DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 75/125

SEC POWER STATION SITES OFFSHORE SEISMIC PROFILING SURVEY, TYABB AND RED BLUFF, WESTERNPORT BAY, VICTORIA 1973

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SUMMARY

A shallow offshore seismic profiling and refraction survey was carried out in September 1973 by the Bureau of Mineral Resources, Geology & Geophysics (BMR) at two possible power station sites under investigation by the State Electricity Commission of Victoria in Westernport Bay, Victoria. One site was near Tyabb, the other near Red Bluff on French Island. A BMR modified sparker was used for this work.

The results show that at the Tyabb site up to 80 m of Quaternary and Tertiary sediments overlie a Silurian bedrock. At Red Bluff much of the bedrock, which is Mesozoic, has little or no younger sedimentary cover although east of a fault in the area there are sediments over 40 m thick.

1. INTRODUCTION

The State Electricity Commission of Victoria (SEC) is investigating a number of sites on the Victoria Coast for the construction of a power station. This would entail the construction of pipes to carry water between the power station and the sea. As part of the investigation it was considered that a sparker survey of the area offshore from the sites would provide important information on the underwater geology.

As a result BMR was asked to carry out a survey at two sites, one near Tyabb in Westernport Bay and the other near Red Bluff, French Island. Special conditions were encountered at these sites, viz.: very shallow water and the requirement for high resolution.

The investigation was carried out by a party from BMR consisting of B.H.Dolan (Party Leader), F.V. Mooney (Technical Officer), and S.J. Hall (field hand). All the position fixing, which required greater accuracy than on most profiling surveys, was done by surveyors from SEC. SEC also provided bottom profiles of the lines surveyed. Two vessels were used on the survey. The Melbourne and Metropolitan Board of Works boat Investigator was used at Red Bluff and the R.V. William Buckland from Melbourne University was used at Tyabb. The Investigator had been used on a previous survey by BMR (Dolan, 1973).

2. GEOLOGY

The geology of the Western port area is described by Jenkin (1962). A simplified stratigraphic sequence taken from Jenkin is shown below.

TABLE 1

Stratigraphic sequence in the Western port area

CAINOZOIC Quaternary		Mangrove swamps, salt marsh, and tidal mud flats. Contemporary beach deposits. Swamp deposits and alluvium. Cranbourne Sand and similar sands near Lang Lang. Fluviatile deposits including Cardinia Sand. Warneet Beds and Cranville Gravels.
Tertiary	Pliocene to Miocene	Marine sands at Warneet. Baxter Sandstone and equivalents on French Island and at Lang Lang. Sherwood marl and Flinders Limestone.
	Oligocene to Eocene	Carbonaceous clay, sand, and gravel with seams of brown coal. Basic volcanics and associated sediments. Carbonaceous clay, sand, and gravel with minor brown coals.
MESOZOIC	Cretaceous and/ or Jurassic	Feldspathic sandstone and mudstone of the Strzelecki Group including the Wonthaggi Coal Measures and the Rhyll Arkose.
PALAEOZOIC	Devonian	Granite and granodiorite.
	Silurian to Ordovician	Mudstone, sandstone, shale, and quartzite.

The geology of the area on shore from the Tyabb site is described in more detail in the report by the SEC(SEC 1969). A stratigraphic sequence is shown below.

TABLE 2

Age	Material	Average thickness (to nearest whole metre)	Engineering characteristics
Quaternary	Clayey sand	1	
Pliocene	Sandy clay	5	Very stiff, stiff
Miocene	Clayey sand and sand	13	Soft-firm
Miocene	Marl, calcareous sand, and sand	30	
Oligocene to	Brown coal, ligneous clay		
Eocene	Conglomerate, gravel	12	Medium dense
Silurian	Mudstone, sandstone (forms bedrock of area)	Average depth to bedrock 61 m	Weathered to fresh

Examination of the geological logs obtained from drill holes in the area (SEC, loc cit) show that there exists a limestone layer at the base of the Sherwood Marl of thickness 2-4 metres. This formation is described as 'hard' whereas the overlying marl is variable between 'soft' and 'hard' but generally 'soft'. The boundary between the marl and the limestone should provide a good reflecting horizon.

3. METHODS AND EQUIPMENT

The reflection method

In shallow reflection profiling a pressure wave is introduced into the water by a transducer, and the transmission frequencies (100-2000 Hz) are such that appreciable energy will be transmitted through water-saturated unconsolidated layers. The energy will be reflected at boundaries between media of contrasting acoustic impedance, a characteristic which depends mainly on the density of the sediment.

The amplitude of the reflected signal increases with the contrast in acoustic impedance. For example a boundary between sand and silt would result in about 10-20% reflection of the pressure wave, whereas a boundary between sea water and average sand would result in about 30-40% reflection (Taylor Smith & Li, 1966).

The reflections are received by a pressure sensitive transducer (hydrophone) towed by the vessel, and are recorded graphically in a time scale. The pulses are transmitted regularly at short intervals (less than one second) as the vessel moves at a constant speed of about 5 knots across the area of investigation. Reflections from a boundary are therefore recorded continuously, and the resulting record looks somewhat like a geological section but the depth scale is a time scale.

The depth to a reflector is the product of half the time and the average velocity. For water this velocity is approximately 1.5 km /s and varies with salinity and temperature. For sea water in a temperature range of 0-30°C this value is correct to 4% (Matthews, 1939). The velocity in unconsolidated sediments usually ranges from 1.5 to 1.8 km/s, the velocity increasing with the degree of consolidation (Shumway, 1960). Consolidated sediments, igneous rocks, and metamorphic rocks have velocities from about 1.8 to 7 km/s (Heiland, 1946).

The resolution is affected by the wavelength of the transmitted energy, the existence of additional transmissions, and interference of the transmitted and received signals by surface reflections. The signals received from sub-bottom horizons are further affected by interference by 'multiples'; these are signals from some horizon which reflect off the air/water interface and are again returned from the water bottom. In deep water, i.e. where the water depth is greater than twice the deepest sub-bottom reflections, multiples do not pose a problem, but as the water depth decreases the problem becomes greater (Sargent, 1969).

Once a horizon is clearly identified, the accuracy of depth determination depends on measuring the time to the leading edge of the pressure wave reflected from that horizon and knowing the average velocity.

The refraction method

In the refraction method the transmission and reception transducers are moved apart while the pressure pulse is being transmitted at regular intervals. By recording the arrival of the energy on a time scale a measure of the velocity in the water and underlying formations can be determined. The depth to a formation with higher acoustic velocity can be interpreted from this information.

A plot is made of the arrival time against distance. From this plot a measure of the velocity in a formation is made by a line of best fit. The accuracy of the determination is affected by irregularities in the refractor. Generally marine sediments are sufficiently horizontal to permit a fairly accurate (±3%) determination of velocity to be made. The intercept of the line of best fit on the time axis is called the intercept time. The depth to a refractor is a function of the velocities in the layers of material above and below the refracting interface, and their respective intercept times.

Formulae for the calculation of depths to different refractors are given in Dolan, 1975.

There are two main limitations of this method:

(a) it will not pick up a low-velocity layer beneath a high-velocity layer;

(b) it is difficult to resolve a thin layer between a low-velocity layer, and a high-velocity layer.

Equipment

BMR uses a modified 'sparker' system which had been developed to achieve high resolution in shallow water with penetration in sediment up to 100 m. The total system for reflection profiling consisted of an EGG Model 232 Power Supply, an EGG Model 231 triggered Capacitor Unit, an EPC Bathymetric Recorder model 4100, a BMR single-element sparker, a BMR multi-element hydrophone, a BMR programmed-gain amplifier, and a Kronhite filter. For the refraction traverses, the sparker system was used for the energy source, an Aquatronics sonabuoy was used to receive the pressure wave and a Nems-Clarke radio receiver to pick up the Sonobuoy transmissions.

4. RESULTS

Seventeen kilometres of seismic profiling lines were completed at the Tyabb site and 26 km at the Red Bluff site. The location of the sites in relation to Melbourne is shown in Plate 1 and the locations of the lines are shown in Plates 2 & 6. In addition one refraction line was run at Tyabb, centred at E13, and three at Red Bluff where indicated (F1, P1, and Z, Plate 6). The plan of Red Bluff shows the area where a thickness of sediment was recorded, but over most of this area no sediment was recorded above bedrock.

Tyabb site

The results from the Tyabb site are shown as seismic cross-sections in Plates 3 to 5. The two most prominent horizons are indicated in the cross-section. One of these is the strongest and most continuous reflector in the records. The depth at which this occurs nearest the shore line is about 35 m below Mean Sea Level. The depth to the limestone formation in a hole (21T) 3 km from the Yaningha beacon is 35.6 m. The depths to the formation in the other holes in the area up to 7.4 km away are 51.3, 31.5 35.6, and 38.4 metres (SEC 1969). Hence this reflector is considered to be the top of the limestone layer at the base of the Sherwood marl.

The refraction traverse showed that the depth to a high-velocity refractor (3.0 km/s) is 70 ± 5 m at E(13). This depth corresponds with the deepest reflector recorded. The depth to the reflector increases out into the bay, and is about 50 to 55 metres close inshore. Silurian sedimentary rocks were encountered in the drill holes near the site at depth from 45 to 53 m. Hence it is considered that this reflector is the top of the Silurian formations. The fact that it is also a rather irregular reflector also suggests an old erosional surface.

The overlying horizons are considered to represent the boundaries between different sediment types within the Tertiary sequence and between the Tertiary and Quaternary, such as between the "Sherwood Marl" and "Baxter Sandstone".

The depths to the various horizons increase to the southeast and there is some minor folding which trends approximately northeast. One distinct fault was recorded; it is marked in the plan (Plate 2) and shown in the sections (Plates 3-5). This fault has a throw of about 14 m in the west of the area and 9 m in the east. The plan (Plate 2) also shows the depth to the limestone reflector over the whole site.

Red Bluff site

The results from the Red Bluff site show that over most of the site there is little or no younger sediment overlying bedrock, which is most likely Mesozoic. Therefore no seismic cross-sections are presented for the Red Bluff area. The areas where sediment was recorded, i.e. where the thickness was greater than about one metre, are shown in the plan of the Red Bluff site (Plate 6).

A fault is indicated in the east of the area. East of the fault the thickness of sediments is at least 40 m overlying a reflector above bedrock. Over much of the rest of the site the sedimentary cover appears to have been removed. In some lines parts of the sediment cover were thin and the depth of water shallow; as a result the record quality made accurate determination of thickness impossible.

5. CONCLUSIONS

Tyabb site

The thickness of Tertiary sediments in the area investigated was up to 80 m. The sequence increased in thickness to the southeast and some folding and a fault were recorded.

Red Bluff site

Much of this site was without any detectable sediment cover. A fault was recorded in the east of the site, where the thickness of sediments increased to over 40 m.

6. RECOMMENDATIONS

It is recommended that a drill hole be put down at the Tyabb site to correlate accurately the stratigraphic sequence with the seismic results. It should be drilled deep enough to reach Silurian bedrock to give a complete coverage. Midway along line E would be the most useful position for correlation with the seismic data.

At the Red Bluff site it would be desirable to have at least two drill holes, one west and one east of the fault. The one to the west should be located to pass through several metres of the sedimentary cover.

7. REFERENCES

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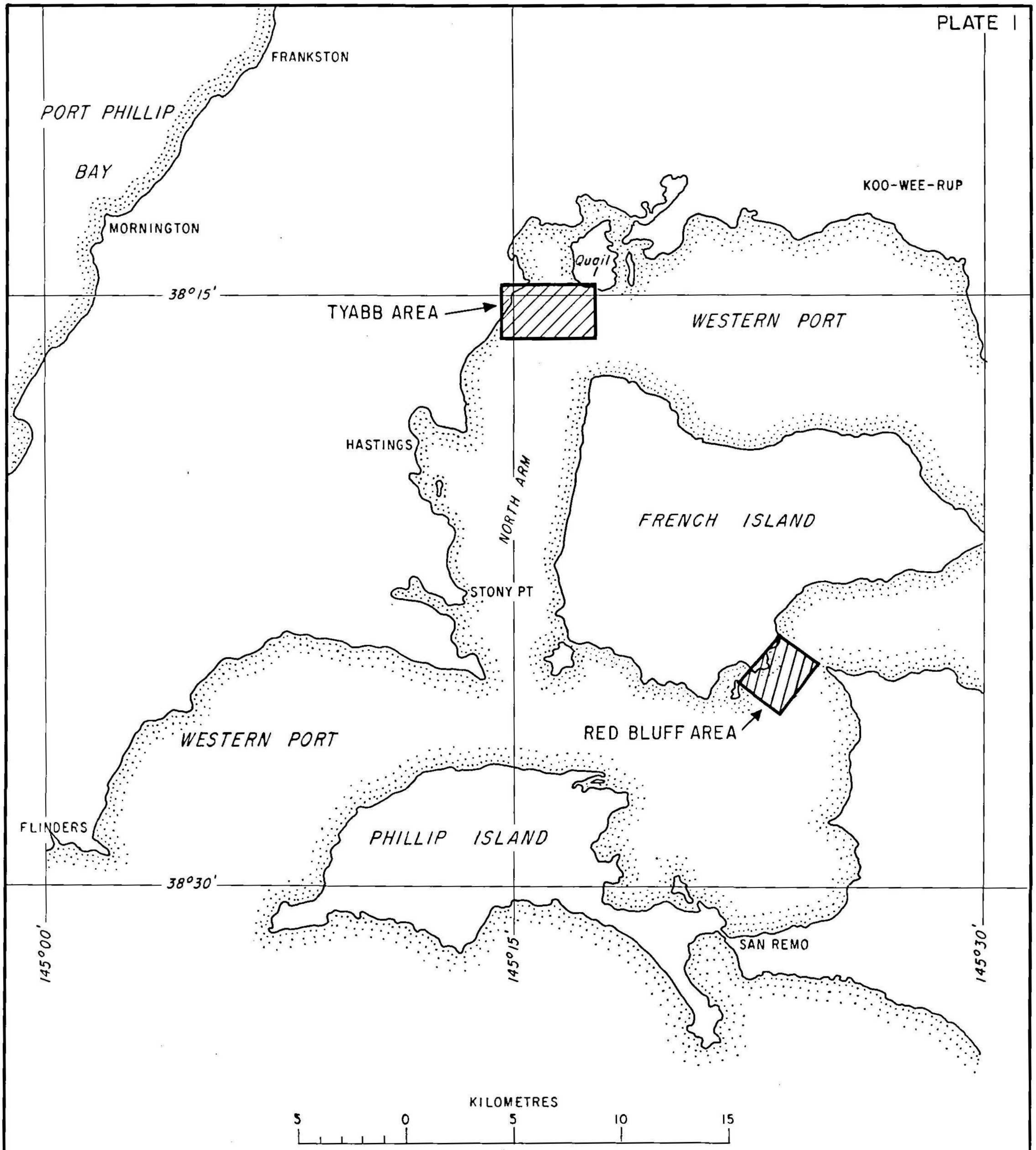
PLATE I



SEC POWER STATION SITES
WESTERN PORT BAY
LOCALITY MAP

Record No. 1975/125

J55/B5-110A

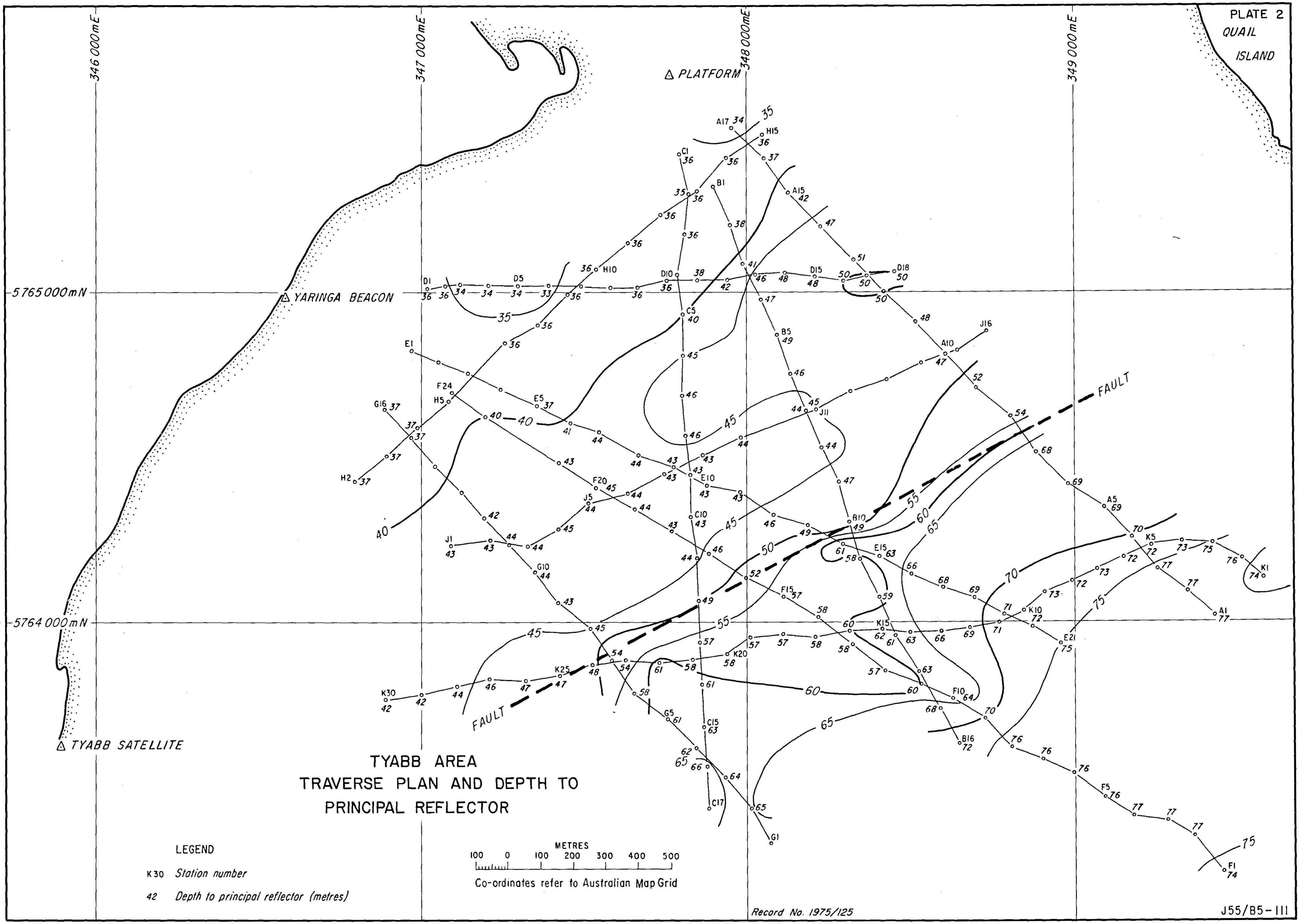
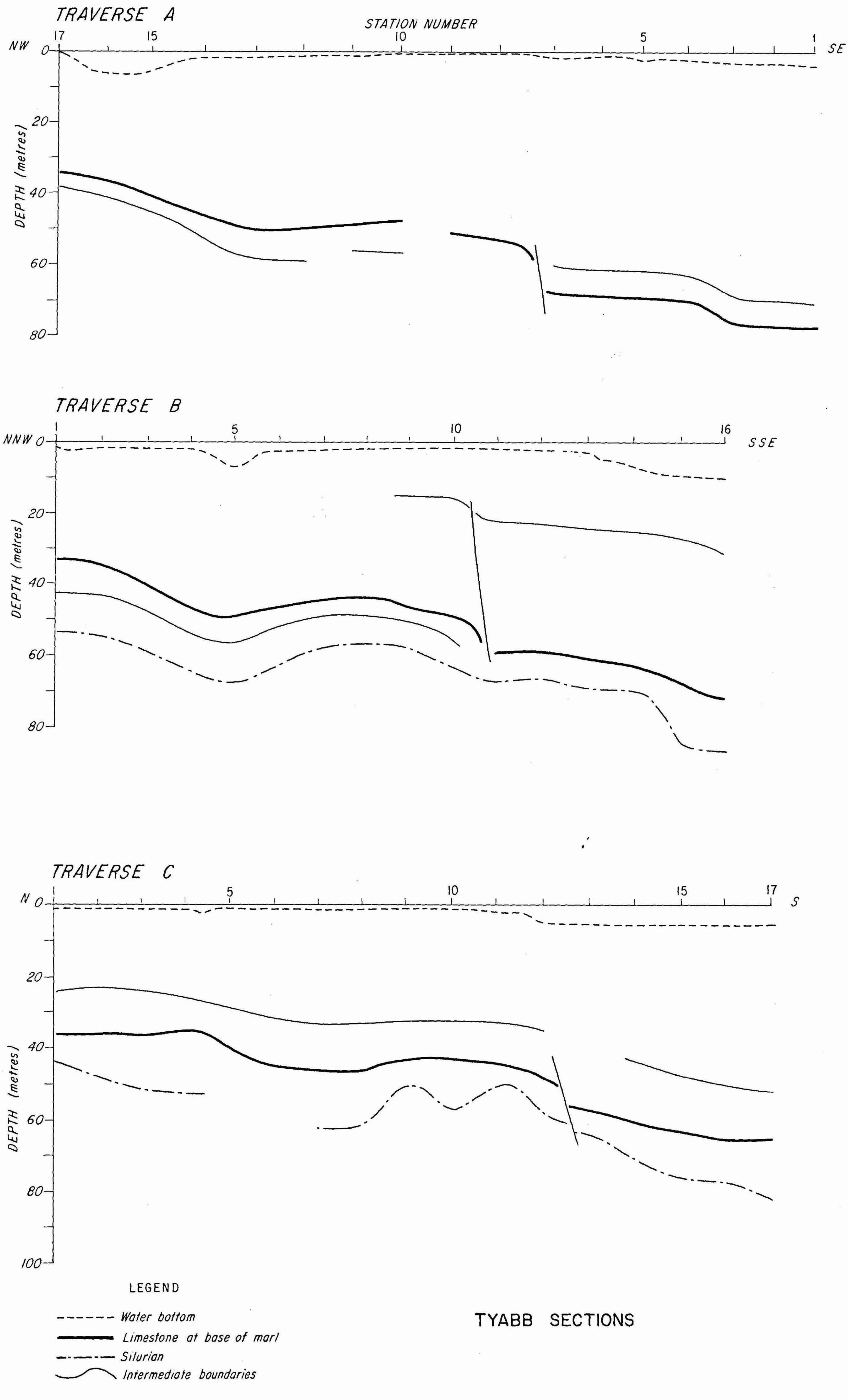


PLATE 2
QUAIL ISLAND
346 000mE
347 000mE
348 000mE
349 000mE
5765 000mN
5764 000mN
△ PLATFORM
△ YARINGA BEACON
△ TYABB SATELLITE
FAULT
FAULT
TYABB AREA
TRAVERSE PLAN AND DEPTH TO
PRINCIPAL REFLECTOR
LEGEND
K30 Station number
42 Depth to principal reflector (metres)
METRES
100 0 100 200 300 400 500
Co-ordinates refer to Australian Map Grid
Record No. 1975/125
J55/B5-111

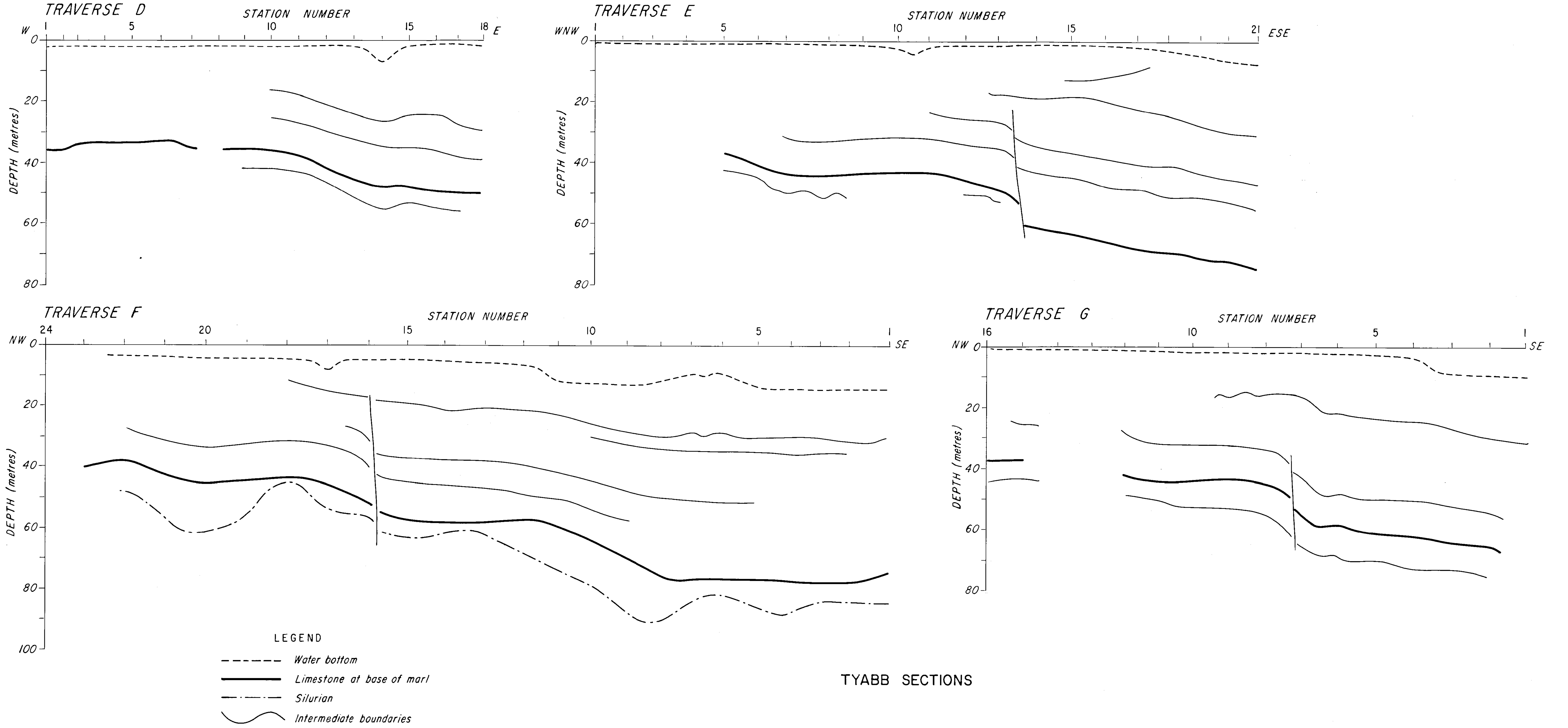


TYABB SECTIONS

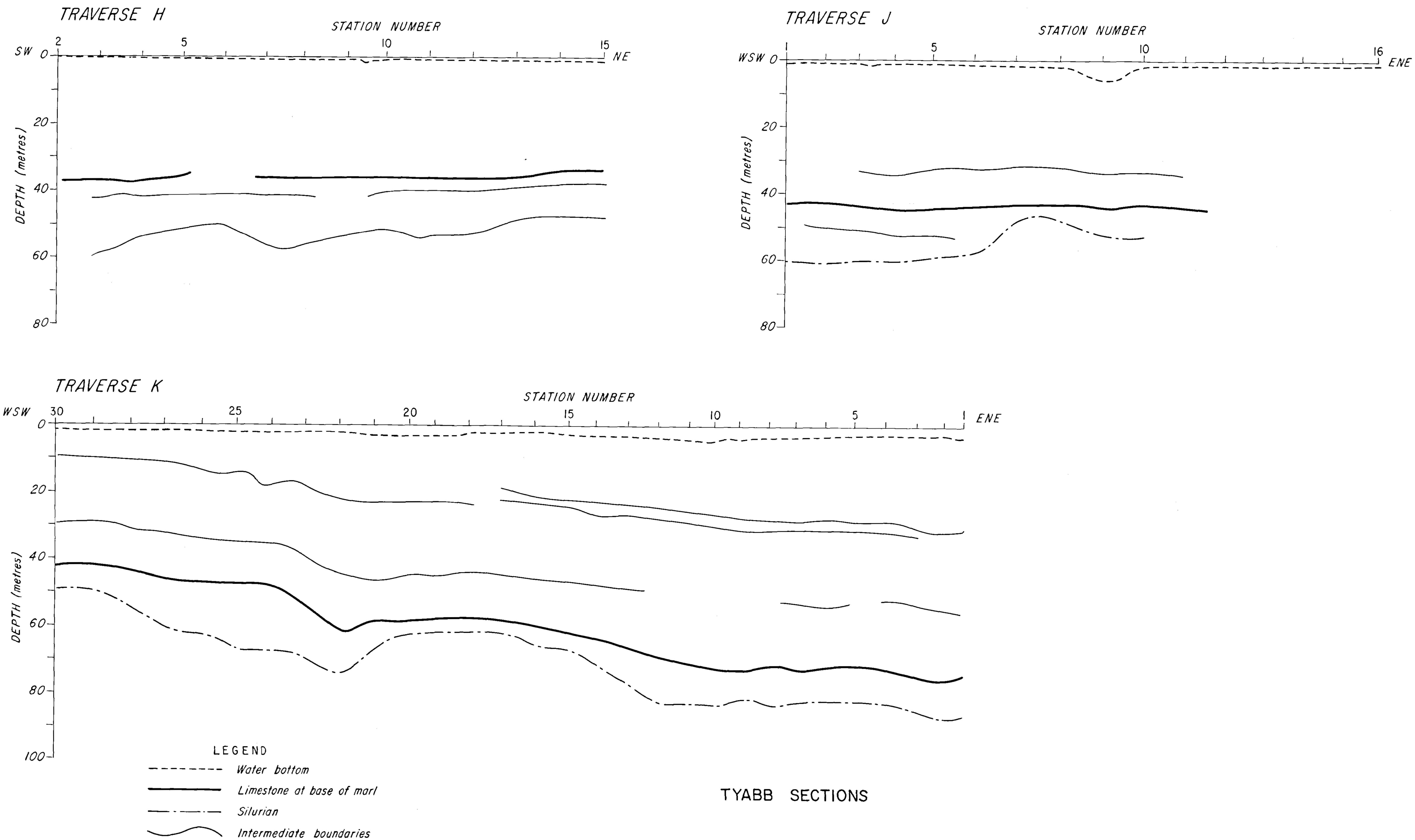
PLATE 3

Record No. 1975/125

J55/B5-113

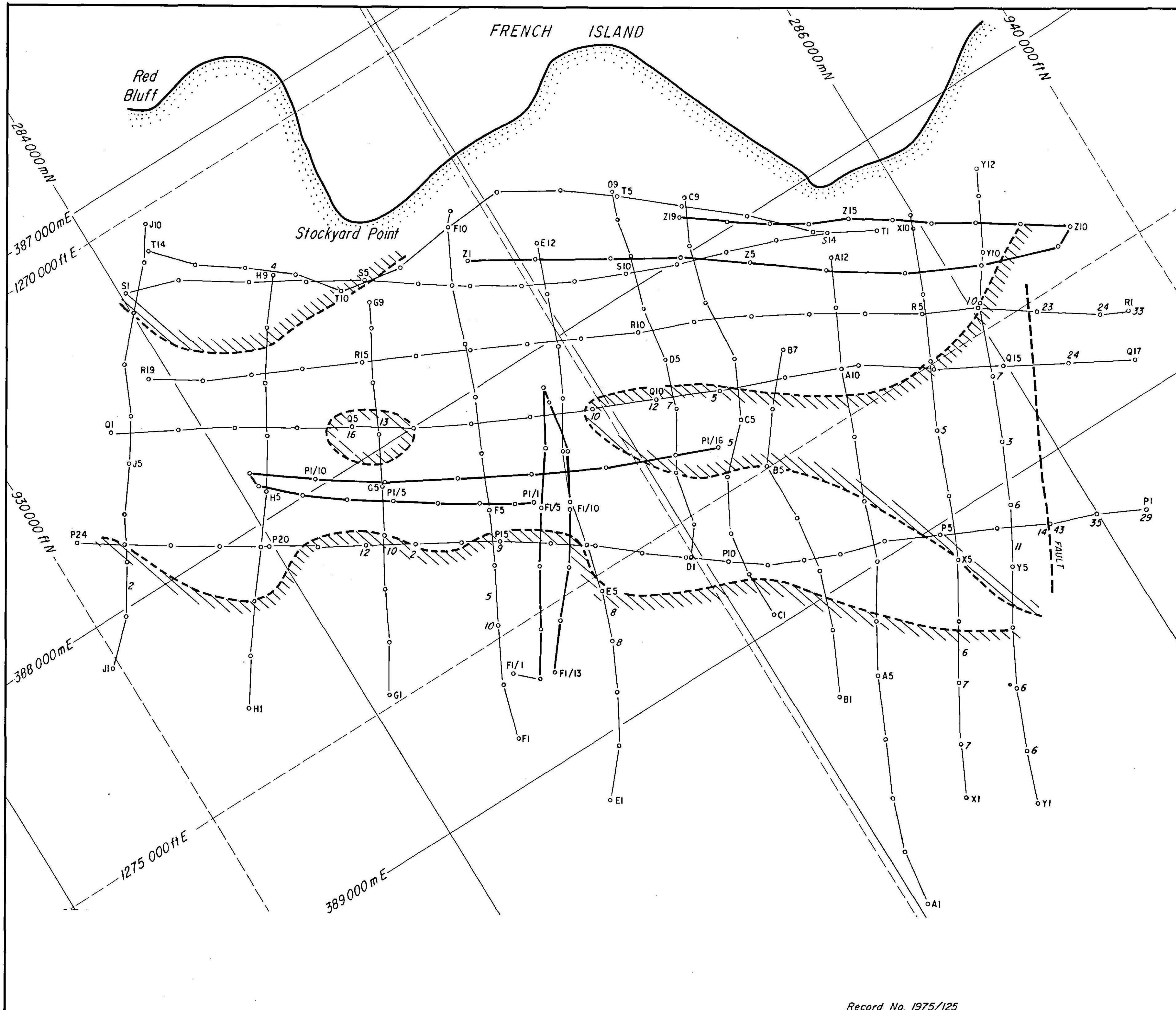


TYABB SECTIONS



TYABB SECTIONS

PLATE 6



LEGEND

P1 Station number

Areas of sediment cover

29 Sediment thickness (metres)

Refraction lines

METRES

100 0 100 200 300 400 500

Co-ordinates refer to MMBW grid

RED BLUFF AREA TRAVERSE PLAN AND SEDIMENT THICKNESS

J55/B5-112