DEPARTMENT OF MINERALS AND ENERGY

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Record 1974/99

ORIGIN OF THE NATURALISTE PLATEAU

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Lying off the southwest coast of Australia (see Fig. 1) some 2500 m below sea level is the broad, rectangular Naturaliste Plateau, which forms a relatively flat ledge half way between sea level and the abyssal plain. How the plateau came to be in this position, and whether its origin is continental or oceanic, are two questions relevant to the evolution of the southeast Indian Ocean.

Until recently the only data bearing on the origin of the plateau were seismic profiles recorded by R.V. "Vema" [1] and by R.V. "Robert D. Conrad", which also obtained 2 m of Upper Cretaceous sedimentary rock by gravity coring (RC8-56)[2]. Deeper core information was obtained in late 1972 by the drilling vessel "Glomar Challenger" at Deep Sea Drilling Project sites 258 and 264[3, 4] (see Fig. 2). Preliminary study of DSDP data indicates that the plateau has been at its present depth since Early Cretaceous (Middle Albian) time, accumulating pelagic sediments, and 'has probably been uplifted since that time rather than having subsided'.[3]

DSDP 258 penetrated 525 m of marine sediment up to 105 million years old, containing detrital units in the Early Cretaceous which may be volcanically derived and which support an oceanic origin. However, a Miocene/Santonian unconformity which represents a break of 70 million years was encountered only 100 m below sea floor and may be related to the final separation of Australia and Antarctica in Middle Eocene time. In the "Robert D. Conrad" core (RC8-56) an unconformity separates Pleistocene and Turonian beds.

DSDP 264 near the southern edge of the plateau penetrated 215 m of carbonate sediment and bottomed in an undated volcaniclastic conglomerate containing both acid and basic volcanic rocks. The Tertiary/Cretaceous unconformity at the other core sites is here represented by three unconformities spanning late Miocene/late Eocene, early Eocene/mid-Palaeocene, and mid-Palaeocene/Cenomanian times. The erosion causing these shallow

unconformities appears to have been less severe at the margins of the plateau, as evidenced by the presence of Eocene and Palaeocene sections at site 264.

The first systematic survey of the area was achieved when the Australian Bureau of Mineral Resources (BMR) completed a series of 13 profiles over the plateau in December 1972. This was part of BMR's survey of the Australian continental margin using continuous gravity, magnetic, seismic, and bathymetric recording at a line spacing of 30 nautical miles. A preliminary study of these data together with previous information suggests a continental origin for the plateau.

The western and eastern halves of the Naturaliste Plateau differ significantly in bathymetric, seismic, and magnetic characteristics. The western half is the shallower and is characterized by shallow seismic basement and intense magnetic anomalies. The basin-like eastern area has thick sediments and less intense magnetic anomalies. Along the southern and parts of the western margin, but not along the northern margin, scarp-like bathymetric features suggest faulting in the basement. Elsewhere the seismic results show that the plateau sediments are not faulted or folded. The thickest sedimentary sequence is in the northwest corner and in the low area to the east, where at least 2 km of sediment is present.

The Tertiary/Cretaceous uncomformity is too close to the sediment/water interface at drilling sites 258 and 264 for detection on BMR seismic records. However, three deeper unconformities were revealed. All four (A, B, C, and D) are shown on the cross-section along XX' shown in Fig. 3. The Tertiary/Cretaceous unconformity (A), detected in all three plateau cores, also occurs at Broken Ridge and Wharton Basin Sites [3], and is of

regional extent. Unconformity B extends over the whole plateau and truncates unconformity C, restricting it to the eastern part. The sediment/acoustic basement unconformity (D) is most readily identifiable in the areas of thin sediments in the west.

The well stratified sequence above unconformity B constitutes about half the total volume of sediments evident on the plateau and shows several local unconformities. Its thickness ranges from 200 to 1100 m, assuming a sediment seismic velocity of 2.0 km/sec, and DSDP data indicate that it is largely of Cretaceous age with only about 100 m of Miocene and younger beds. Most sedimentation on the plateau, therefore, preceded the separation of Antarctica and Australia in Eocene time.

DSDP 258 was near the pinch-out between unconformities B and C, and bottomed just short of C in a thick sequence of Albian clays and glauconitic sands. Thus, the beds between B and C, which reach a thickness of 700 m in the deep eastern area, are evidently these Albian clays. On the seismic sections they are largely transparent, but stratigication becomes increasingly evident northwards.

Unconformity C seems likely to be Neocomian because it is close to the Albian clays at the bottom of DSDP 258 and because prominent prior tectonic activity known in the area took place in the Perth basin within Neocomian time. Jones and Pearson [5] believe this to be the time when India became detached from the west coast of Australia during the breakup of Gondwanaland. However, recent DSDP data from site 259 in the Perth Abyssal Plain indicated that this fracturing continued throughout the Cretaceous [6]. The basalt at the base of DSDP 259 was dated as Neocomian.

Below Unconformities B in the west and C in the east are well stratified sediments ranging in thickness from 0 to 1000 m. In the west there are draped over the basement. In the east they extend to the limit

of seismic penetration. They are only gently folded and faulted, and were deposited before the Cretaceous activity.

Acoustic basement is more visible on the seismic records from the western parts of the plateau, where sediments are generally thinner than in the east. Basement topography resembles a block-faulted and eroded plateau. Occasional reflection events below the basement unconformity suggest that the sequence is sedimentary, and this may be supported by the lack of strong reflectivity contrast with overlying sediments in some areas. Elsewhere there are features in the seismic sections showing intrusive form.

The magnetic anomaly pattern is more disturbed in the west, indicating a shallower magnetic basement than in the east. The high frequency and amplitude of magnetic features in the west suggest that the basement in this region is a complex of basic igneous and metamorphic rocks. This, together with the seismic evidence, points to a basement of metamorphosed sedimentary rock with basic igneous intrusions.

The Bouguer anomaly model showing the best fit with observed gravity is illustrated in Fig. 3: crustal thickness is about 22 km, intermediate between continental and oceanic thicknesses, and is a further indication that the plateau was not originally an oceanic feature. A similar thickness was found under Broken Ridge from seismic refraction surveying in 1962[7] and it was suggested then that this feature is continental and may have been contiguous in the past with the Naturaliste Plateau and the Western Australian Shield.

BMR and DSDP data indicate that most of the plateau sedimentation preceded the separation of Australia and Antarctica and a large part was almost certainly pre-Cretaceous. The sediments were deposited on a

basement of metamorphic rocks, and have remained tectonically undisturbed except along the southern and western margins. It is concluded that the plateau is of continental origin and existed as part of the continental mass of Gondwanaland in essentially the same position relative to Australia that it occupies today. Location of marginal scarp features suggests that there were landmasses along its southern and western margins, but not along its northern margin.

The reconstruction of Gondwanaland by Veevers et.al.[8] places India against the southwest coast of Australia and the Naturaliste Plateau some 500 km north of its present position. The reconstruction was based upon evidence that the Perth Basin was within the interior of Gondwanaland up to the earliest Cretaceous. The BMR and DSDP data cast doubt on this reconstruction. The western basement block of the plateau could not have moved great distances horizontally relative to Australia since the deposition of the sediments without causing sedimentary deformations in the east that would be unmistakeable in seismic records.

In the fit of Australia and Antarctica proposed by Sproll and Dietz[9] the Naturaliste Plateau lies against a similar Antarctic marginal bathymetric feature known as the Bruce Plateau, offshore from Knox Coast. Rocks outcropping on Knox Coast are shown on the Geological Map of Antarctica [10] to be Precambrian gneisses and schists of granulite facies. As suggested by the geophysical evidence such rocks are more likely than oceanic igneous rocks to form the basement of the Naturaliste Plateau. There is reason to believe, therefore, that the plateau once formed part of the Gondwanaland continental shelf (hence the intermediate crustal thickness) abutting the Bruce Plateau. It broke away from Antarctica in the initial rifting which formed the southern Australian continental scarps and thereafter it remained attached to the Australian crustal plate.

References

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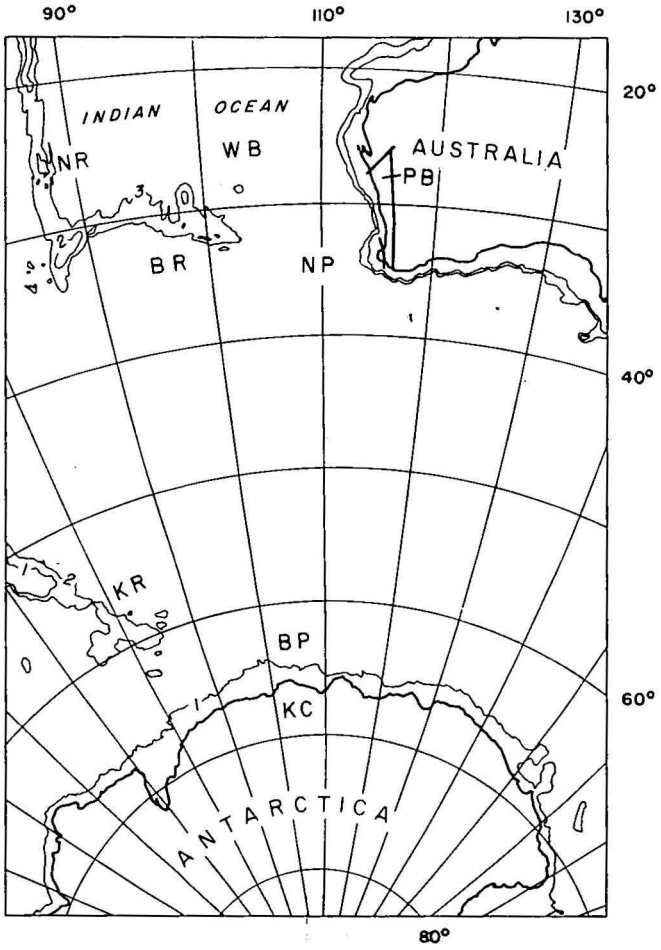
Fig 1 Location of the Naturaliste Plateau (NP) in the southeast Indian Ocean. BR, Broken Ridge; NR, Ninetyeast Ridge; WB, Wharton Basin; KC, Knox Coast; BP, Bruce Plateau; KR, Kerguelen Ridge; PB, Perth Basin. Bathymetric contours in km after McKenzie and Sclater [11].



ORIGIN OF THE NATURALISTE PLATEAU

LOCATION

NP: Naturaliste Plateau	KR: Kerguelen Ridge
PB: Perth Basin	NR: Ninetyeast Ridge
BR: Broken Ridge	BP: Bruce Plateau
WB: Wharton Basin	KC: Knox Coast

Bathymetric contours in km (after McKenzie and Sclater)

Fig. 2 Bathymetry of Naturaliste Plateau, BMR traverses and core locations. RC8-56, core by "Robert D. Conrad"; 258, DSDP core site 258; 264, DSDP core site 264. Bathymetric contour interval 200 m.

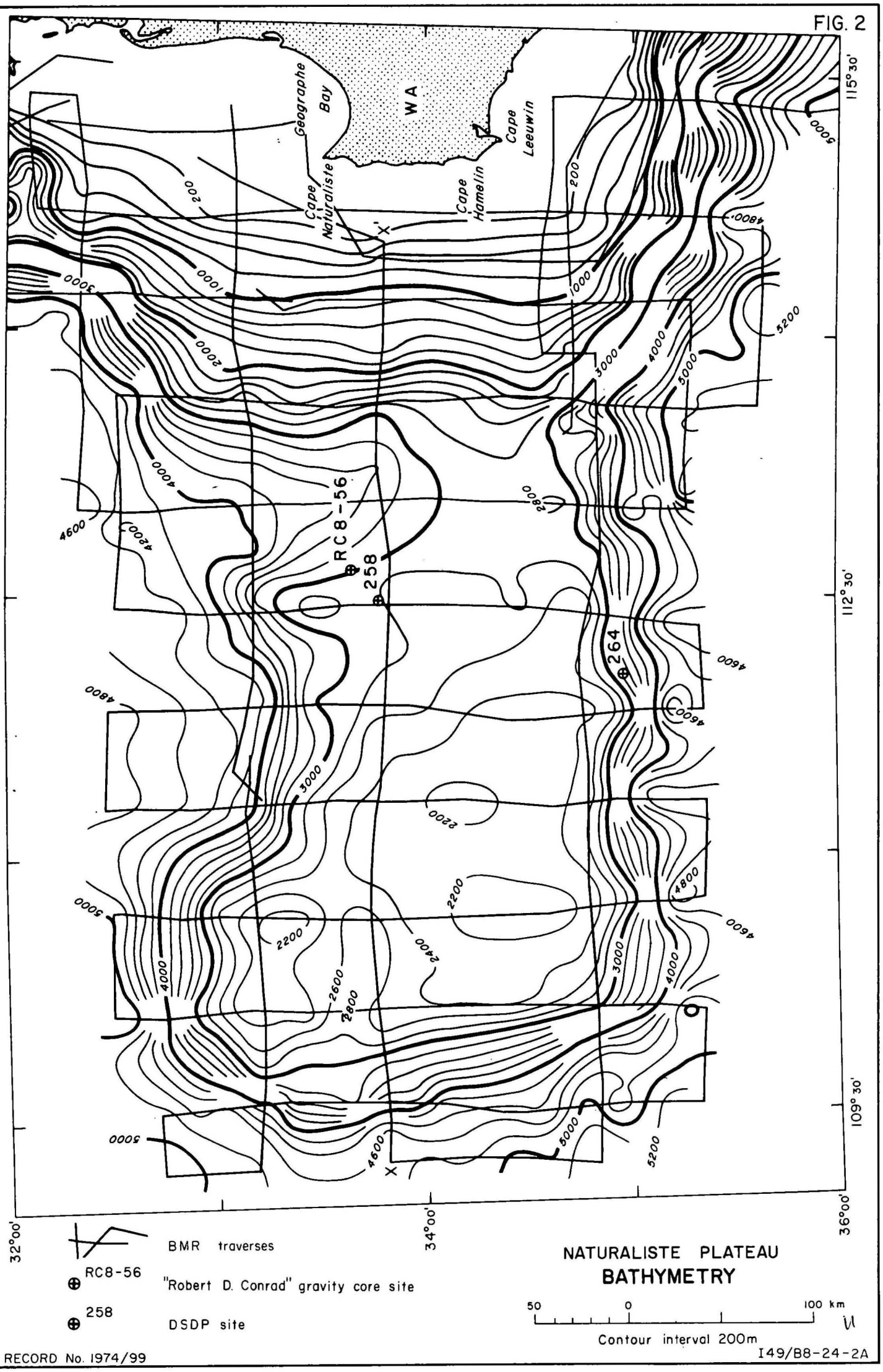


FIG. 2
WA
Geographe Bay
Cape Naturaliste
Cape Hamelin
Cape Leeuwin
RC8-56
258
264
X
X'
115°30'
112°30'
109°30'
32°00'
34°00'
36°00'
BMR traverses
RC8-56 "Robert D. Conrad" gravity core site
258 DSDP site
NATURALISTE PLATEAU
BATHYMETRY
50 0 100 km
Contour interval 200m
RECORD No. 1974/99
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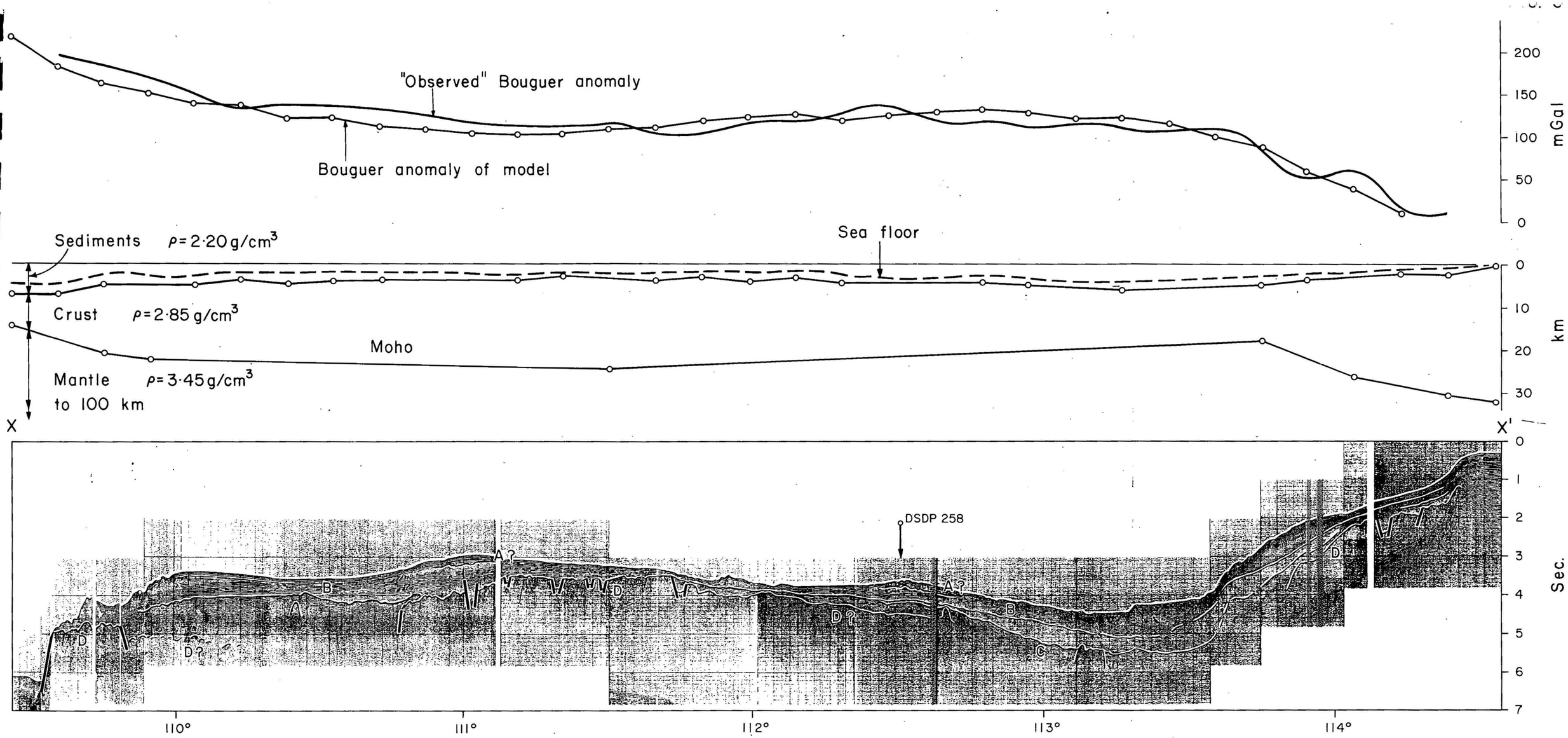
Fig. 3 Bouguer anomaly crustal model of the Naturaliste Plateau and seismic interpretation for section XX'. Densities used in gravity model: mantle 3.45 g/cc; crust, 2.85; sediments, 2.20. Standard crust for southwest Australia taken as 31 km thick after Mathur[12]. A, B, C, D are uncomformities. ⚲ DSDP site 258.



Standard crust for southwest Australia taken as 31km after Mathur

A, B, C, D are unconformities

RECORD No. 1974/99

BOUGUER ANOMALY CRUSTAL MODEL OF THE NATURALISTE PLATEAU AND SEISMIC INTERPRETATION FOR SECTION XX'

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