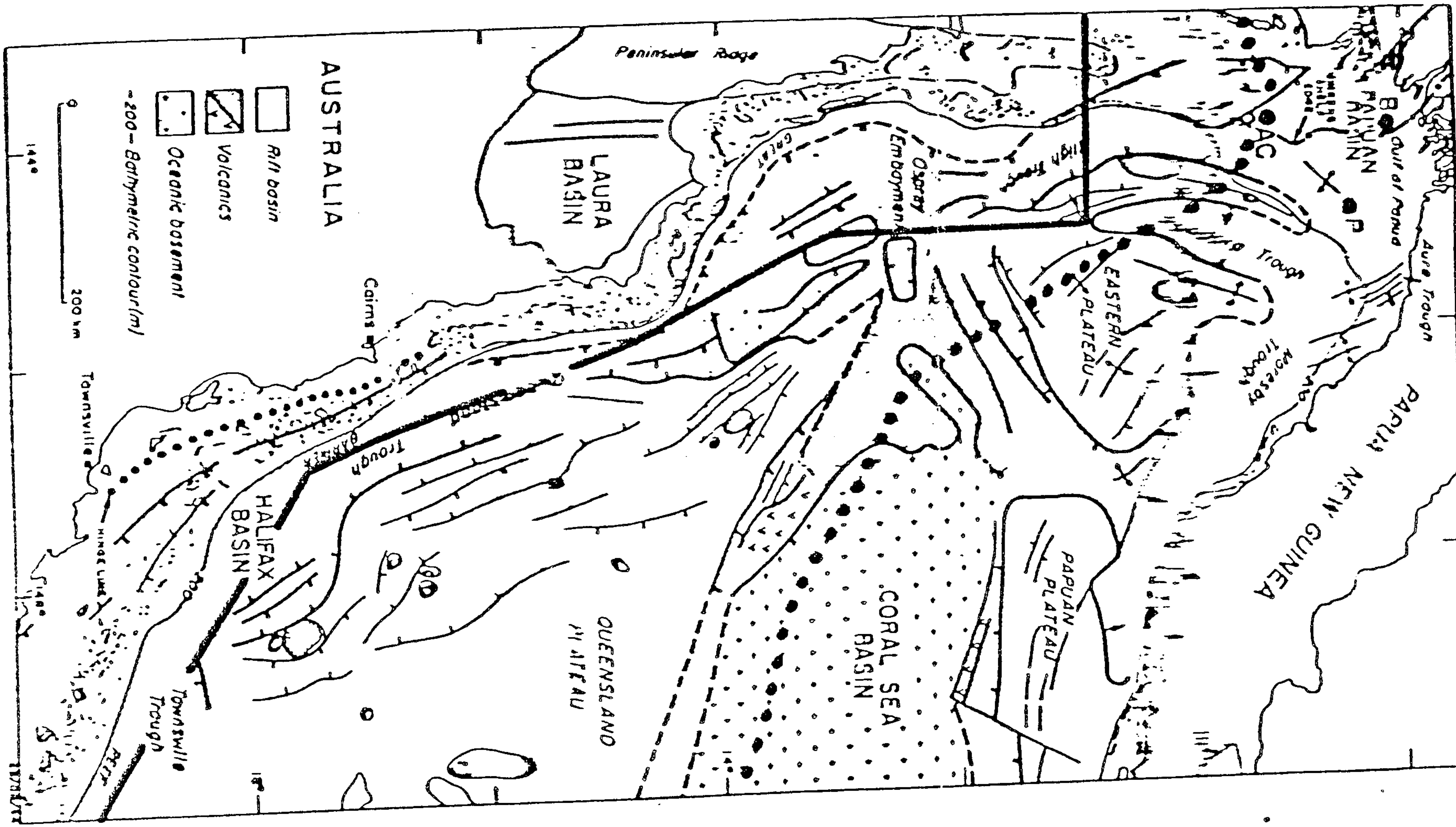


Figure 3. Structural and basement features off northeastern Australia. The thick continuous and broken lines with fault symbol are rift basin boundaries. The thin lines show the trends of fault and fold structures within the main structural elements. The long arrow heads indicate basement dip. The locations of some deep drill holes are shown by the large dots; AC - Anchor Cay No. 1, B - Borabi No. 1, P - Pasca No. 1. Modified from Symonds (1977).

Approx. boundary of the Great Barrier Reef Region.

Approx. Seabed boundary between Australia and Papua New Guinea.

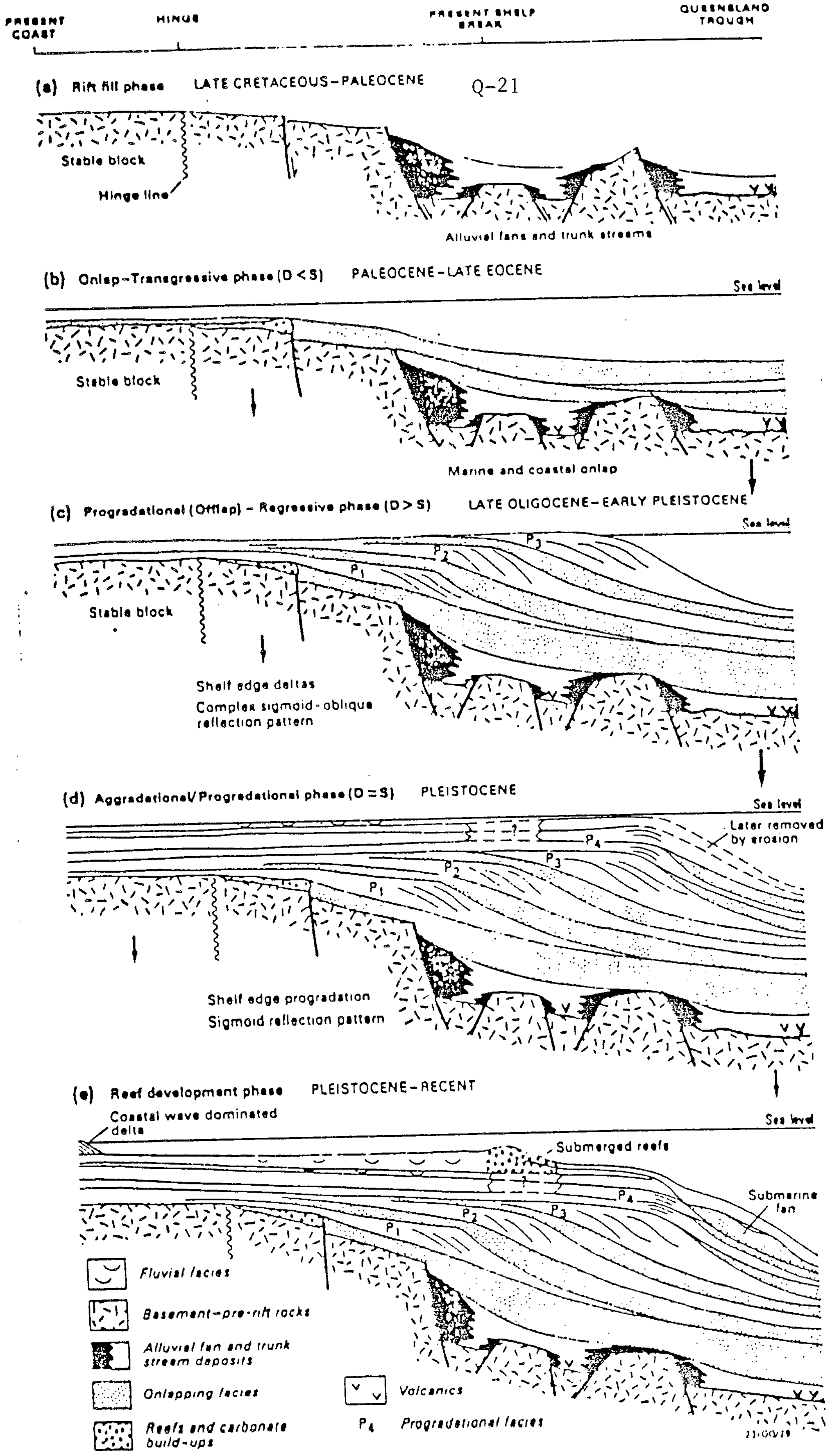


Figure 9-Conceptual evolutionary scheme for the development of the continental shelf in the central Great Barrier Reef Province. D and S indicate the relationship between deposition (sediment supply) and subsidence (relative rise in sea level). The vertical arrows indicate the relative amounts of subsidence across the area.

(After Symonds & others, 1983.)

Paleocene subsidence followed seafloor spreading, with transgressive onlap of terrigenous and pelagic sediment onto the rift separated plateaus throughout the Eocene (Fig. 9b). At this time, subsidence of the western rift basin continued about a hinge line beneath the present-day inner to middle shelf, and a marginal to open onlapping sequence was deposited.

The offshore plateaus and rift troughs experienced significant submarine erosion in the late Eocene to mid-Oligocene, attributed to sub-tropical oceanic current influxes. Stabilization of the sub-tropical ocean current system followed deepening of the basins and plateaus which in turn led to reef development on plateau highs in the late Oligocene to early Miocene and pelagic sedimentation in the deeper areas.

On the continental shelf in the central Great Barrier Reef significant continental shelf construction (both aggradation and progradation) characterized the time period from late Oligocene to Pleistocene. Late Oligocene, late Miocene and late Pliocene progradational episodes occurred which were the result of fluvial and wave-dominated shelf-margin deltaic sedimentation during periods of low sea level (Fig. 9c). Uniform Pleistocene shelf subsidence led to massive shelf aggradation during a time of continuing shelf-edge progradation (Fig. 9d). Significant reef growth on siliciclastic, fluviodeltaic foundations appears to have begun sometime in the Pleistocene. The development of a shelf-edge barrier caused a change in the style of sedimentation on the slope from progradational to mounded onlapping submarine fans and sheetdrape. Concurrent inner shelf sedimentation consisted of prodeltaic sediments associated with coastal wave-dominated deltas (Fig. 9e).

The Oligocene to Pleistocene history of the continental shelf in the tectonically active Gulf of Papua area was somewhat different. Following orogenic activity and uplift in the early and middle Oligocene, shelf limestones were deposited in the early Miocene. Significant barrier and platform reef growth occurred during subsidence in the early middle Miocene. Late middle Miocene uplift exposed and eroded the limestone shelf and reefs. During the following subsidence period a large tide-dominated deltaic system was initiated, and this rapidly buried the remnant reefs with Plio-Pleistocene clastics. This phase of rapid subsidence and deposition has essentially continued to the present day.

Differences in the style of sedimentation beneath the continental shelf off northeastern Australia appear to reflect differences in the factors controlling the relative height of sea level. In the central Great Barrier Reef eustatic changes and long-term subsidence appear to have been important, but these factors were overwhelmed by the effects of major tectonic events in the Gulf of Papua area.

A generalized time-stratigraphic cross section from the Queensland slope to the Coral Sea is shown in Fig. 10. Structuring is primarily controlled by large scale normal faulting of Paleozoic basement. The Oligocene to Recent section is almost completely undisturbed by faulting. Both in frequency and intensity faulting is clearly concentrated in the troughs. The dominant fault trend in the Queensland Trough is north-northwest, in contrast to the more northwest trend of the trough itself. The western margin of the Queensland Trough lies beneath the Queensland continental shelf (Fig. 11). The eastern margin of the trough is defined by a series of en echelon horsts and grabens.

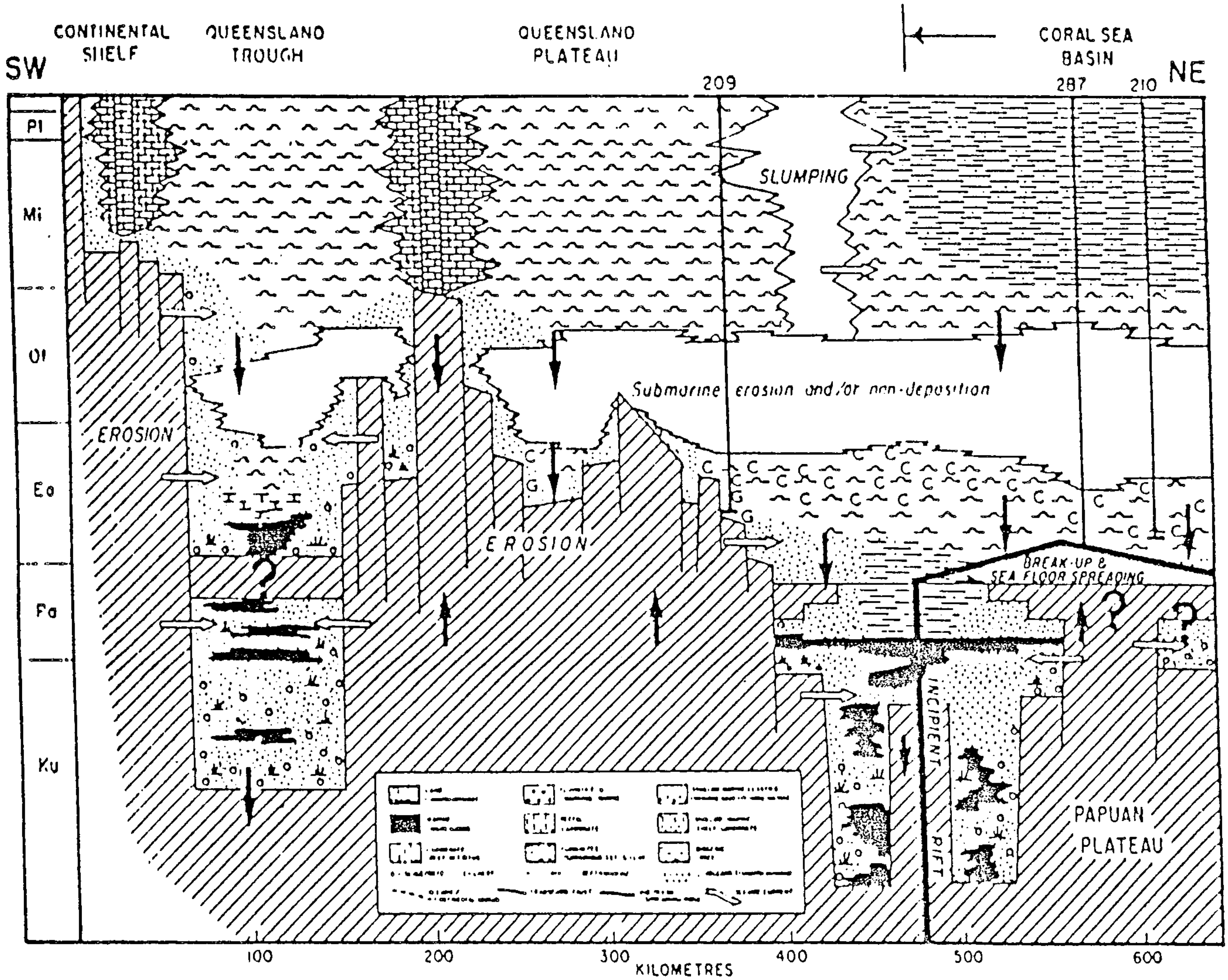


Figure 10 . *Generalised time-stratigraphic cross-section from the Queensland Shelf to the Coral Sea Basin. The onset and cessation of seafloor spreading in the Coral Sea Basin is assumed to have been approximately 55 and 50 m.yrs. respectively, but these times are constrained only by DSDP Site 287. East Papua New Guinea and the Papuan Plateau was translated to the right by roughly 200 km by this seafloor spreading episode. Situations analogous to DSDP Sites 209, 210 and 287 are shown (modified after Falvey and Taylor, 1974).*

(After Taylor & Falvey, 1977)

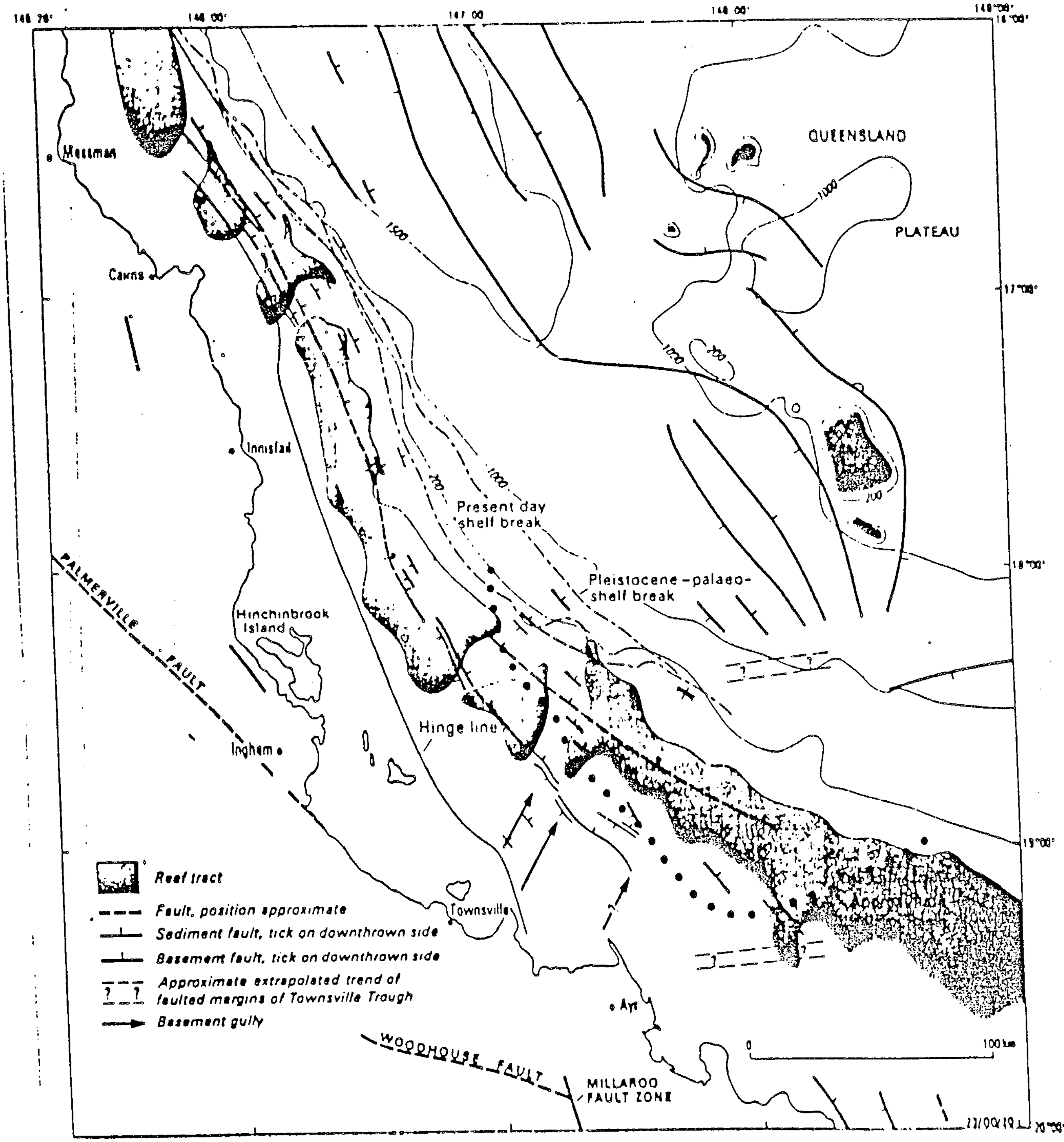


Figure 11. Map of structural and basement features in the central Great Barrier Reef region. Reef tract shaded. Also shown are the positions of the present-day shelf break and a Pleistocene palaeoshelf break.

(After Symonds & others, 1983)

At the junction of the Queensland and Townsville Troughs faulting is comprised of both north-northwesterly and westerly-trending components. Faulting on the Queensland Plateau defines several small grabens and half-grabens containing rift-fill sediments.

Structual relations between the Queensland Plateau, the Osprey Embayment, and the Eastern Plateau are very complex. The western margin of the Eastern Plateau is defined by north to northeast-trending fault controlled troughs - the Pandora and Bligh Troughs. The Pandora Trough is formed over a large eastward-tilted fault block (Symonds and others, 1984). In places its eastern flank exhibits evidence of thrust faulting. The Bligh Trough is underlain by many small, tilted fault blocks and opens out to the south into the Osprey Embayment, our knowledge of which is very sparse. The western margin of the Embayment is probably rift related and of continental origin, whereas to the southeast, near the Queensland Plateau and Trough, it may be of oceanic origin.

Reef Development

Coral reefs occur in the Great Barrier Reef and its extension into the Torres Shelf area, on the Queensland and Eastern Plateaus, and between the Pandora Trough and the Torres Shelf.

Outside of the Great Barrier Reef, the Queensland Plateau represents the site of the most dense growth of coral reefs (Fig. 1). Currently coral reefs occupy 25% of the plateau surface, occurring in fifteen distinct reefal areas (Mutter, 1977). Drowned reefs identified on echo and seismic profiles suggest that reef growth was more widespread in the past. In addition, possible buried reefs have been identified from more than 25 locations, three of which occur on the flank of the Queensland Trough (Fig. 12). At the present time, the reefs on the plateau occur along three major lineaments: (1) north-northwest along the western margin of the plateau; (2) north-south from Moore to Herald to Malay Reefs, and (3) west-east along the southern margin of the plateau and including Malay, Tregrosse and Lihou Reefs. Mutter (1977) concludes that reefs currently occur on top of major basement highs. In this region the distribution of reefs may present a key to the post-breakup history of the region. The distribution of drowned reefs interspersed with living reefs poses the problem of the cause of such selective drowning. It is unlikely to have occurred as a result of regional environmental factors, but may be related to differential subsidence resulting from faulting. This implies Tertiary faulting for which there is little evidence on seismic sections. Eocene reef growth on the Queensland Plateau has been suggested by Mutter (1977) and Pinchin and Hudspeth (1975), and this merits further detailed investigation. The tilt of the plateau to the north suggests a progressive younging of the reefs to the south.

The reefs of the Great Barrier Reef form the western boundary of the study area. Recent published work in the Cairns to Bowen region indicates that this part of the Great Barrier Reef is mainly a Pleistocene feature (Symonds and others, 1983). Other unpublished BMR studies indicate the Great Barrier Reef is considerably older in the extreme northern section, probably Miocene and perhaps Eocene. The Anchor Cay to Portlock Reef area will provide an excellent test of this hypothesis.

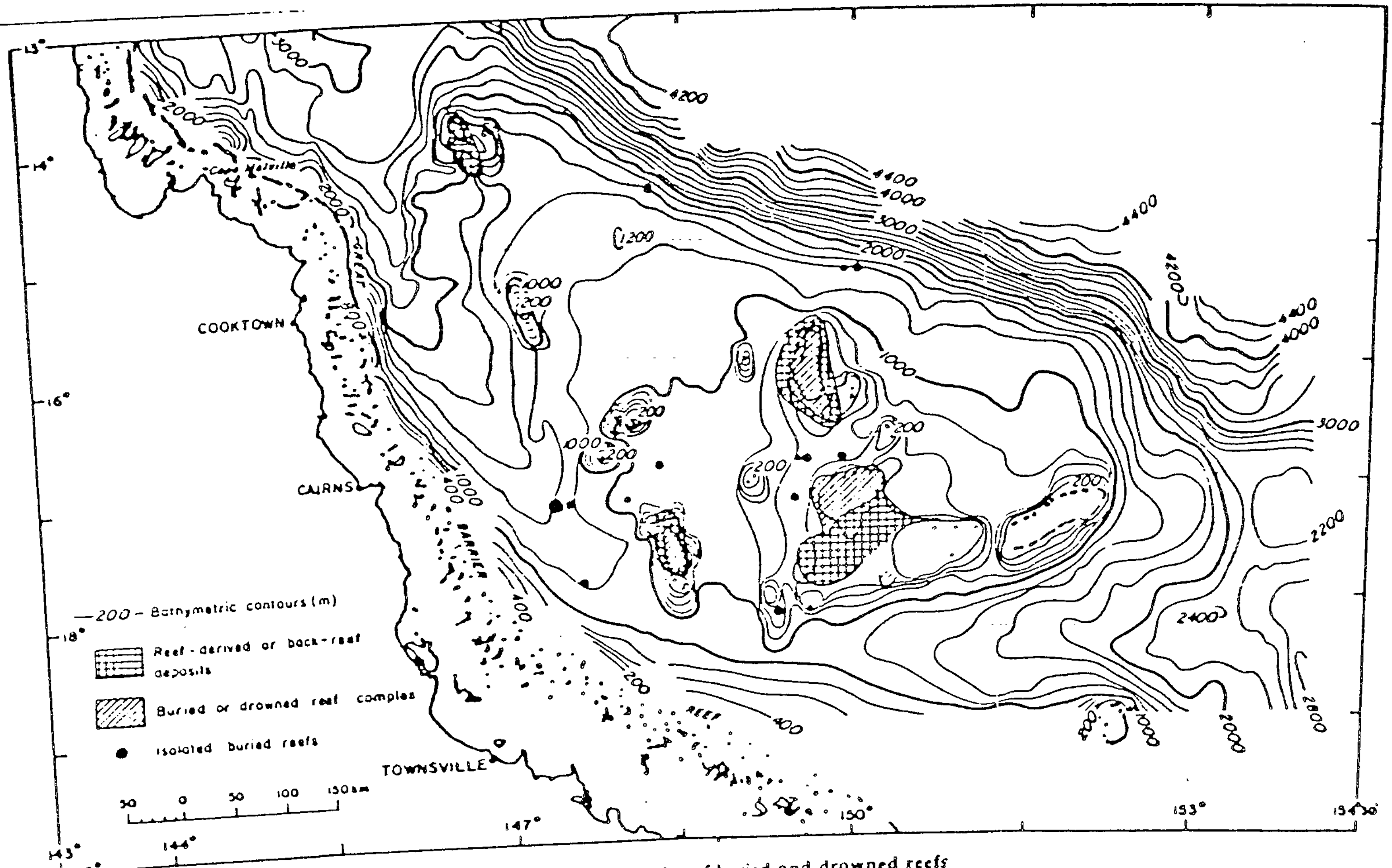


Figure 12. Distribution of buried and drowned reefs

(After Mutter, 1977)

The earliest reef growth in the region probably began on basement highs on the Queensland Plateau in the early to middle Eocene, although some consider that reef growth did not commence until the late Oligocene and early Miocene following the stabilization of an equatorial circulation pattern. The presently growing reefs on the plateau are probably about 1000-1500m thick. Eastern Fields Reef, and the Ashmore-Boot-Portlock Reefs grew on northeast-trending structural highs bounding the Pandora Trough. These reefs, which are up to 1800m thick, are also associated with large areas of submerged reefs and, in a few places, buried reefs (Fig. 13).

The main reef growth phase in the Gulf of Papua occurred during the early middle Miocene, as barrier reefs associated with carbonate shelf development (Borabi), and as isolated platforms on structural (Pasca) and volcanic highs (Uramu). These buried reefs can be up to 1300m thick. Reef growth was terminated by late middle Miocene uplift which caused emergence, and subsequent erosion of the shelf and reefs. Recolonization of old sites during the following period of subsidence never occurred, probably due to a combination of an extremely high rate of subsidence (early Pliocene rates as high as 500m/m.y. are indicated at Pasca); a rapid early Pliocene sea level rise; inimical water related to highly variable temperatures, salinity, and sediment load during the flooding phase; and an enormous input of terrigenous sediment into the Gulf of Papua via the Fly, Kikori and Purari River systems. This last factor is also probably the main reason for the lack of present-day reef growth in the area.

There is no direct evidence for substantial thicknesses of reef rock older than the Pleistocene anywhere in the Great Barrier Reef, although the presence of middle Miocene limestones interpreted to be sheltered back-reef facies in the Capricorn Basin to the south, and at Anchor Cay well to the north, have been taken as indicative of Miocene reef development beneath the northeast Australian shelf. In the central Great Barrier Reef no large areas of buried reef have been discovered and reef growth probably only commenced in the Pleistocene. The reefs, which appear to be only 150-250m thick, grew on and occur within siliciclastic fluviatile and deltaic sediments. Reef growth occurred during short periods of high sea level, but the reefs were subaerially eroded during the intervening and longer periods of low sea level. Continued recolonization of the same sites throughout their growth history has produced reefs that are composite features made up of a series of remnant reefs separated by unconformities. A shelf-edge barrier reef system, now generally submerged, occurs along much of the central Great Barrier Reef province except east of Townsville. Unlike the Gulf of Papua area, it appears that the central Great Barrier Reef has been a major reef province only during its most recent stage of development.

5. SPECIFIC OBJECTIVES (Those of most relevance to the Carbonate Workshop are underlined)

1. <u>To determine the effects of northward plate motion on the growth and evolution of the Great Barrier Reef; i.e. does the reef and associated facies carry an imprint indicating the progressive drift of Australia into the tropics</u>?

2. <u>To determine the effects of sea level change on the style and facies of slope sedimentation</u>. <u>As major and minor facies variations are clearly visible</u>

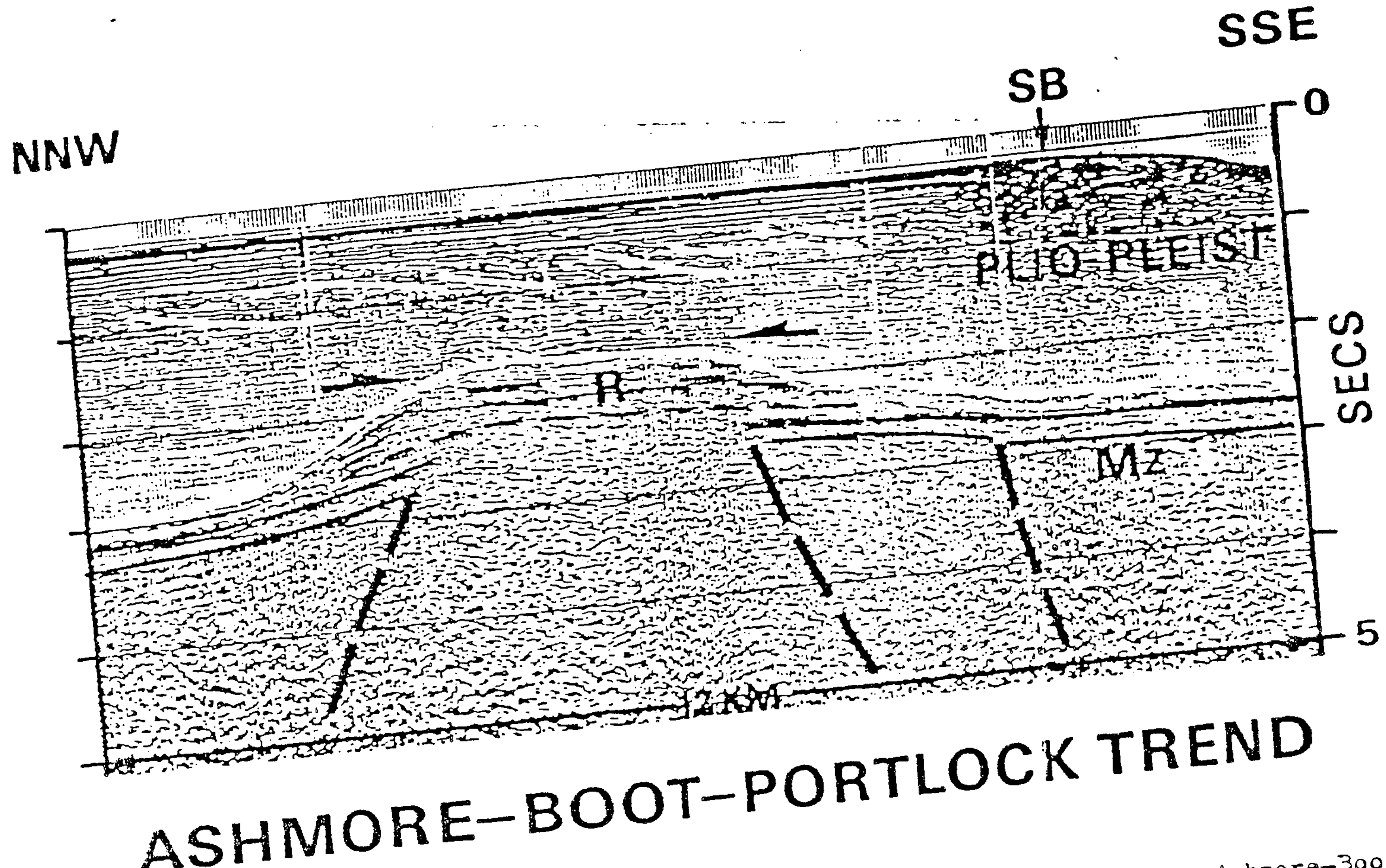


Figure 13. Shell seismic profile across a buried reef at the northern end of the Ashmore-Boot-Portlock Reef trend (see Figure 5 for location).

on seismic sections, a major objective will be to correlate sea level, facies and seismic stratigraphy in an area where the seismic coverage now approaches 250,000 line kilometers and particularly in an area where nearly 12,000 like kilometers of good quality multichannel seismics have been collected in the past four years.

3. To document the changing response of chemical and physical oceanography to changes in the physiography of the western Coral Sea as a result of plate motion and sea level variations. The position of the ACD and the lysocline are currently very shallow due to general undersaturation of western Coral Sea waters.

4. 4. To determine the nature of submarine fans and slump deposits and their relation to sea level and tectonics. The unique carbonate/terrigenous facies variations may well tie process types to sea level position.

5. To determine the influence of passive margin subsidence history on sedimentologic evolution. The subsidence history of northeast Australia shows a series of subsidence pulses, the last of which occurred some 3.5 million years ago. These pulses may tie to specific sediment packages and major sea level fluctuations.

6. To define the subsidence history and related reef growth history of the Queensland Plateau. Seismic and dredge data currently suggest an Eocene to Oligocene age for the initiation of reef growth and a differential subsidence of the plateau, increasing to the north.

7. To determine whether the reefs of the Queensland Plateau are ancestral to the reefs of the Great Barrier Reef and to define the effects of sea level variation on reef establishment in an oceanic situation.

8. To define the sedimentologic facies and depositional mechanisms affecting the western margin of the Queensland Plateau. Recent data (Rig Seismic Cruises 50 and 51) suggest sedimentologic sources to the west.

9. To compare the seismic stratigraphy of the margin of the Great Barrier Reef, the basin of the Queensland Trough and the relatively starved but carbonate-dominated margin of the western Queensland Plateau.

6. SPECIFIC TARGETS (Those of most relevance to the Carbonate Workshop are underlined)

Sixteen location specific targets are nominated for study as part of an ongoing drilling program (Fig. 14). A brief description of each target follows although detailed site proposal forms are attached for each location.

Site 1. Two potential sites are nominated, both in the northern Great Barrier Reef: 1A occurs between Boot and Portlock Reefs and aims at defining the oldest reef growth in the region; 1B occurs south of the Great Detached Reef and is aimed at defining the slope facies developed over the old reef platform.

Site 2. Three sites are suggested defining three different problems: 2A targets the development of mixed carbonate/clastic fans on the upper slope while 2B targets similar features on the lower slope; 2C aims at defining the base

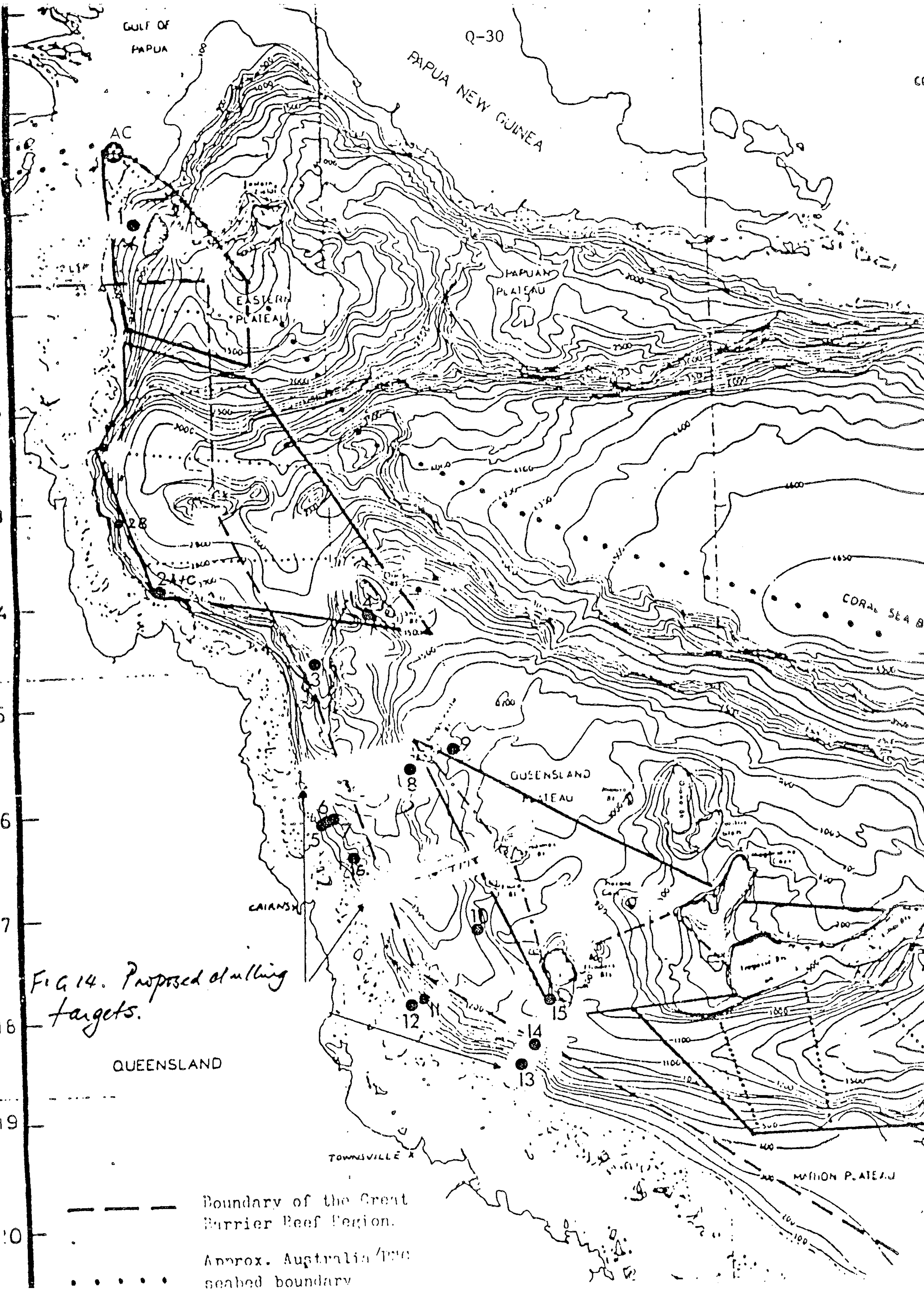


FIG 14. Proposed drilling targets.

Boundary of the Great Barrier Reef Region.

Approx. Australia/PNG seabed boundary

of slope facies overlying basement to the east of Lizard Island. All three holes are targeted into the Northern Great Barrier Reef region.

Site 3. One site is suggested in the northern part of the Queensland Trough. Seismic control is excellent and the hole is aimed at defining trough stratigraphy and development.

Site 4. This site is on the northern end of the Queensland Plateau and is targeted into the condensed sequences above basement.

Site 5. This site is aimed at determining the sedimentologic and stratigraphic development of the upper slope of the Great Barrier Reef. Gravity slide masses overlie prograding sequences.

Site 6. This site is down slope from site 5 and is also targeted into gravity slide and prograding sequences.

Site 7. Trough sequence east of sites 5 and 6. Piston cores show alternating carbonate/clastic units and an excellent potential sea level and paleoceanographic story.

Site 8. This site occurs in the eastern side of the Queensland Trough and is targeted into mound structures which may be reefs.

Site 9. Sedimentological development of the Plateau sequence is the proposed target. The site occurs to the east of Bougainville Reef which is the northwestern part of the Queensland Plateau; when did reef growth start and to what extent has it affected adjacent plateau development?

Site 10. A very important site in the eastern Queensland trough, the target is the Eocene (?) reef overlying acoustic basement. This site will provide the key to the reef history of the plateau.

Site 11. Geranium Passage in the south central Great Barrier Reef region is the suggested focus for a number of holes. Site 11A is proposed into the reef and associated talus on the upper slope; site 11B (sites 1 and 2) are proposed for the upper and lower slope and aimed at defining the progradative and aggradative slope forming processes.

Site 12. In the same vicinity, site 12 targets one of a series of large mounds on the slope. Piston cores show the effects of changing sea level and Pliocene ages close to the surface.

Site 13. Two sites are nominated in the slope of the south central region. Both targets 13A and B are aimed at defining the age of reef growth in the region, the effects of such growth on slope development, and the low sea level effects of fluvio-deltaic input.

Site 14. In the same central Great Barrier Reef region as the previous sites, Sites 14A and B target the mid and lower slope edges of the several prograding clastic wedges forming the slope.

Site 15. A single site in the eastern side of the southern Queensland Trough is targeted into potential buried reefs overlying prograding sequences derived from the east and therefore likely to be carbonate and not clastic dominated.

Site 16. One site is proposed into the slope sequence in front of Grafton Passage to define the age, composition and mode of development of the prograding units, also to determine the relations between high sea level reef growth and low sea level reef destruction and clastic deposition. Seismic stratigraphic imprints and platform/basin correlation form critical objectives.

The above sites are proposed on the clear predication that at least two drilling legs are required to solve the major problems outlined in the objectives. However, if only one leg is accepted as requisite to achieving some of these objectives, then the priority sites would likely be 1, 3, 10, 11, 12 and 16.

ANCHOR CAY #1

Tenneco - Signal
Drilled: 1969

Compiled by J. Colwell, BMR 1983.

Stratigraphy intersected in Anchor Cay #1.

0' - 2750' Recent, Pleistocene, Pliocene.
No circulated samples from 0-980' - samples from driving bit cone only, therefore poor control.
No samples 0-240'.
240'-980'. Very poor control etc. - Some sandstone, and coral debris (near base).
980'-1160' Coral debris
1160'-1308' Lost circulation
1308'-1510' Mudstone with minor coral debris mudstone contains minor black/green volcanics.
1510'-2020' Coral debris - white, chalky, bery fossiliferous.
2020'-2380' Limestone, uniformly graded biomicrite, some argillaceous mudstone.
2380'-2460' Marl.
2460'-2750' Limestone in places very marly.

2750'-3650' Miocene (upper-middle Taurian) - boundary determined on a faunal basis.
2750'-3021' Limestone, as above, occasional oolites or algal balls.
3021'-3130' No samples.
3130'-3650' Limestone with some porous, calcarenite with some calcirudite.

3650'-3950' Miocene, Lower Taurian. (formation boundary determined on faunal basis).
3650'-3760' Limestone as above.
3760'-3950' Dolomite, calcareous in part, slightly fossiliferous.

3950'-5870' Miocene, Kererun.
3950'-4170' Mudstone and marl, light to medium grey, very cherty.
4170'-4990' Limestone and marl. In places very cherty.
4990'-5870' Marlstone & limestone, alternating.

5870'-6800' Upper Eocene.
5870'-6260' Argillaceous limestone, white crystalline to medium grey fossiliferous Lst., contains qtz grains.
6260'-6800' Limestone, very cherty, some dolomite.

6800'-6950' Middle to Lower Eocene. (Boundary determined on, in faunal basis).
6800'-6870' Limestone as above
6870'-6950' Shale (Variegated red, yellow and ochre

6950'-11888'(TD) Mesozoic section

Consists of sandstones alternating with shales; chalcopyrite and pyrite common; some granite outwash deposits; shale, conglomerate & sandstone interbeds. Slate & sandstone are commonly pyritic. Based upon Palmieri's work (included in the well completion report), the Mesozoic section can be divided into 3 depositional environments, as follows-

PARALIC	1. "Molasse" segment from 6950' to 7650' with grey lithic quartzose micaceous sandstones and siltstones, showing cross bedding.
'STARVED' MARINE EUXINIC	2. "Euxinic" sequence (restricted circulation) from 7650' to 10850' with black slates and black mudstones showing pyrite aggregates.
EPICONTINENTAL	3. "Flysch" sequence from 10850'-11 888' with interbedding of shales, mudstones and sandstones showing graded bedding.

NOTE: Disagreement amongst palaeontologists on completeness of the Tertiary section.

NOTE: Maps included after each Site Proposal Summary Form will have to be pieced together by the reader. The originals were too voluminous to be reduced in a satisfactory manner. We regret the inconvenience.

ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 1A Northern Great Barrier Reef General Area: Western Coral Sea Position: 9°50'S: 144°45'E Alternate Site: 1B 11°50'S: 144°00'E	General Objective: Clastic/carbonate accretion as a result of lateral plate motion, subsidence and sea level change Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P.-R.P.

Specific Objectives:

1. To define the age of reef growth in the Northern Great Barrier Reef
2. To determine the nature of post-reef sedimentation
3. To determine the relating role of subsidence, lateral plate motion, and collision with New Guinea on platform development.

Background Information:

Regional Data: A wealth of geophysical data is available for the area: the most recent studies

Seismic profiles: were completed in late 1985 by BMR (see Figs. 3, 4, and 5).

Other data:

Site Survey Data-Conducted by: BMR - Completed December 1985

Date:

Main results: See attached seismic sections

Operational Considerations

Water Depth: (m) 500 Sed. Thickness: (m) <1000 Total Penetration: (m) <1000

HPC yes, 500 Double HPC yes Rotary Drill yes Single Bit yes Reentry _____

Nature of sediments/rock anticipated: carbonates/fluvioclastics reefs cemented

Weather conditions/window: Possible cyclones in January/February: heaviest swell June to August. Generally fair weather.

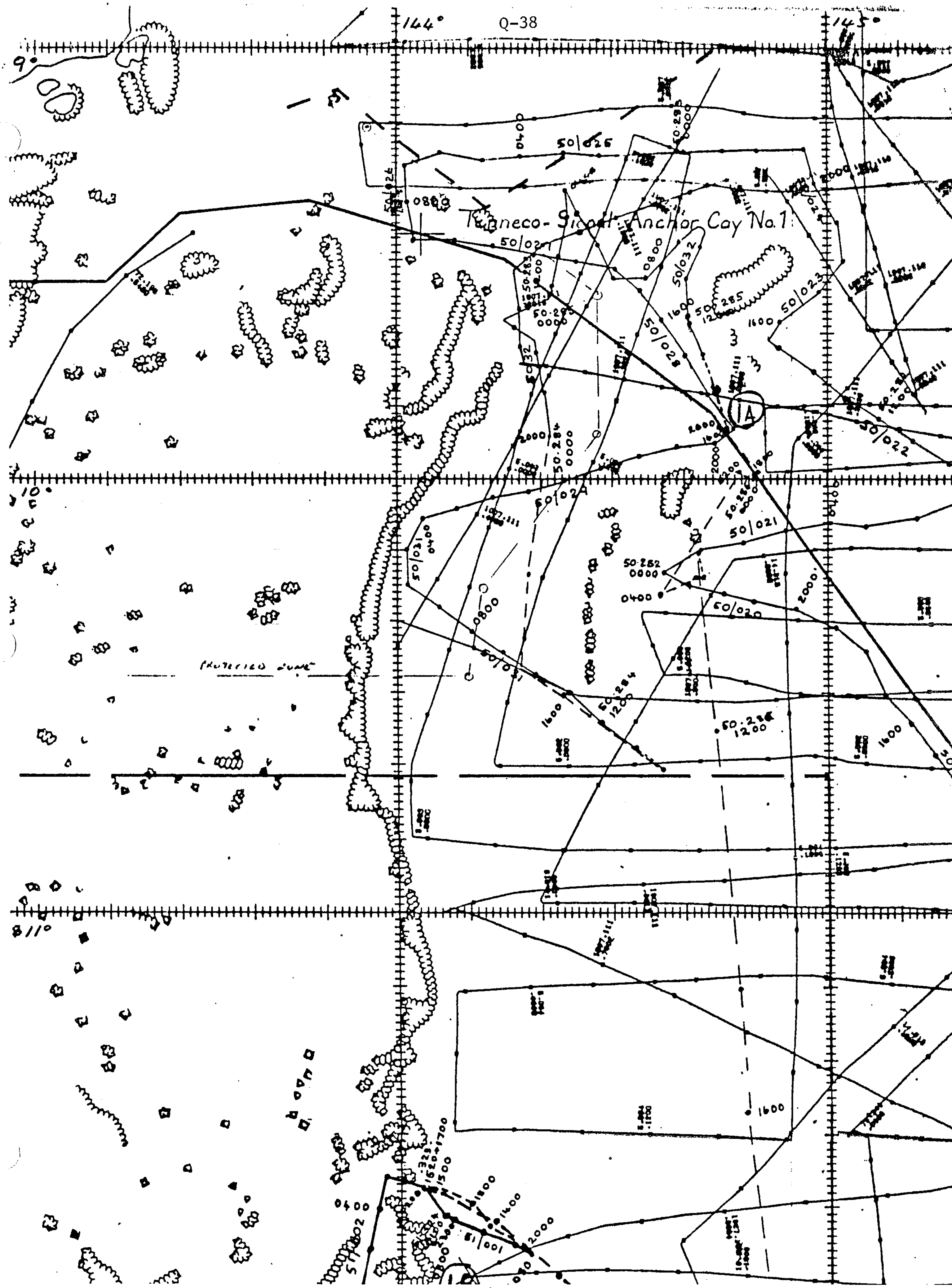
Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra A.C.T. 2601
AUSTRALIA

Date submitted to JOIDES Office: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145°
9°
10°
11°
Anchor Cay No.1
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50/027
50/032
50/023
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50/021
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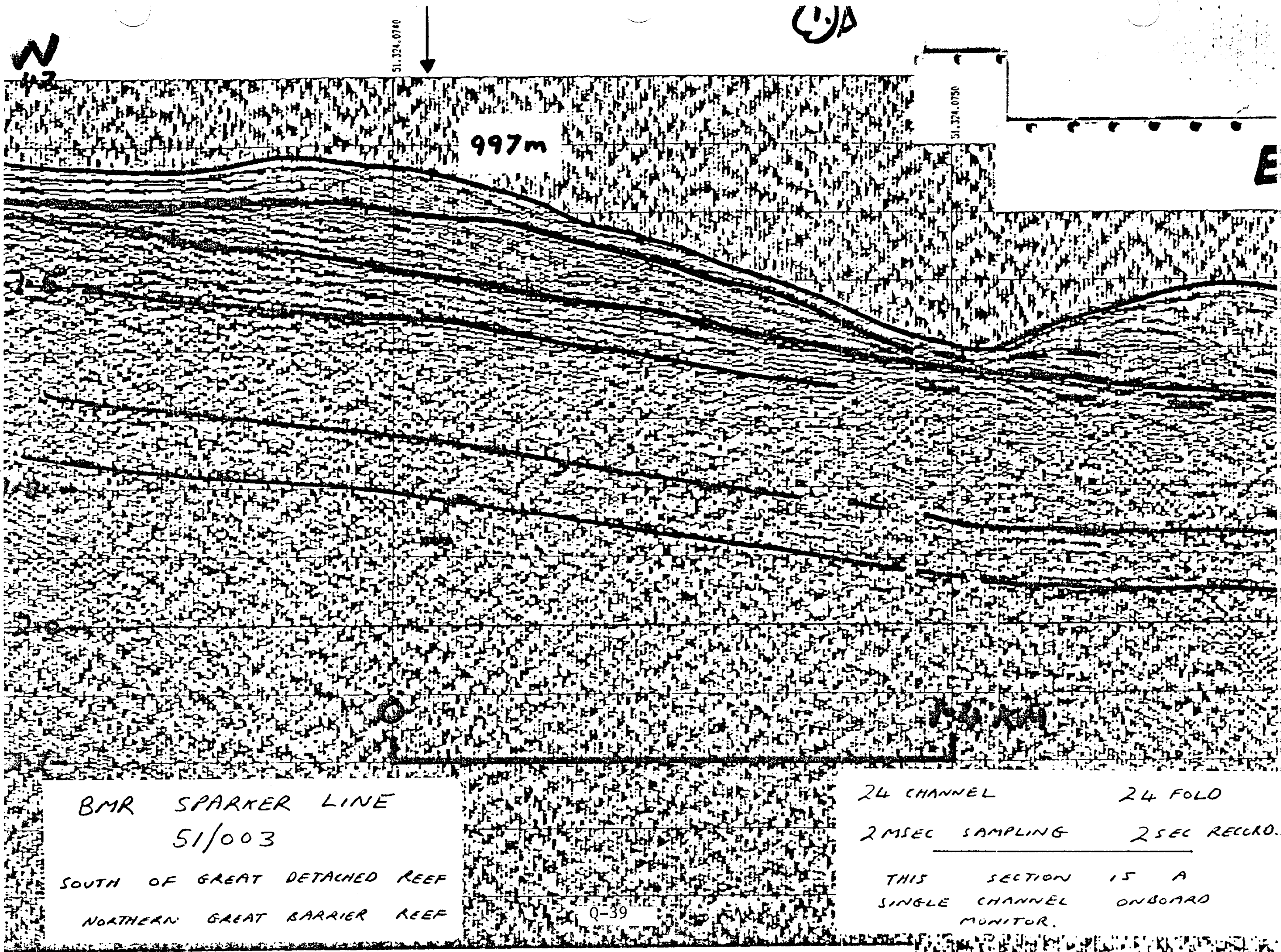
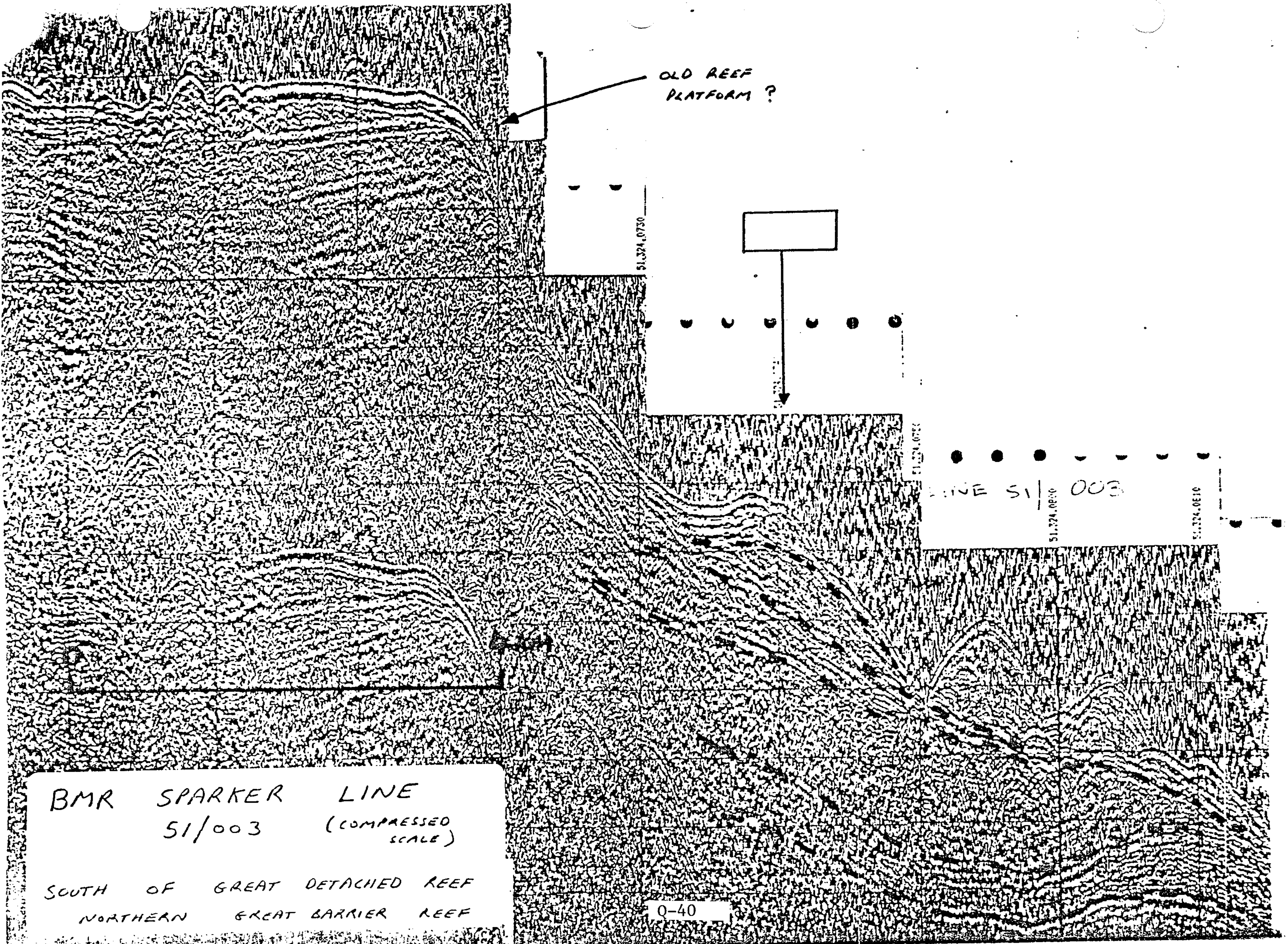
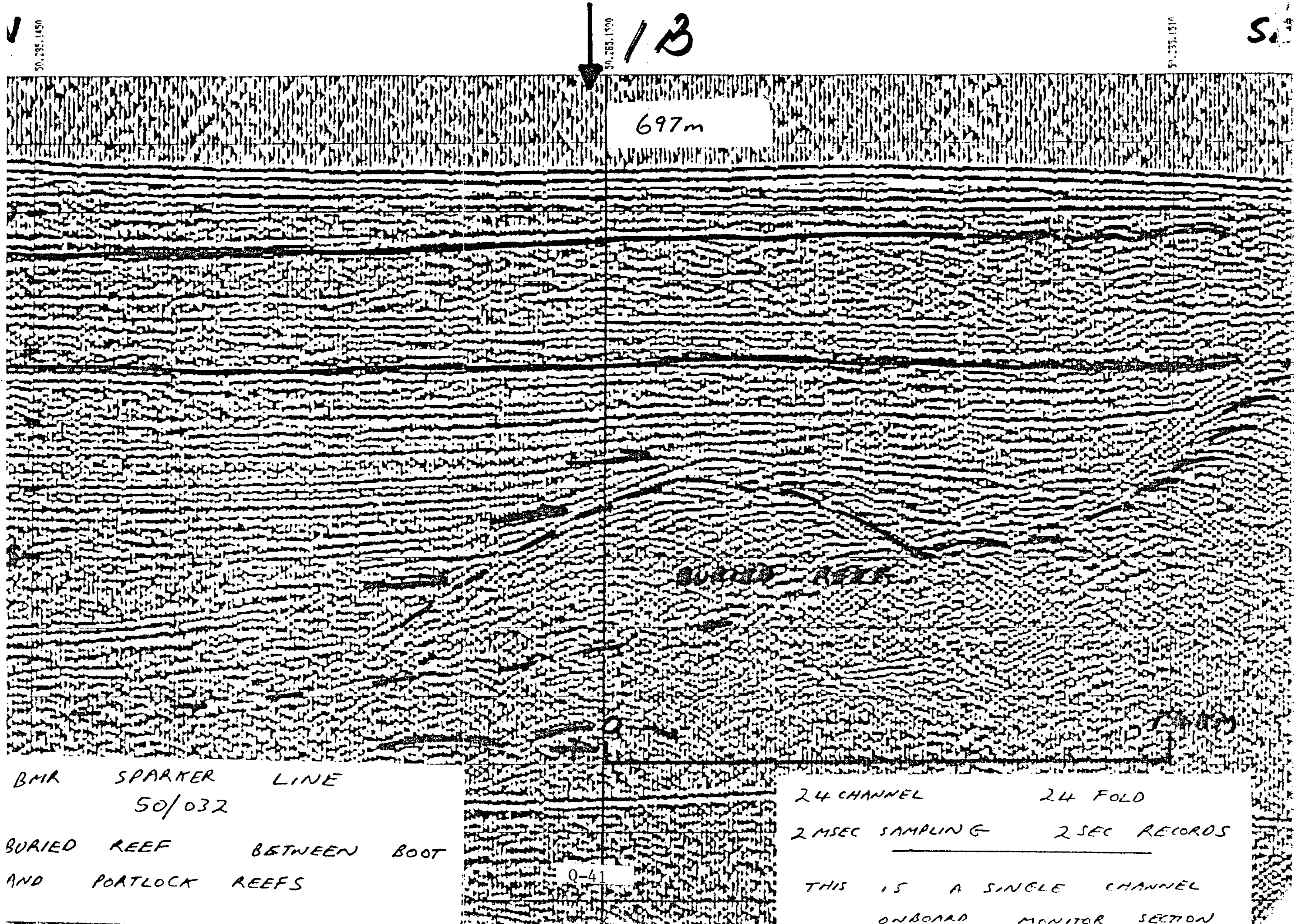


W
E
51.324.0740
51.324.0750
997m
10 km
BMR SPARKER LINE
51/003
SOUTH OF GREAT DETACHED REEF
NORTHERN GREAT BARRIER REEF
24 CHANNEL
24 FOLD
2 MSEC SAMPLING
2 SEC RECORD.
THIS SECTION IS A SINGLE CHANNEL ONBOARD MONITOR.


OLD REEF PLATFORM ?
51.324.0730
LINE 51/003
51.324.0800
51.324.0810
BMR SPARKER LINE 51/003 (COMPRESSED SCALE)
SOUTH OF GREAT DETACHED REEF
NORTHERN GREAT BARRIER REEF
0-40



BMR SPARKER LINE
50/032

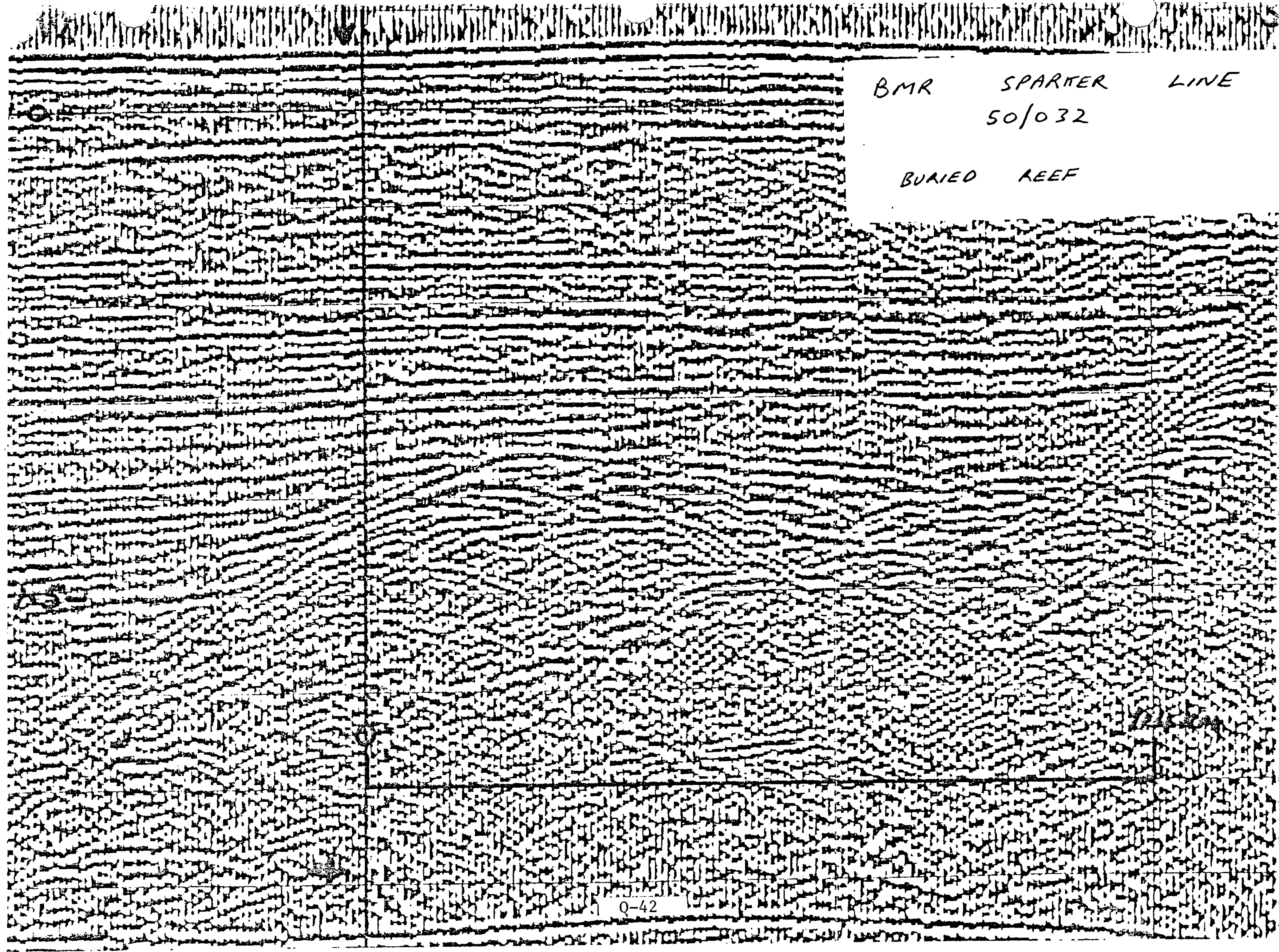
BURIED REEF BETWEEN BOOT
AND PORTLOCK REEFS

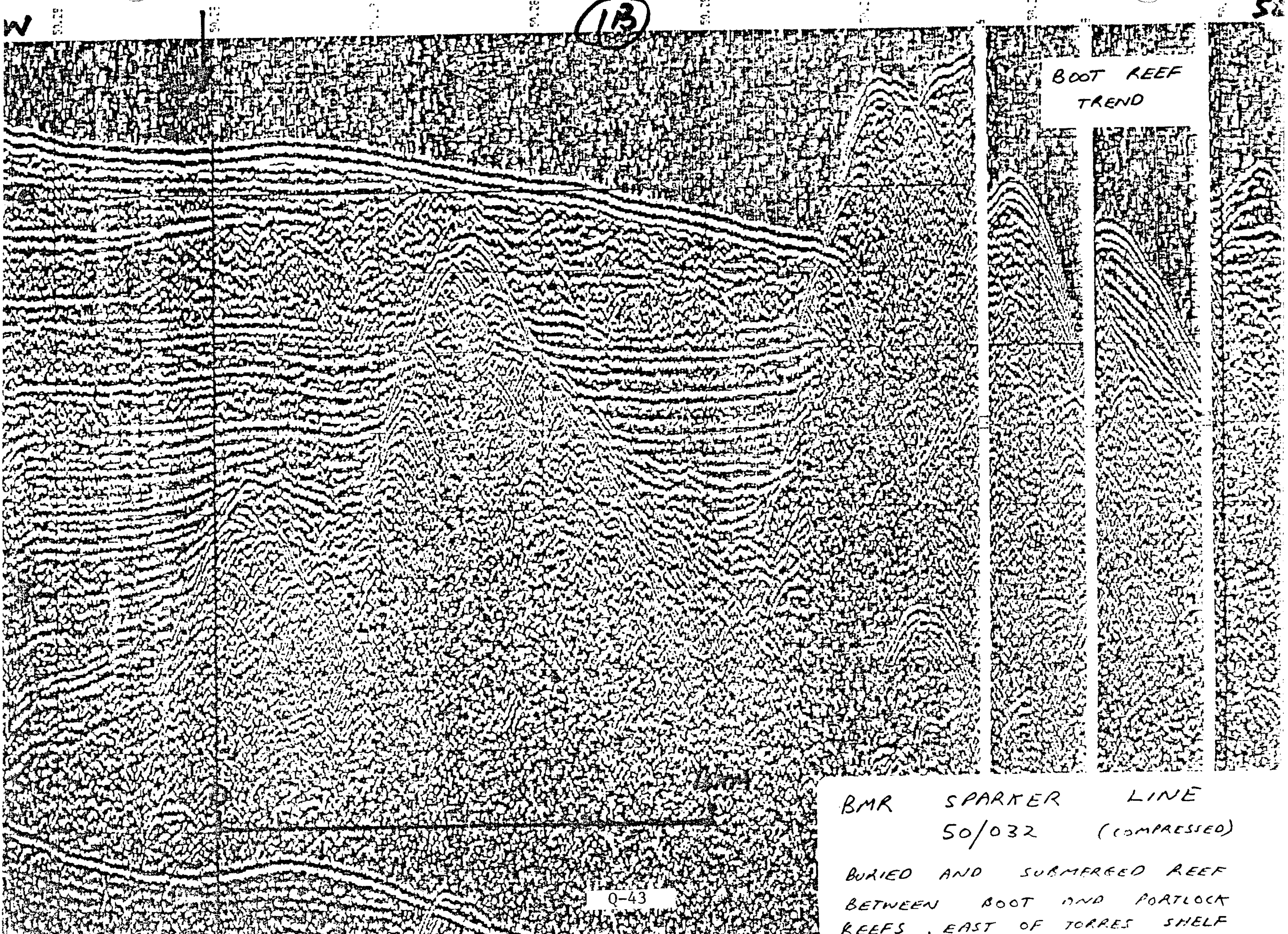
Q-41

24 CHANNEL 24 FOLD

2 MSEC SAMPLING 2 SEC RECORDS

THIS IS A SINGLE CHANNEL
ONBOARD MONITOR SECTION


BMR SPARKER LINE
50/032
BURIED REEF



BMR SPARKER LINE
50/032 (COMPRESSED)

BURIED AND SUBMERGED REEF
BETWEEN BOOT AND PORTLOCK
REEFS, EAST OF TORRES SHELF

ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 2A & C Northern Great Barrier Reef General Area: Western Coral Sea Position: 14°13'S; 145°25'E Alternate Site: 2B; 11°50'S; 144°00'E	General Objective: Reef and slope development in the southern part of the northern province. Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P.-R.P.

Specific Objectives:

1. To define the age of reef growth and particularly its demise
2. To define the importance of canyoning and fan development in slope formation
3. To relate reef growth to sea level change and subsidence.

Background Information:
Regional Data:
Seismic profiles: SEE FIGS. 3, 4, & 5 IN PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR - Completed December 1985; 48, 24 and 12 channel multichannel
Date: seismics. Also piston cores in slope.
Main results: Excellent definition of seismic facies. Slope mound facies and base of slope facies overlying reef (?)

Operational Considerations

Water Depth: (m) Sed. Thickness: (m) Total Penetration: (m)

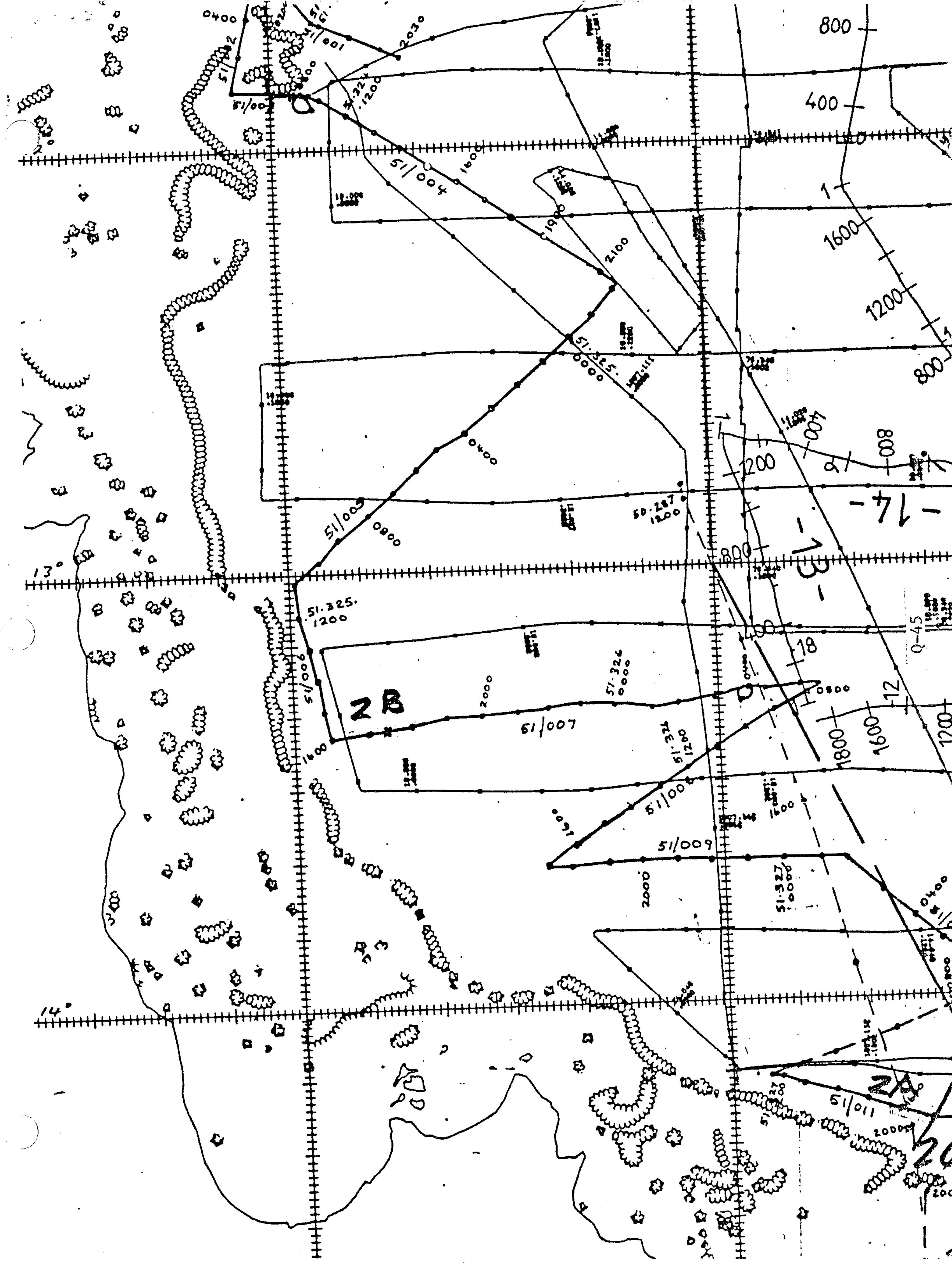
HPC yes Double HPC yes Rotary Drill yes Single Bit yes Reentry no

Nature of sediments/rock anticipated:
Carbonate/siliciclastic sediments and reef rock.
Weather conditions/window:
Possible cyclones in January/February. Heaviest swell June to August. Generally fair weather.
Territorial jurisdiction:
Australia
Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/R. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT. 2601
AUSTRALIA

Date submitted to JOIDES Office:



2B
2A
51/004
51/005
51/006
51/007
51/008
51/009
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51.325.
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51.326
0000
13°
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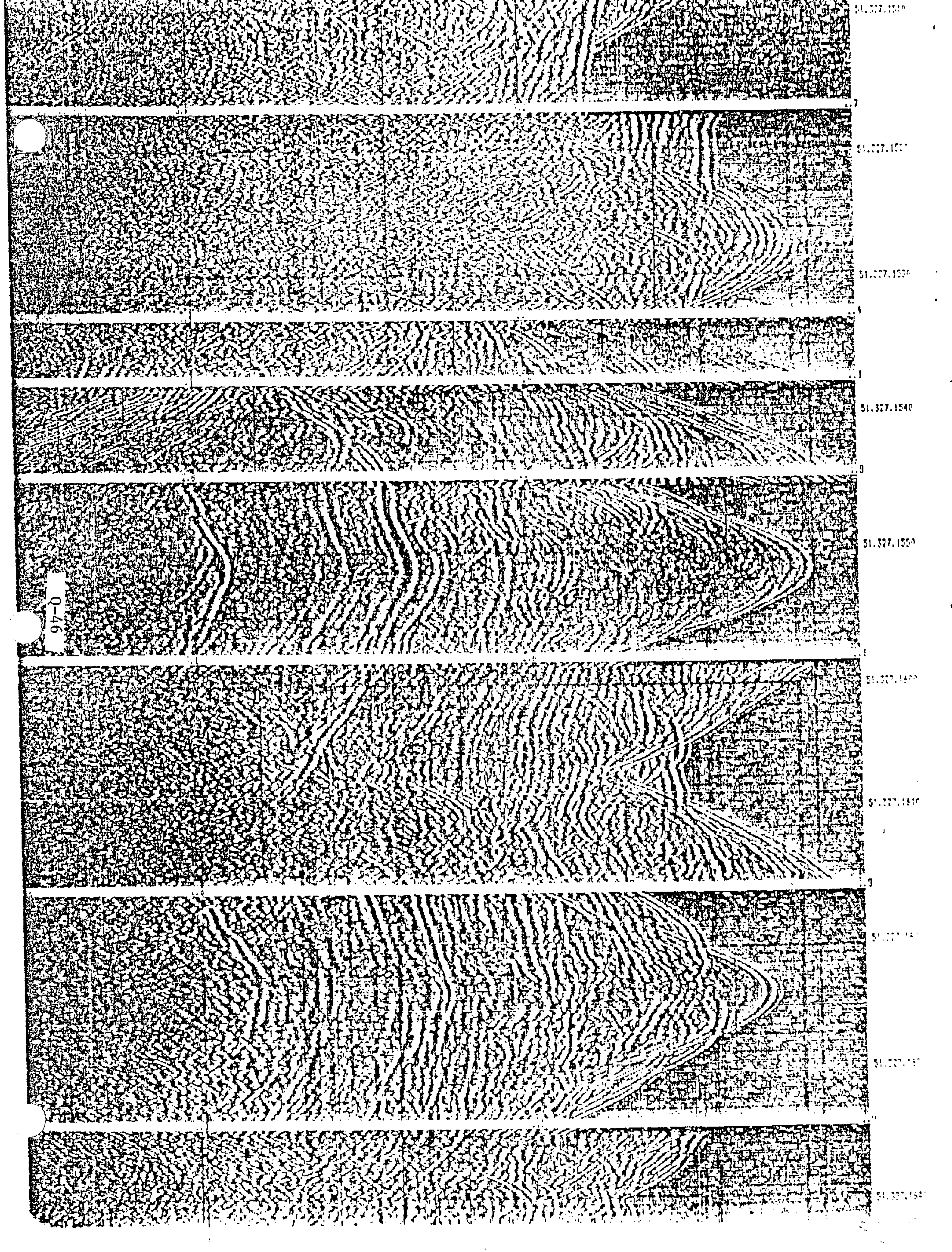
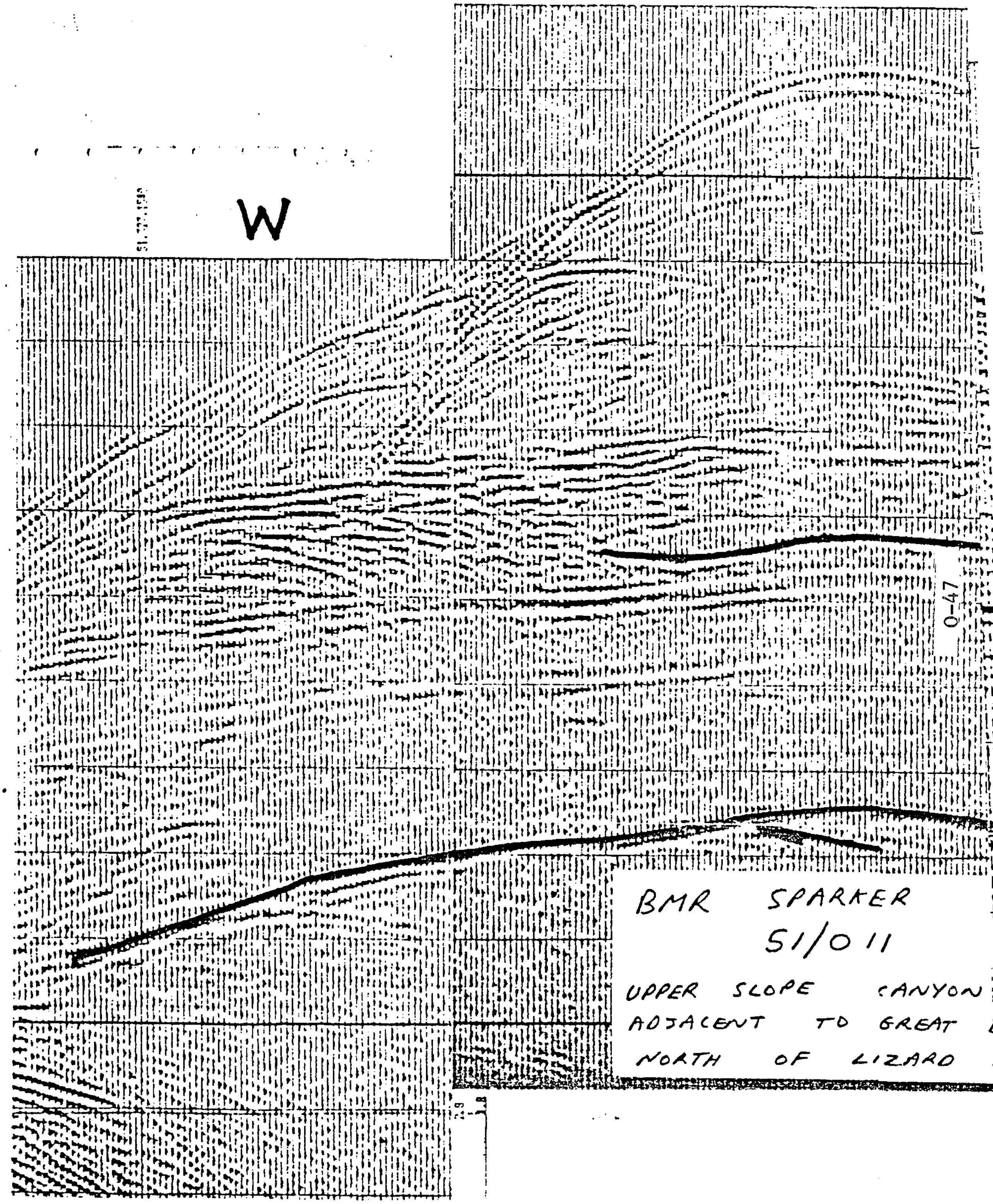
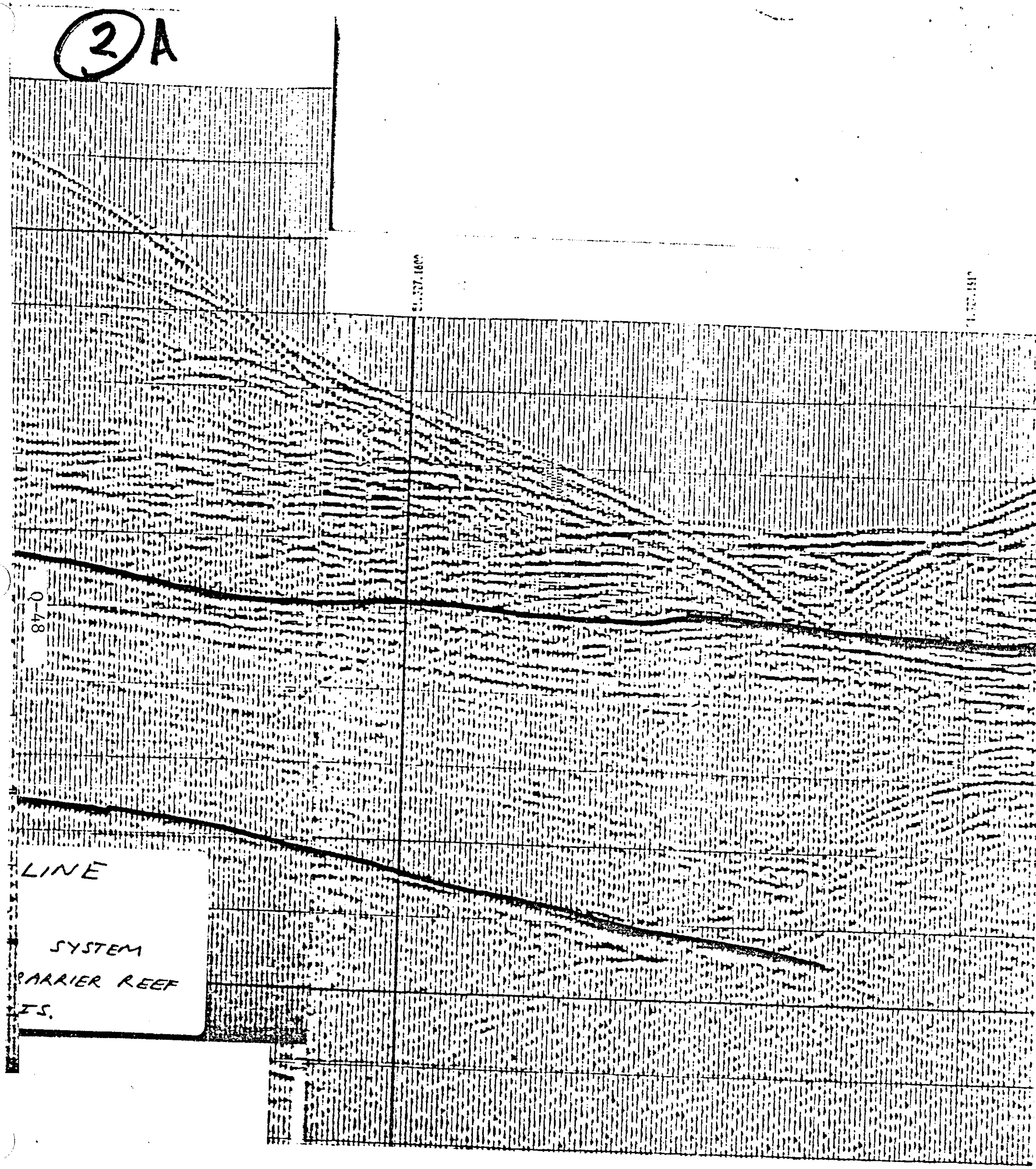
Q-45

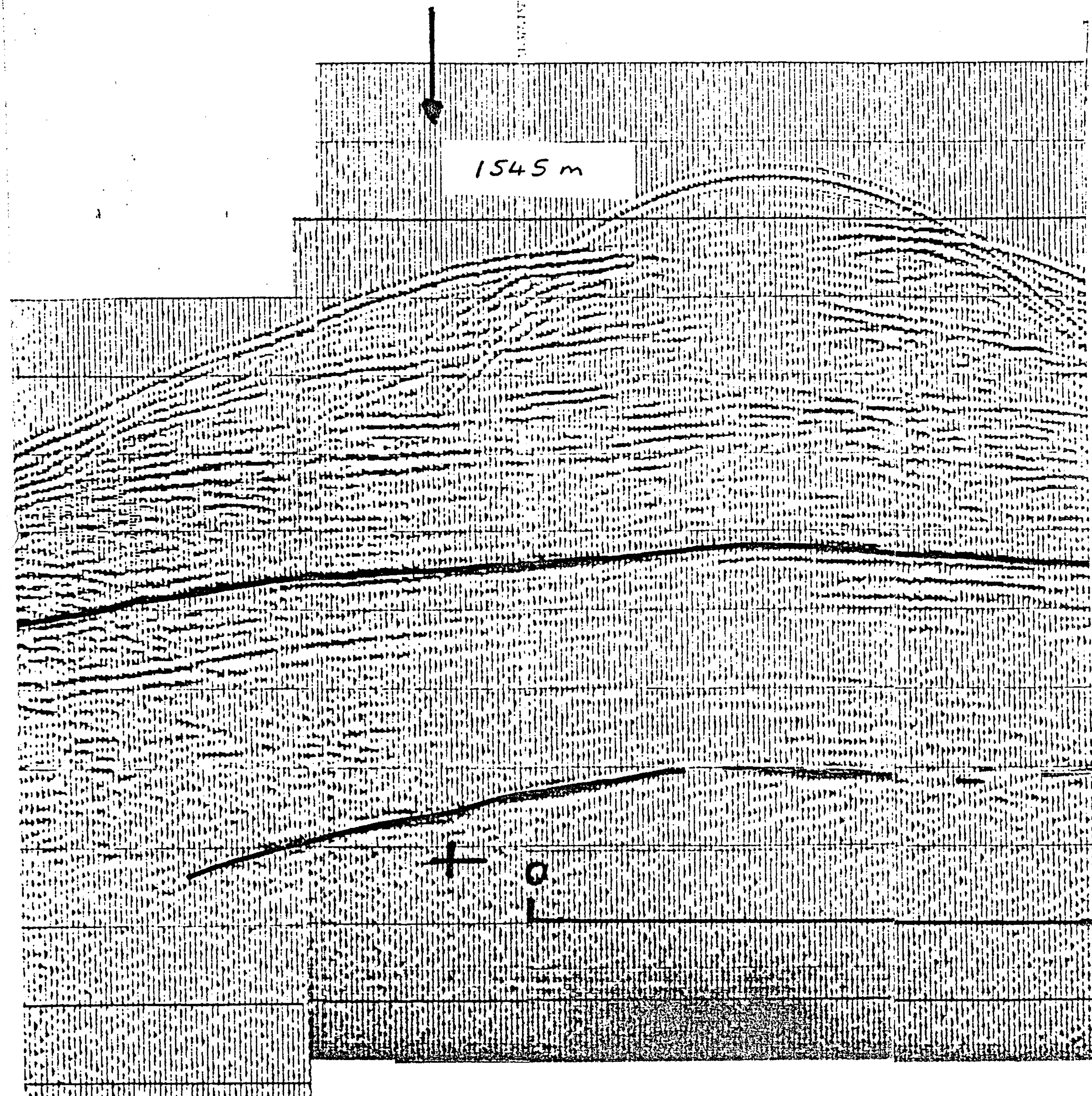


0-46
51.327.1540


W
0-47
BMR SPARKER
51/011
UPPER SLOPE CANYON
ADJACENT TO GREAT
NORTH OF LIZARD

2 A





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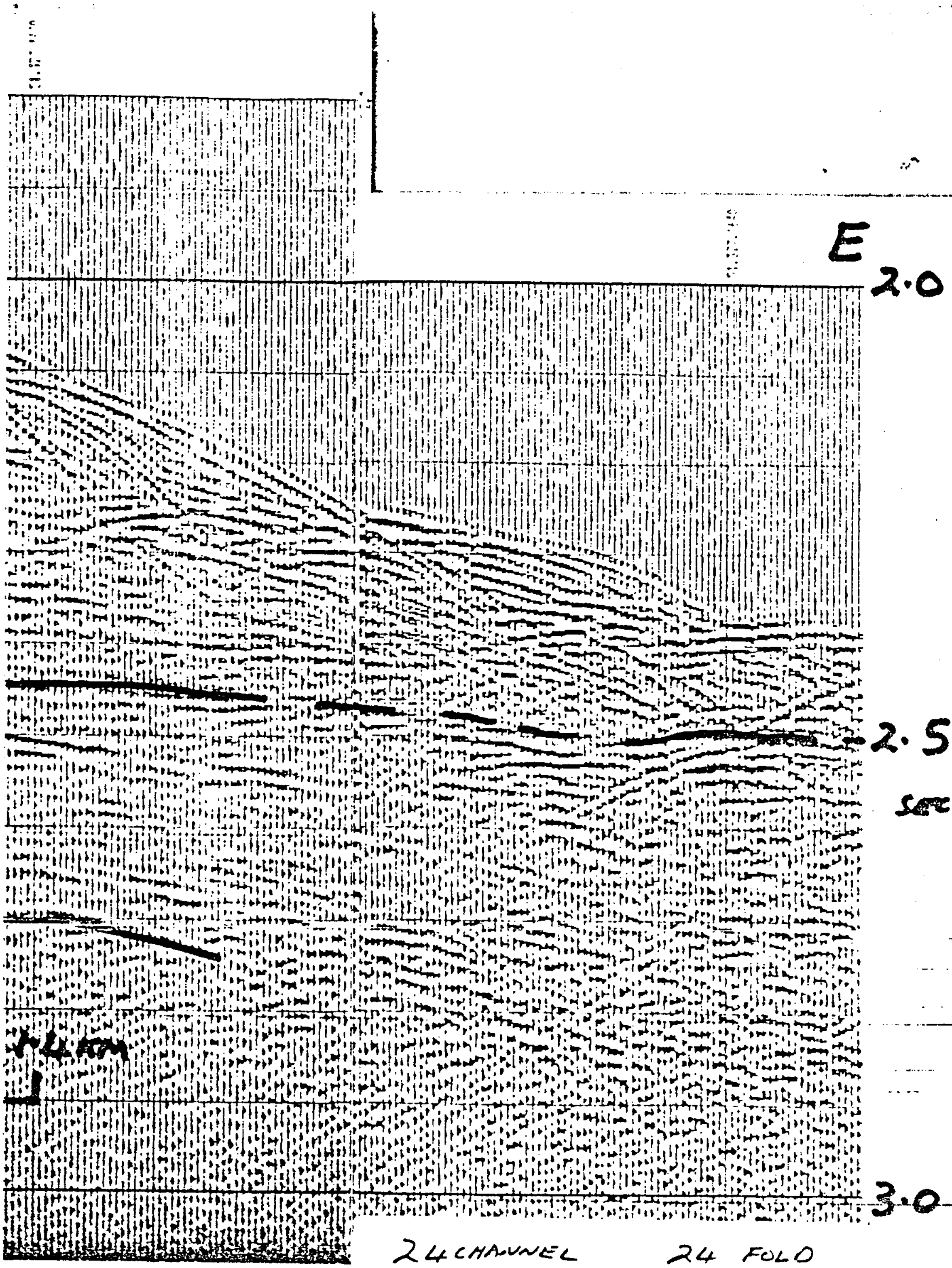

24 CHANNEL 24 FOLD

2 MSEC SAMPLING 2 SEC RECORDS

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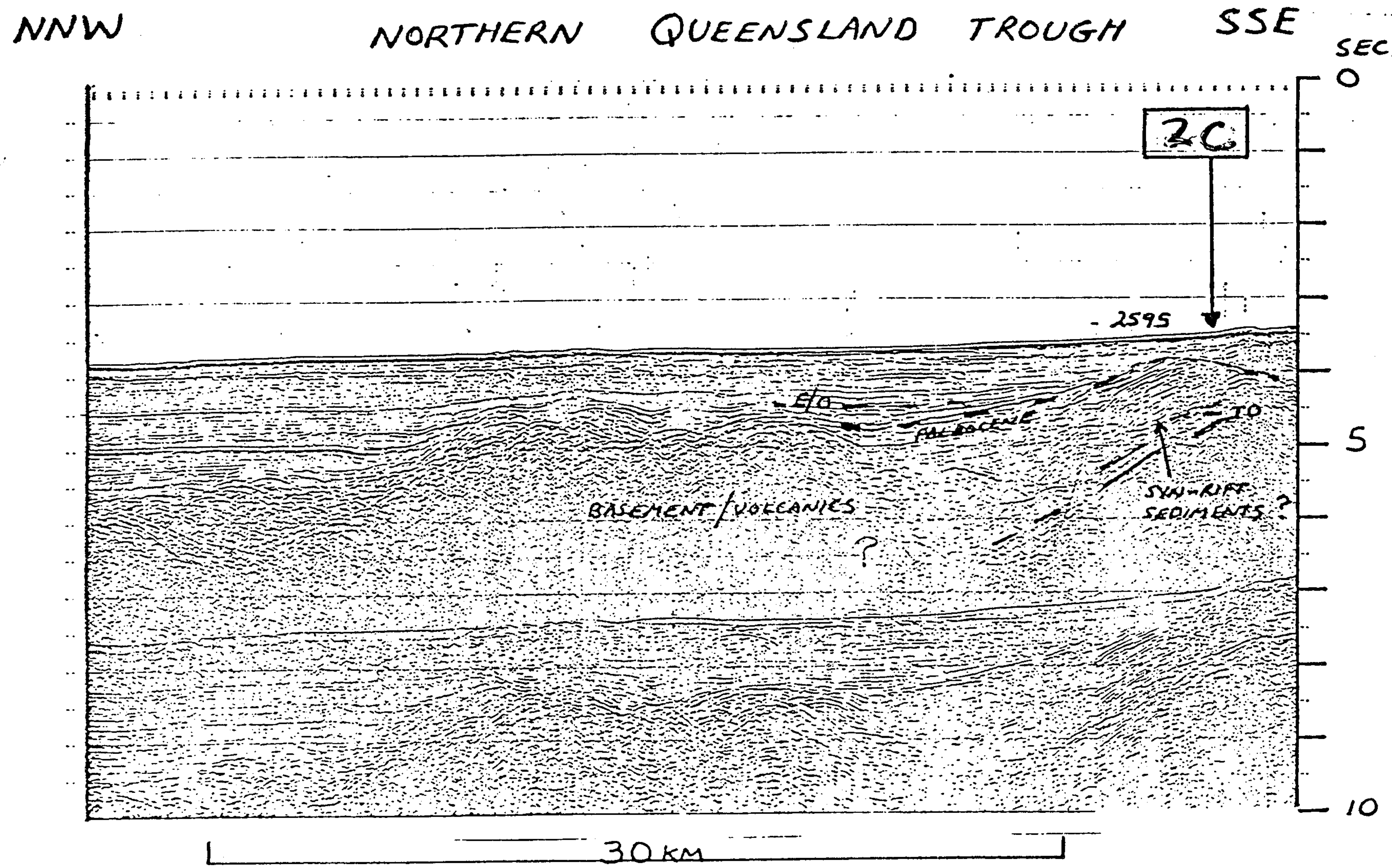
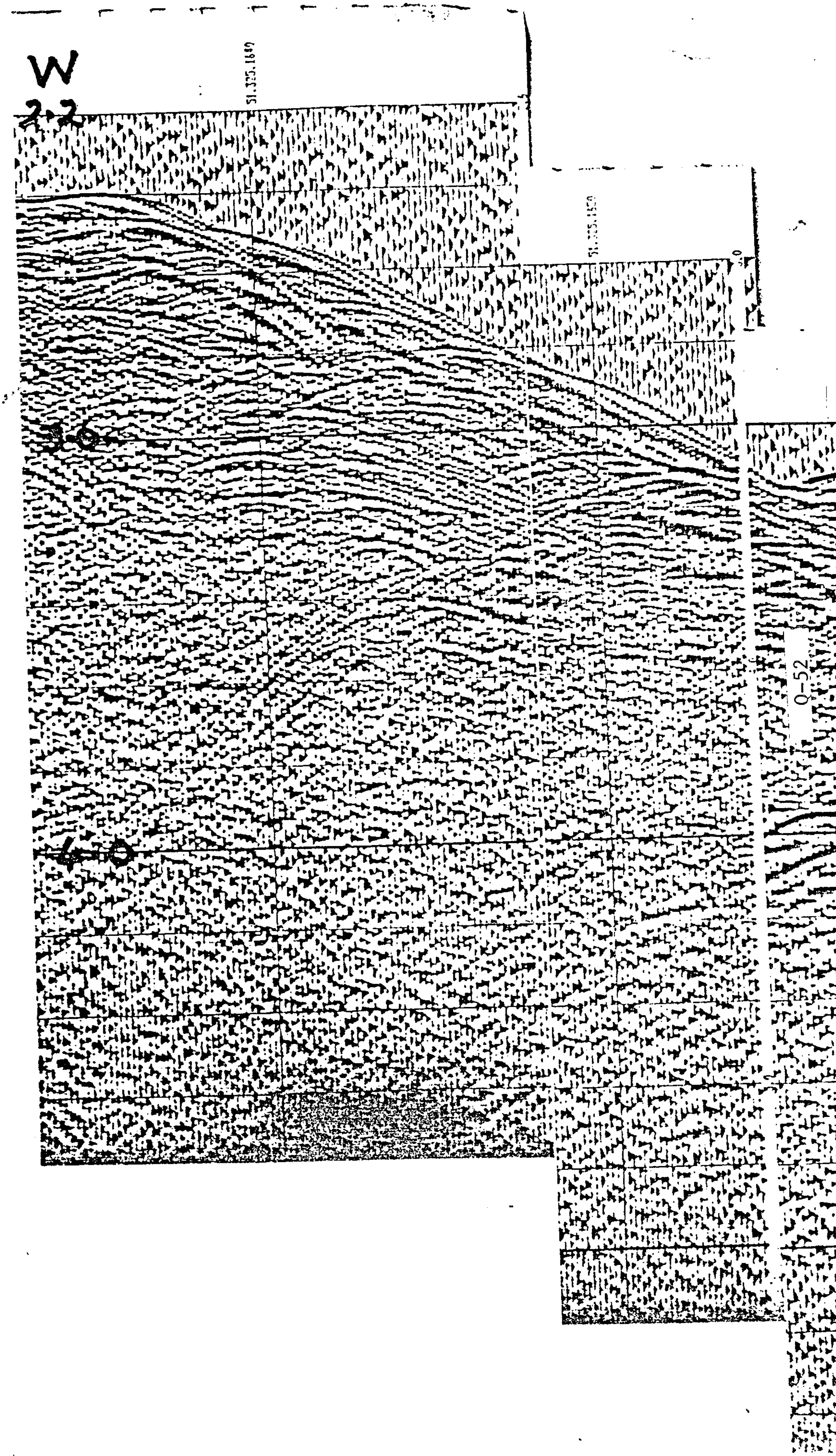
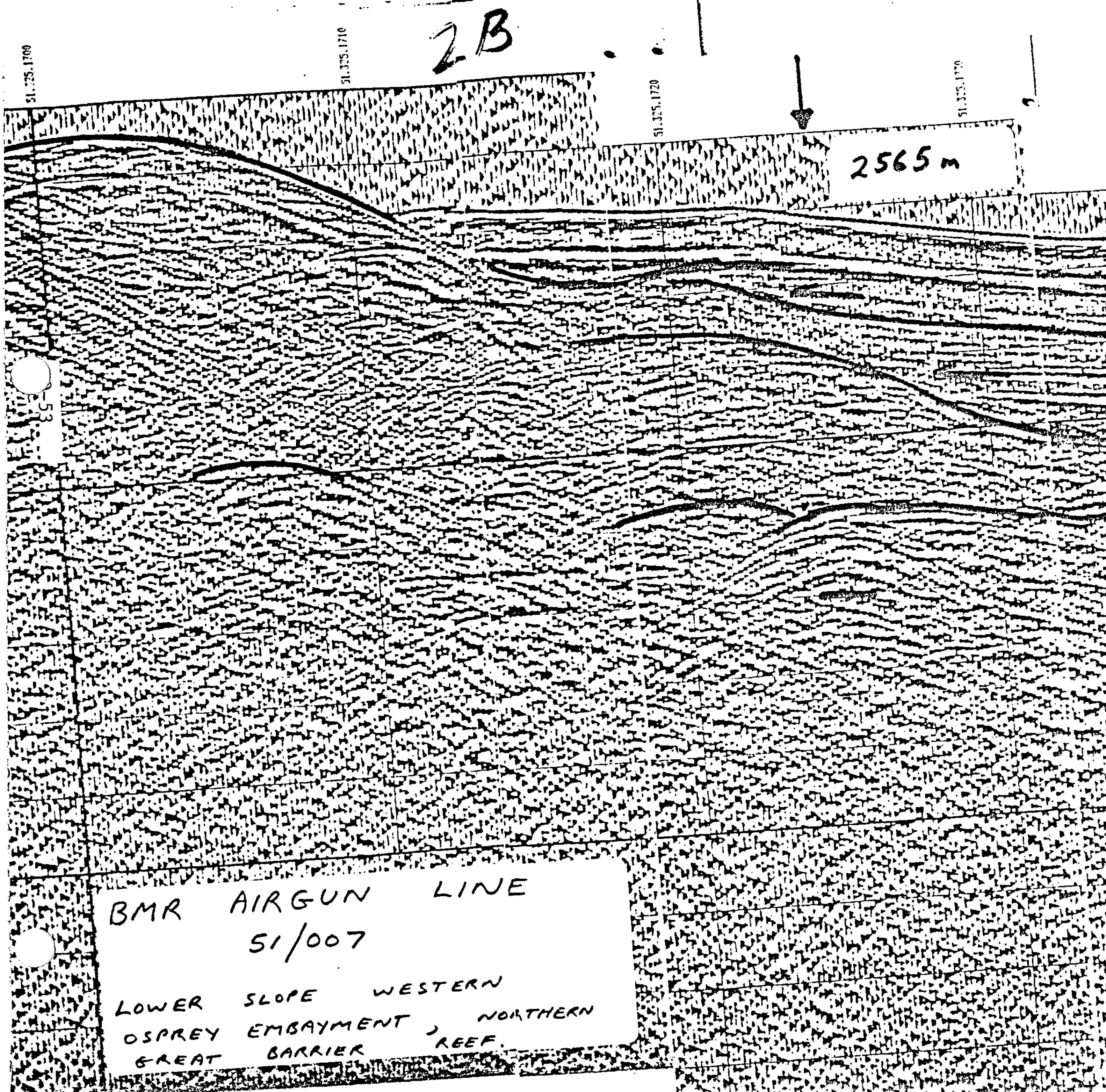
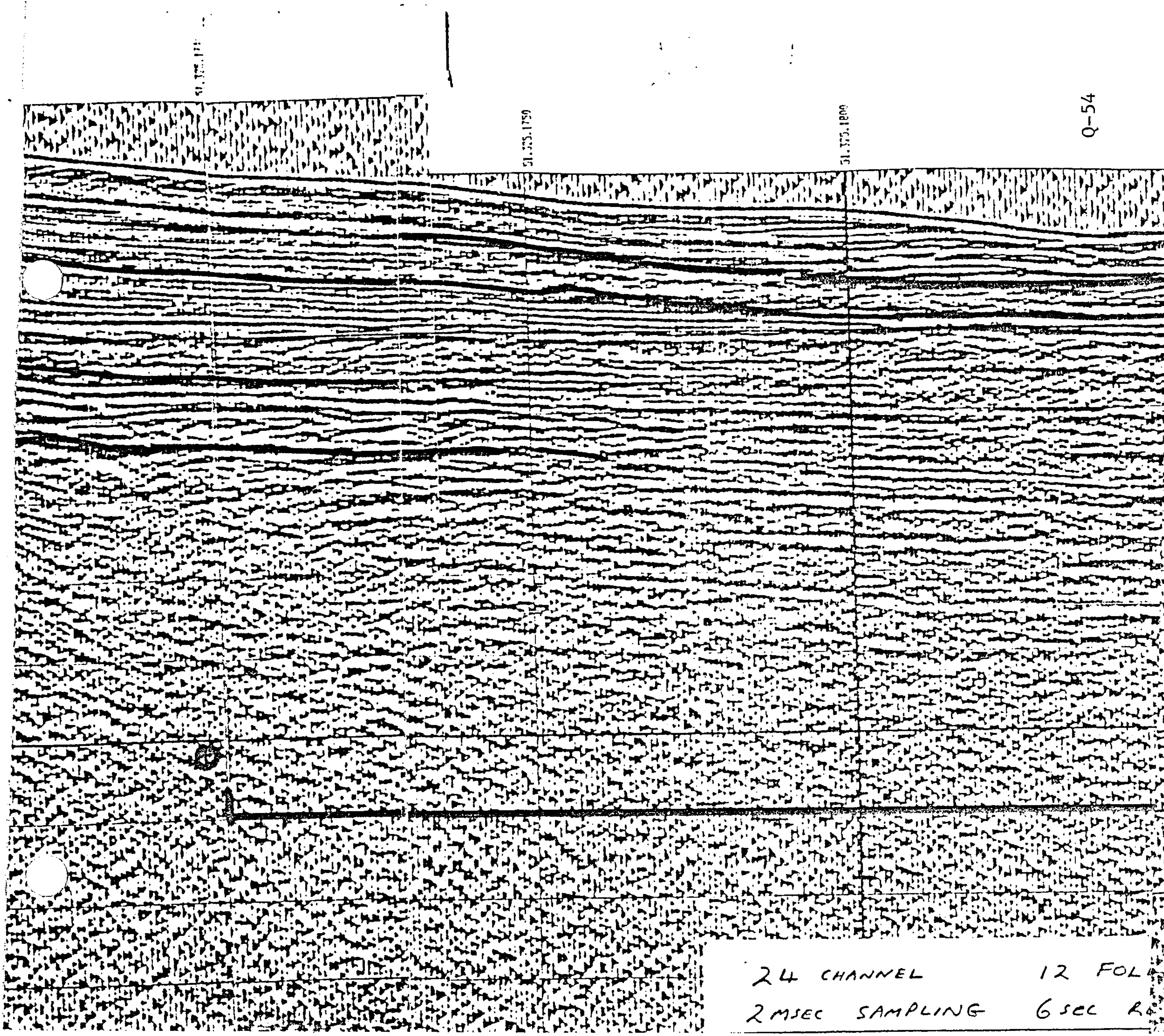


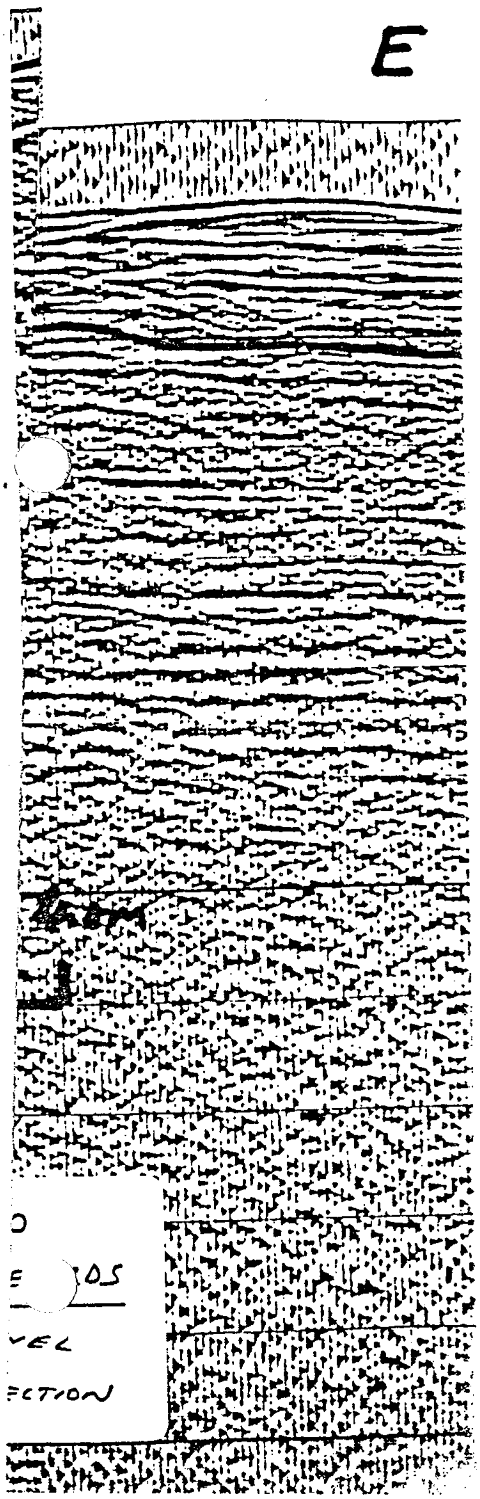
SONNE LINE 16-09


W
2.2
3.0
4.0
0-52


2B
51.335.1710
51.335.1720
2565 m
BMR AIRGUN LINE
51/007
LOWER SLOPE WESTERN
OSPREY EMBAYMENT, NORTHERN
GREAT BARRIER REEF.


Q-54
24 CHANNEL 12 FOL
2 MSEC SAMPLING 6 SEC R

Q-55



ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 3 NORTHERN QUEENSLAND TROUGH

General Area: Western Coral Sea
Position: 14°19.2'S, 146°8'E
Alternate Site: (4)
14°18'S, 145°42'E

General Objective:
Early rifting history of passive continental margins.
History of ocean circulation.

Thematic Panel interest: SOHP, TECP
Regional Panel interest: WP-RP

Specific Objectives: Determine:

- Age, nature and depositional environment of primary rift-fill sediments.
- Response of sedimentation to fluctuations in sea level.
- The nature of basement.
- The burial history of the Trough.
- History of ocean circulation.
- Nature of sedimentary and organic diagenesis.

Background Information:

Regional Data:

Seismic profiles: BMR (1970) 6-fold; Shell (1973/74) 24-fold; BGR/BMR Sonne (1978 and 1980) 24-fold, GSI Group Shoot (1979) 48-fold (confidential)

Other data: A considerable amount of gravity and magnetic data; some shallow and crustal refraction profiles; some dredging and coring around the marings of Queesland Plateau.

Site Survey Data - Conducted by:

Date: Site located using Sonne data; line SO-16-08 SP850 (Alternate line SO-16-08 SP60)

Main results: Blanket of Early Oligocene and younger ooze and turbidites overlying onlapping Eocene ooze and terrigenous detritus. These overly trough fill alluvial and submarine fan deposits of Paleocene and older age.

Operational Considerations

Water Depth: (m) 2745 (2595) Sed. Thickness: (m) 2014 (1393) Total penetration: (m) 2200 (1600)

HPC Yes to refusal | Double HPC ____ Rotary Drill Yes Single Bit ____ Reentry Yes

Nature of sediments/rock anticipated: Top - pelagic ooze and terrigenous detritus. Middle - sands and shales, restricted shallow marine; Bottom - conglomerates, sands and shales, mainly alluvial and fluvial deposits at base.

Weather conditions/window:
Fair all year except for possible cyclones in January and February.

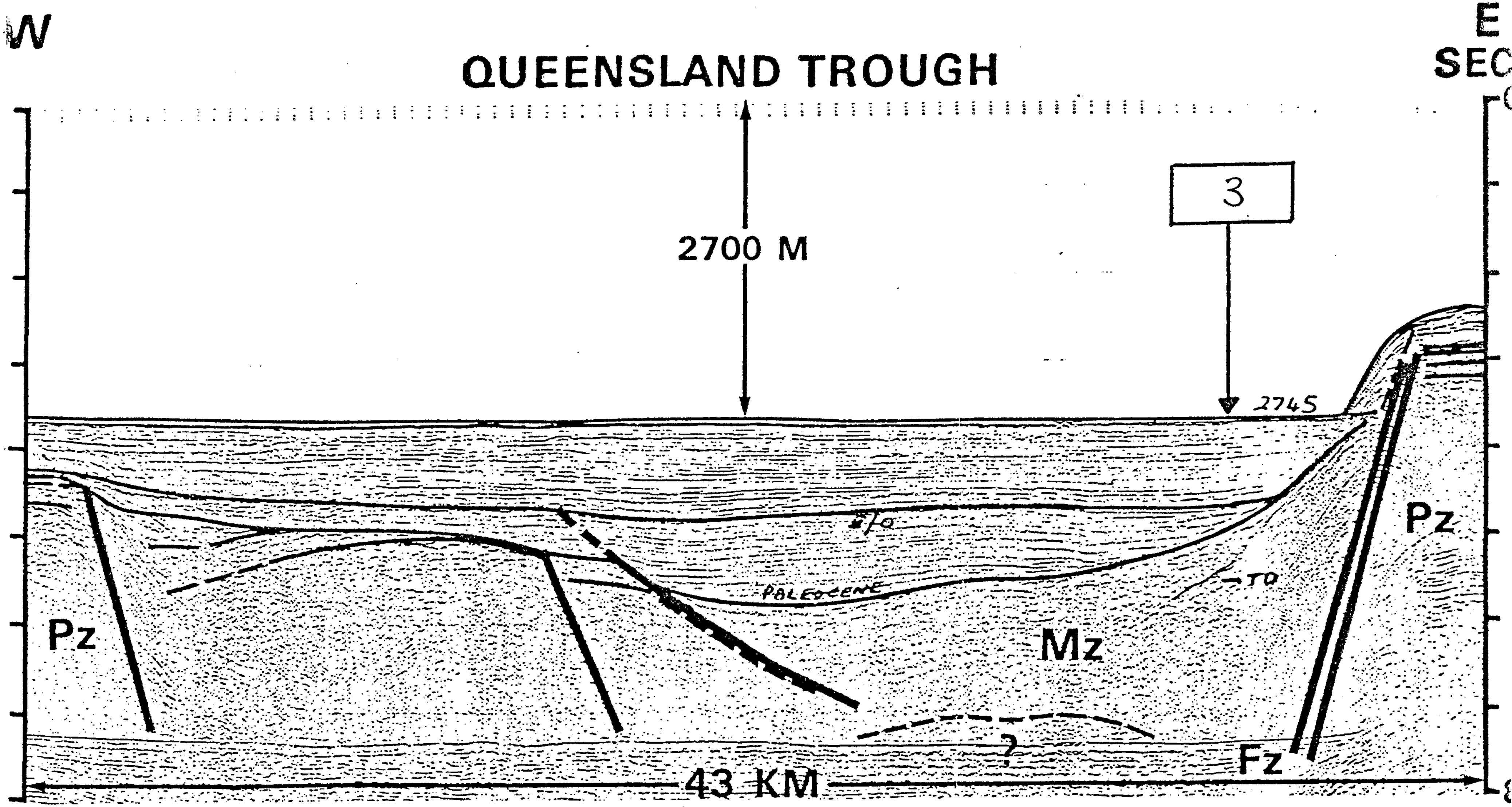
Territorial jurisdiction: Inside Australian 200 nautical limit.

Other:

Special requirements (Staffing, instrumentation, etc.)

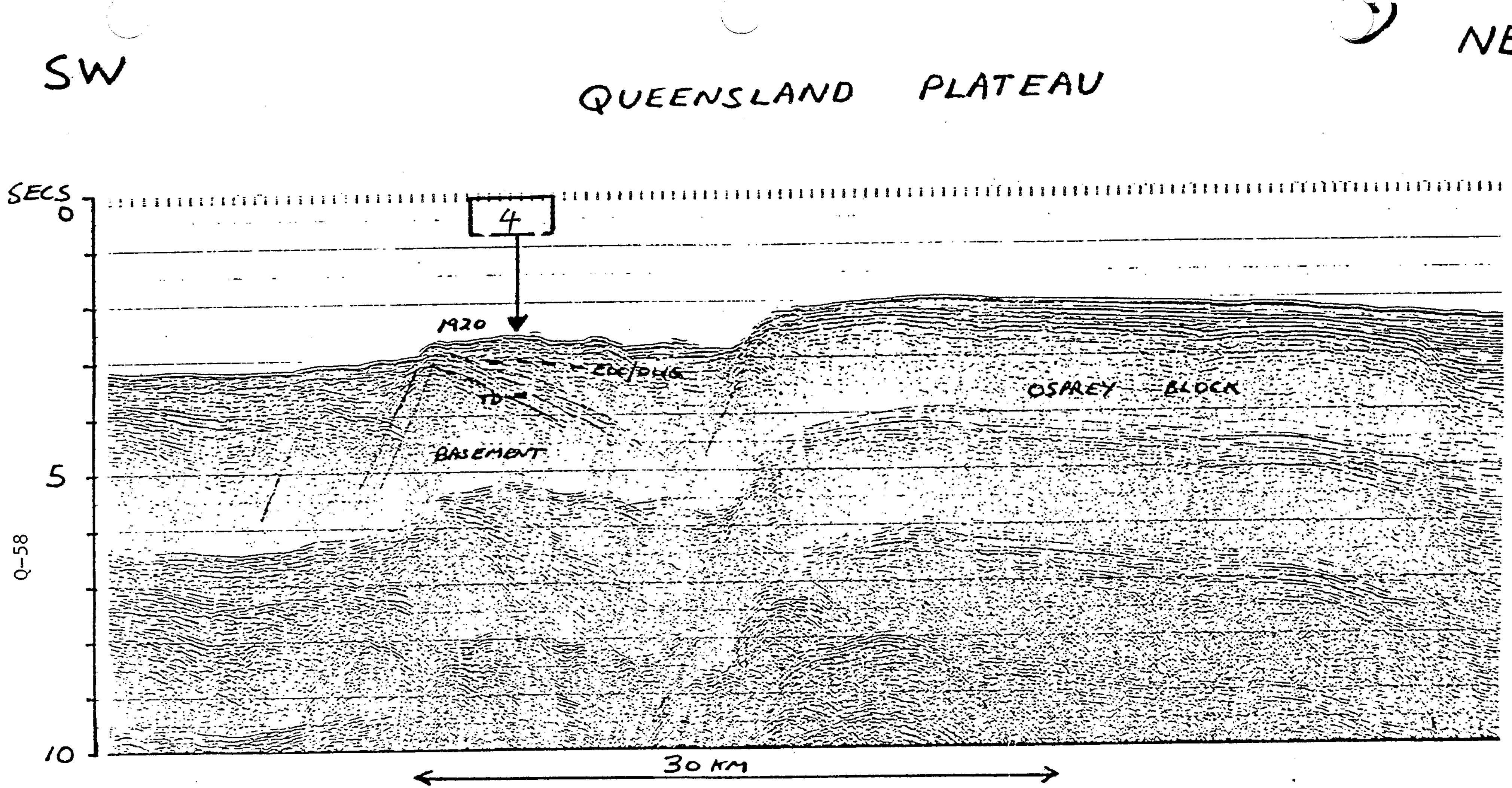
Proponent: P A Symonds : P.J. Davies.
Bureau of Mineral Resources
G P O Box 378
CANBERRA A C T 2601

Date submitted to JOIDES Office:



SONNE LINE 16-08

QUEENSLAND PLATEAU



SONNE LINE 16-07

ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 5 Northern Great Barrier Reef General Area: Northeast Australia Position: 15°41.5'S; 145°50'E Alternate Site:	General Objective: To define relations of reef and fluviodeltaic facies. History of ocean circulation. Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To define the nature of acoustic basement
2. To define importance of gravity sliding in slope formation
3. To define nature of reef/slope facies variations
4. To relate facies to sea level change.

Background Information:

Regional Data:
Seismic profiles: SEE FIGURES 3, 4, 5 OF PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR - completed in December 1985. Specifically line 50/018
Date: (50.279.0814) attached.
Main results: Excellent delineation of facies variations. Fluvio-clastic/reef facies interdigitation. Upper shelf mounds.

Operational Considerations

Water Depth: (m) 495 Sed. Thickness: (m) >1000 Total Penetration: (m) 1000

HPC yes Double HPC yes Rotary Drill yes Single Bit yes Reentry no

Nature of sediments/rock anticipated: Reef carbonates: fluvioclastics and reef-derived carbonates

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June to August. Generally fair weather.

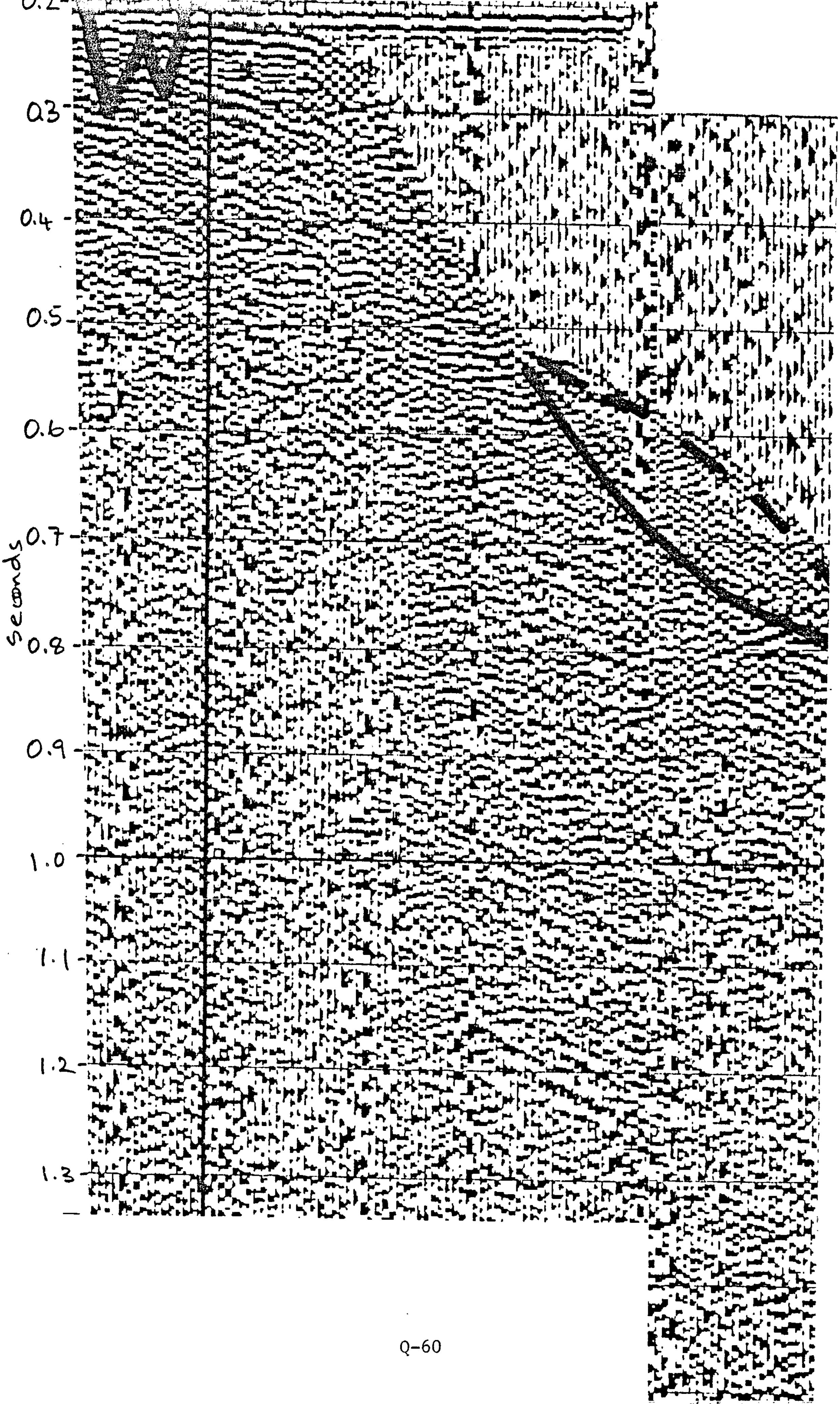
Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office: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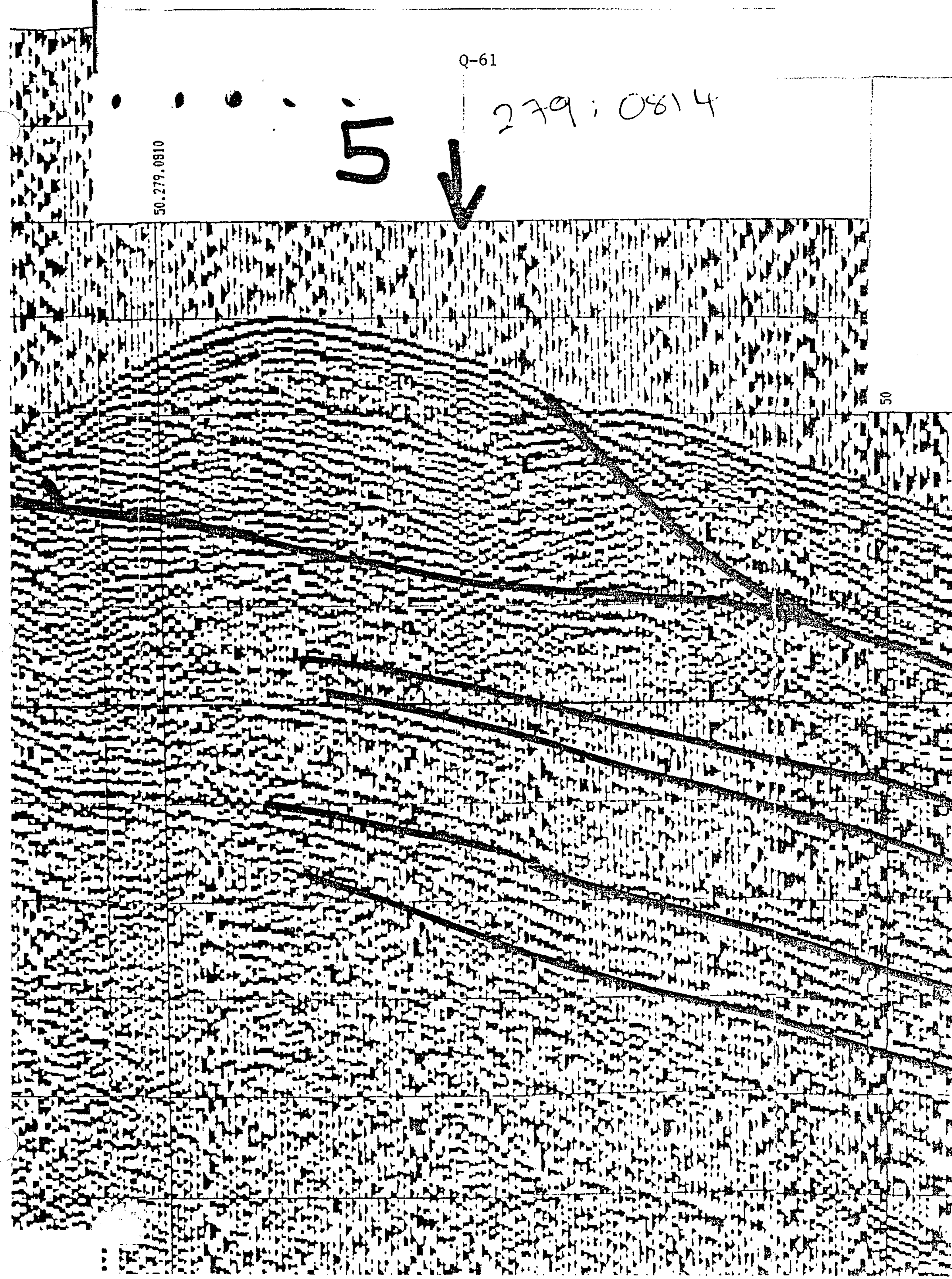
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279; 0814
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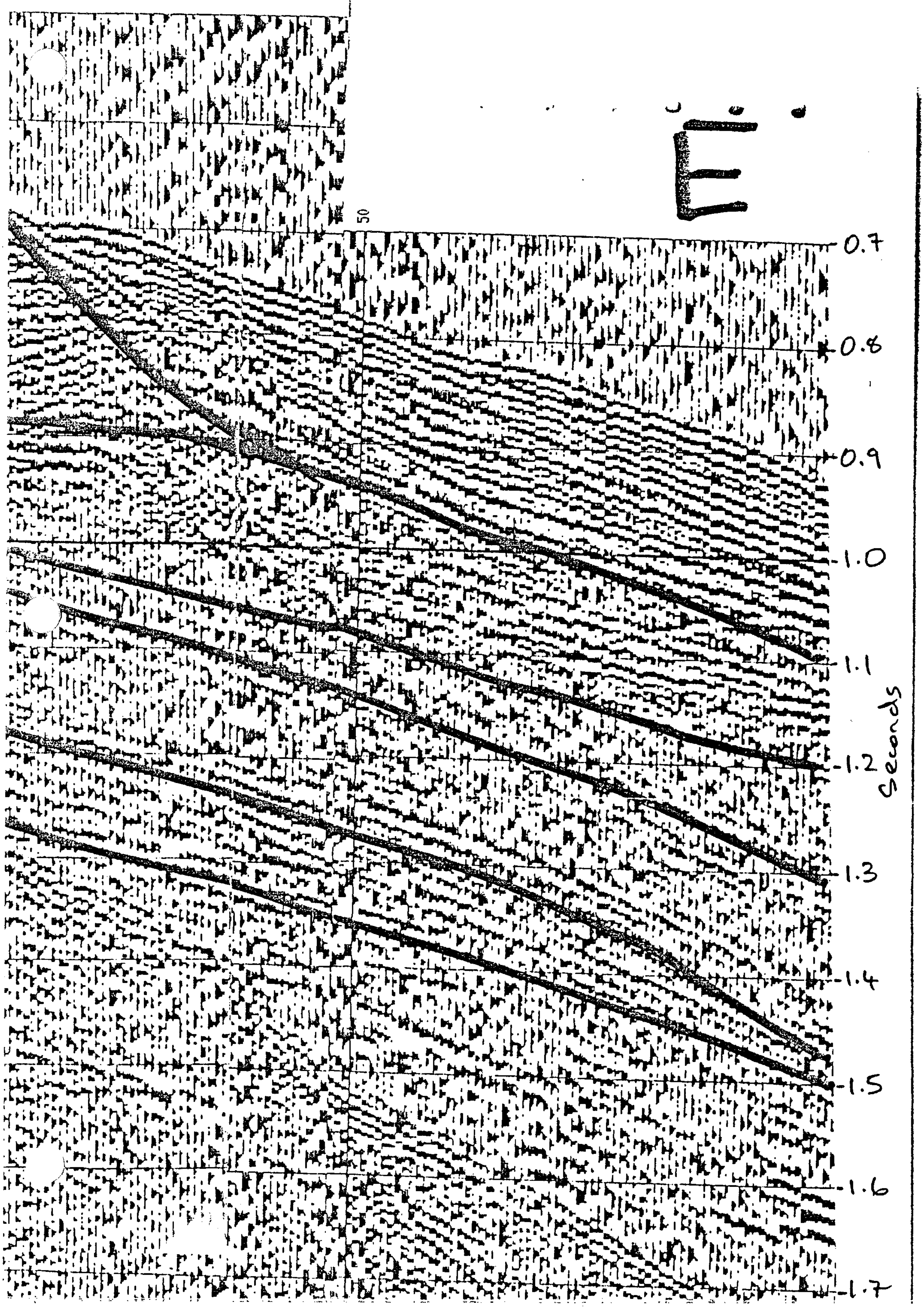
E
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Seconds

ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 6 Northern Great Barrier Reef General Area: Northeast Australia Position: 15°40.9S; 145°53.0E Alternate Site:	General Objective: To define the importance of fluvio-deltaic progradative processes in margin development. Sea level and oceanographic history. Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To determine nature of acoustic basement
2. To define midslope progradative facies
3. To define importnace of gravity sliding in margin accretion
4. To relate to sea level oscillations
5. To examine phosphate variations

Background Information:

Regional Data:

Seismic profiles: SEE FIGURES 3, 4, AND 5 OF PROPOSAL

Other data:

Site Survey Data-Conducted by: Bureau of Mineral Resources-completed in December 1985
Date: Specifically line 50/018 (50.279.0853) - high resolution
Main results: multichannel. Five distinct seismic facies can be mapped above acoustic basement.

Operational Considerations

Water Depth: (m) 1050 Sed. Thickness: (m) Total Penetration: (m)

HPC yes Double HPC yes Rotary Drill yes Single Bit yes Reentry ____

Nature of sediments/rock anticipated: Fluvio-deltaic sands and muds.

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June-August. Generally fair weather.

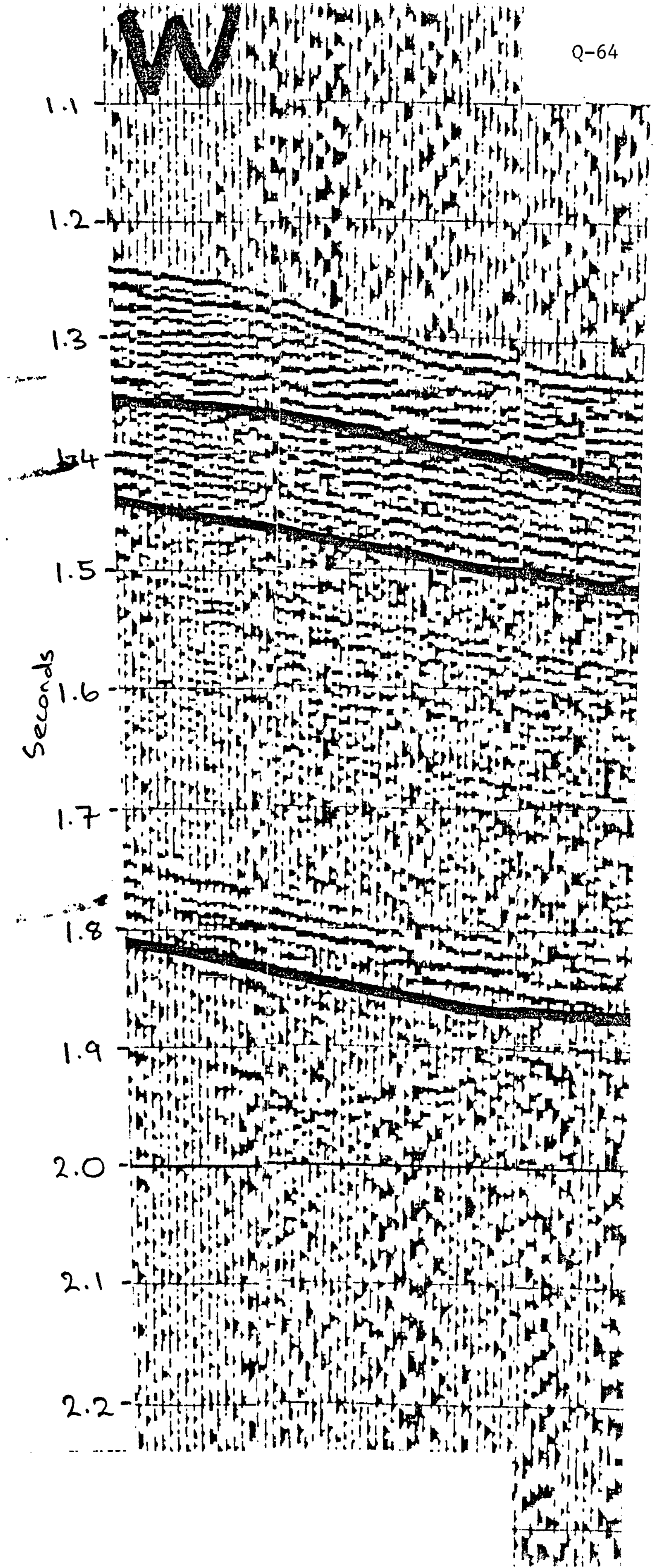
Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra, A.C.T. 2601
AUSTRALIA

Date submitted to JOIDES Office: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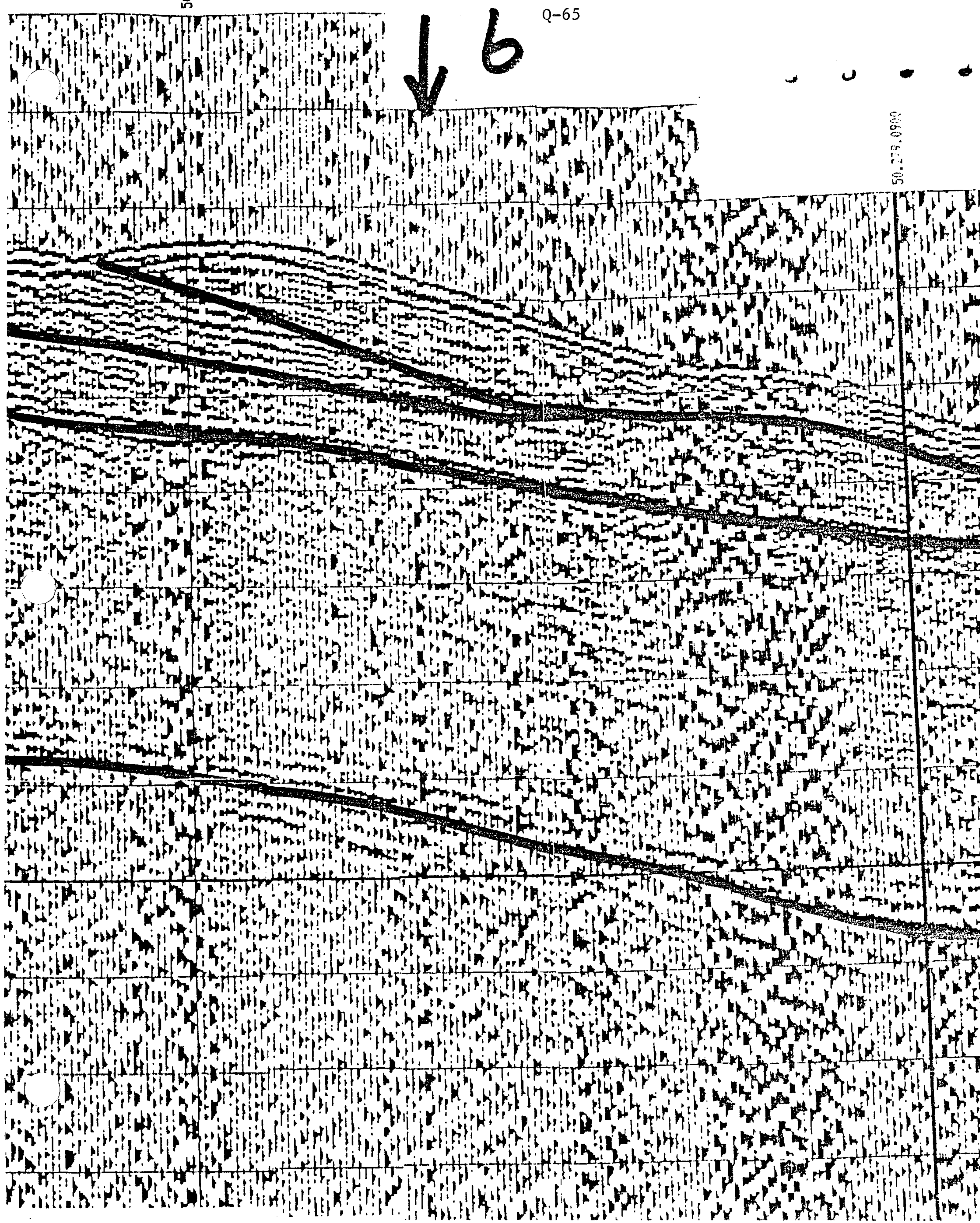
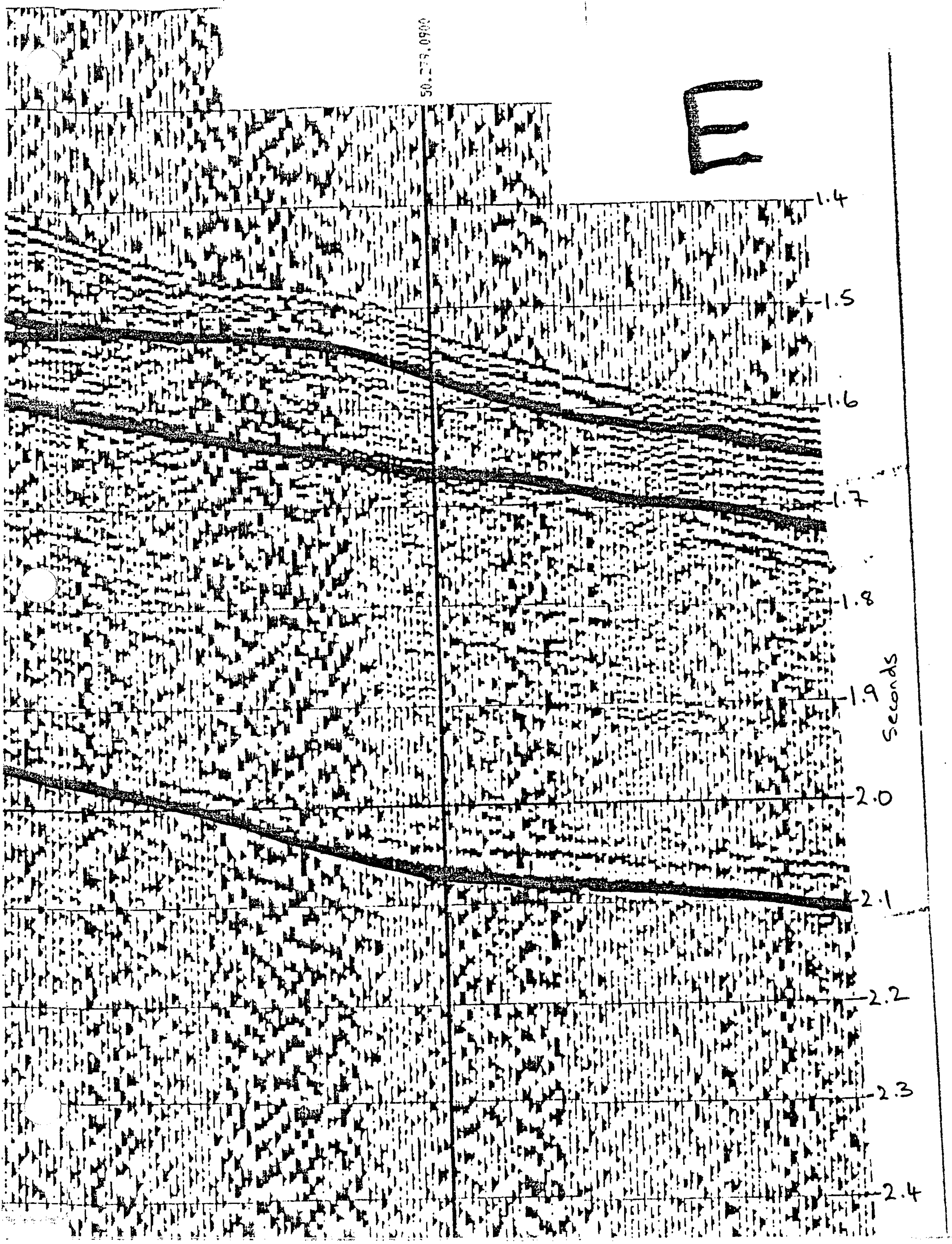
Q-65





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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 7 Western Queensland Trough General Area: Northeast Australia Position: 15°39,8'S; 146°02.9'E Alternate Site:	General Objective: Rift history; mechanisms of rift infill Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To define nature of rift infill
2. To determine particularly the facies and lithologies of gravity fed flow lobes underlying the quaternary stratified sequences.
3. To define a sea level curve for the region

Background Information:

Regional Data:

Seismic profiles: SEE FIGURES 3, 4, AND 5 OF PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR - completed in December 1985. Specifically line 50/018 (50.279.1108). - high resolution multichannel - see attached.

Date:

Main results: Facies variations at base of slope suest sand bodies deposited by long shore currents.

Operational Considerations

Water Depth: (m) 1980 Sed. Thickness: (m) 2000 Total Penetration: (m) 1600

HPC yes Double HPC yes Rotary Drill _____ Single Bit _____ Reentry _____

Nature of sediments/rock anticipated: Fluvio-clastics: carbonates

Weather conditions/window: Possible cyclones in January/February. Heaviest swell June to August. Generally fair weather.

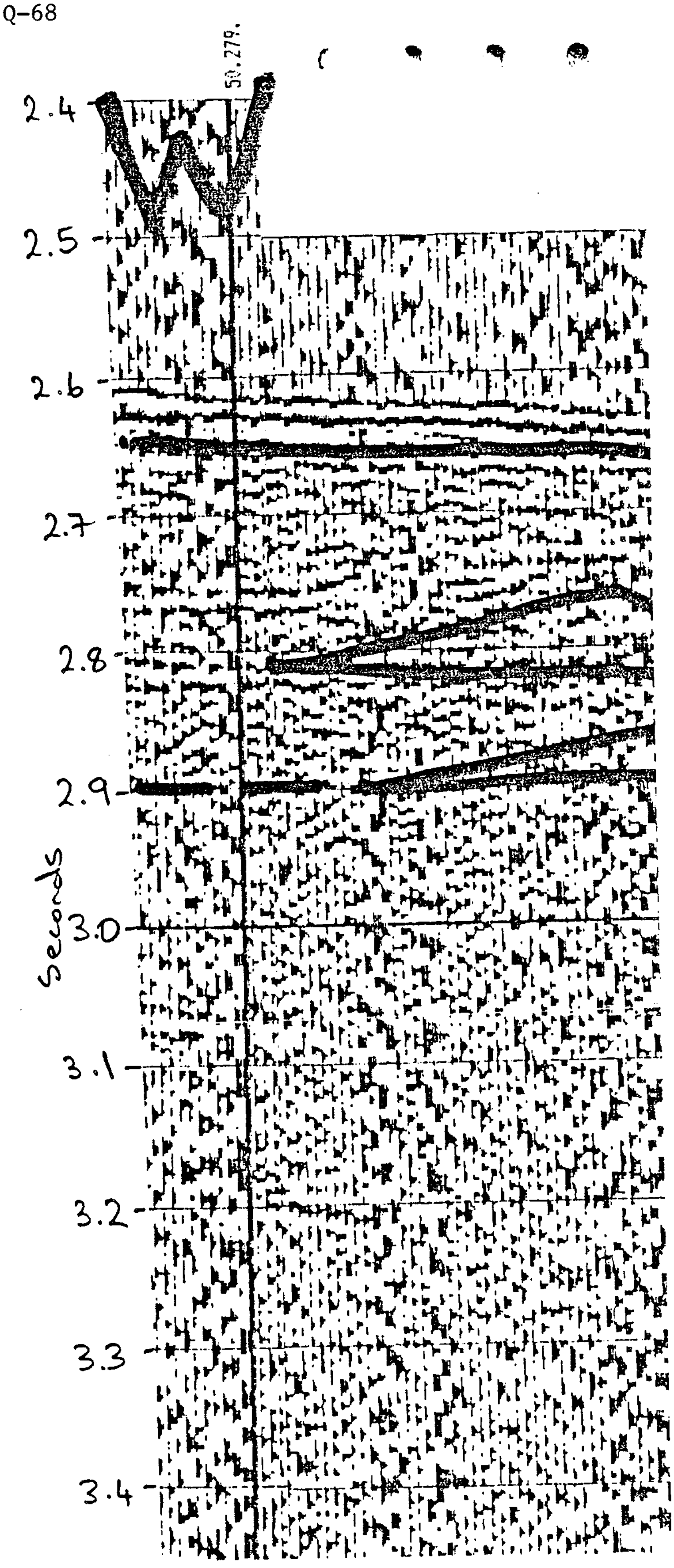
Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra A.C.T. 2601
AUSTRALIA

Date submitted to JOIDES Office: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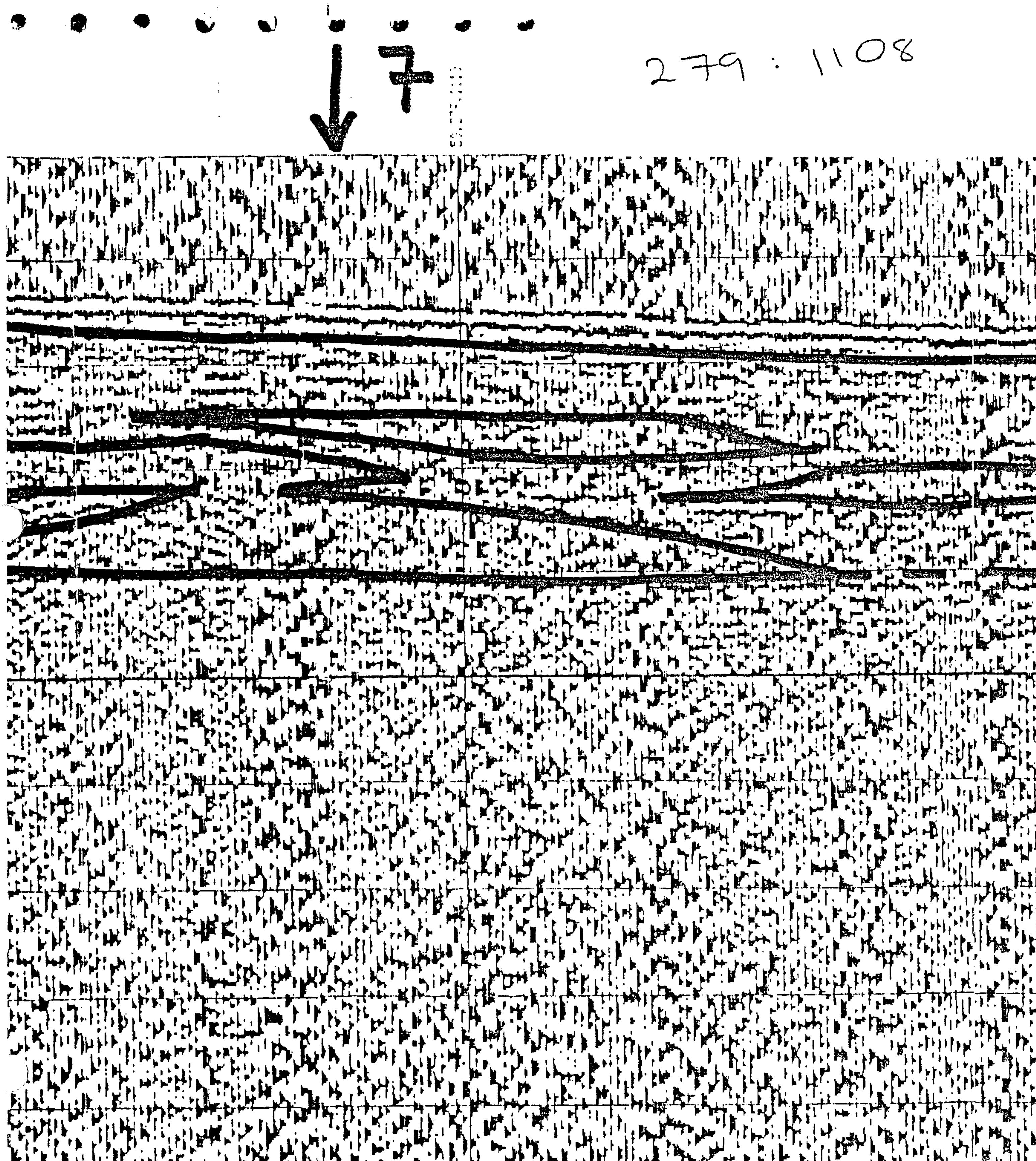

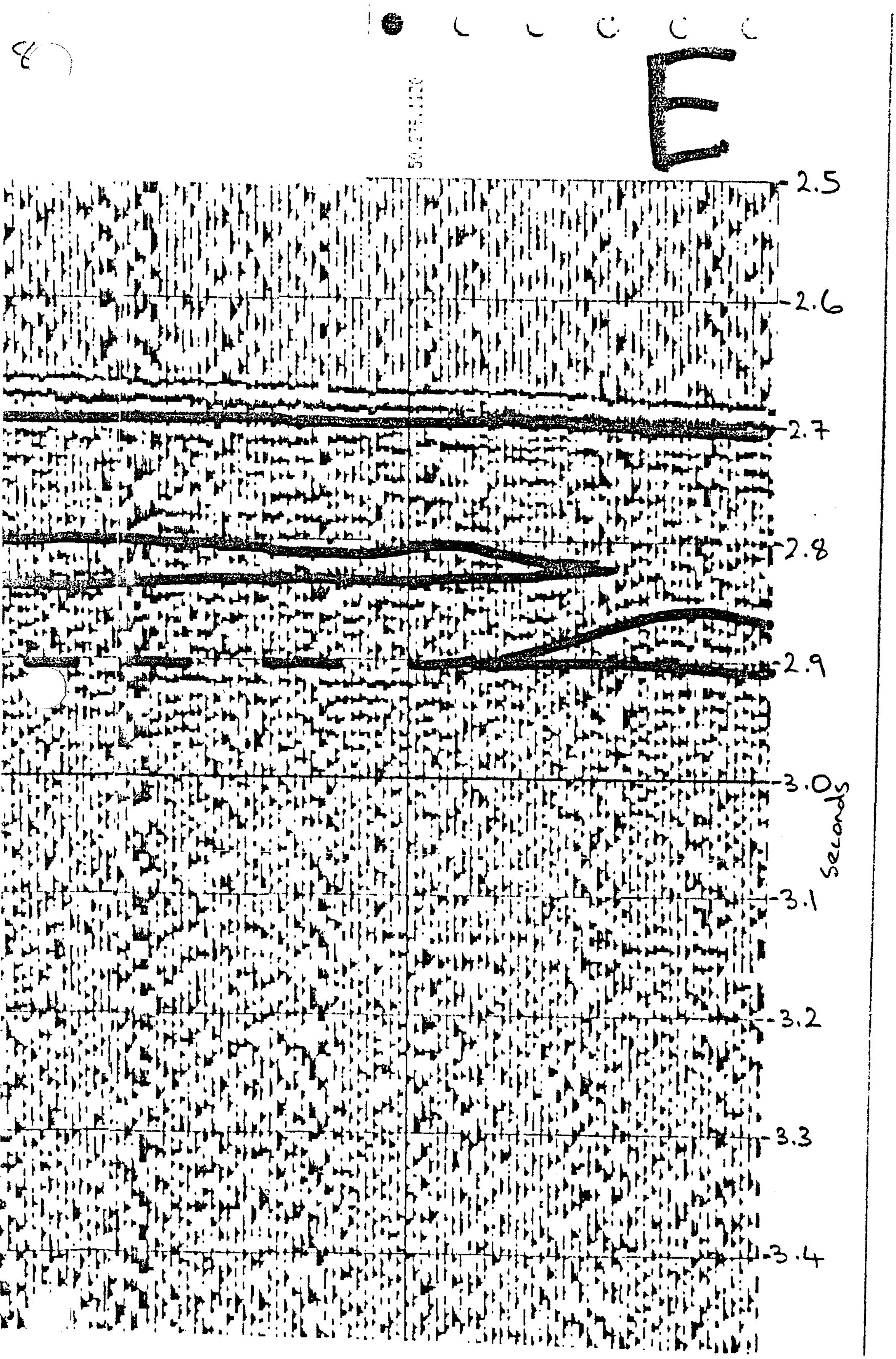
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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 8 Eastern Queensland Trough General Area: Northeast Australia Position: 15°32.75'S; 146°58.2'E Alternate Site:	General Objective: Rift history, ocean circulation, chemical oceanography Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To determine nature and variation in rift fill lithologies
2. To determine the source of clastic derived quartz and clays in the sediments
3. To define the reef nature of mound structures and the history of reef development along the western margin of the Queensland Plateau.
4. To determine whether reef development cooperates with changes in physical and chemical oceanography as suggested for the quaternary.

Background Information:

Regional Data:

Seismic profiles: SEE FIGURES 3, 4, and 5 IN PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR- completed in December 1985. Specifically line 50/018 (50.279.2235). Basinal sequence over rift faults.

Date:

Main results:

Operational Considerations

Water Depth: (m) 1670 Sed. Thickness: (m) 2000 Total Penetration: (m) 1000

HPC yes Double HPC yes Rotary Drill no Single Bit no Reentry no

Nature of sediments/rock anticipated: Reef carbonates; turbidites

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June to August. Generally fair weather.

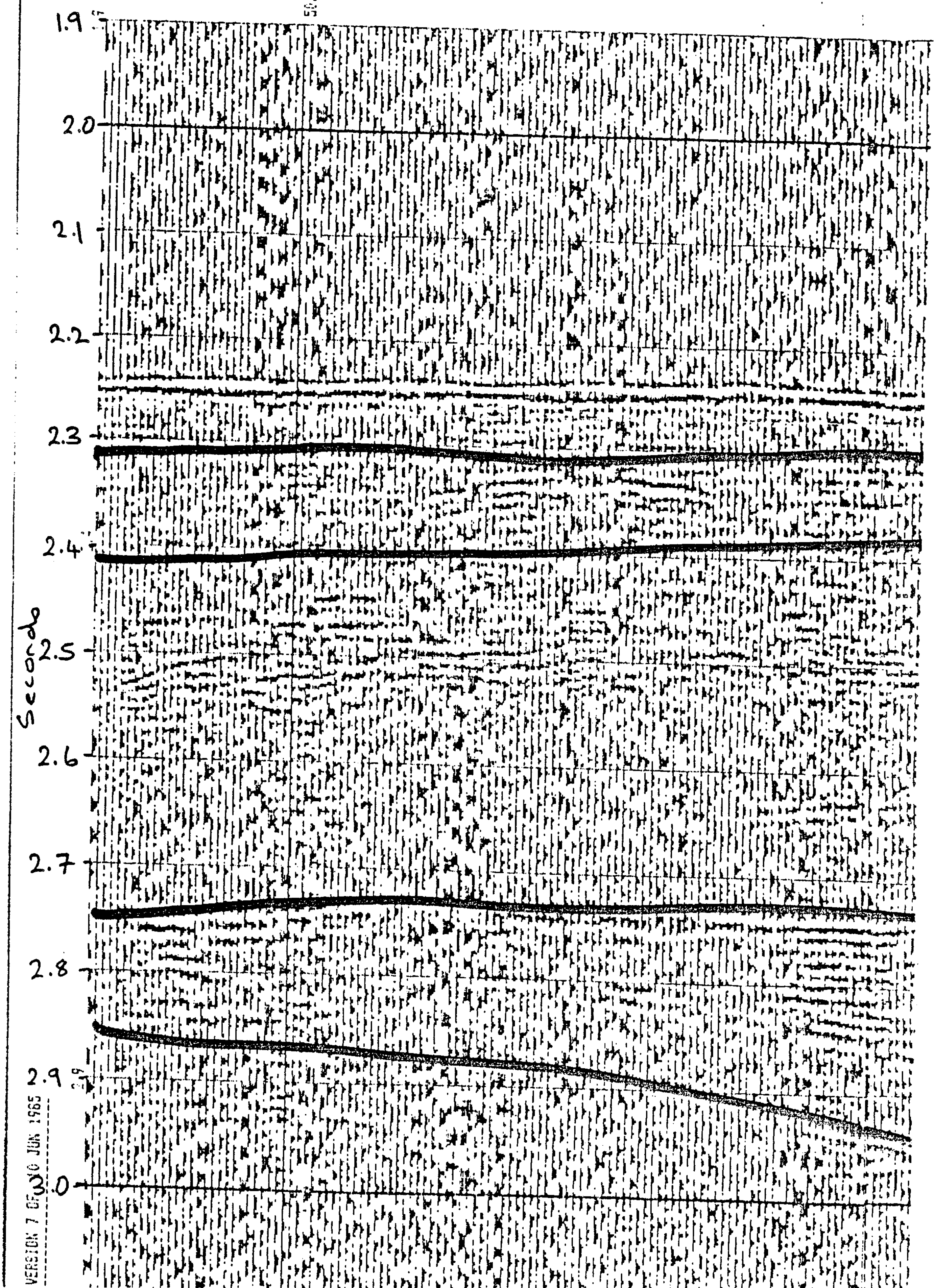
Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office:



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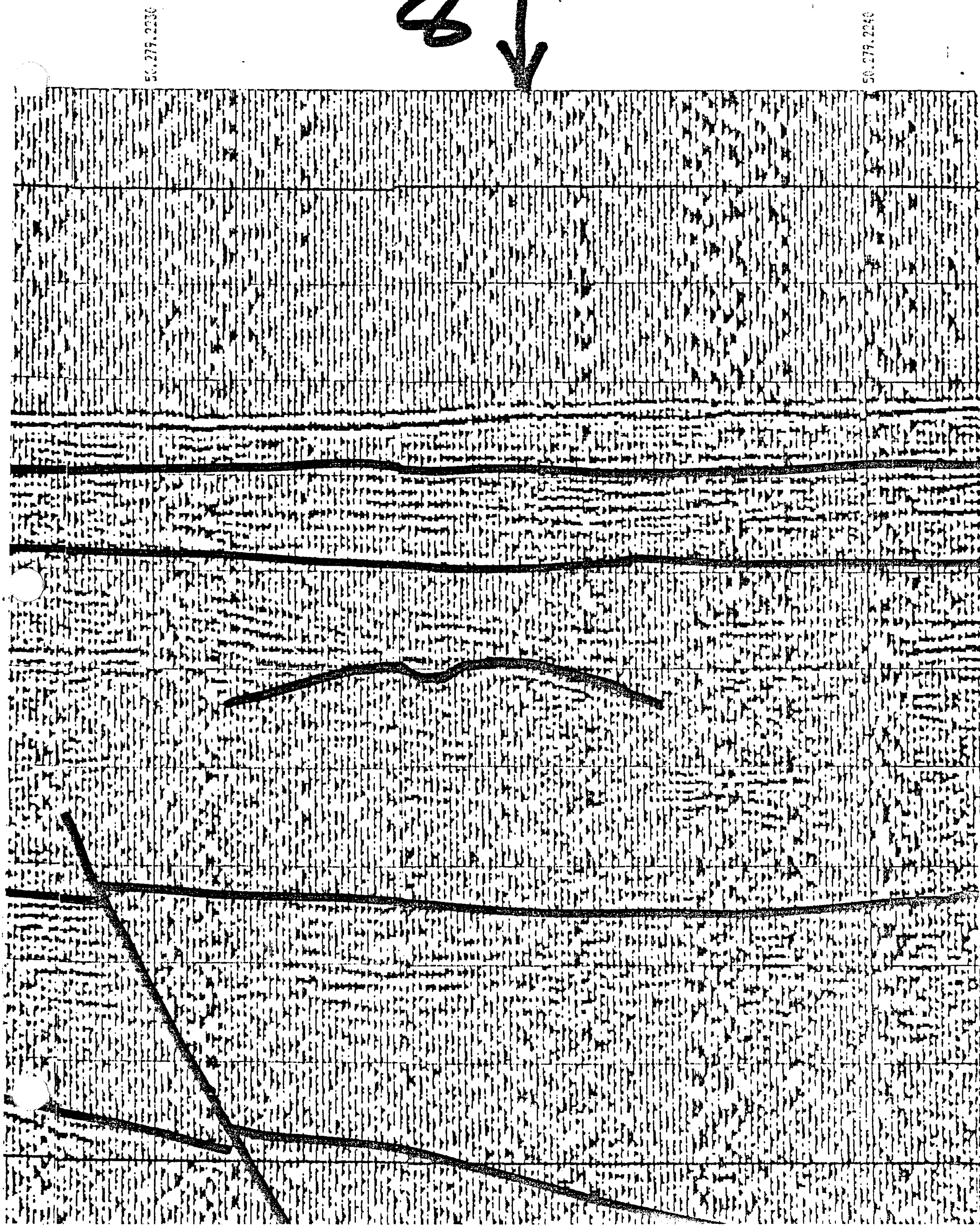

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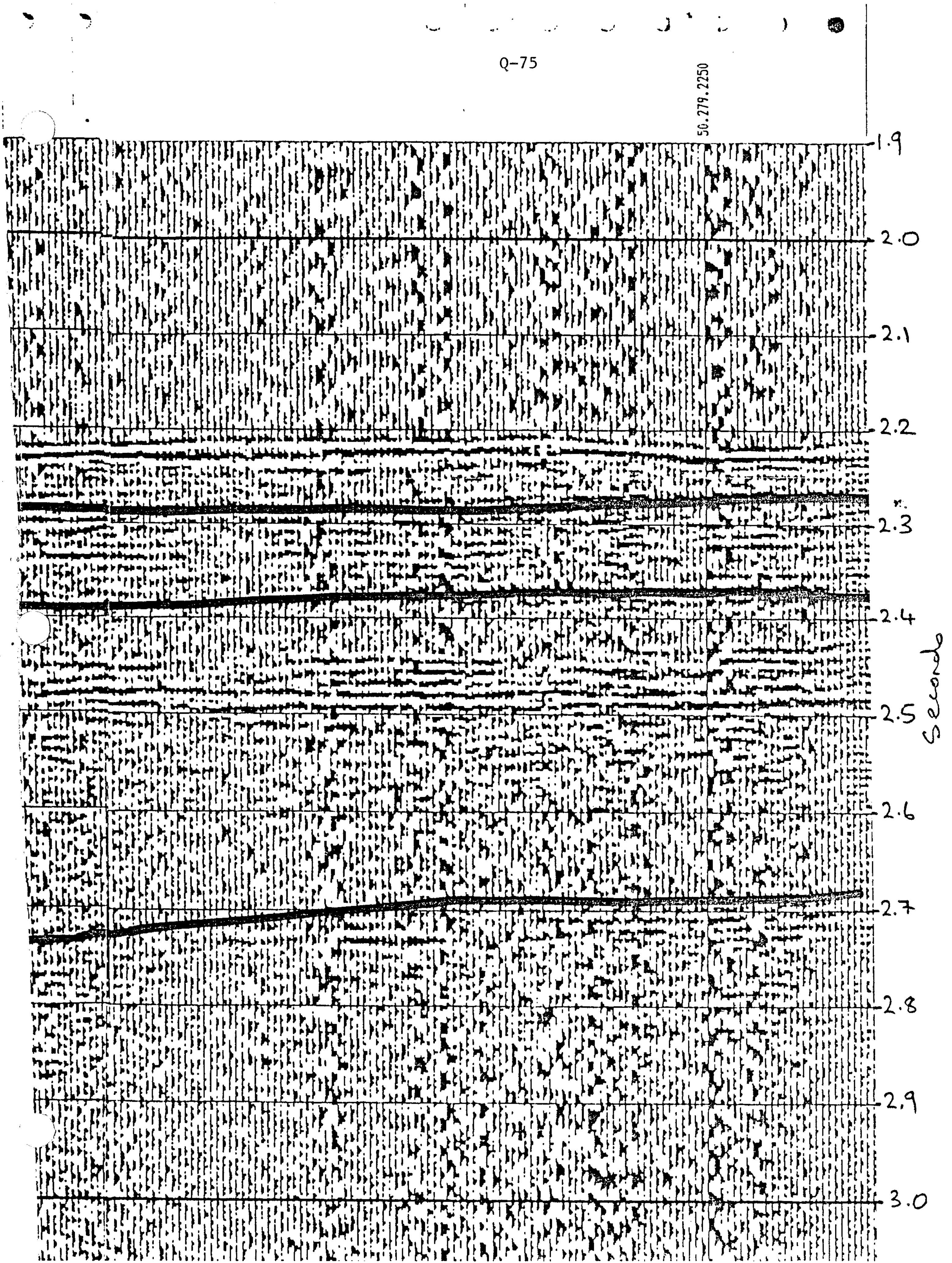


ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 9 Western Queensland Plateau- east of Bougainville Reef General Area: Northeast Australia Position: 15°31.25'S; 147°09.4'E Alternate Site:	General Objective: Rift margin and reef history. Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To determine earliest age of reef growth
2. To define relations of reef and adjacent plateau facies
3. To define subsidence history of plateau
4. To categorize seismic facies variations
5. To define effects of reef growth on oceanography of western plateau margin.

Background Information:

Regional Data:

Seismic profiles: SEE FIGURES 3, 4, AND 5 OF PROPOSAL

Other data:

Site Survey Data-Conducted by:
Date:
Main results:

BMR - completed December 1985. Specifically line 50/018 (50.280.0045). Facies developed to east of Bougainville reef interdigitation of reef with plateau carbonates.

Operational Considerations

Water Depth: (m) 1190 Sed. Thickness: (m) 2000 Total Penetration: (m) 1000-1500

HPC yes Double HPC ____ Rotary Drill yes Single Bit yes Reentry ____

Nature of sediments/rock anticipated: Reef carbonates: foram-nanno oozes

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June to August. Generally fair weather.

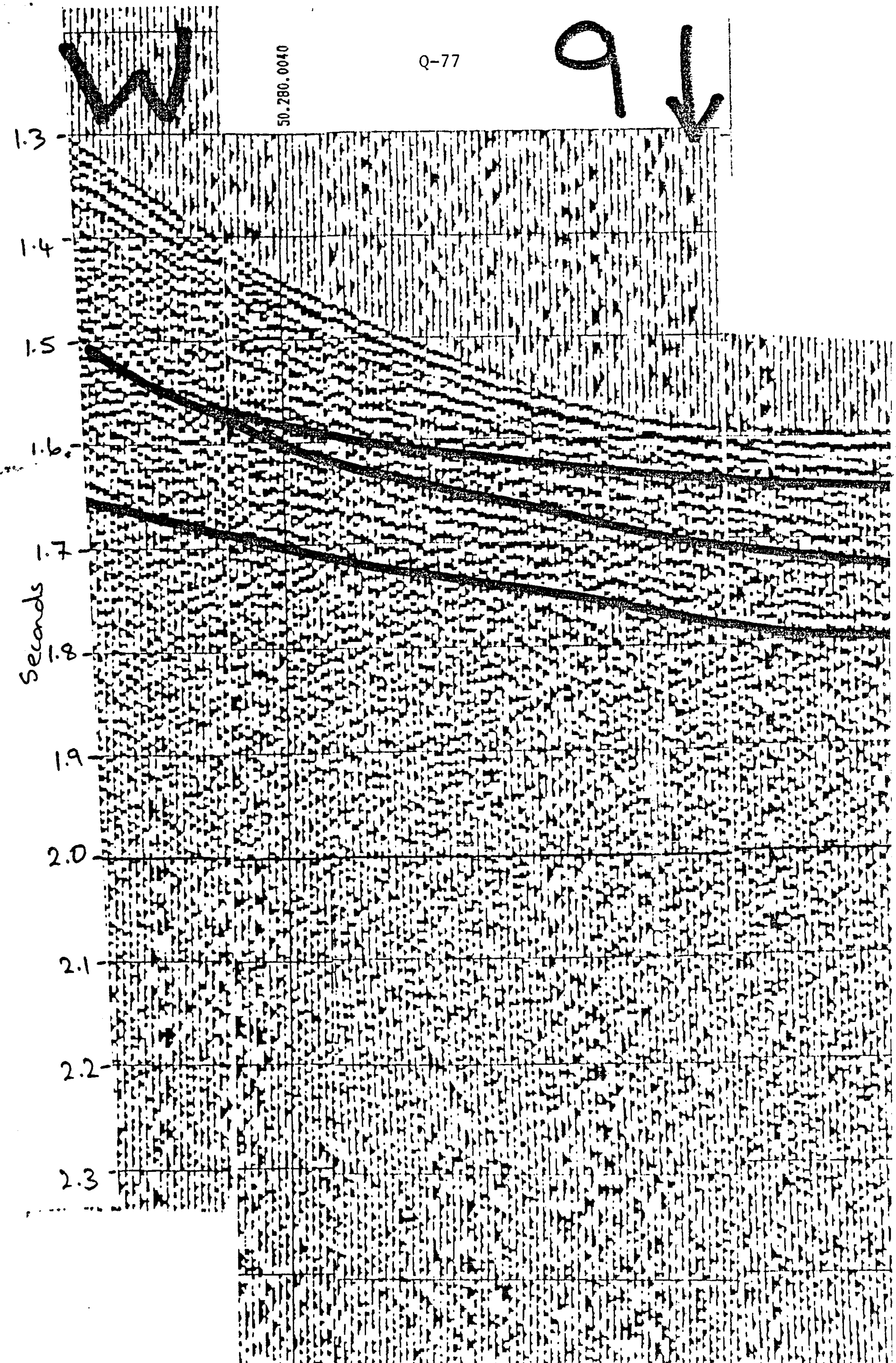
Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/S. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office: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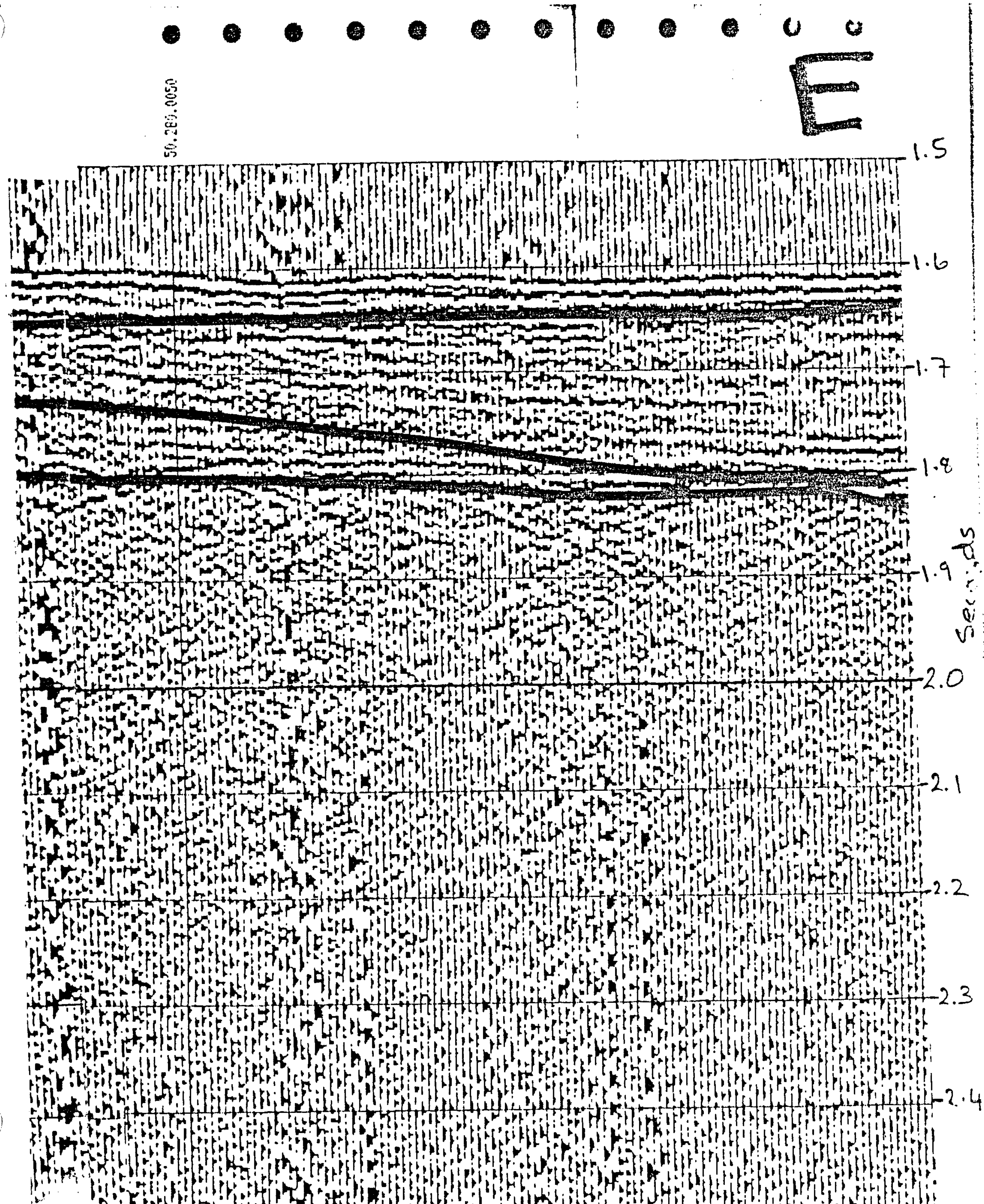
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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 10
Eastern Queensland Trough

General Area: Northeast Australia
Position: 17.06.2'S; 147.19.9'E
Alternate Site:

General Objective: Mechanisms of rift infill earliest reef growth, subsidence history.

Thematic Panel Interest: S.O.H.P.
Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To determine the nature and age of mounds (? reefs) on acoustic basement
2. To determine the causes of reef (?) demise
3. To determine the subsidence history of rift
4. To determine facies variations and sedimentary mechanisms responsible for rift infill

Background Information:
Regional Data:
Seismic profiles: SEE FIGURES 3, 4, and 5 OF PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR- completed in December 1985. Specifically BMR line 51/014-015 (51.337.1553) GSI line 10. Shot points. 4600-4900 - see attached
Date:
Main results: Reef structure, possibly Eocene, prograding on basement. Rift infill covers reef.

Operational Considerations

Water Depth: (m) 1500 Sed. Thickness: (m)1000 Total Penetration: (m) 1000

HPC yes Double HPC yes Rotary Drill yes Single Bit yes Reentry ____

Nature of sediments/rock anticipated: Turbidites, reef rocks, foram oozes

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June to August. Generally fair weather.

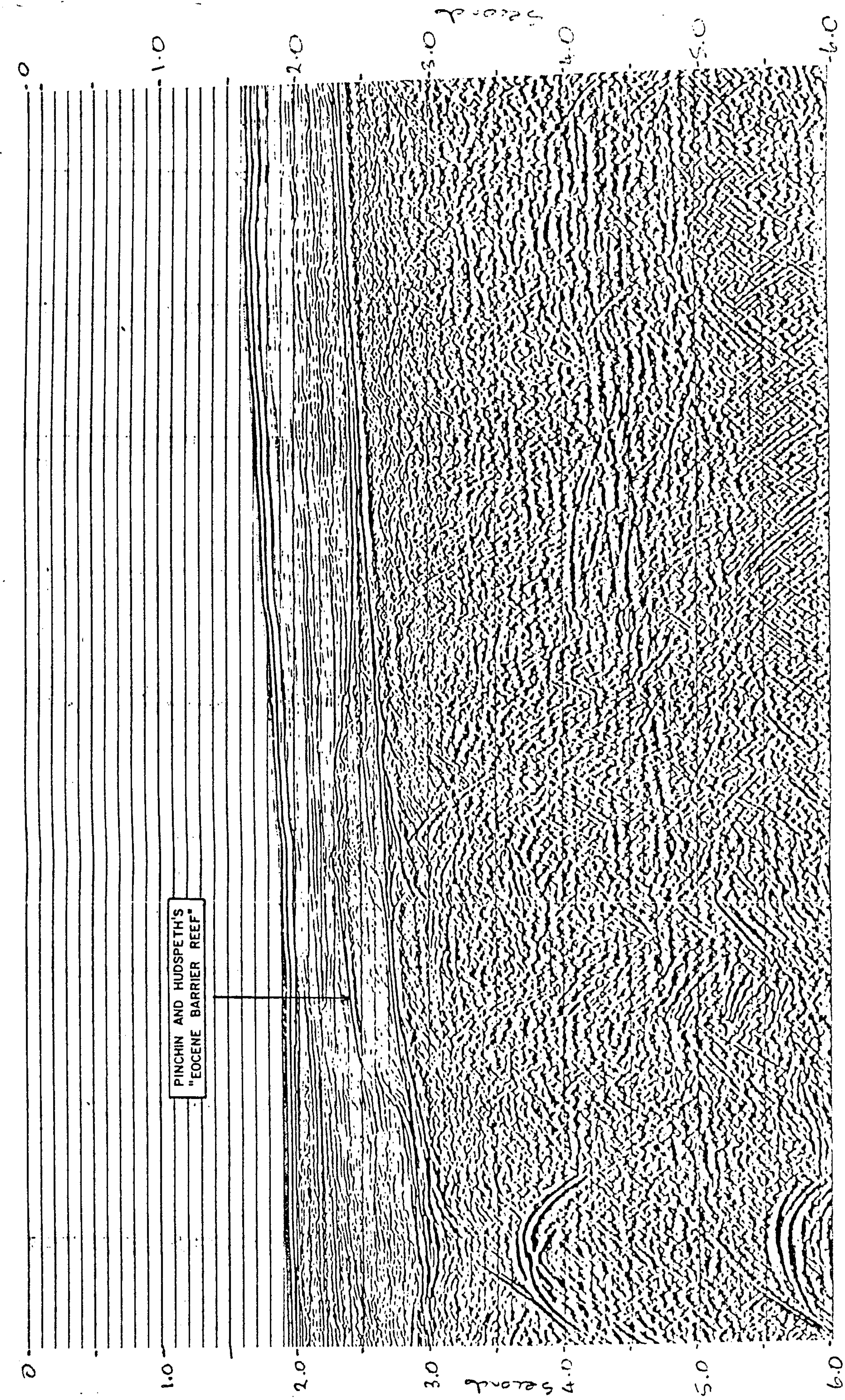
Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office:


PINCHIN AND HUDSPETH'S "EOCENE BARRIER REEF"
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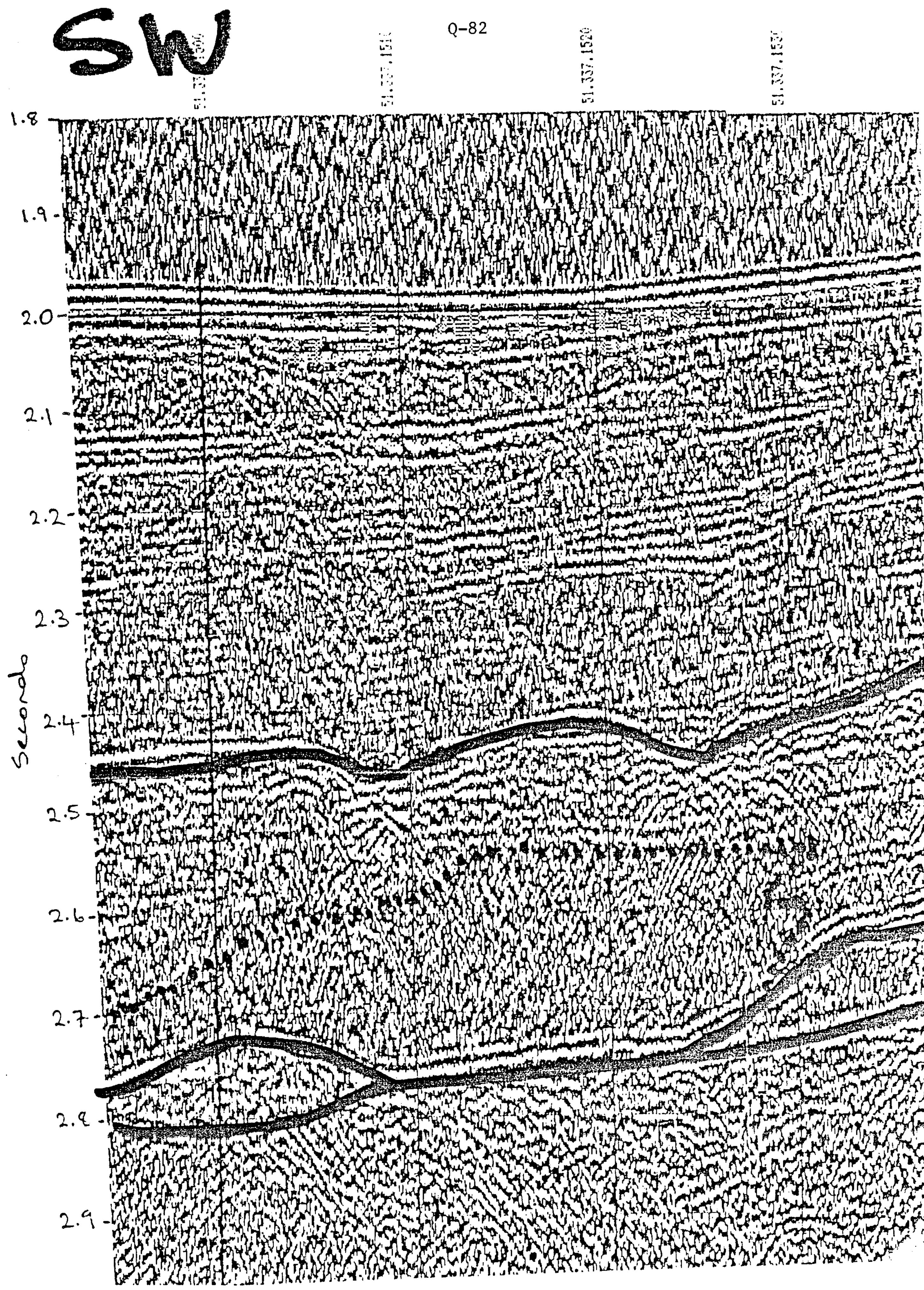

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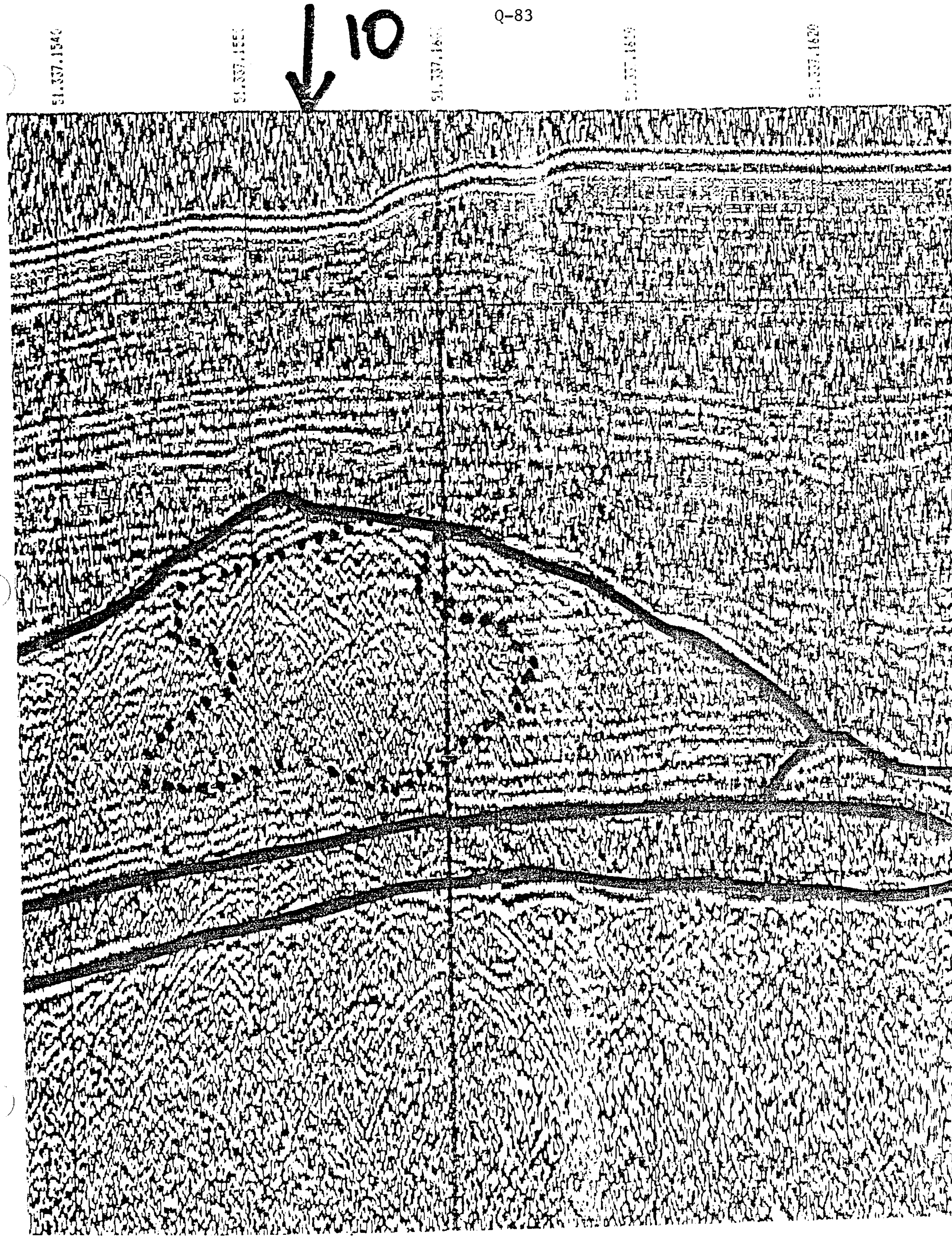

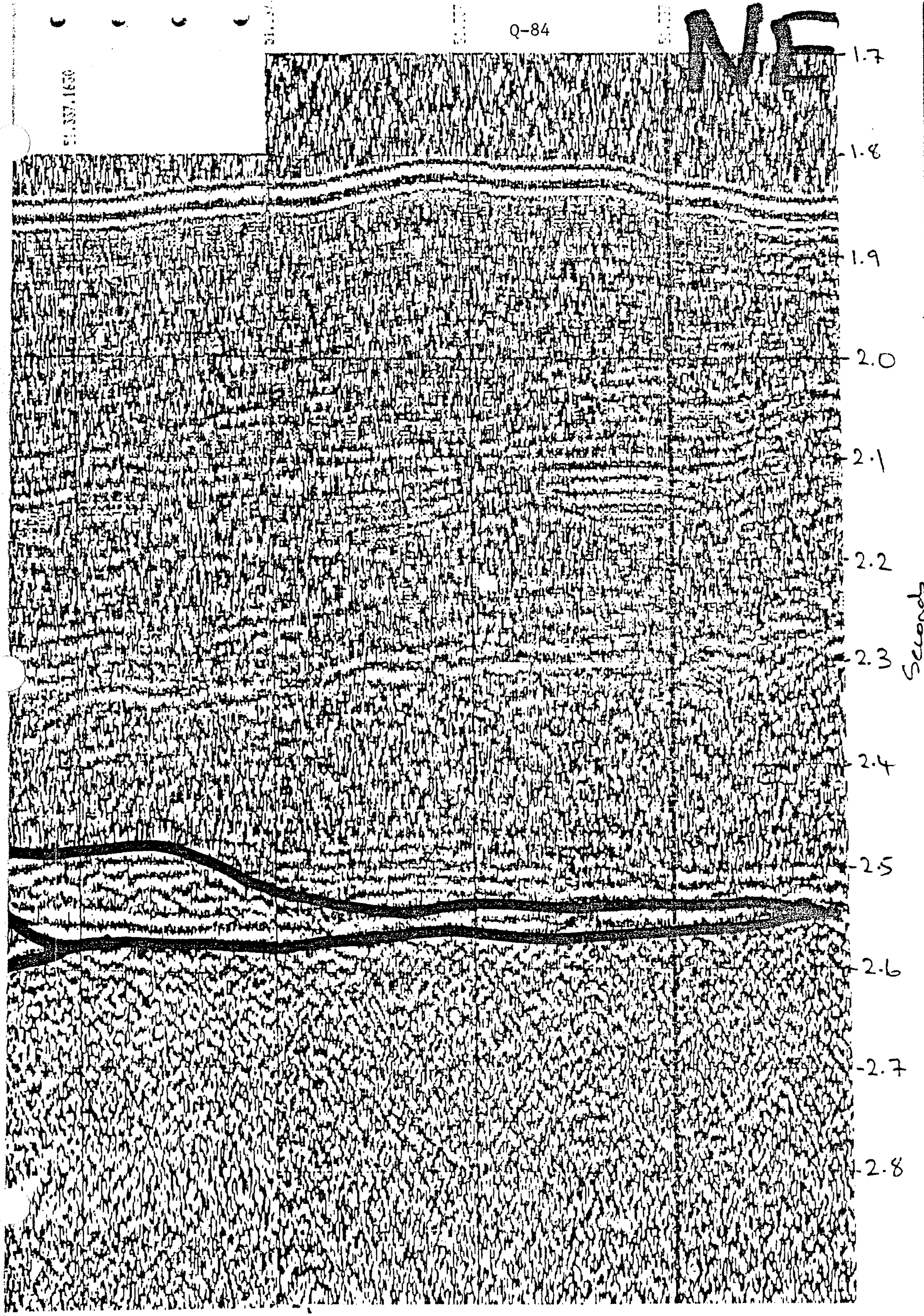
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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 11A and B, 12
Central Great Barrier Reef

General Area: Northeast Australia
Position: 16°39.2'S: 146°16.8'E
Alternate Site:

General Objective:
Sedimentation and sea level. Reef growth and effects on margin evolution. Upwelling history.
Thematic Panel Interest: S.O.H.P.
Regional Panel Interest: W.P. - R.P.

Specific Objectives: Address general objectives by examining the nature of tropical carbonate/epiclastic dominated passive margin.

1. To determine nature, extent and age of fore reef talus.
2. To determine nature of sea level silicoclastic sequences.
3. To define the diagenetic and geochemical imprints in carbonates and clastics.
4. To relate facies to seismic facies.
5. To relate phosphate in sediments to sea level and puwelling intensity.

Background Information:
Regional Data:
Seismic profiles: SEE FIGURES 3, 4, & 5 OF PROPOSAL. BMR HAS RECENTLY COMPLETED HIGH-RESOLUTION MULTICHANNEL PROFILES.

Other data:

Site Survey Data-Conducted by: BMR - completed in December.
Date: Specifically BMR Line 41/21-41.206.0156
Main results: Reef sequences overlying upper slope low sea level progradational facies. Lower slope-distal part of prograding facies, fans, levee banks, channel fill.

Operational Considerations

Water Depth: (m) 430-600 Sed. Thickness: (m)2-3000 Total Penetration: (m)700-800

HPC Yes to refusal Double HPC ____ Rotary Drill yes Single Bit yes Reentry ____

Nature of sediments/rock anticipated: Thin carbonates, epiclastics, fan and debris flow, levee muds and sands.
Weather conditions/window: Possible cyclones in January-February. Heaviest swell in June to August. Generally fair weather.
Territorial jurisdiction: Australia
Other:

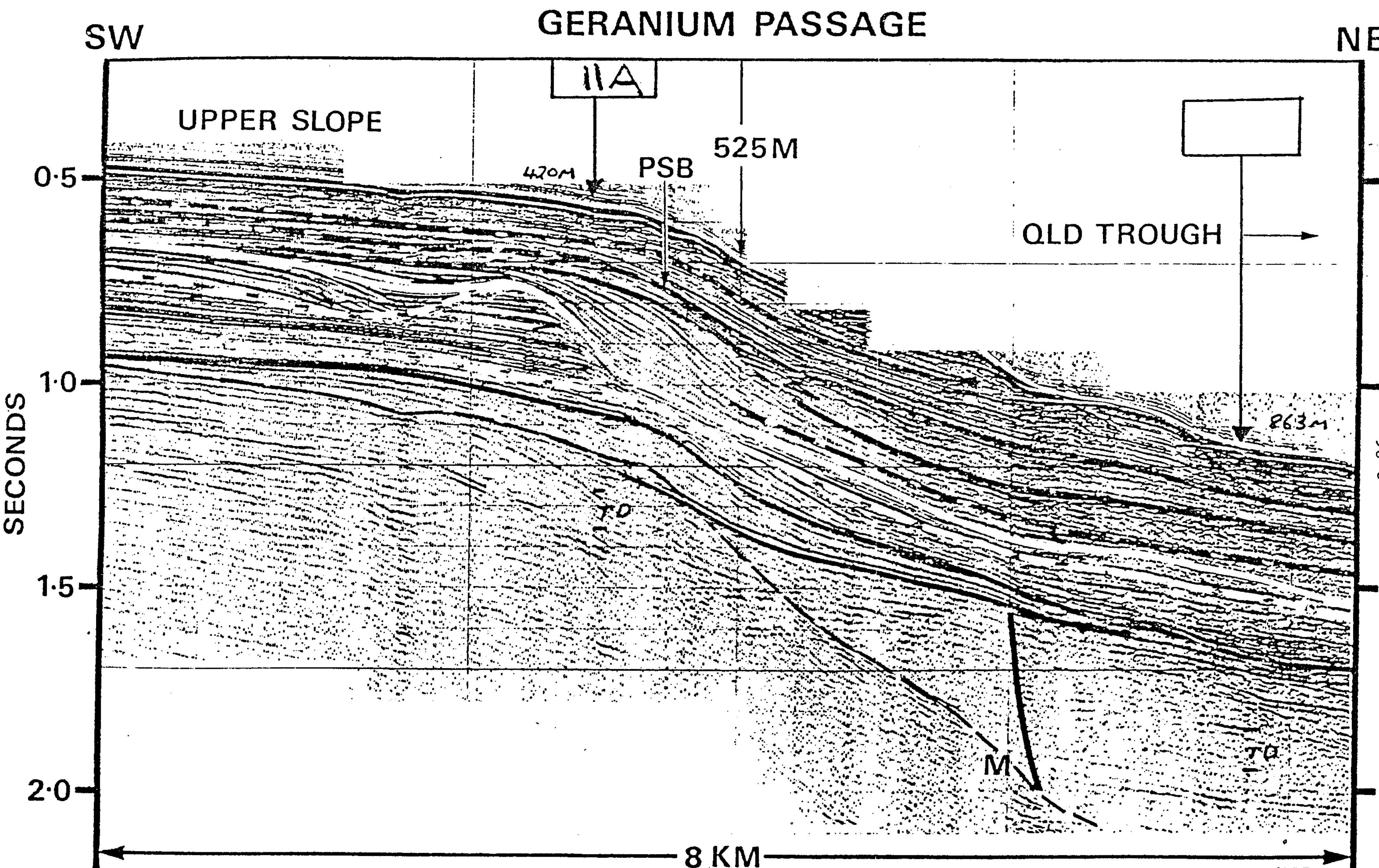
Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office:

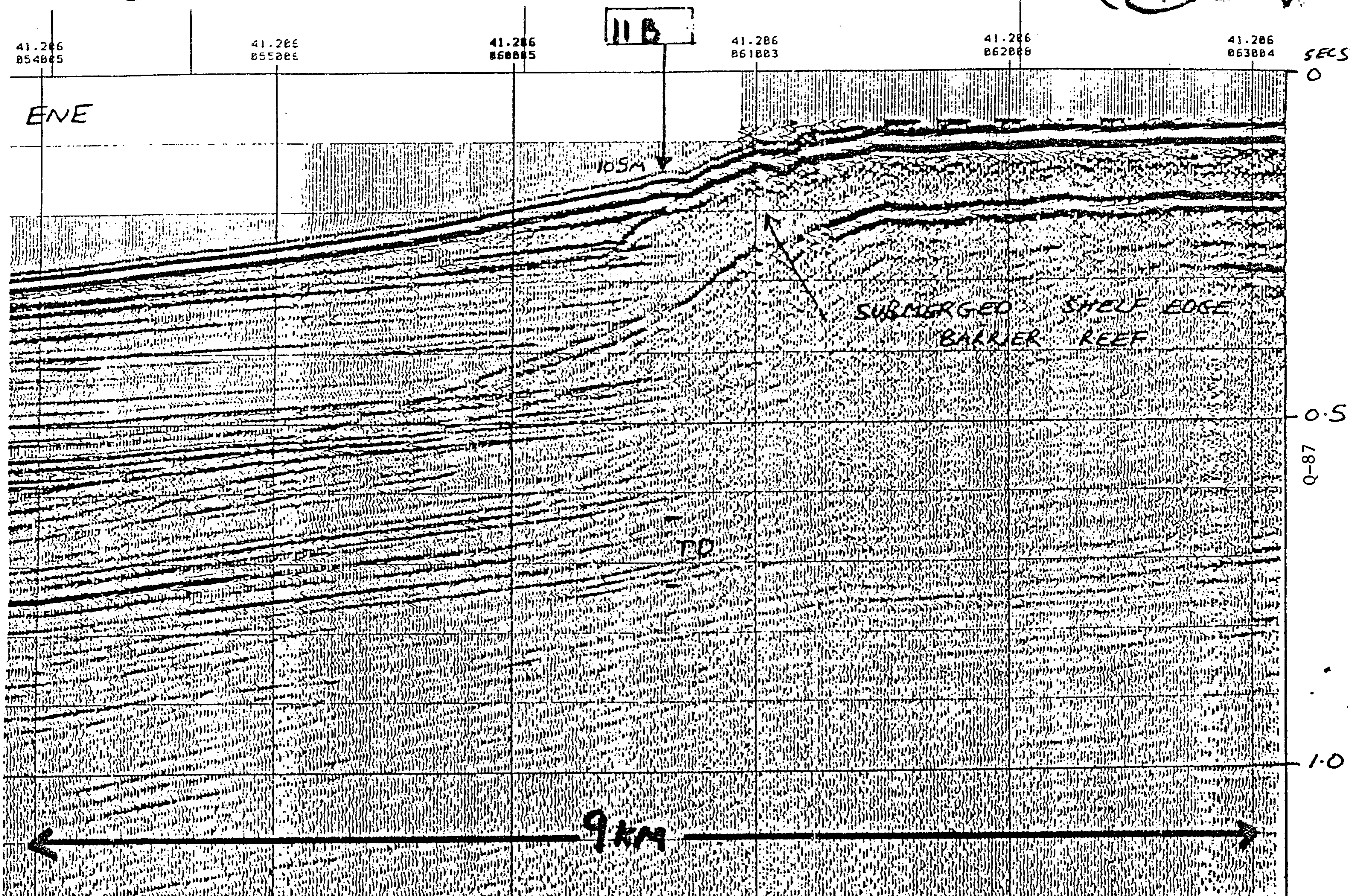
CENTRAL GREAT BARRIER REEF

(11)



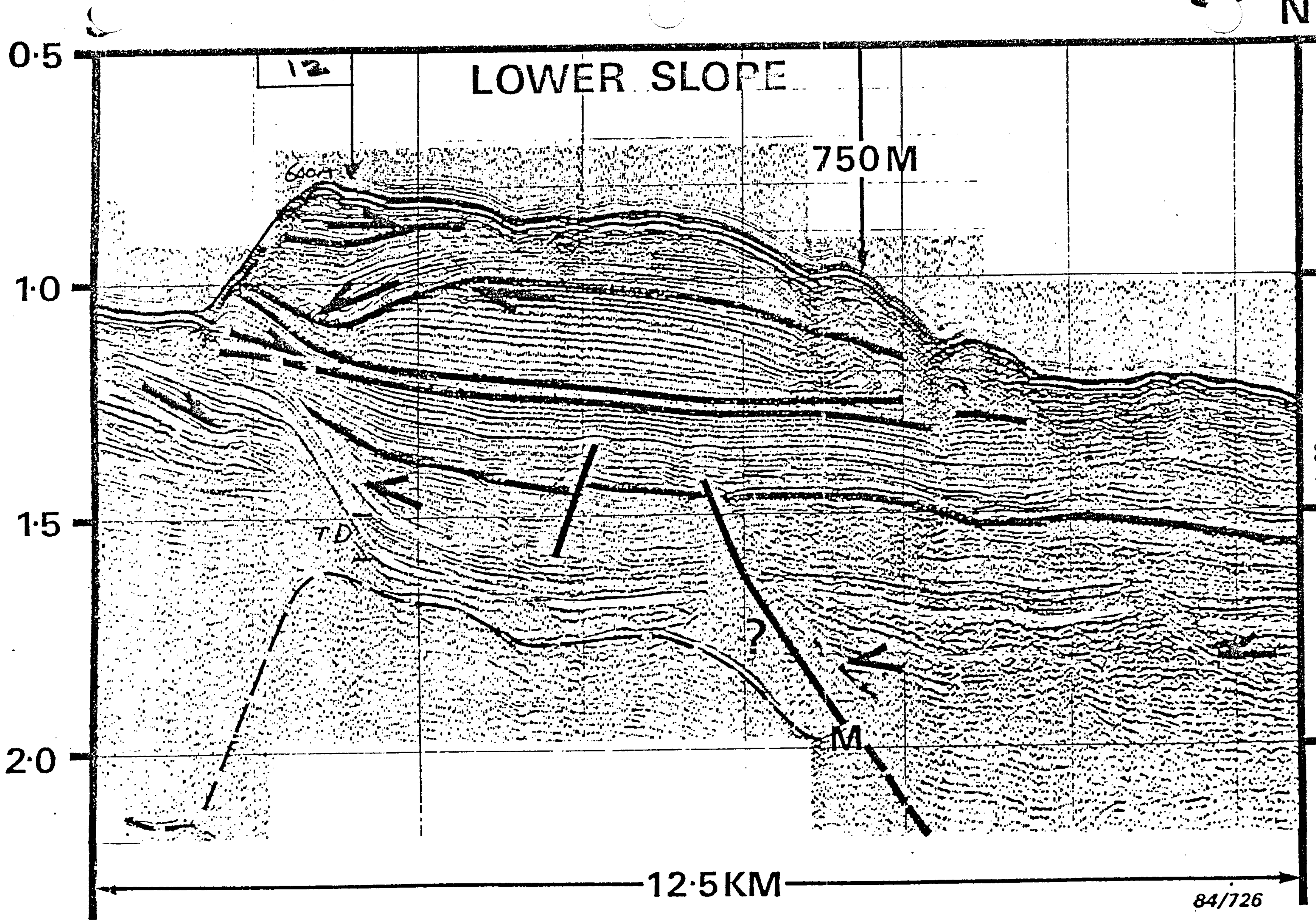
BMR SPARKER LINE 41/22

CENTRAL GREAT BARRIER REEF (11B)



BMR SPARKER LINE 41/22
GERANIUM PASSAGE

CENTRAL GREAT BARRIER REEF



BMR SPARKER LINE 41/21

ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 13A Central Great Barrier Reef General Area: Northeast Australia Position: 18°141S; 147°22.6'E Alternate Site:	General Objective: Age of Great Barrier Reef, facies and sea level, upwelling and sea level variations Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To define earliest reef growth
2. To define extent reef-derived debris on slope
3. To determine nature of pre-reef facies and their effects on reef growth
4. To define relations of prograding wedges and sea level variations
5. To define effects of sea level oscillations on shelf margin upwelling

Background Information:

Regional Data:

Seismic profiles: SEE FIGURES 3, 4, & 5 OF PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR - completed in December 1985. Specifically Line 50/013 (50.277.0326-0401).

Date:

Main results: Reef, debris, gravity slide, wave-dominated deltaic and other fluvio-deltaic facies identified in seismics.

Operational Considerations

Water Depth: (m) 300 Sed. Thickness: (m) 1000 Total Penetration: (m) 800

HPC yes Double HPC yes Rotary Drill yes Single Bit yes Reentry no

Nature of sediments/rock anticipated: Reefs; fluvio-deltaics

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June to August. Generally fair weather.

Territorial jurisdiction: Australia

Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/ P. Symonds/ D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office:

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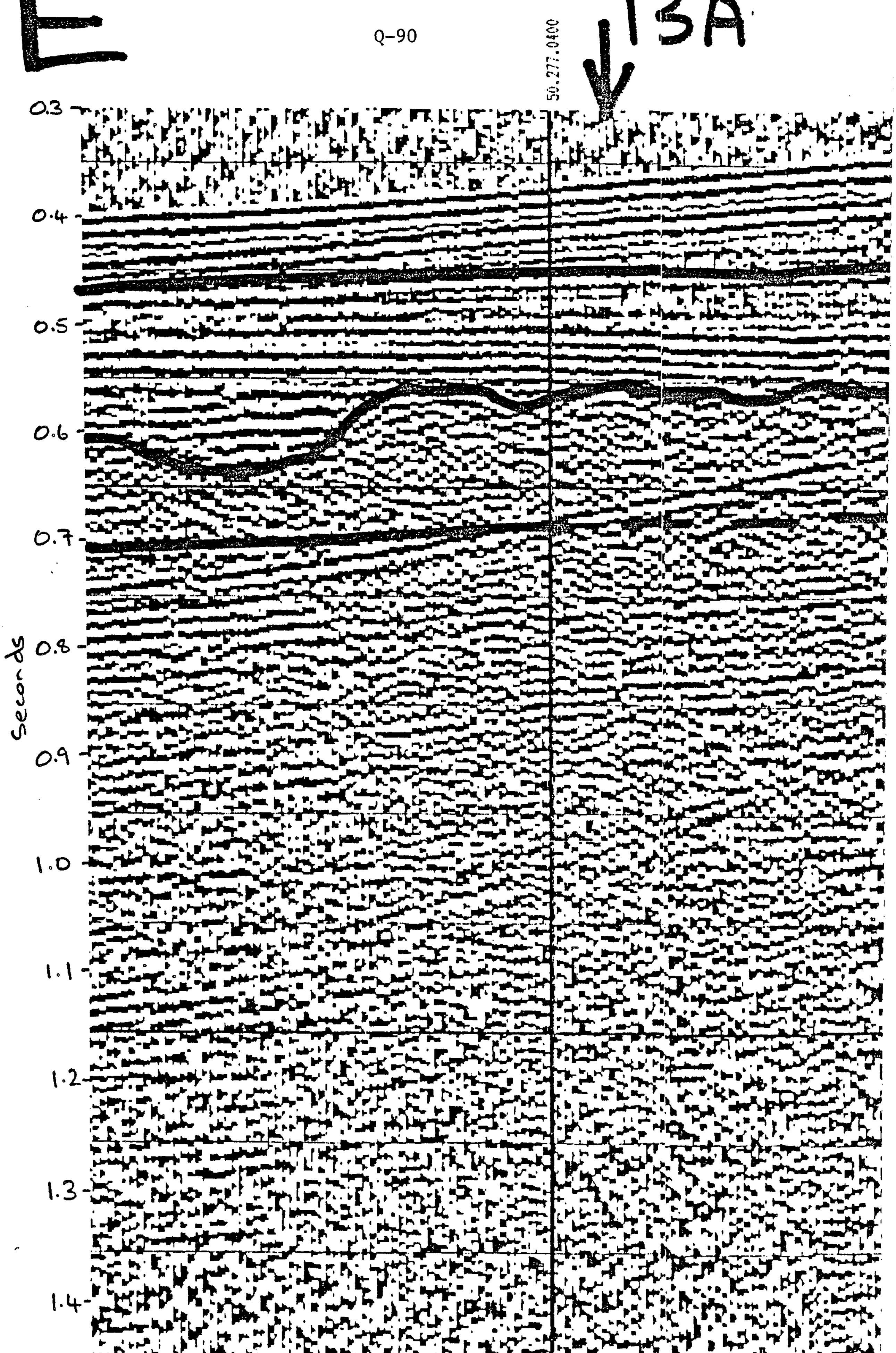

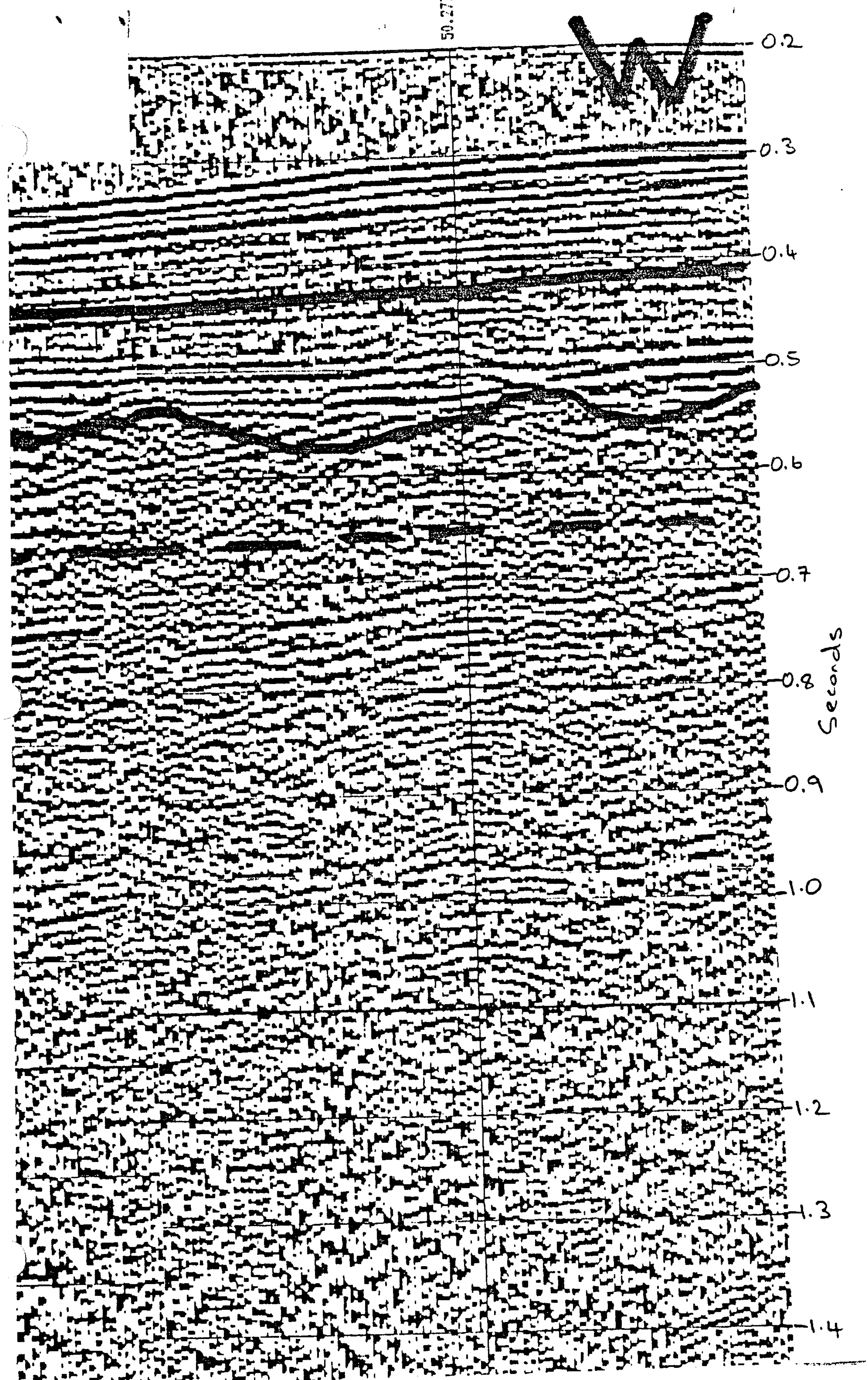
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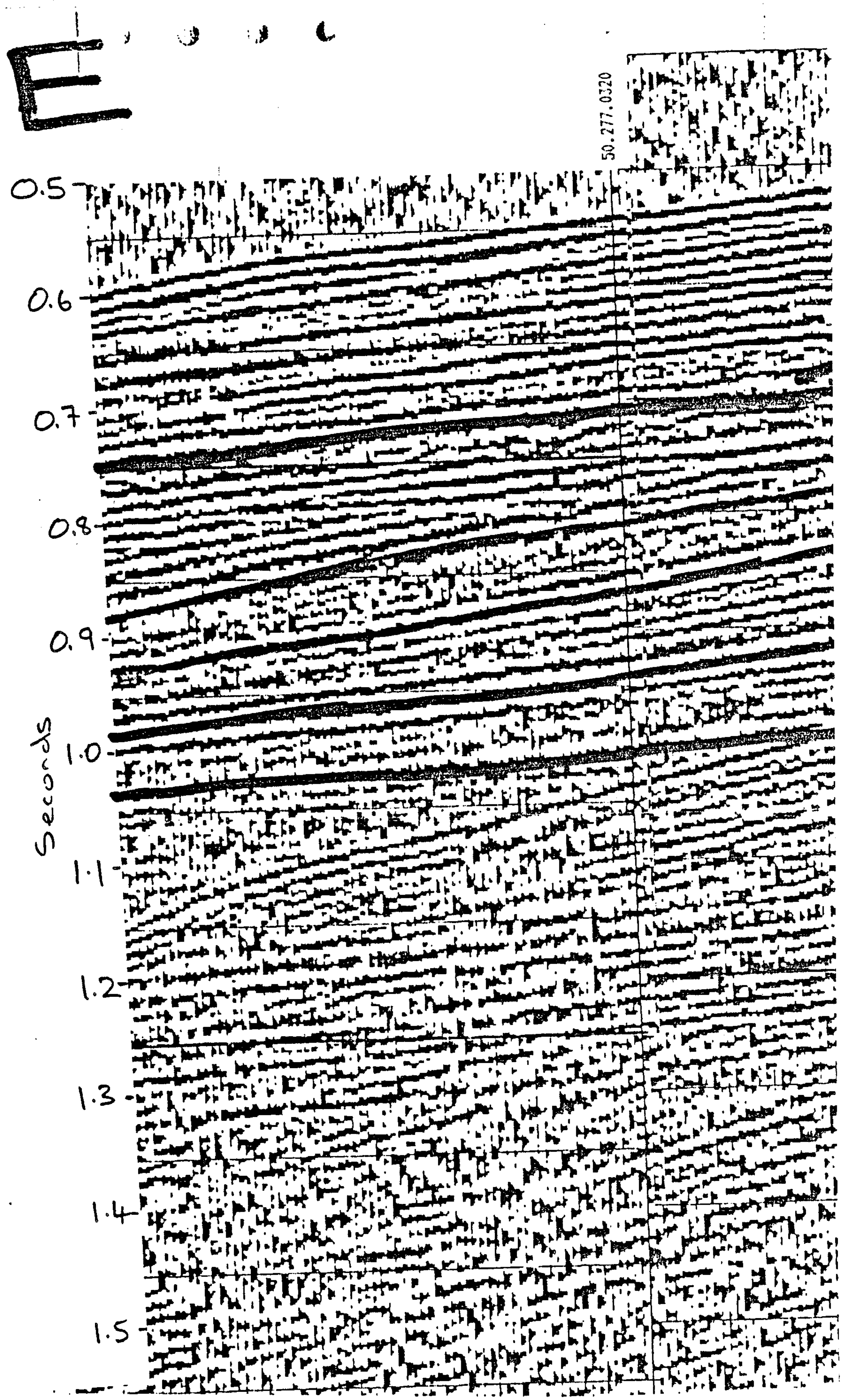
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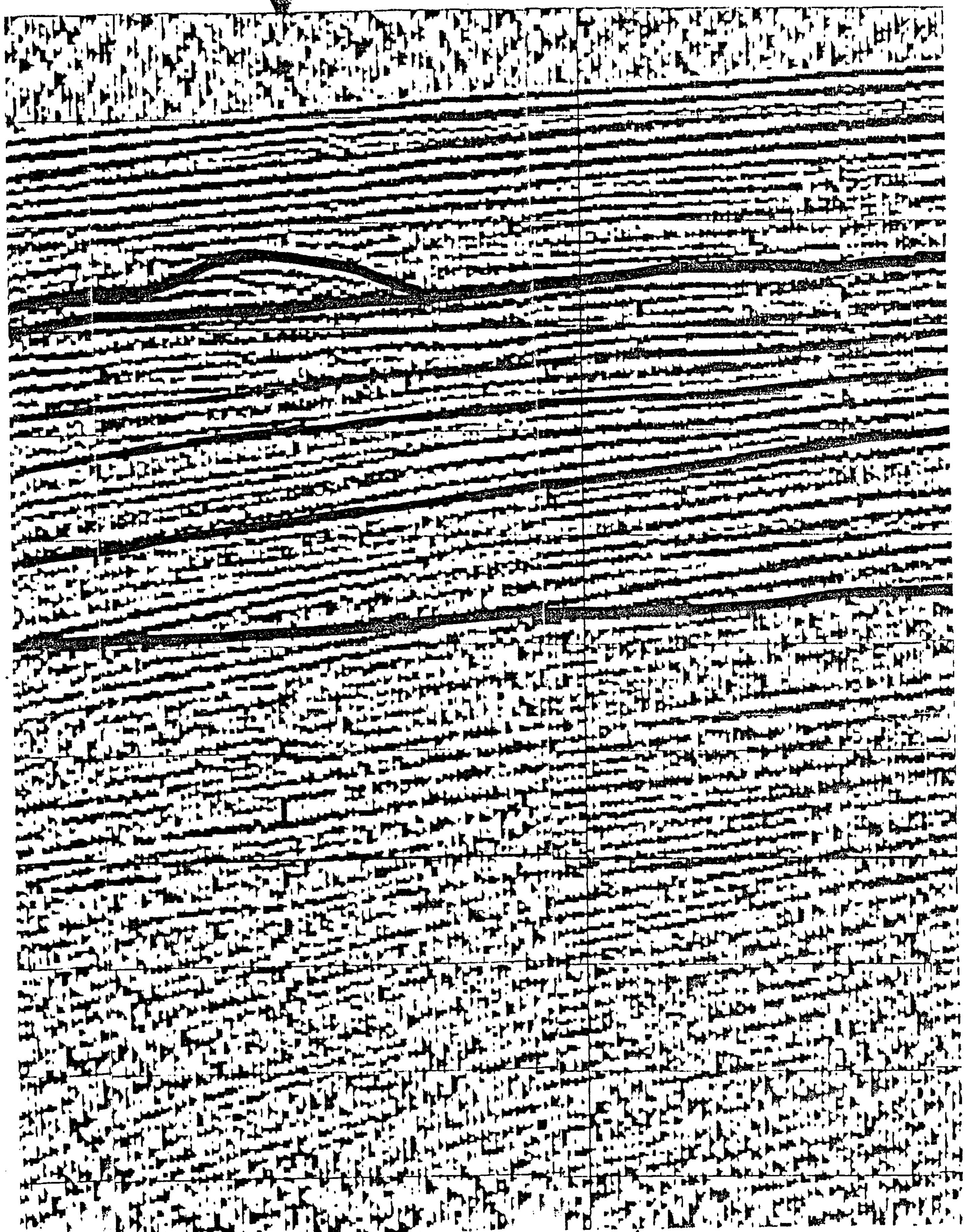

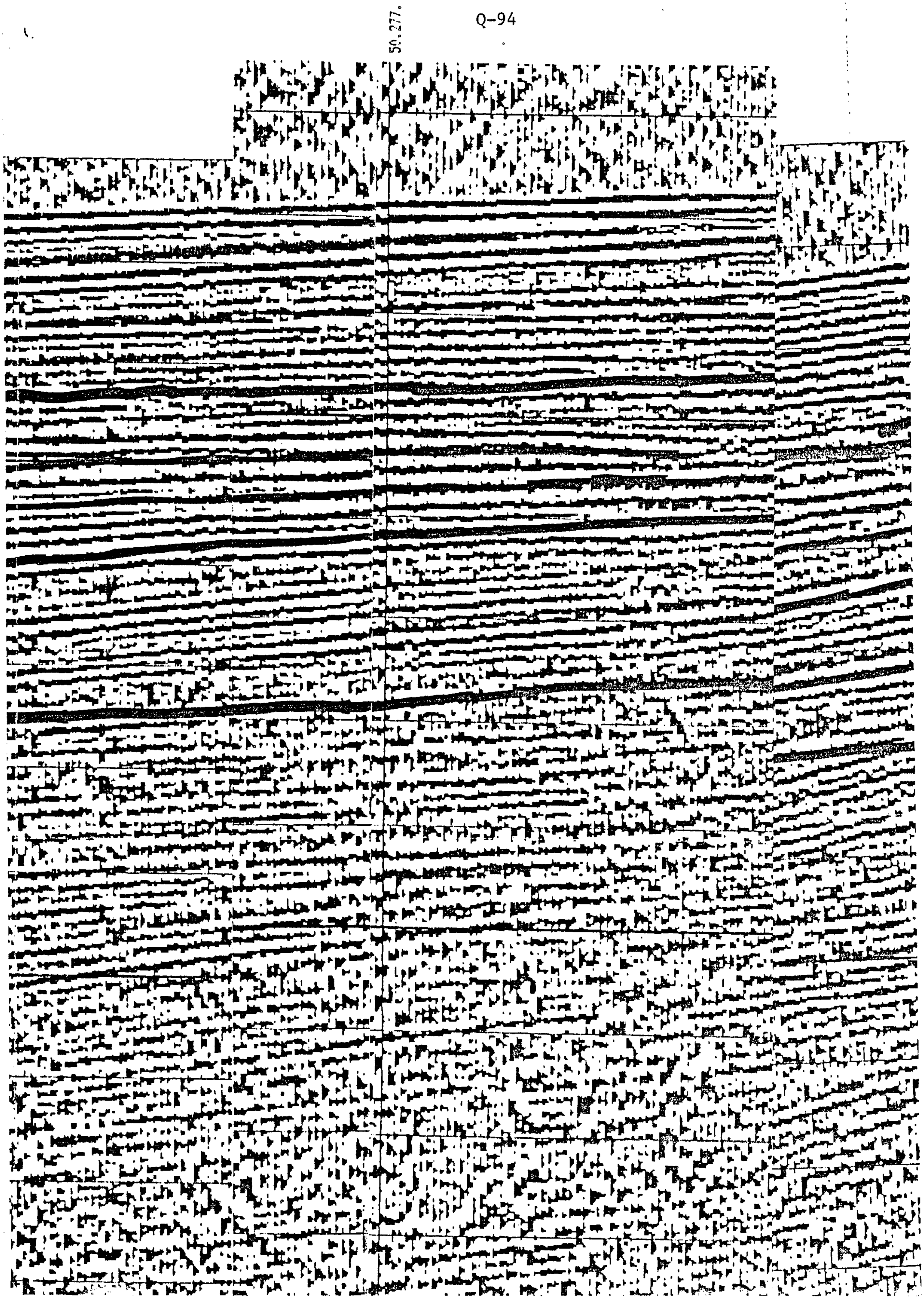
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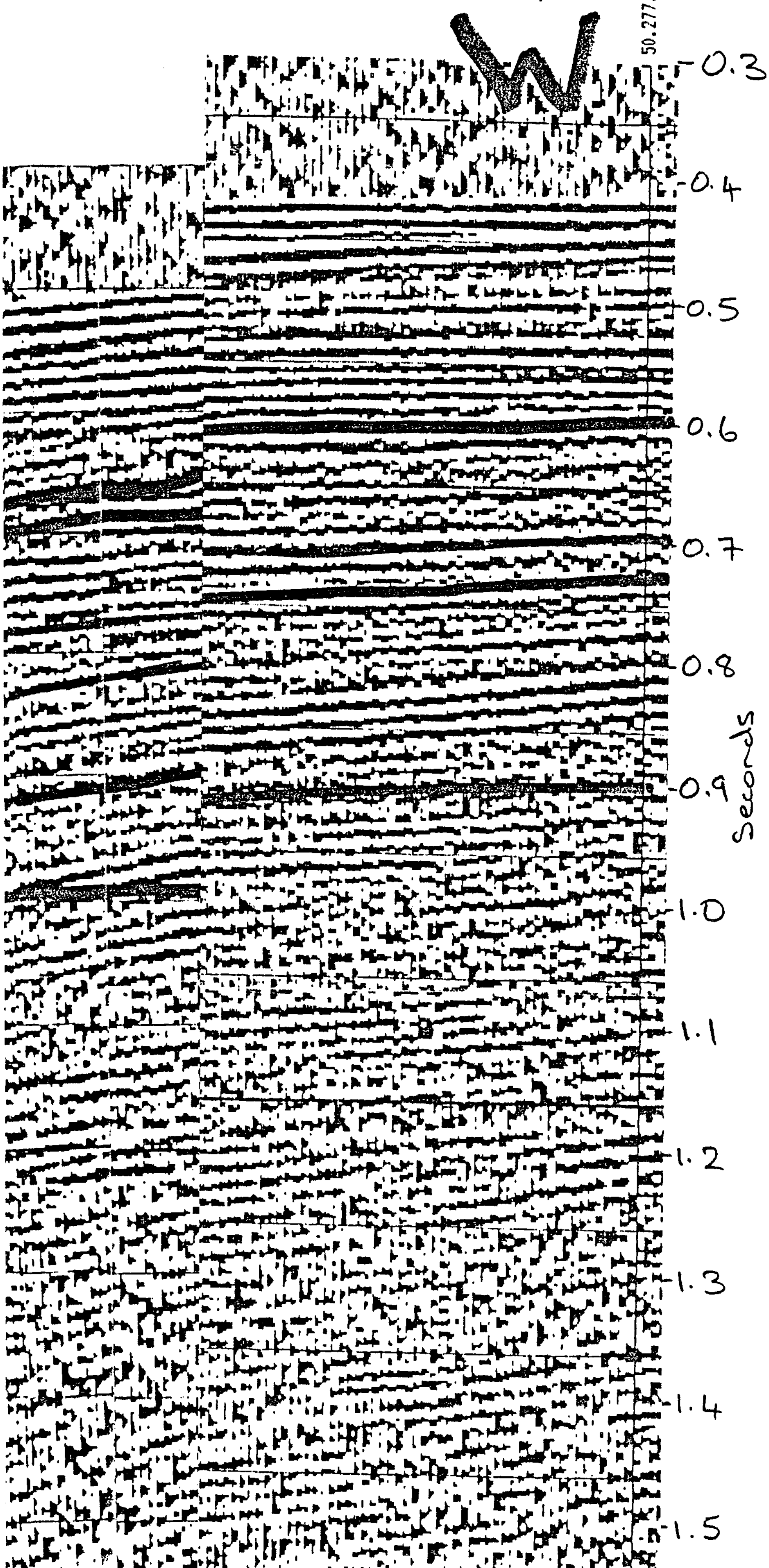


ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 14A and B Western Queensland Trough General Area: Northeast Australia Position: 18°07.45: 147°28.4E Alternate Site:	General Objective: Facies and sea level Thematic Panel Interest: S.O.H.P. Regional Panel Interest: W.P. - R.P.

Specific Objectives:

1. To define age and lithology of prograding sequence and the enclosing stratified sequences
2. To relate lithologies to sea level
3. To relate facies variations to seismic signatures

Background Information:

Regional Data:
Seismic profiles: SEE FIGURES 3, 4, and % OF PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR - Completed December 1985.
Date: Specifically BMR Line 50/13 (50.277.0205-0246).
Main results: Base of slope sequences

Operational Considerations

Water Depth: (m) 735-960 Sed. Thickness: (m) 1500 Total Penetration: (m)1000

HPC yes Double HPC yes Rotary Drill _____ Single Bit _____ Reentry _____

Nature of sediments/rock anticipated: Fluvio deltaic sands and muds

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June to August. Generally fair weather.

Territorial jurisdiction: Australia

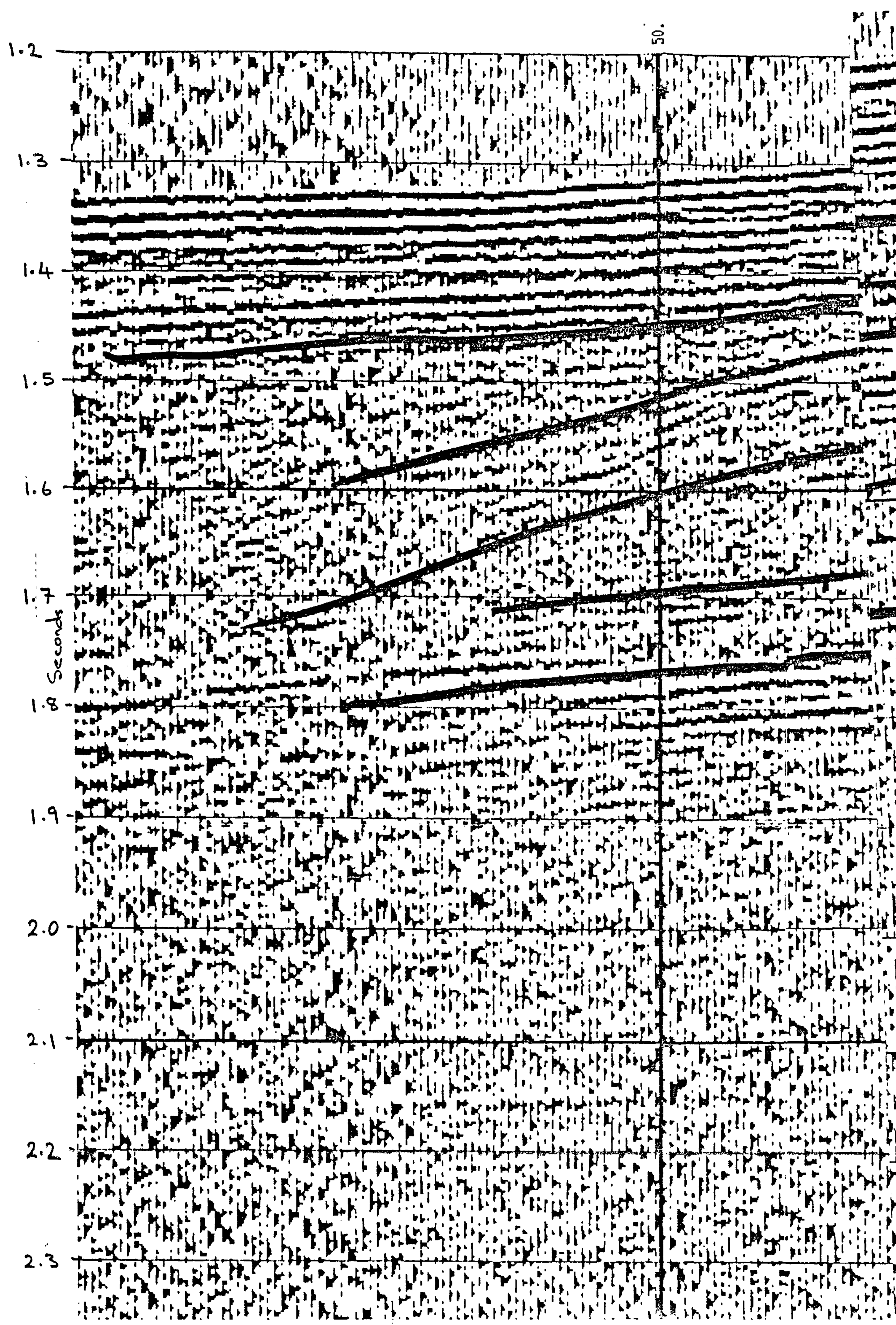
Other:

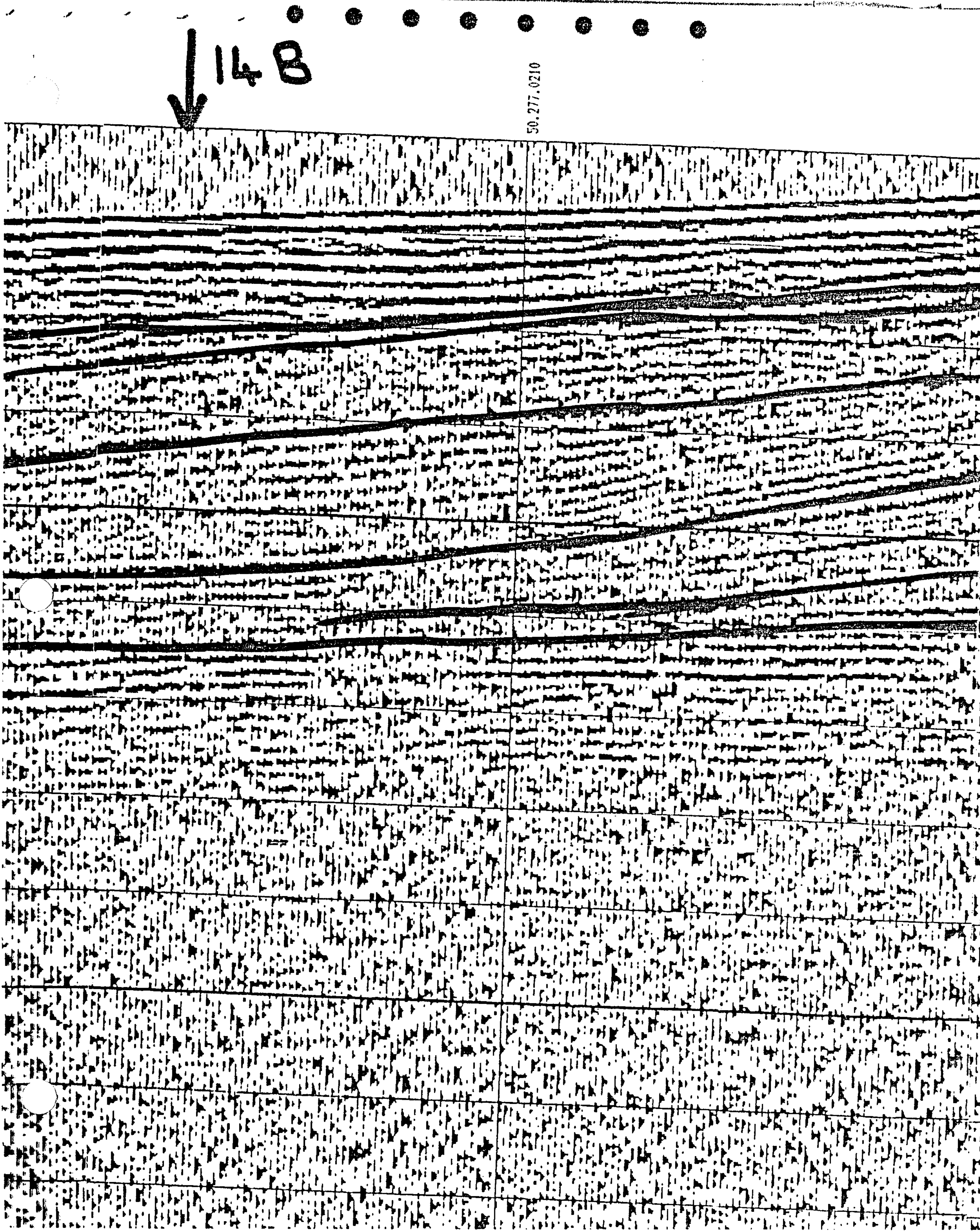
Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office:

E

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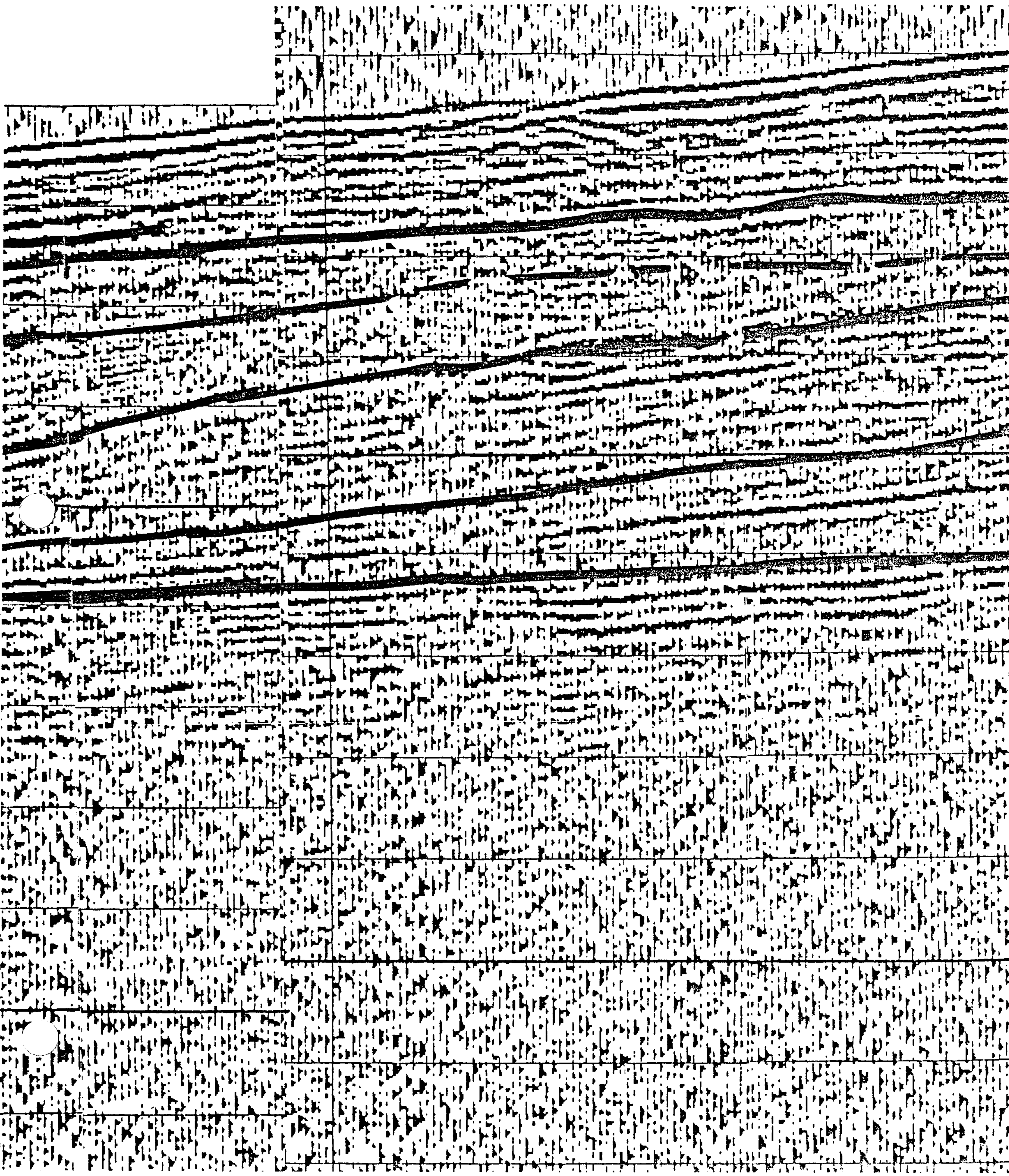

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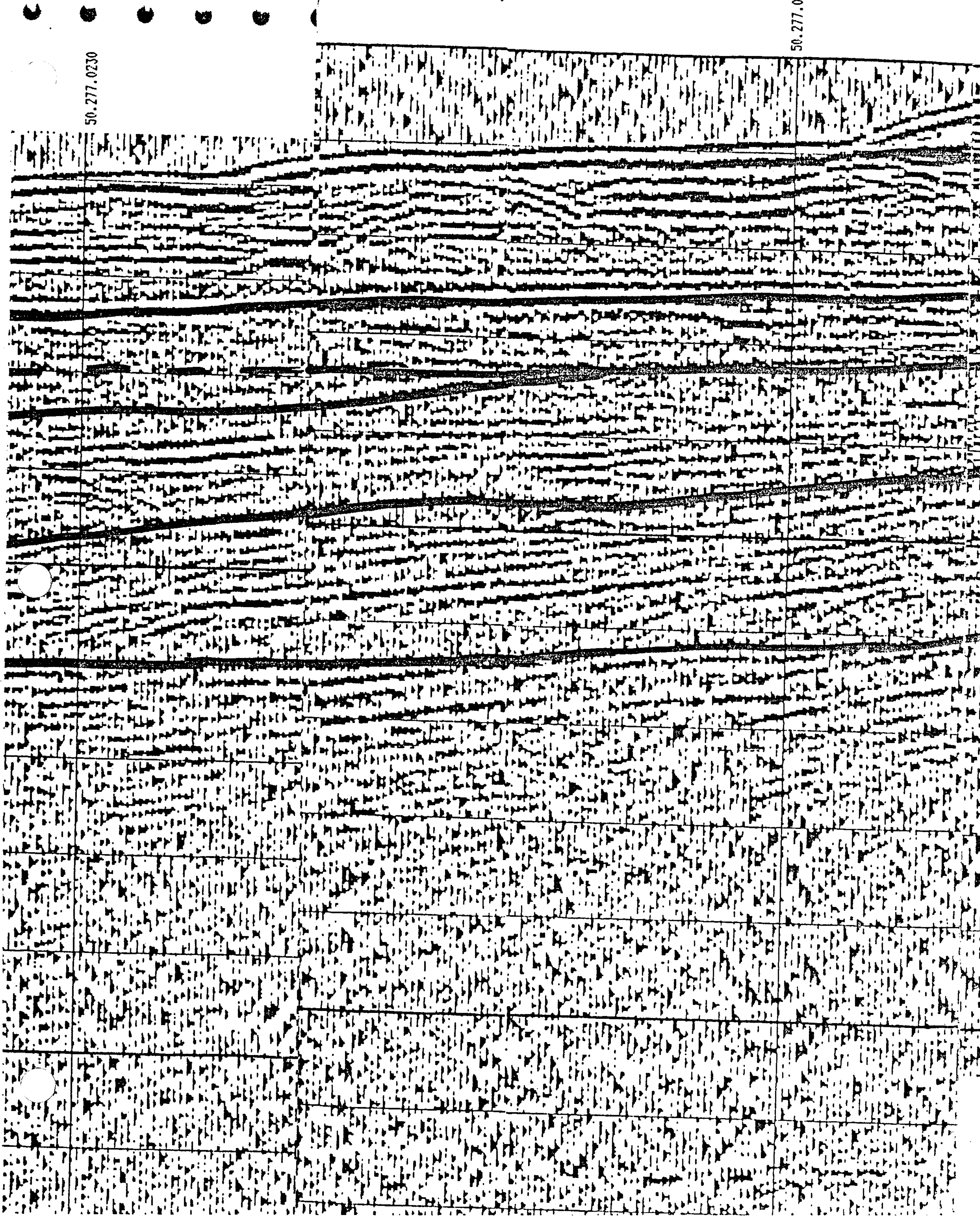

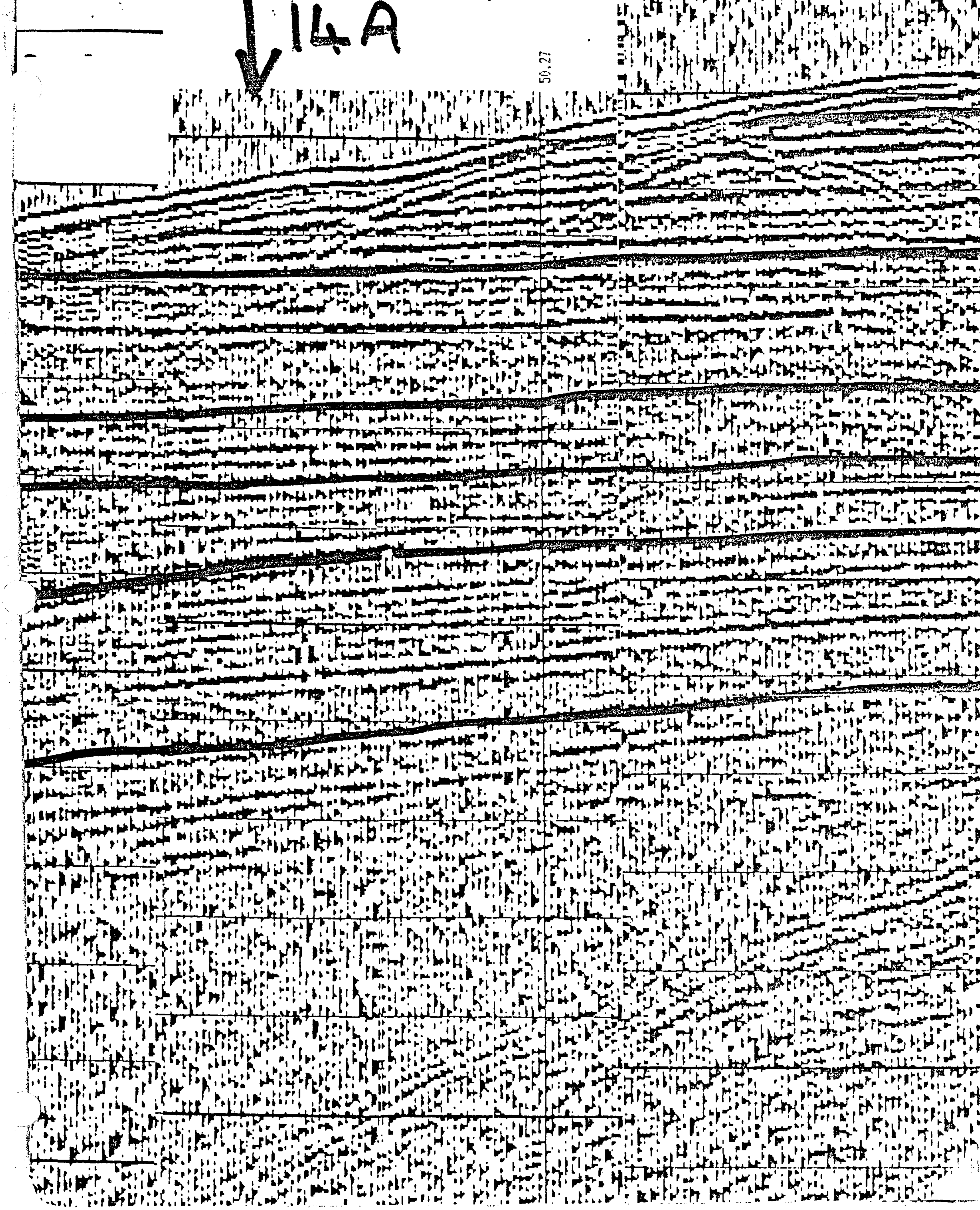
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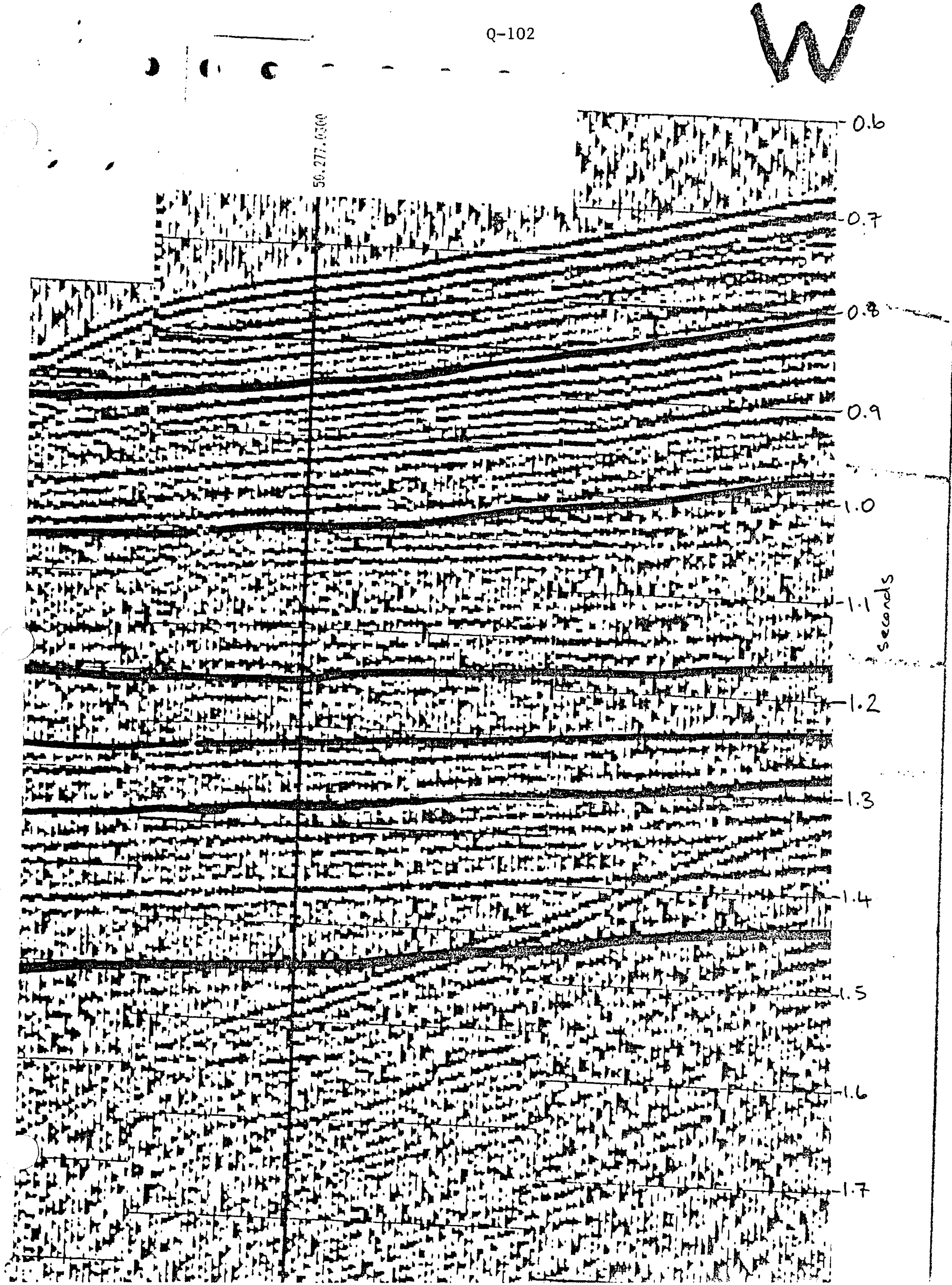
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ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 15 Southeastern Queensland Trough; adjacent Flinders Reef General Area: Northeast Australia Position: 17°46.2S; 148°15.4E Alternate Site:	General Objective: Thematic Panel Interest: Regional Panel Interest:

Specific Objectives:

1. To define the nature and age of reef-like mounds some 200-300m below sea floor
2. To determine subsidence history of southern Queensland Plateau
3. To determine mechanisms of sedimentation; particularly to determine whether transport is down or across the trough.

Background Information:

Regional Data:
Seismic profiles: SEE FIGURES 3, 4, 5 OF PROPOSAL

Other data:

Site Survey Data-Conducted by: BMR-completed December 1985. Specifically BMR Line 50/012 (50.276.0720)
Date:
Main results: Prograding over basement

Operational Considerations

Water Depth: (m) 1140   Sed. Thickness: (m) 2000   Total Penetration: (m) 1500

HPC yes   Double HPC yes   Rotary Drill yes   Single Bit yes   Reentry ____

Nature of sediments/rock anticipated:

Weather conditions/window: Possible cyclones in January/February. Heaviest swell in June to August. Generally fair weather.

Territorial jurisdiction: Australia

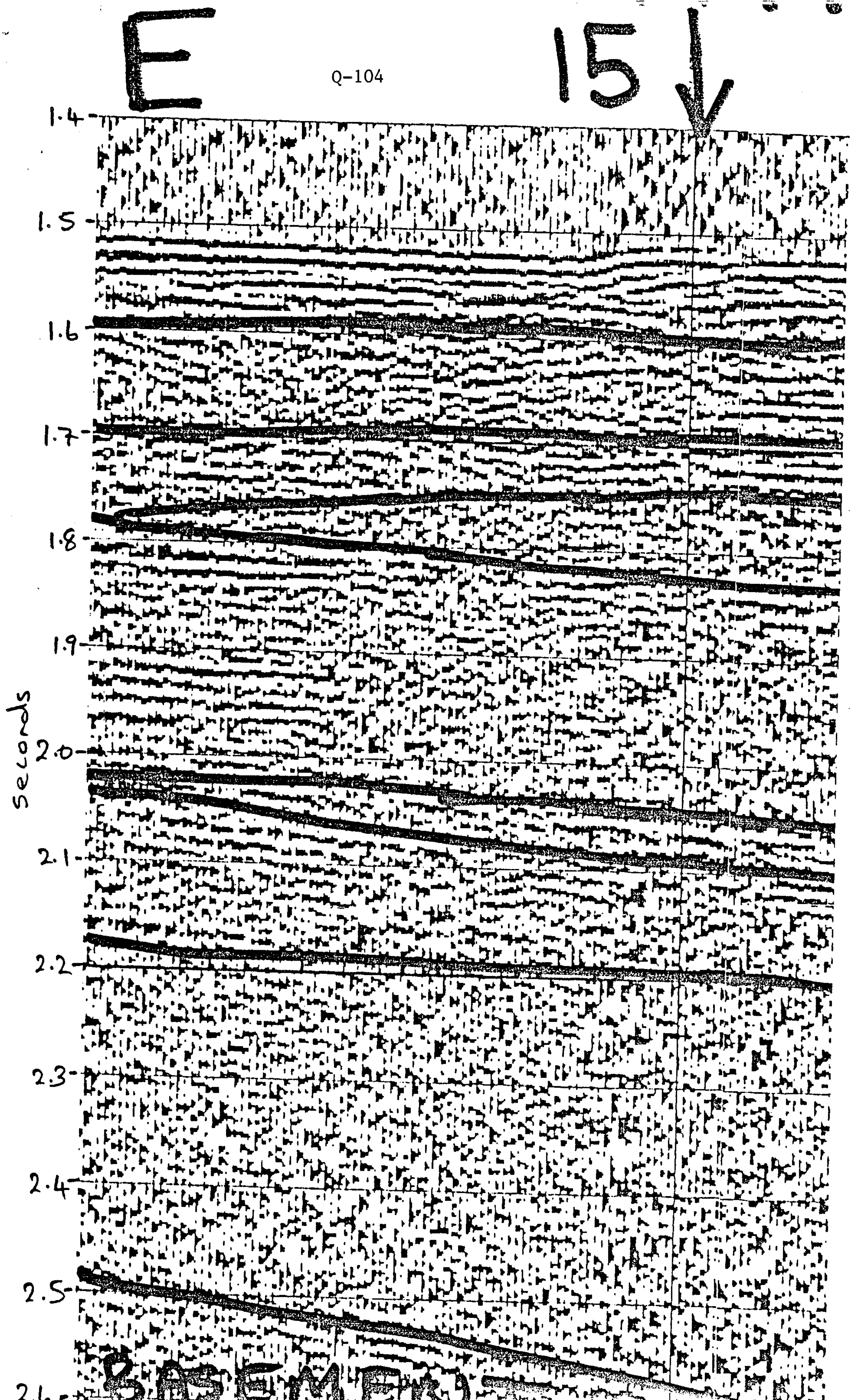
Other:

Special requirements (staffing, instrumentation, etc.)

Proponent: P.J. Davies/P. Symonds/D. Feary
Bureau of Mineral Resources
G.P.O. Box 378
Canberra ACT 2601
AUSTRALIA

Date submitted to JOIDES Office:

Q-104



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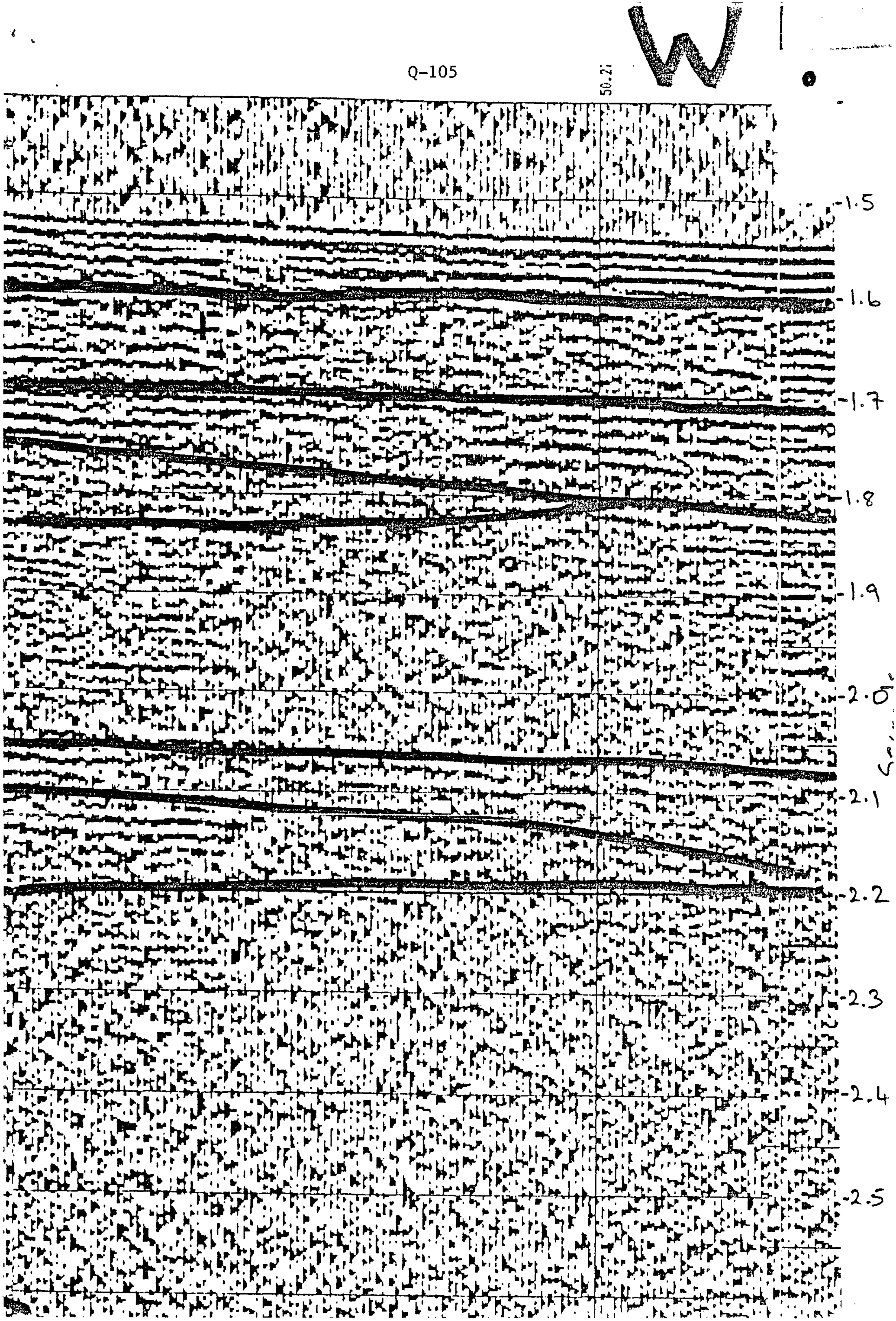


ODP SITE PROPOSAL SUMMARY FORM

Proposed Site: 16
CENTRAL GREAT BARRIER REEF SLOPE

General Area: Western Coral Sea
Position: 1: 16°39.2'S, 146°16.5'E
2: 16°38.2'S, 146°18.5'E
Alternate Site: 17°33.8'S, 146°43.2'E

General Objective:
Response of marine sedimentation to fluctuations in sea level. History of ocean circulation.

Thematic Panel interest: SOHP
Regional Panel interest: WP-RP

Specific Objectives: Address general objectives by examining the nature of tropical carbonate/epiclastic dominated passive margin.

- Nature of fore-reef talus associated with submerged shelf edge barrier reef.
- Nature of any low sea level deposits interfingering with reef rocks.
- Nature of reef sediments

- Nature and basinward extent of carbonate sequences
- Nature and depositional environment of prograding sequences-low sea level shelf edge delta?

Background Information:
Regional Data: Seismic profiles: BMR (1970) 6-fold sparker; Gulf (1973) 24-fold Aquapulse; Shell (1974) 24-fold airgun; BMR (1982) 12-fold high resolution sparker.
Other data: A considerable amount of gravity and magnetic data seaward of reef; aeromagnetics throughout reef. Boomer profiles and vibroseising throughout central GBR
Site Survey Data - Conducted by: Sites located using BMR high resolution sparker data
Date: line 41/63 - 41.248.237;
Main results: - line 41/63 - 41.248.2330;
Submerged shelf edge reef facies; seaward carbonate sequence which is laterally continuous with reef; underlain by complex sigmoid-oblique and sigmoid progradational facies.

Operational Considerations

Water Depth: (m) GBR2 -315 Sed. Thickness: (m) > 3000 Total penetration: (m) 1: 500-600
2: 600-800

HPC Yes 500m Double HPC ____ Rotary Drill ____ Single Bit ____ Reentry ____

Nature of sediments/rock anticipated: Upper - thin outer shelf carbonates; 200-200m reef rock; Lower - interbedded shelf carbonates and siliciclastic sediments.
Weather conditions/window: Possible cyclones in January-February; heaviest swell June to August. Generally fair weather.
Territorial jurisdiction: Australia

Other:

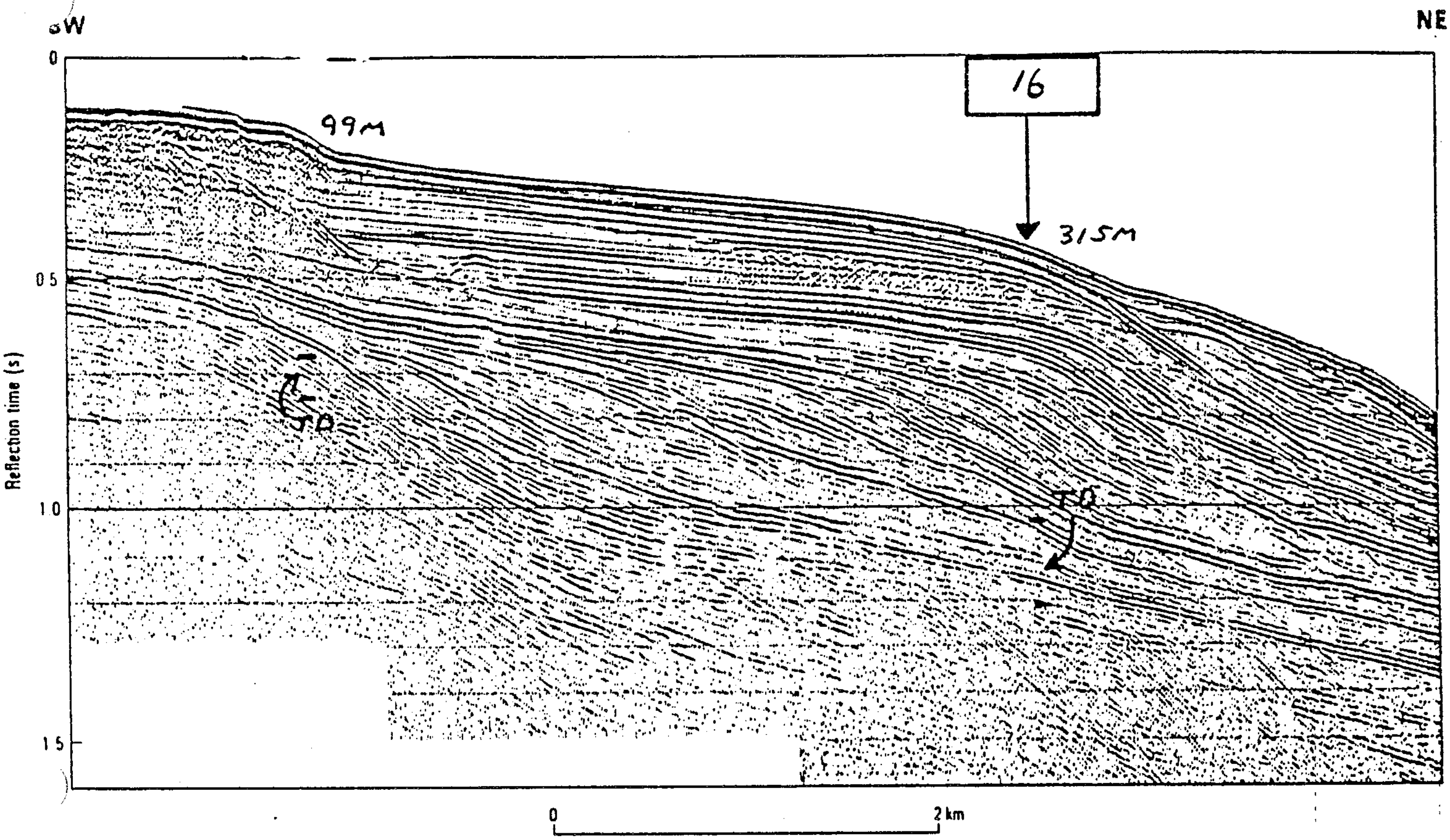
Special requirements (Staffing, instrumentation, etc.)

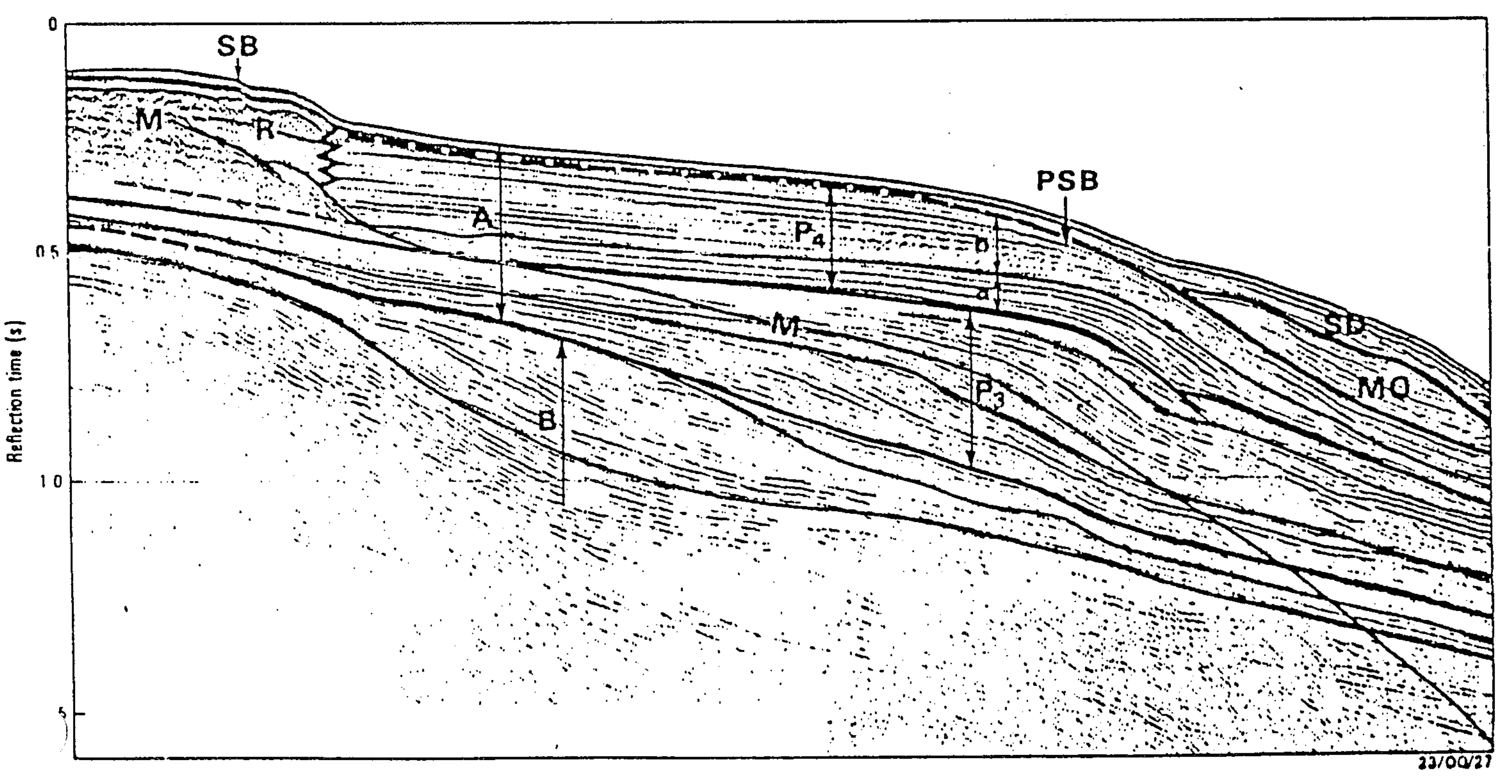
Proponent: P A Symonds & P J Davies
Bureau of Mineral Resources
G P O Box 378
CANBERRA A C T 2601
Australia

Date submitted to JOIDES Office:

CENTRAL GREAT BARRIER REEF

(16)





BMR SPARKER LINE

Q-107

41/63 - GRAFTON PASSAGE

PERIPLATFORM OOZE IN THE INDIAN OCEAN

Proponents:

Andre W. Droxler
Douglas F. Williams
University of South Carolina
Department of Geology
Columbia, SC 29208

Paul A. Baker
Duke University
Department of Geology
Box 6729
Durham, NC 27708

Abstract

This proposal requests the coring of three HPC sites, covering a water-depth range between 400 m and maximum 2000 m in the Laccadive basin off the Maldives Archipelago. The main objective of this coring project is to recover continuous Neogene sequences of periplatform ooze devoid of turbidite layers, and deposited as drape on highs and isolated slope terraces. These sequences should have recorded climatic-induced depth variation of the carbonate saturation level in intermediate water masses, by the preservation or dissolution of shallow carbonate banks derived aragonite and magnesian calcite. Numerous other studies will be applied to this suite of cores, i.e., variable input through time of carbonate bank derived material, variable import through time of non-carbonate (terrigenous) material, interstitial water chemistry and its implications for early diagenesis.

We are proposing to core three HPC holes (maximum penetration 200-250 m), the shallowest one between 400 and 600 m, the intermediate one between 700 and 800 m, and the deepest one between 1600 and 1800 m.

Introduction

This drilling proposal is the result of discussion during the USSAC-JOI workshop on drilling carbonate banks and guyots, August, 1985, co-chairmen Drs. Winterer and Schlager. The proposed idea is to core three HPC sites on a bathymetric transect between 400 and 2000 m in the vicinity of shallow carbonate banks in the Northern Indian Ocean, received great support from the participants of the workshop.

The potential to gather new paleoceanographic and paleoclimatic information in intermediate water environments, surrounding shallow carbonate banks, has been discovered only a few years ago and mainly developed in the Bahamian basins and in the adjacent Atlantic Ocean. It has been demonstrated in the Bahamas that late Pleistocene aragonite cycles are climatically induced because of their high correlation with the oxygen isotope record on planktic foraminifera as well as the variation of the carbonate content and the mineralogical composition of the terrigenous import. We have suggested that the preservation or dissolution of bank derived metastable aragonite and magnesium calcite in the pelagic sediment deposited around shallow carbonate banks were directly related to the variations through time of the carbonate saturation levels in intermediate waterdepth. In the past year, the aragonite cycles have been demonstrated to occur also on the Nicaraguan Rise (Caribbean Sea), in the Laccadive basin off the Maldives Islands (Northern Indian Ocean) and on the Queensland Plateau (SW Pacific Ocean), where the cycles are more ambiguous.

The first results of detailed carbonate mineralogy analysis for ODP site 633 (Leg 101) show an unexpected and extended (3.5 10^6 year long) aragonite record, in close correlation with the oxygen isotope record established for that period of time in the North Atlantic. ODP sites 633 as well as 630, once the analysis is done, will extend the aragonite record even further in time, possibly to 6 10^6 years; these sites however, were not selected with the intention of coring a continuous undisturbed periplatform ooze sequence for paleoceanography, paleoclimatology purposes, even though they turned out to be very suitable for such a project. The two sites were part of two slope transects, cored to investigate the development of different carbonate slope sedimentation regimes. Sites for pure paleoceanography and paleoclimatology, have to be selected on top of reliefs, as well as isolated slope terraces, where the periplatform ooze is deposited as drape and usually remains undisturbed by gravity flows.

This proposal is to select the best sites suitable to study the paleoceanography evolution of intermediate water masses in the northern Indian Ocean off the Maldives Islands (Laccadive Basin).

Specific Objectives

This proposal seeks drilling time in order to obtain an HPC transect of continuous Neogene sections of periplatform carbonate ooze, deposited in the surroundings of shallow carbonate banks as the Maldives Atolls, or as an alternative, the Chagos Bank in a range of intermediate water depths (300-2500 m).

The major objectives are paleoceanographic and paleoclimatologic records of climatic related variations in the periplatform ooze to:

1. Test the integrity of the correlations of the late Pleistocene 0-18 and C-13 with aragonite cycles further back into the Neogene.

2. Compare the relationships between periplatform oozes of the Northern Indian Ocean with reconstructions of the deep water lysocline and calcium carbonate compensation depth.

3. Compare the C-13 record with the preservation record of carbonate components as part of the carbon cyle in the ocean-atmosphere system.

4. Use the geochemical signature in the aragonite needles to study changes in the shallow subsurface and possibly subaerial conditions on the Northern Indian Ocean periplatforms through time.

5. Estimate the terrigenous influx at different water depths and determine its relationship with the climatic variations and its dilution effect on the carbonate periplatform ooze.

6. Determine the interaction between sea level and carbonate sedimentation from periplatform areas into the deeper parts of the Northern Indian Ocean.

7. Determine the effects of monsoonal circulation in the Northern Indian Ocean in the Neogene to carbonate production and preservation in general and on periplatform oozes in particular.

8. Locate and decipher the possible diagenetic imprint on the primary signal as well as determine the fate of the metastable shallow water derived components, aragonite and magnesium calcite through burial diagenesis.

A transect of three sites is proposed, which could be combined with some of the sites for basement drilling, proposed by Duncan, Fisk and White of Oregon State University. This proposal is a complement of Peterson's proposal designed to reconstruct dissolution deep water profiles, equatorial surface productivity, vertical oceanic gradients and high resolution biostratigraphy on the Mascarene Plateau and the Sychelles area.

Scientific Rationale

In the past decade, a great deal of energy has been invested in the study of the origin and fate of pelagic components, principally coccoliths and foraminifera. It has long been recognized that the dissolution of these calcareous organisms plays a significant role in the global carbon dioxide cycle. Those shells which escape dissolution in the water column or on the seafloor preserve a chemical and isotopic record of sea water. Such records have been of great importance in the reconstruction of paleoclimate and ancient ocean chemistry.

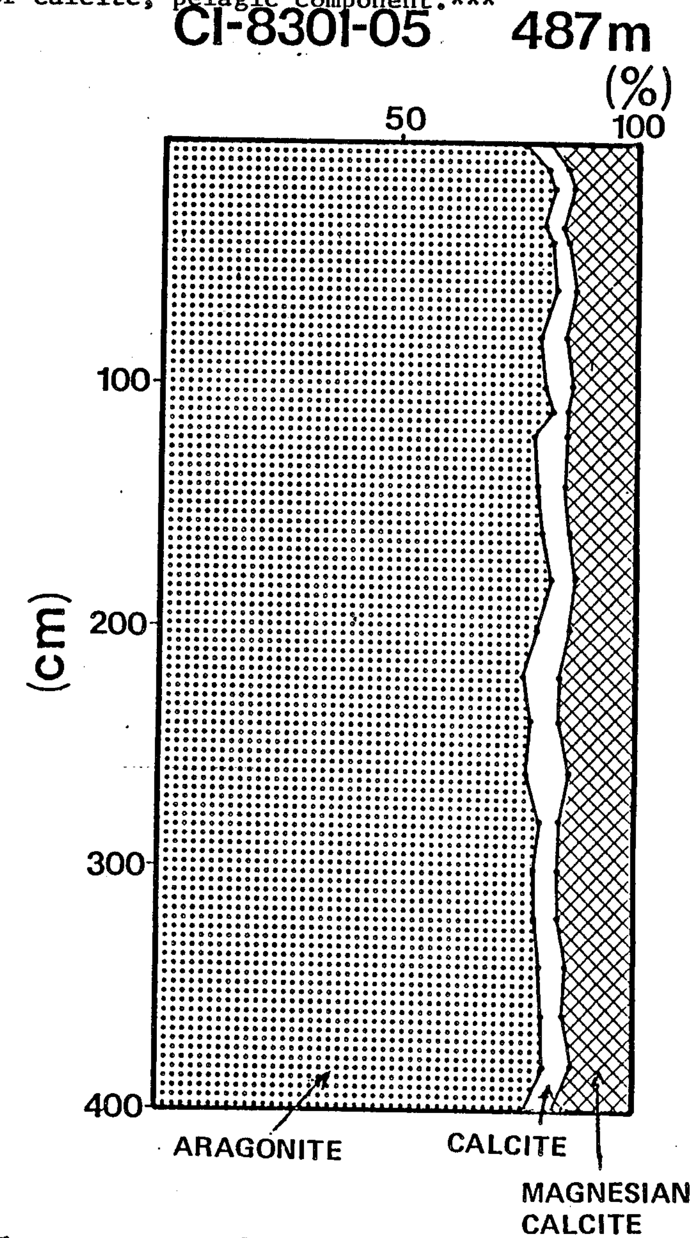
Far less attention has been paid to the fate of the shallow-water calcareous components incorporated with the pelagic marine sediments. The carbonate ooze deposited around shallow carbonate banks (periplatform ooze) contains a great deal of paleoceanographic and paleoclimatologic information. Besides coccoliths, planktic/benthic foraminifera and pteropods, the periplatform carbonate ooze contains large amounts of needle-like fine aragonite and some magnesian calcite in the form of skeletal fragments and micrite, both produced in the shallow carbonate environments. Because the shallow water carbonate components are mainly aragonite and magnesian calcite, they are susceptible to more rapid and shallower dissolution than calcitic components.

We have observed cyclic variations in the proportion of aragonite and calcite, as well as more irregular variations of magnesian calcite; the former variations are highly correlatable with the oxygen isotope record on planktonic foraminifera (Droxler et al., 1983 and Droxler, 1985), a well established climatic record of the glacial/interglacial rhythm of the Earth's climate (Emiliani, 1955). The aragonite cycles have been observed during late Pleistocene in several areas surrounding shallow carbonate banks, as the Bahamas (Atlantic Ocean), the Nicaraguan Rise (Caribbean Sea) and the Maldives (Indian Ocean) (see Figs. 1-9). The aragonite also are closely correlated with the cyclic variations of carbonate and quartz content (see figs. 1-9) as well as in the Bahamas the composition of clay and feldspar.

The record in the Bahamas has been greatly expanded by drilling a 5 to 6 10^6 year continuous sedimentary sequence of periplatform ooze, during ODP Leg 101 in sites 633 and 630. The first results of Leg 101 analyses are just starting to come in. The carbonate mineralogy of the top 55 m of site 633 displays a detailed cyclic record of the climatic evolution for the past 3.5 10^6 years (see fig. 10). Major events as the 2.4 10^6 years glaciation onset in the North Atlantic, are well displayed in the aragonite variations as well as the appearance and disappearance of dolomite and magnesian calcite and seem to be well correlated with the oxygen isotope curve established in the North Atlantic by Shackleton and Hall (1984) (see fig. 11).

Based on the detailed correlations of aragonite cyclic variations with the oxygen isotope record on foraminifera observed in different oceans during the late Pleistocene, but also during the Plio/Pleistocene in the Bahamas, we are interpreting the aragonite cycles as part of the glacial/interglacial dissolution and preservation cycles observed in all major ocean basins, and

FIGURE 2 : Carbonate mineralogy (bulk sediment) of the top 4 m of core CI 8301-05. Note the high proportion of aragonite and the presence of magnesian calcite, both shallow crabonate bank derived components, and the small amount of calcite, pelagic component.***



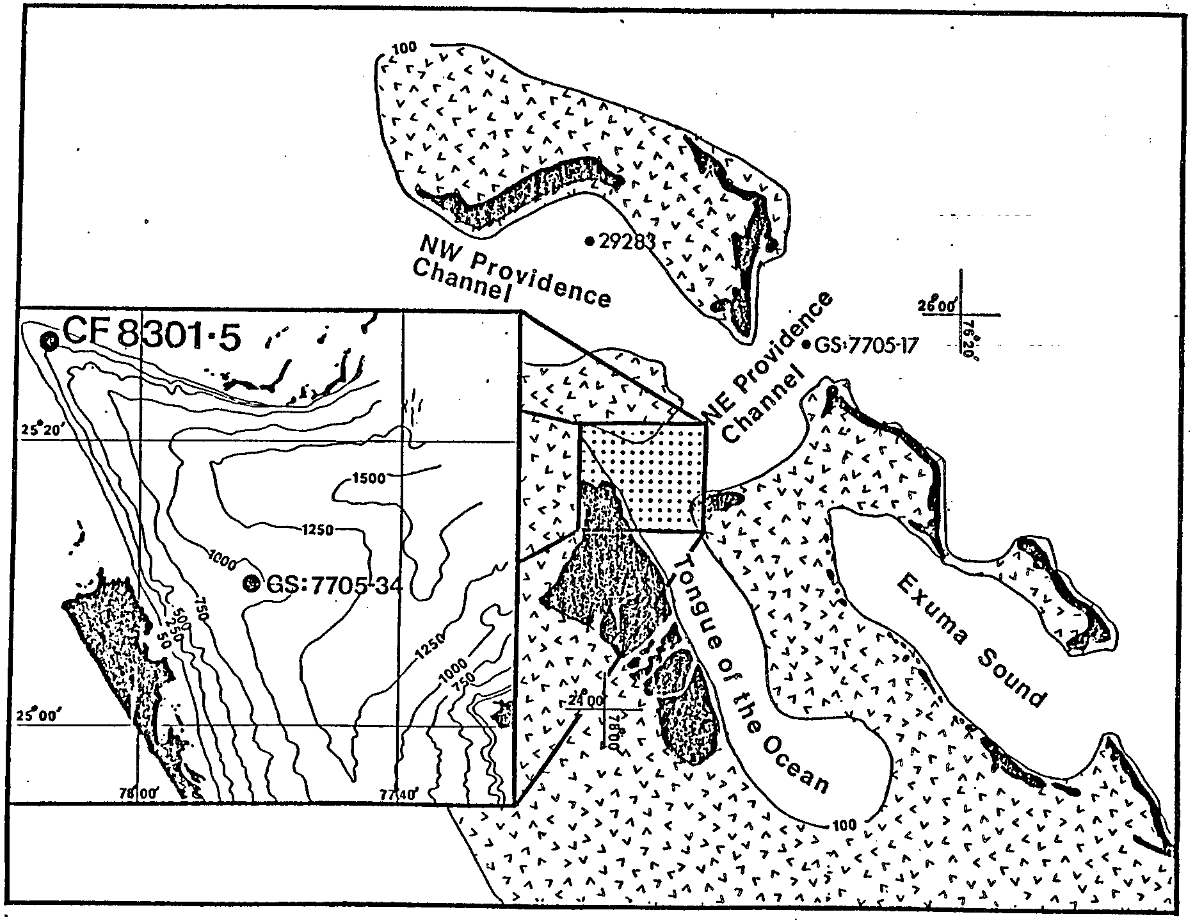


FIGURE 1 : Location of a shallow core CF 8301-5 (487 m) (see Fig. 2) and a deeper core GS 7705-34 (1933 m) (see Fig. 3) in the northern part of Tongue of the Ocean, Bahamas. The"v"pattern delineated the shallow carbonate banks, covered by 5 to 6 m of water in average.

*** The proportion of the three mineralogical components remain constant downcore. The bottom of the core (8 m) was dated by ^{14}C at 3,250 years B.P., therefore well Holocene.

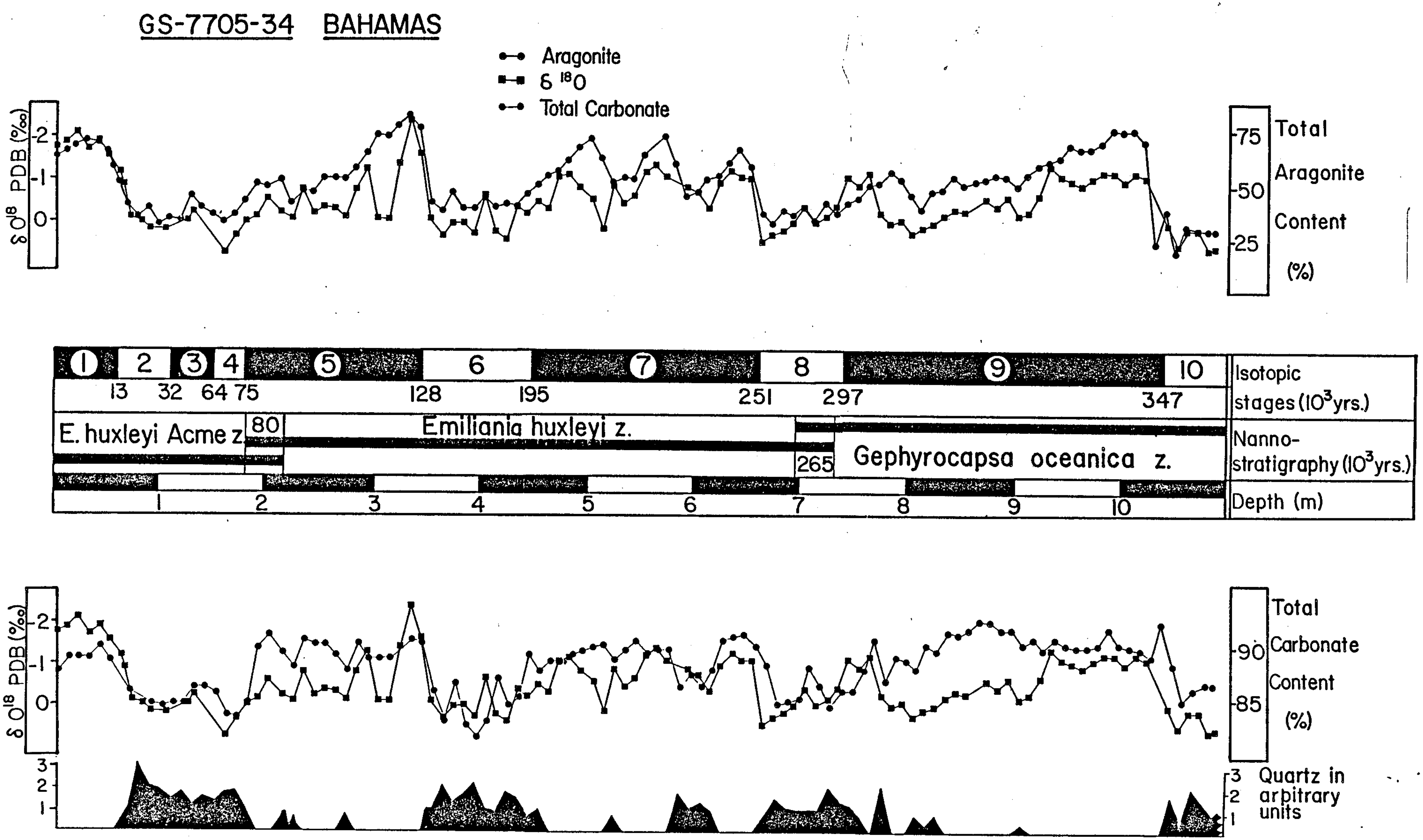


Figure 3 : Cyclic variation of aragonite and carbonate content as well as quartz occurrence in core GS 7705-34 (see Fig. 1 for location) closely correlated with the oxygen isotope record on G. rubra. Isotopic stratigraphy fits with the nannostratigraphy. Low aragonite, low carbonate and high quartz content correspond to glacial stages heavy delta 18-0, and high aragonite, high carbonate and absence of quartz to interglacial stages light delta 18-0.

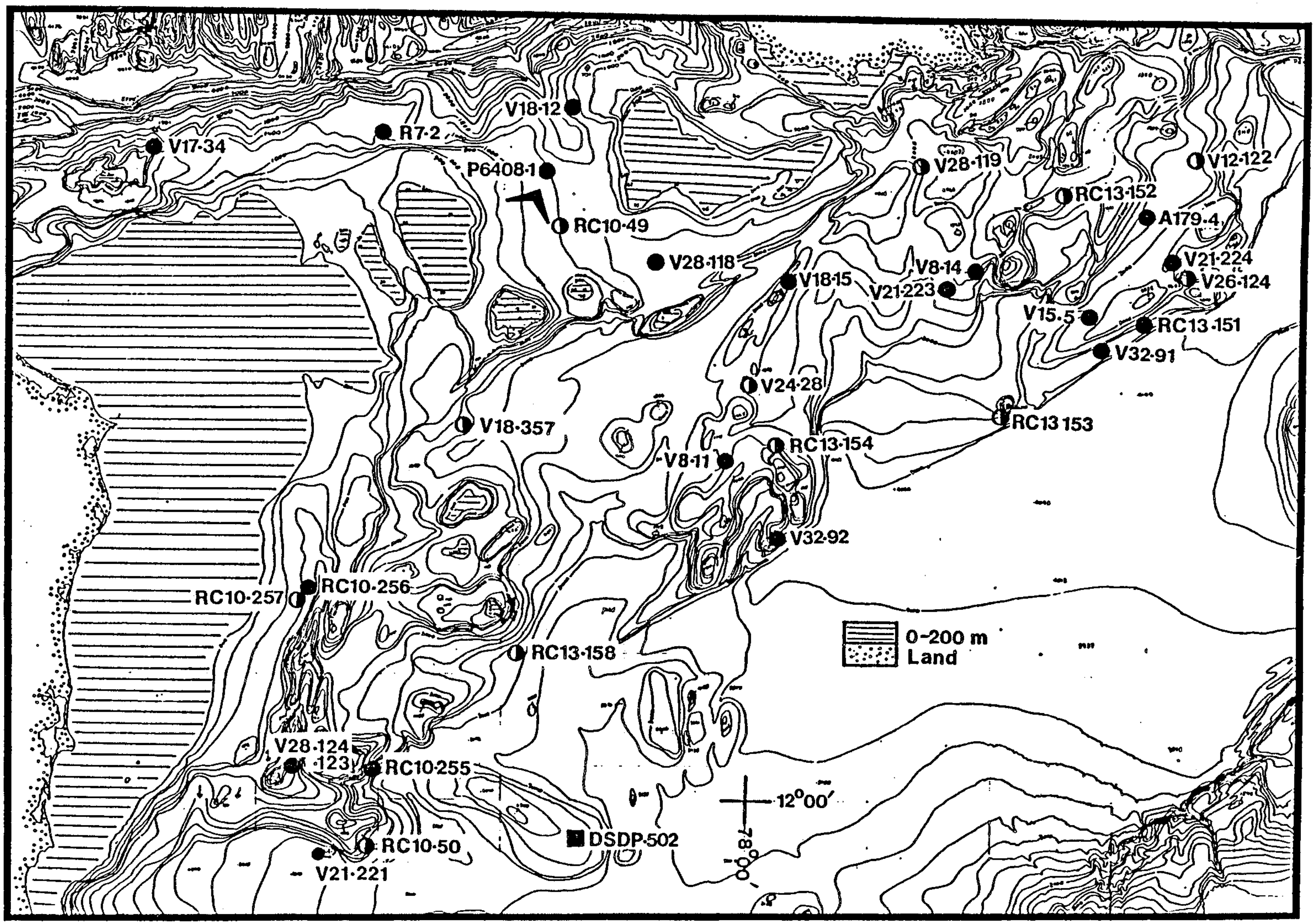


Figure 4 : Location of core P 6408-1 (see Fig. 5) located at 1000 m between two shallow carbonate banks on the Nicaraguan Rise (Caribbean Sea)

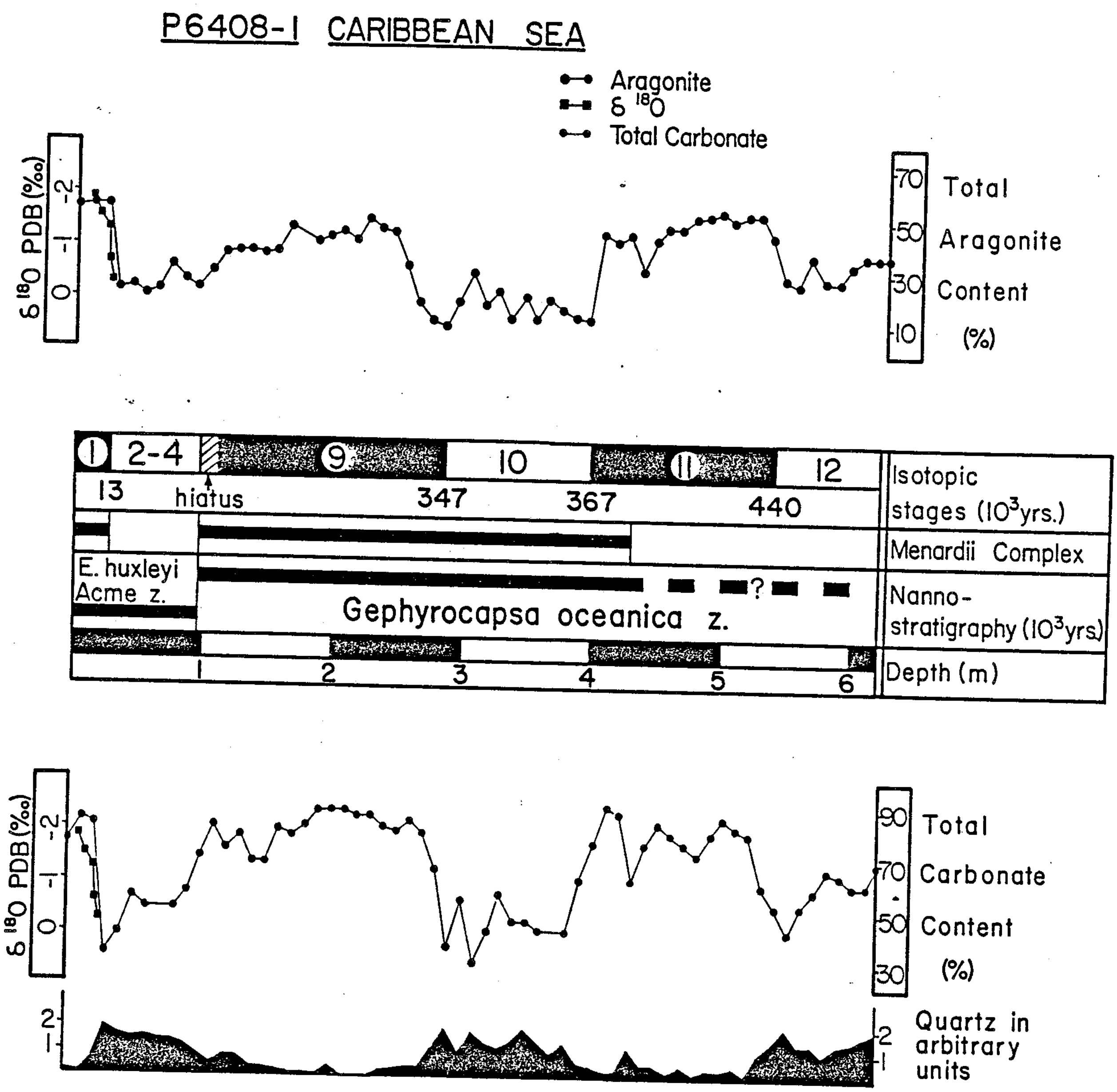


Figure 5 : Cyclic variation of aragonite and carbonate content as well as quartz occurrence in core P 6408-1 (see fig. 4 for location) closely correlate with the oxygen isotope record on G. sacculifera on the top 50 cm. Note major hiatus at 100 cm down core.

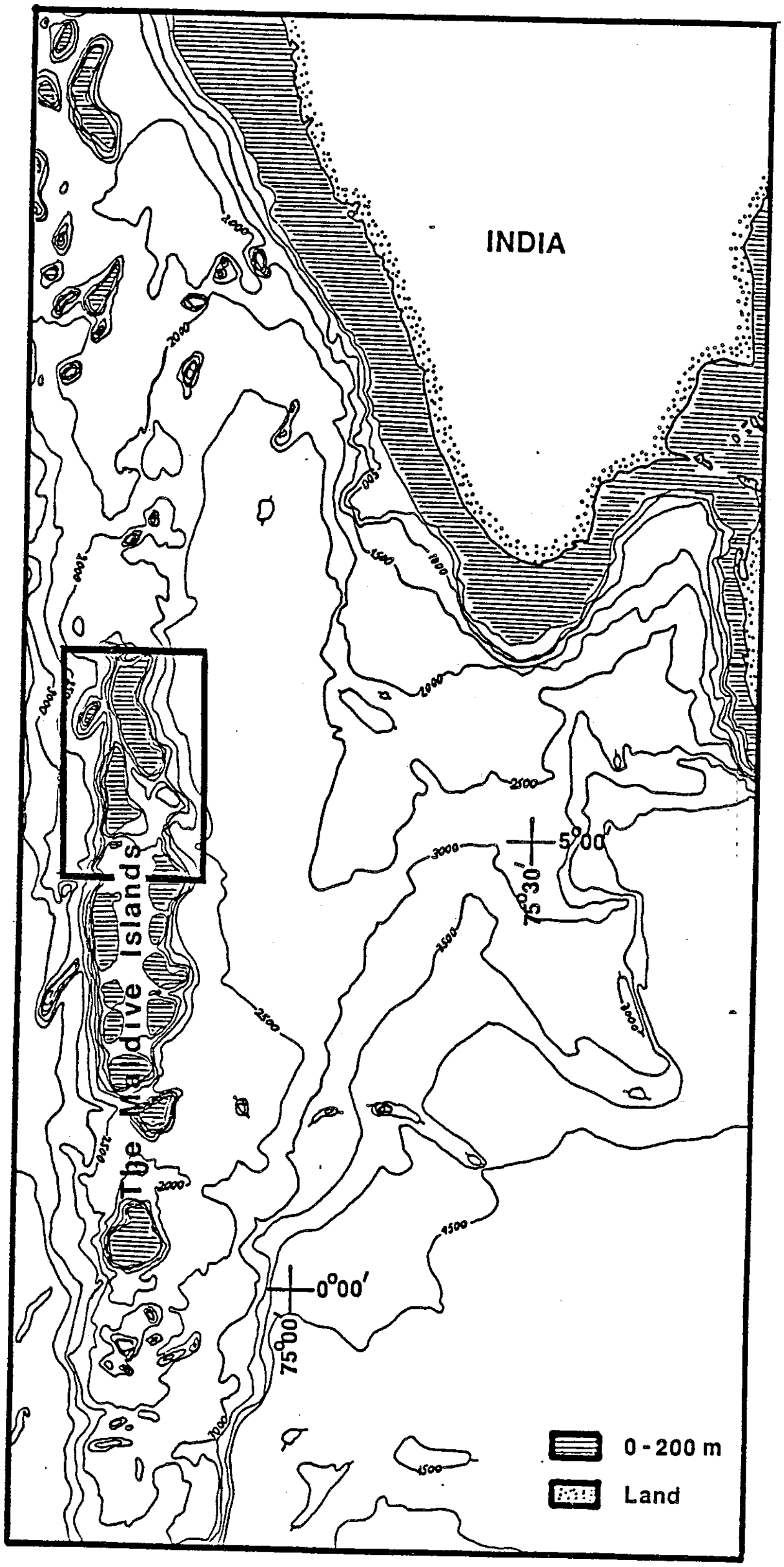


Figure 6 : Location of the northern part of the Maldives (see Fig. 7 for details)

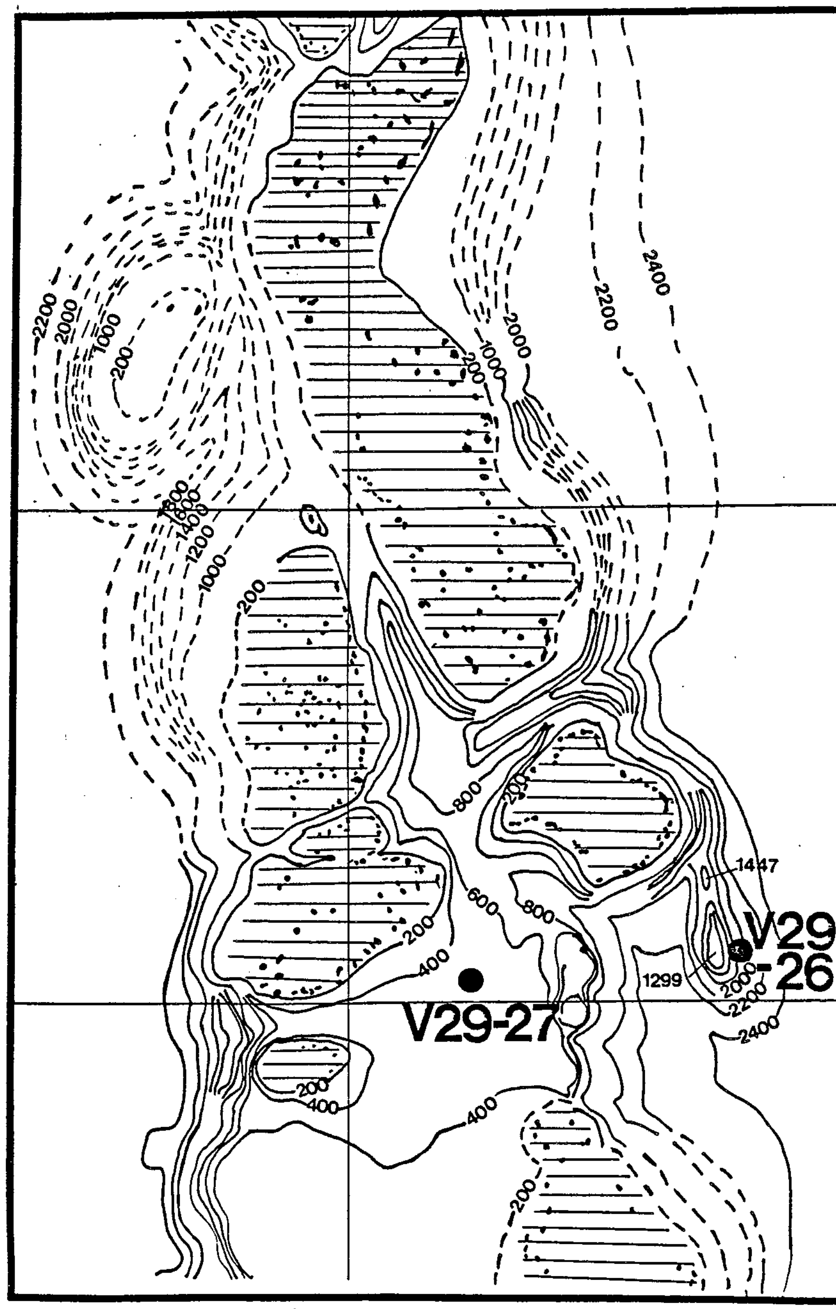


Figure 7 : Detailed map of the northern part of the Maldives, source Navoceano sheet 2901 (N-1). Location of a shallow core (450 m) V29-27 and a deeper core (2100 m) V29-26.

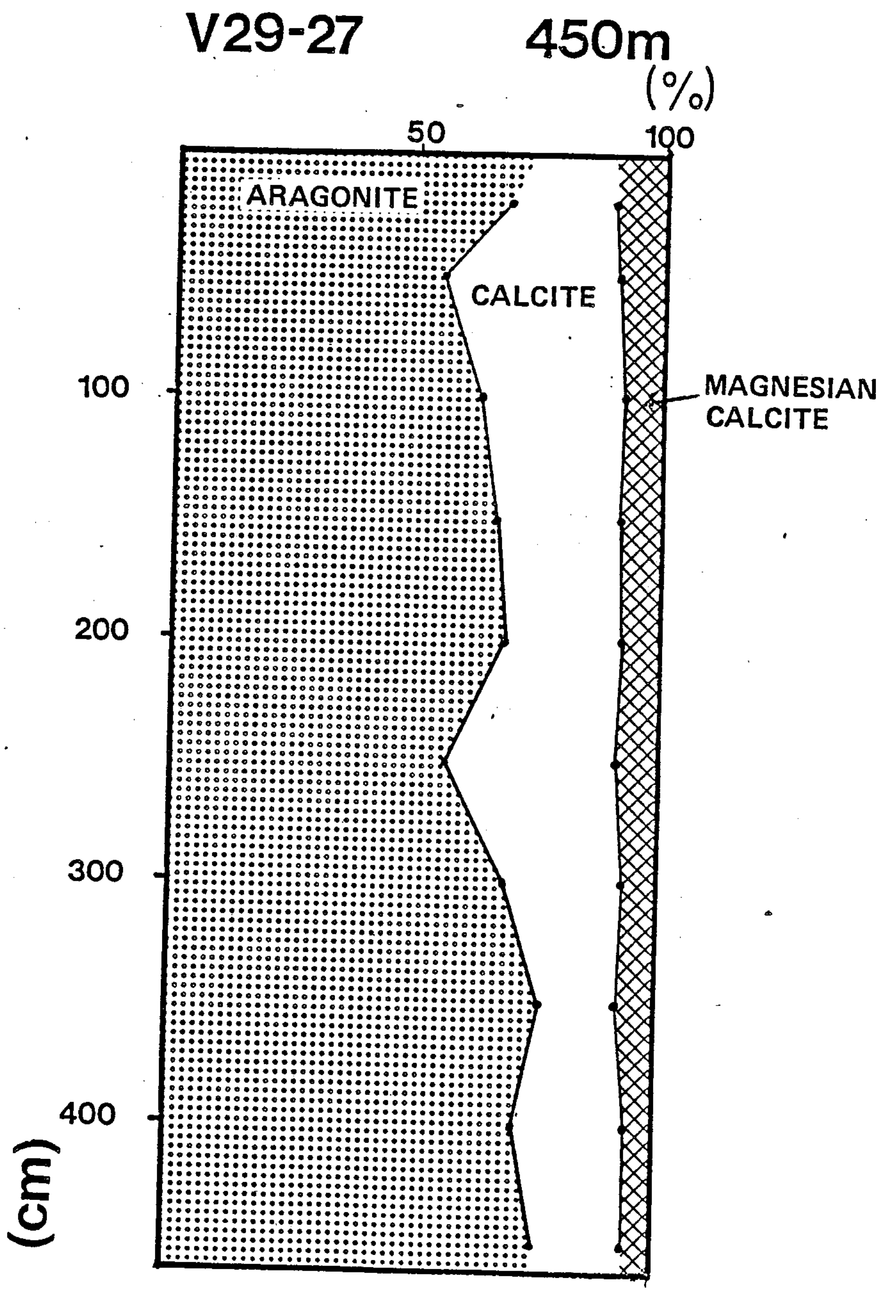


Figure 8 : Carbonate mineralogy of the fine fraction (∠ 62 μ) for core V29-27 (see location on fig.7). Note the high proportion of aragonite, the presence of both calcite and magnesian calcite. The proportions of the three minerals remain fairly constant downcore. The stratigraphy has not been established yet, but these 4 m of sediment recall the Bahamian core CF 8301-5; the age of the core is expected to be Holocene.

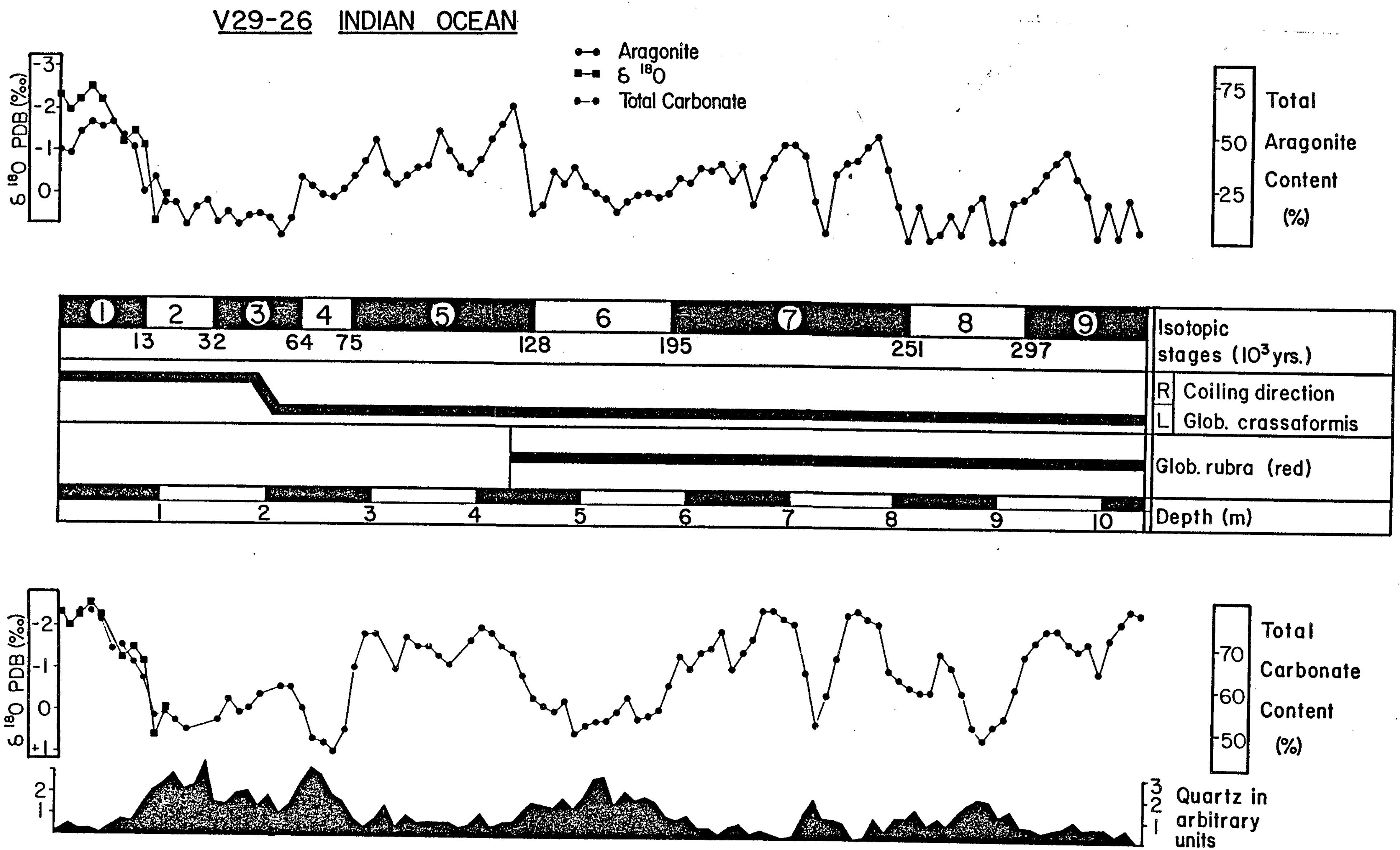


Figure 9 : Cyclic variation of aragonite and carbonate content as well as quartz occurrence in core V29-26 (see fig. 7 for location) closely correlated with the oxygen isotope record on G. sacculifera on the top 100 cm. Note the similarities between core V29-26 and Gs 7705-34 from the Bahamas (see Fig. 3).

Figure 10 : Variations of carbonate mineralogy and carbonate content in the top 55 m of site 633 ODP leg 101, Exuma Sound Bahamas (1690 m in waterdepth); the bottom of core 6 is dated by nannostratigraphy between 3.5 and 4.0 10^6 years. The cyclic variation of aragonite corresponds with the variation of carbonate content, low aragonite corresponds to relatively low carbonate content. Note the disappearance of aragonite at certain levels in core 5, corresponding to one of the lowest carbonate content interval as well as the high and fairly constant aragonite content in core 6. Dolomite is present in core 6 and suddenly disappears when aragonite drops to zero at the end of section 5 of core 5. Magnesian calcite is present in the first four sections of core 1, disappears further down to reappear twicw during intervals of aragonite content. See fig. 11 and compare both the aragonite cycles with the delta 18-O record and carbonate content for the last 3.5 10^6 years in the North Atlantic (Shackleton and Hall, 1984). The sudden disappearance of dolomite and aragonite at the end of core 5, section 5, could represent the onset of the North Atlantic glaciation, 2.4 10^6 years ago.

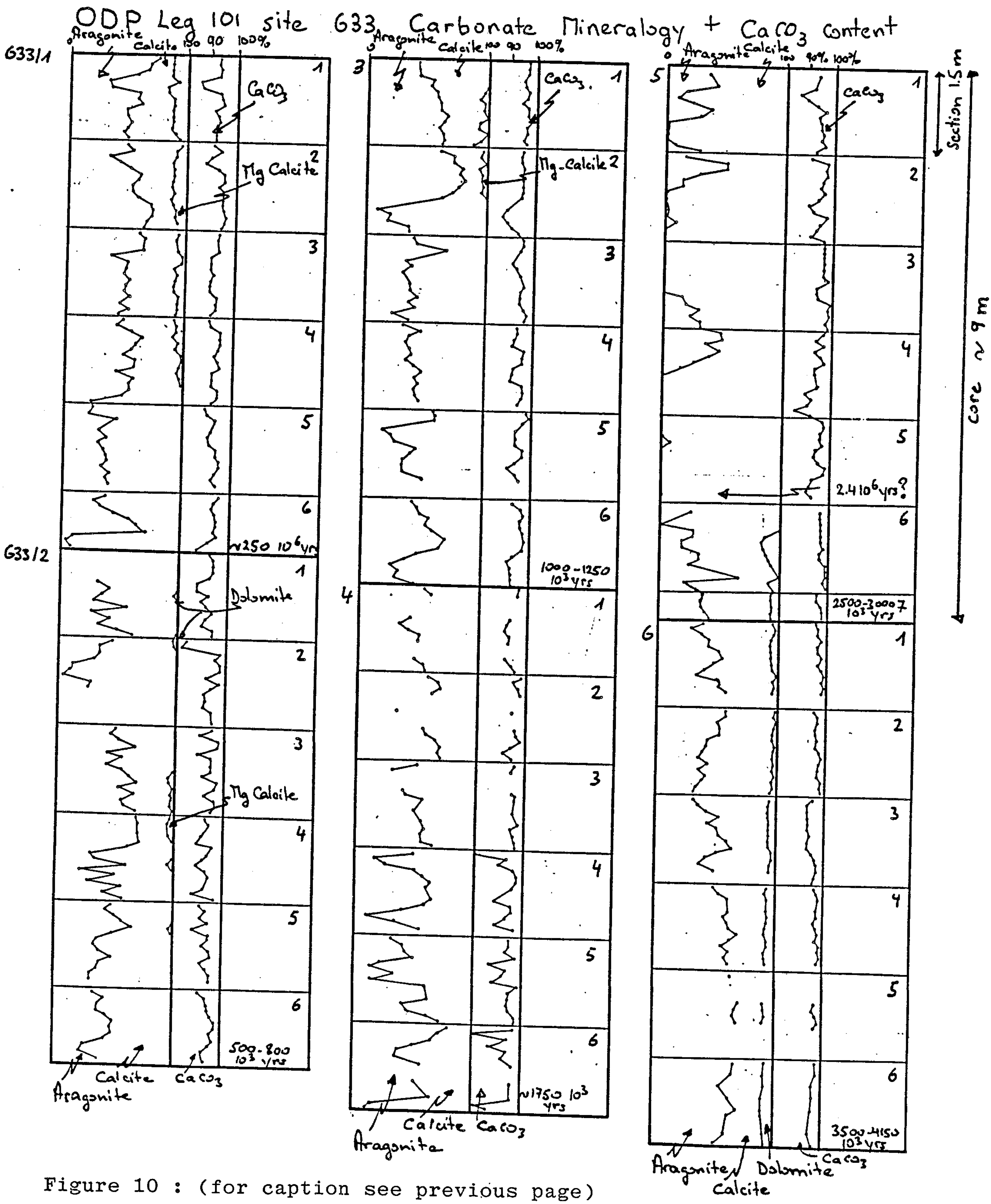


Figure 10 : (for caption see previous page)

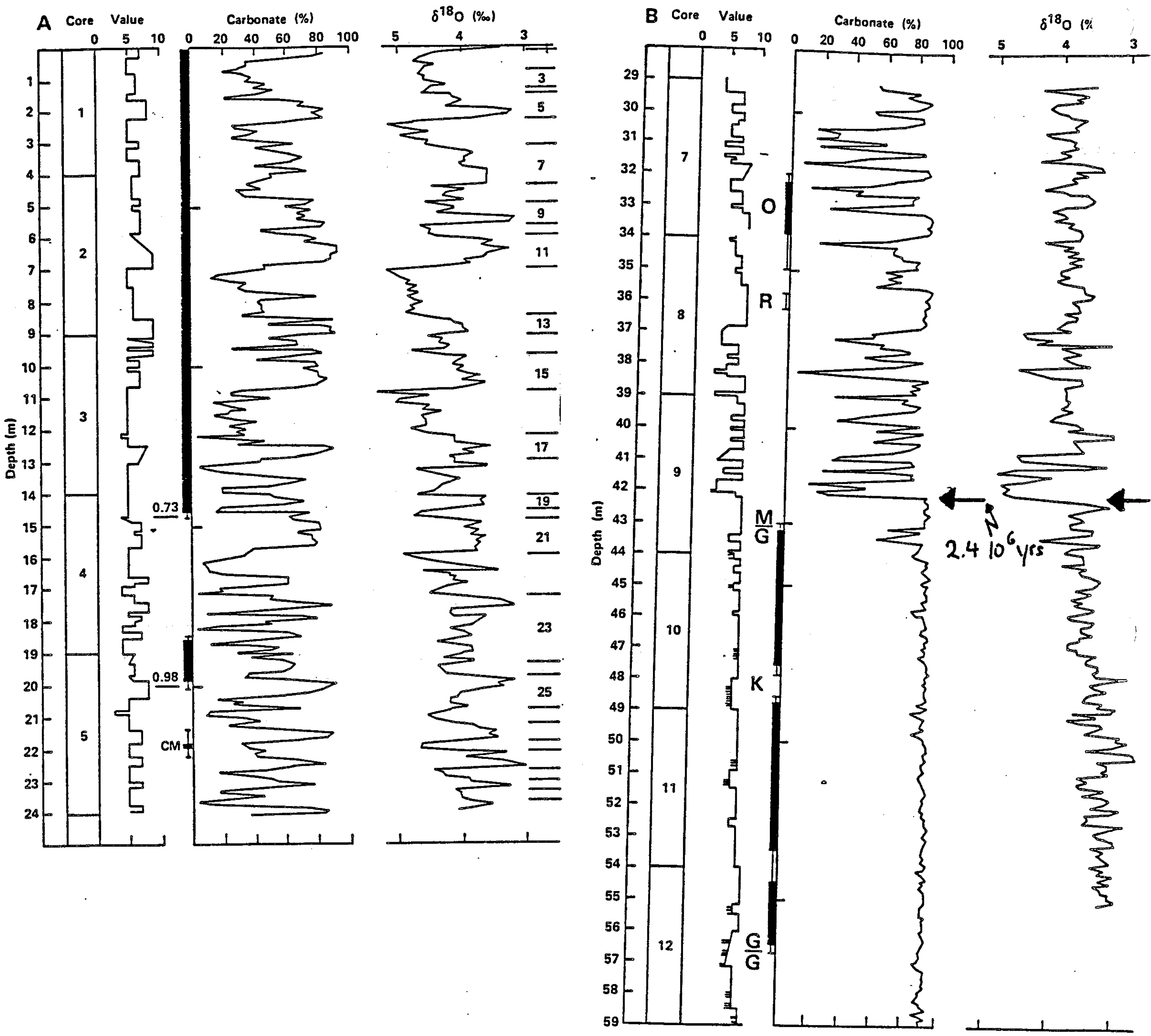


Figure 11 : (from Zimmerman et al., 1984, DSDP Leg 81, Initial Reports. Delta 18-O and carbonate content for the past 3.5 10^6 years from the Rockall Plateau (North Atlantic)). Note in core 9 the sudden increase of delta 18-O and the sudden decrease of carbonate content at the same time. This event at 2.4 10^6 years has been interpreted as the onset of the glaciation in the North Atlantic.

analogous to the well established late Pleistocene calcite dissolution/preservation cycles in the Atlantic, Indian and Pacific deep waters. Because aragonite is metastable relatively to calcite, the aragonite cycles become a more sensitive tool to record carbonate saturation variations in intermediate water masses (300-3000 m). Carbonate preservation in general and aragonite preservation in particular in the Indian Ocean has received much less attention than in Atlantic and Pacific deep sea sediments. In addition. very few studies have been carried out on the preservation of carbonates at intermediate water depths. Diagenetic effects have to be minimum on this long record since the aragonite curve displays such detailed correlations with the known climatic record.

Also the period of the last five to seven million years is a critical one in the paleoceanographic and paleoclimatic development of the Cenozoic. During this time major ice sheet expansion occurred both on the Antarctic continent as well as in the Northern Hemisphere. In addition, closure of the Isthmus of Panama in the Late Pliocene effectively broke the inter-ocean connection between the equatorial Atlantic and Pacific and thereby redirected the warm waters of the Gulf stream into the high latitudes of the North Atlantic. This process had a significant impact on the deep water circulation of the oceans and thereby the preservation record of carbonate in the Neogene. Very little is known about the effects of such major paleoceanographic developments on the carbonate record in the Northern Indian Ocean.

Finally, the problem of submarine diagenesis of shallow-water carbonate sediment will be addressed. The aragonite and magnesian calcite components, which are buried in marine sediments should also undergo more rapid diagenesis than calcitic shells. Nevertheless, it has been shown in the recent Bahama platform drilling during ODP Leg 101, that aragonite components and to a lesser extent magnesian calcite are preserved in marine sediments for at least several million years. This rather surprising discovery demonstrates that the time constant for aragonite dissolution in marine porewaters is of the order of one to ten million years, whereas in fresh water the time constant is of the order of ten to one-hundred thousand years. One of our major objectives in studying their diagenesis is to be able to differentiate between the processes of water-column or seafloor dissolution and burial diagenesis. We hope to be able to subtract outthe effects of diagenesis to better reconstruct the original signal. A second major objective of the diagenetic studies is to better understand the processes involved in the formation of limestones. Many ancient limestones were originally composed of aragonite and magnesian calcite shallow water debris deposited in subsiding marine basins. These sediments subsequently often underwent only marine burial diagenesis, escaping the much more rapid process of freshwater diagenesis. Because of the large changes in sea level during the Pleistocene, most shallow water carbonate sediments have been exposed to freshwater. Only by studying the off-bank shallow water derived sediments can we avoid this overprinting to study marine diagenesis. Such studies will therefore provide us with a far better understanding of the origin of ancient limestones.

We propose to conduct detailed mineralogic, stable isotopic, trace element and, where necessary, micropaleontologic studies of the various carbonate components of the three HPC sequences. These studies will be associated with analyses for chemical and isotopic composition of the associated pore fluids.

Our ultimate goals are to better understand:

1. the nature of aragonite cycles through the Neogene.
2. the record of carbonate saturation in intermediate water masses over the Northern Indian Ocean.
3. the effects and faith of aragonite and magnesian calcite incorporated in the original sediment during burial diagenesis.

Site Requirements

We propose to drill a transect of three HPC holes in the Indian Ocean, in areas surrounding shallow carbonate banks. We have selected as a priority the northern area of the Maldives since we have already established there the existence of the aragonite cycles during late Pleistocene (see fig. 9). The transect should cover a water depth range between 400 and 2000 m. We are proposing to core three HPC (expected penetration 200-250 m), the shallowest one at around 400 m, the next one at 800 m and the deepest at 1500 m. The coring sites have to be located in some topographic highs or isolated slope terraces in order to sample a continuous sequence of periplatform drape. Also they should be located as close as possible off a shallow carbonate bank, since they are the aragonite producers. The HPC transect could be done during the transit toward site 6A and 6B of the Duncan et al. proposal. Their site 6 in the southern part of the Maldives might also include the characteristic requirements of our project. However 2000 m is the maximum water depth that we should drill for this project in the northern Indian Ocean and shallowest HPC sites then site 6 would have to be selected. Another alternative is the area of site 5 of Duncan et al. around the Chagos Bank. In that case, this site should be moved closer to the shallow Bank.

Site Characteristics and Location

Three HPC sites will be necessary to cover the intermediate water depth range between 300 and 2000 m. The global sedimentation rates for core V29-26 collected at 2180 m come to an average of 30 mm/10^3 years during the Upper Pleistocene. Assuming these sedimentation rates representative for the past 5 to 6 10^6 years, the deepest HPC site (1500-1800 m) would have to penetrate a sedimentary sequence of 150 to 200 m to cover the entire Plio-Pleistocene. The same Plio-Pleistocene sequence at the shallowest site (300-500 m) should be quite thicker, since the sedimentation rate of core V29-27 (water depth 460 m) appears to be much higher than for core V29-27; because the first 4 m of core V29-27 seem to represent only the current Holocene. At this shallowest site, the first 200-250 m sedimentary sequence should cover the past 3 to 4 10^6 years.

Both available bathymetric and seismic data are fairly poor in the northern part of the Maldives area. We have tentatively positioned the three sites of the proposed depth transect in the area where both cores V29-26 and V29-27 came from, as well as a single channel seismic survey of LDGO exists. The bathymetry is based on contour Navoceano sheet 2901 (N-1) Indian Ocean. The seismic lines available (Vema 2902, December 20, between 10 to 20 hour) show a thick sedimentary cover on the plateau culminating at 400-500 m between the two chains of atolls.

Fig. 12 and fig. 13 show the three sites placed on the bathymetric map and the seismic profiles respectively.

Site M-1 73° 20' E, 4° 58' N
on the plateau between the atolls
close to core V29-27 400-500 m
LDGO Seismic Profile V2902
Depth of hole 200-250 m
Est. drilling time 1 1/2 day for single HPC

Site M-2 73° 15' E, 5° 18' N
700-800 m
On a morphological saddle
projected location on seismic V2902 profile
Depth of hole 200-250 m
Est. drilling time 1 1/2-2 days for single HPC

Site M-3 73° 43' E, 5° 13'N
1600-1800 m
On a ridge crest close to core V29-26
Projected location on seismic profile V2902
Est. drilling time 2-2 1/2 days for single HPC

We have contacted Dr. Roland Schlich, JOIDES/Indian Panel, from Strasbourg (France) to investigate the French or German bathymetry and seismic data bank for possible existing surveys in the northern part of the Maldives. Predrilling site surveys for more detailed bathymetry and multichannel survey seismic will be necessary in order to select the final location of the three sites, if the data shown in this proposal are the single ones existing.

Possible alternative areas are the region of the southern part of the Maldives around site 6 of the Duncan et al. proposal as well as the region of the Chagos Bank around their site 5. Our preference has been given to northern part of the Maldives since preliminary research on the Upper Pleistocene has been done in core V29-26 and V29-27.

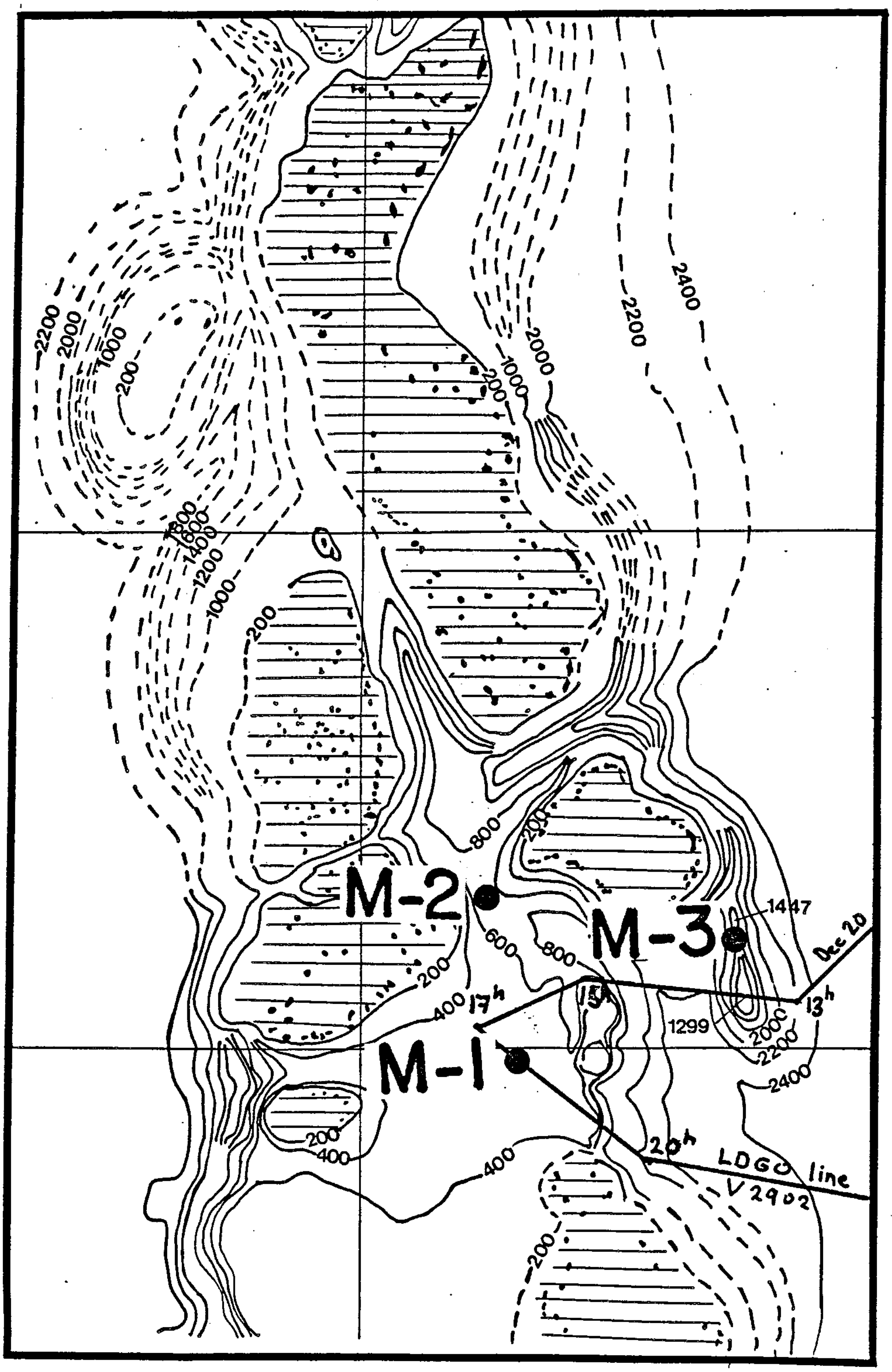


Figure 12 : Detailed bathymetric map of the northern part of the Maldives, source Navoceano sheet 2901 (N-1). Location of three HPC sites M-1, M-2 and M-3. Position of LDGO seismic line Vema 2902.

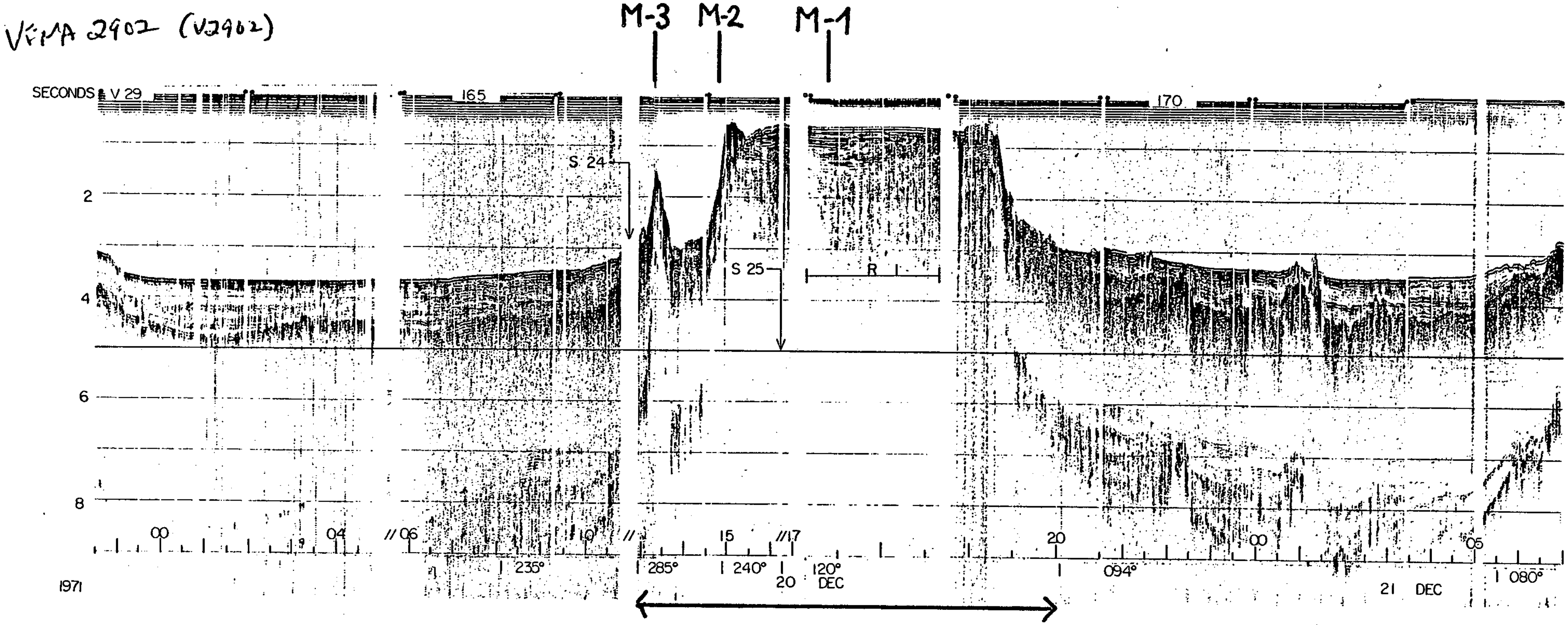


Figure 13 : LDGO seismic line Vema 2902. Part of the line (Dec 20 13^h–20^h) ~~is~~ positioned on map in fig. 12. The three HPC sites M-1, M-2 and M-3 are positioned on the line, either directly or by projection.

REFERENCES

Droxler, A.W., 1985. Last deglaciation in the Bahamian basins and the adjacent Atlantic Ocean - a dissolution record from variations of aragonite content. In: Sandquist, E.T. and W.S. Broecker, eds. The carbonate cycle and atmospheric CO_2 - Natural variations, Archean to Present: American Geophysical Union Monograph 32, 195-207.

Droxler, A.W. and C.C. Whallon, 1979. Quaternary temporal framework of reef to basin sedimentation, Grand Cayman, B.W.I.: Geological Society of America Abstracts with Programs, v. 11, p. 438.

Emiliani, C., 1955. Pleistocene temperatures. Jour. Geol., v. 63, 538-578.

Shackleton, N.J. and M.A. Hall, 1984. Oxygen and carbon isotope stratigraphy of Deep Sea Drilling Project Hole 552A: Plio-Pleistocene glacial history, In: Roberts, D.G. and D. Schmitker, eds. Initial Reports of the Deep Sea Drilling Project, v. LXXXI, 599-609.

ODP SITE PROPOSAL SUMMARY FORM
(Submit 6 copies of mature proposals, 3 copies of preliminary proposals)

Proposed Site: M-1; M-2; M-3
General Area: Northern part of the Maldives.
Position: 3 sites between E73°10' - 73°50'
N04°50' - 05°20'
Alternative Site: Southern part of the Maldives - Around Chagos Bank

General Objective:
HPC depth transect (3 sites)
Coring continuous Negogene sedimentary sequence of periplatform carbonate ooze for paleoceanographic studies.

Thematic Panel interest: Sed. and Ocean History
Regional Panel interest: Indian Ocean Panel

Specific Objectives:
Paleoceanographic and paleoclimatic informations in carbonate periplatform environments at intermediate water depth (400 - 2000 m) and effect of burial diagenesis on metastable aragonite and magnesian calcite.

Background Information (indicate status of data as outlined in the Guidelines):
Regional Geophysical Data:
Seismic profiles:
All proposed sites are located on or projected on V2902 single channel seismic line of LDGO.
Other data:
Bathymetric chart Navoceano sheet 2901 (N-1); Indian Ocean preliminary research on piston cores V29-26 and V29-27.

Site Specific Survey Data:
Seismic profiles:

Other Data:

Operational Considerations:
Water Depth: (m) 400, 800 and 1600 m Sed. Thickness: (m) variable Tot. penetration: (m) 200 250 m each site

HPC XX Double HPC XX Rotary Drill ____ Single Bit ____ Reentry ____

Nature of sediments/rock anticipated: Periplatform carbonate ooze.

Weather conditions/window:

Territorial jurisdiction: The Republic of The Maldives.

Other: This drilling proposal could be combined with deep drilling basement (see drilling proposal of Duncan et al.

Special Requirements (staffing, instrumentation, etc.):

Proponent:
Address & phone number:
Andre W. Droxler and Douglas F. Williams
Geology Department
University of South Carolina
Columbia SC 29208
Paul A. Baker, Duke University
Department of Geology, Durham NC 27708

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Date received:
Classification no.: 183/B
Panel allocation:

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