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FOOTPRINTS IN QUATERNARY COASTAL SEDIMENTS, WESTERN SOUTH AUSTRALIA

GEOLOGICAL SURVEY

By

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Footprints in Quaternary Coastal Sediments, Western South Australia

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Abstract

Human and animal footprints are preserved in two different settings near Clare Bay, South Australia. Macropod tracks occur in laminated beach sediment of Late Pleistocene age (c. 110 000 yrs B.P.). They are preserved beneath a former prograding coastal fore-dune complex and are now being exposed by shoreline erosion and regression. Human footprints and emu and animal tracks occur a few kilometres inland on the margin of coastal saline lakes. They originated about 5 000 years ago, when soft dolomitic and calcitic marls formed from groundwater seepage and evaporation around gypseous lake margins. Preservation resulted from subsequent lithification of the marl, and the footprints have been subjected to continuing exposure and weathering since formation.

Fossil animal, bird and human foot prints in the Fowlers Bay area were first described by Daisy Bates in her book 'the Passing of the Aborigines' published in 1938. Describing her experiences of living with aborigines in the area during a period around 1914 she wrote -

'on the limestone slabs that have formed, and that now lie exposed in some of these depressions near the coast are numbers of footprints, called by the natives nyeerina jinna, of humans, animals and birds which walked over the soft mud of long ago to get the oysters, mussels and other shellfish whose fossils line the shallow banks girding them'.

Her reference to footprints however was never scientifically investigated, although local aborigines and landholders were aware of footprint sites in the area. "Re-discovery" of footprint sites occurred as a result of two separate scientific investigations of the region.

In 1984 a team investigating coastal landforms in the region (Short et al. 1986) discovered fossil animal tracks on a calcarenite beach platform at Clare Bay. A recent examination of the footprints by scientists from Flinders University and the SA Museum indicates they were produced by a large macropod possibly the extinct giant wallaby Protemnodon.

In 1987 a team of archaeologists from ANUTECH investigating Aboriginal occupation of the Nullarbor Plain were shown a second site containing prints, several kilometres inland from Clare Bay, known to local aborigines and landholders. Consisting of fossil human, animal and bird tracks, the prints were found impressed in carbonate mudstone which occurred along the outer edge of a small gypsum swamp. A sample of the mudstone yielded a C14 age of 5470 $\pm$ 190 yrs BP (Kimd, ANU5795) considered a minimum age due to possible contamination by recent organic materials (Gara and Cane 1988).

Between 1984 and 1988, the South Australian Department of Mines and Energy undertook stratigraphic drilling at Fowlers Bay and regional geological investigations of the coastal Quaternary geology of the area (Belperio 1988). The stratigraphic setting of the fossil sites at Clare Bay (Fig. 1) were examined as part of these investigations. In addition to a mapping and drilling program, samples were also examined in thin section and by X-Ray diffraction (Belperio 1988; Farrand and Belperio 1987) and separates were examined for their molluscan fauna (Ludbrook 1988).

GEOLOGICAL FRAMEWORK

The Quaternary sediments of the Fowlers Bay region evolved from successive episodes of regressive coastal deposition associated with interglacial sea-level high stands (Belperio 1988). Deposition occurred in swell-dominated, littoral and coastal aeolian environments, and in protected back-barrier lagoon, intertidal and evaporative lagoon environments. Exposure and pedogenesis during intervening sea-level low stands resulted in successive episodes of calcretization. Calcretes separate successive marine sequences in the subsurface, although surficially they mask the lateral extent of various formations and facies. Nevertheless, it has been possible to map the distribution of discrete shoreline complexes from a combination of their topography (relict morphology), drilling information, and cliff and pit exposures. Subsurface examination of sediments is necessary because of omnipresent calcretes (Fig. 1). Episodes of beach-dune sedimentation occurred in the Holocene (6 500 yrs B.P. - Present), the Late Pleistocene last interglacial (c. 110,000 yrs B.P.), the Mid-Pleistocene penultimate interglacial (c. 200,000 yrs B.P.) and the Early Pleistocene. These events have been dated by radiocarbon (Short et al. 1986; Belperio et al. 1988) and amino acid racemisation methods (Murray - Wallace et al. 1988 a, b).

COASTAL SITE

Macropod tracks occur on a receding shore platform on the eastern side of Clare Bay (Site A, Fig. 1). The eroding eastern shore of the bay displays a clear cross-section through a Late Pleistocene laminated beach calcarenite and overlying and interfingering dune calcarenite (Fig. 2). The dune calcarenite forms part of a major east-west coastal barrier (Upper Bridgewater Formation, Qpb1) that Belperio

(1988) correlated with last interglacial lagoonal sediments at Fowlers Bay dated at c. 110,000 yrs B.P. by amino acid racemisation of mollusc shells. Radiocarbon dating of the beach calcarenite at Fowlers Bay and at the Clare Bay site produced background results and a minimal age of 26,000 $\pm$ 400 yrs B.P. (Short et al. 1986; Buckley et al. 1987).

The beach calcarenite can be traced landwards for some 300 m at a consistent elevation of one to three metres above present sea level. Very low angle crossbedding (up to 3°) is present, resulting from swash, backwash and overwash littoral processes. The sediment is well laminated on a millimetre to centimetre scale, and contains reworked boulders of an underlying calcrete towards its base. Grains are predominantly medium sand size, well rounded and with little or no matrix. Thin bands of coarser molluscan debris are common. Coralline algae, foraminifera and mollusc fragments are the predominant bioclasts and these are coated with thin micrite alteration envelopes. By contrast, the underlying calcrete, developed on an older calcarenite (Qpb2,3; notation of Belperio 1988), contains heavily altered bioclasts with thick micrite rinds, abundant structureless pisolites and nodules with blackened cores, and a pervasive calcite matrix (Table 1).

A track of paired footprints (5 pairs in total) resembling those of a kangaroo occur on a exposed bedding plane of the beach calcarenite on a receding shore platform (Fig. 3A). Each pair of prints are 195 cm apart, with each footprint approximately 28 cm long, 20 cm wide and 5-10 cm deep. The sandy sediment preserves little detail of the prints, although an offset larger toe is discernable for each print. The tracks are no bigger than those of a modern kangaroo, but the pronounced outer toe suggests they belong to an extinct giant wallaby (Gara and Cane 1988). The individual bedding plane on

which the track formed is part of an overwash sequence that dips gently landwards. The same surface also hosts mollusc feeding trails (Fig. 3B) and other unidentifiable prints. It is overlain and underlain by similar sand laminae that represent successive overwash events. The animal tracks formed in a short time period between overwash events on the landward side of a bar or berm.

The tracks head northeastwards (towards land) beneath a receding dune calcarenite cliff, and with time, more of the track will become exposed. Confidence can be placed in an interpreted age of 110,000 yrs B.P. even though the footprint site has not been specifically dated.

Preservation of trace fossils in such an environment is extremely rare although modern analogues have been recorded (McNamara 1987). Under normal conditions track impressions on beaches are well defined only for a short period while the beach sand is damp. Definition is quickly lost as the sand dries and the impressions collapse. Usually this happens within hours. Notwithstanding this process, extra high tides and wind deflation usually ensure that all track impressions are removed within a time period of weeks.

One possible scenario that may have permitted track preservation is the following (A. Short pers. comm.). At the time the tracks were made the beach was prograding seaward, therefore progressively removing parts of the beach from wave action and overwash. The 300m width of remnant beach calcarenite lends support to this supposition. Secondly, the tracks were made at night, or during cool overcast conditions, and/or were quickly infilled by finer wind blown sand and subsequently overlain by dune bedding. Stranding and lithification of the entire series preserved the impressions until reactivated and exposed by erosional processes associated with the present high sea level.

GYPSUM LAKE SITE

Human and animal footprints occur around the margins of gypseous saline lakes northwest of Clare Bay (Fig. 1). Exact locations are not shown so as to preserve their integrity. The prints are preserved in lithified dolomitic and calcitic mud (Table 1) that forms a thin marginal crust around the gypsum lakes (Fig. 2). The case-hardened carbonate crust consists of a clotted fenestral fabric of intermixed fine dolomite and calcite with some altered calcarenite grains and reworked calcrete pisoliths. Other constituents are a few recognisable bioclasts and gypsum laths. These coastal lakes are typical of many stranded salinas that occur along the Eyre Peninsula coastline (Warren 1982a,b; Belperio et al. 1988). Small evaporite basins such as these formed at the peak of the Holocene marine transgression (c. 6000 radiocarbon yrs B.P.) from marine seepage into enclosed, calcreted interdune depressions. Deposition of crystalline selenite occurred as a result of intense summertime evaporation with sea-water seepage maintaining a consistent lake level equivalent to mean sea level. As these saline lakes rapidly infilled with gypsum, autochthonous limestones and dolomites simultaneously formed around their margins as a result of intermixing of meteoric and marine groundwaters. It is in such marginal dolomitic mudstones that the footprints in question were formed (Fig. 4).

The west coast saline lakes infilled very rapidly. By 5000 yrs B.P., sedimentation had mostly reached sea level and their surfaces became one of equilibrium between winter deposition and summer evaporation and deflation (Belperio et al. 1988). Lithification of marginal carbonate flats also occurred at about this time. A radiocarbon date of 5470 + 190 years B.P.

(ANU 5795) on the host carbonate of one of the footprint site is consistent with these independently - derived models of sedimentation (Gara and Cane 1988).

The prints formed as people, animals and birds walked, not necessarily simultaneously, over the soft carbonate muds. At the time, the main body of the lakes now represented by deflating gypsum surfaces, probably contained saline water, thereby providing a refuge for wildlife. At two sites, both adult and a child's footprints are preserved. The adult prints (Fig. 3C) are 20 cm in length and indicate a stride of 80 cm. The child's prints are 12 cm in length with a shorter stride of 30 cm. Alongside, and in some instances superimposed, are abundant tracks of emus (Fig. 3D) and kangaroos.

The radiocarbon date of 5470 + 190 yrs B.P. is consistent with known geological models. Thin sections indicate the incorporation of a significant proportion (c. 10%) of old or "dead" carbonate by reworking into the sediment. The radiocarbon date therefore most likely predates or overestimates the true age of the event by several hundred years (c.f. Belperio et al. 1984). Lithification and progressive case-hardening occurred soon after formation of the prints. They have since remained exposed to the atmosphere, subject to subaerial weathering. Small and large saline lakes are common along the entire length of the western Eyre Peninsula coastline. Their mode and age of formation are similar and there is good potential for the discovery of further trace fossils in similar marginal environments.

CONCLUSIONS

Trace fossils at several sites near Clare Bay occur in both Pleistocene and Holocene coastal sediments. Macropod tracks are preserved in a former shoreface environment that is now being exposed by coastal erosion. The host sediment dates from the last interglacial sea-level high stand of about 110,000 yrs B.P. A younger suite of prints are preserved in carbonate marl that formed around the margins of Holocene coastal saline lakes. Dated at about 5000 years B.P., these include human, emu and macropod tracks, that have not been buried by later sedimentation. Rather, preservation resulted from post-depositional lithification and sub-aerial case-hardening. There is good potential for discovering similar trace fossils in other coastal saline lakes of the west coast of South Australia.

ACKNOWLEDGEMENTS

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TABLE 1. Semi-quantitative mineralogy from XRD normalised peak heights.

Sample	Facies	Site	Gyp	Qtz	Cal	LMg	Dol
5434RS24	Beach calcarenite	A	-	23	35	38	4
5434RS25	Calcrete	A	-	21	71	-	8
5434RS26	Dolomitic marl	B	-	7	60	-	33
5434RS27	Dolomitic marl	B	5	7	71	-	17

* Gyp = Gypsum, Qtz = Quartz, Cal = Calcite, LMg = Low magnesian calcite, Dol = Dolomite.

FIGURE CAPTIONS

Fig. 1 Surficial geology, Clare Bay region.

Fig. 2 Coastal cross-sections at Clare Bay(A) and west of Clare Bay(B). Section A is based on an exposed cliff section, Section B is largely schematic.

Fig. 3 Photographs of trace fossils. (A) Macropod footprint pair at site A. (B) Mollusc feeding trail on the same surface as A. (C) Human footprint at Site B superimposed over an earlier emu footprint. Mud mounded between the heel and ball suggest slippery conditions. (D) Emu print at Site B.

Fig. 4 Schematic representation of saline lake genesis and environment of the human footprint site.

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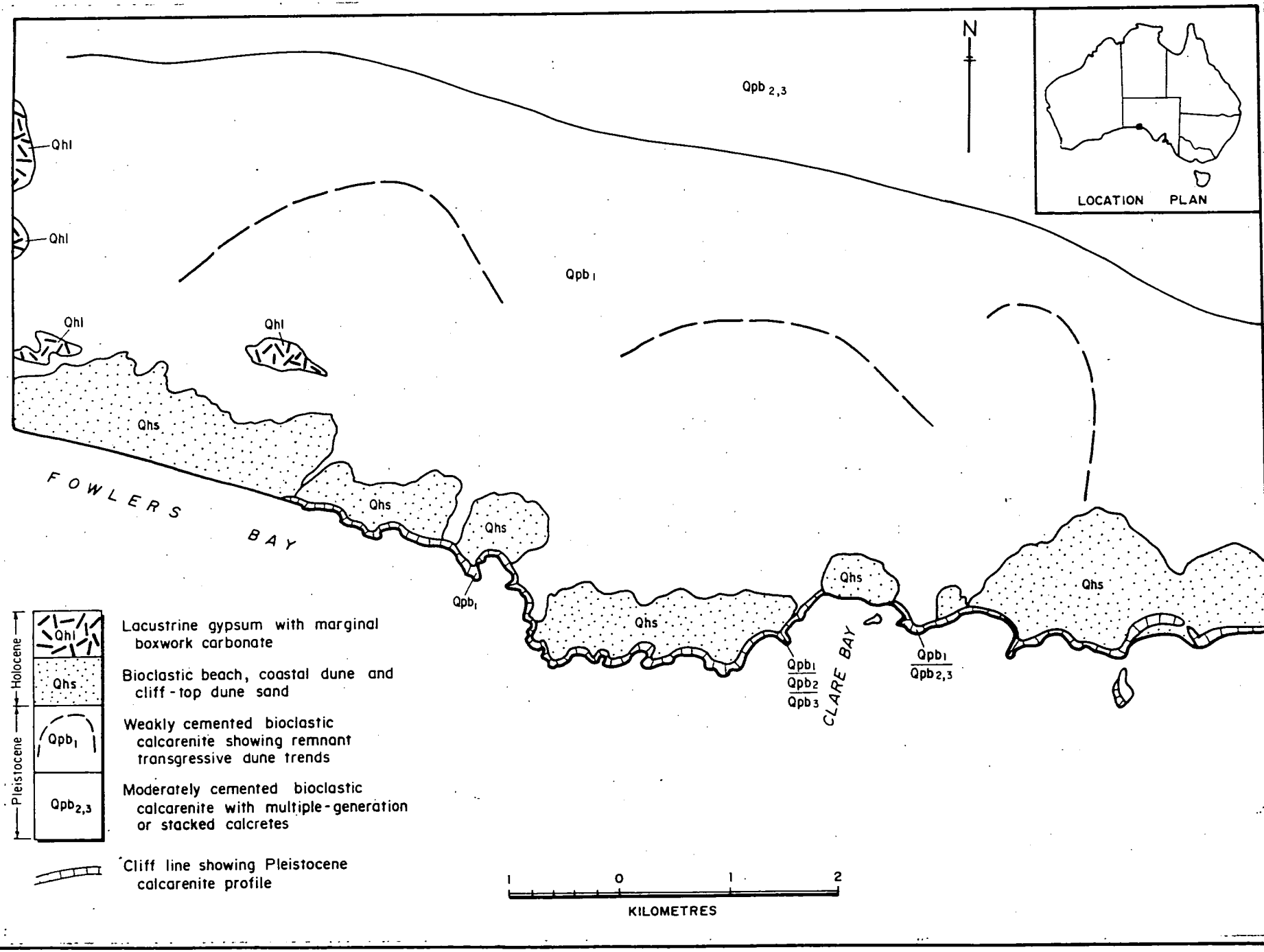


FIG. 1

SURFICIAL GEOLOGY

FOOTPRINTS IN COASTAL SEDIMENTS

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED	DRAWN	DATE	CHECKED
A.B.	R.B.	Dec 1988	C.D.O. 17.2.89

SCALE As shown

PLAN NUMBER **S20564**

4725

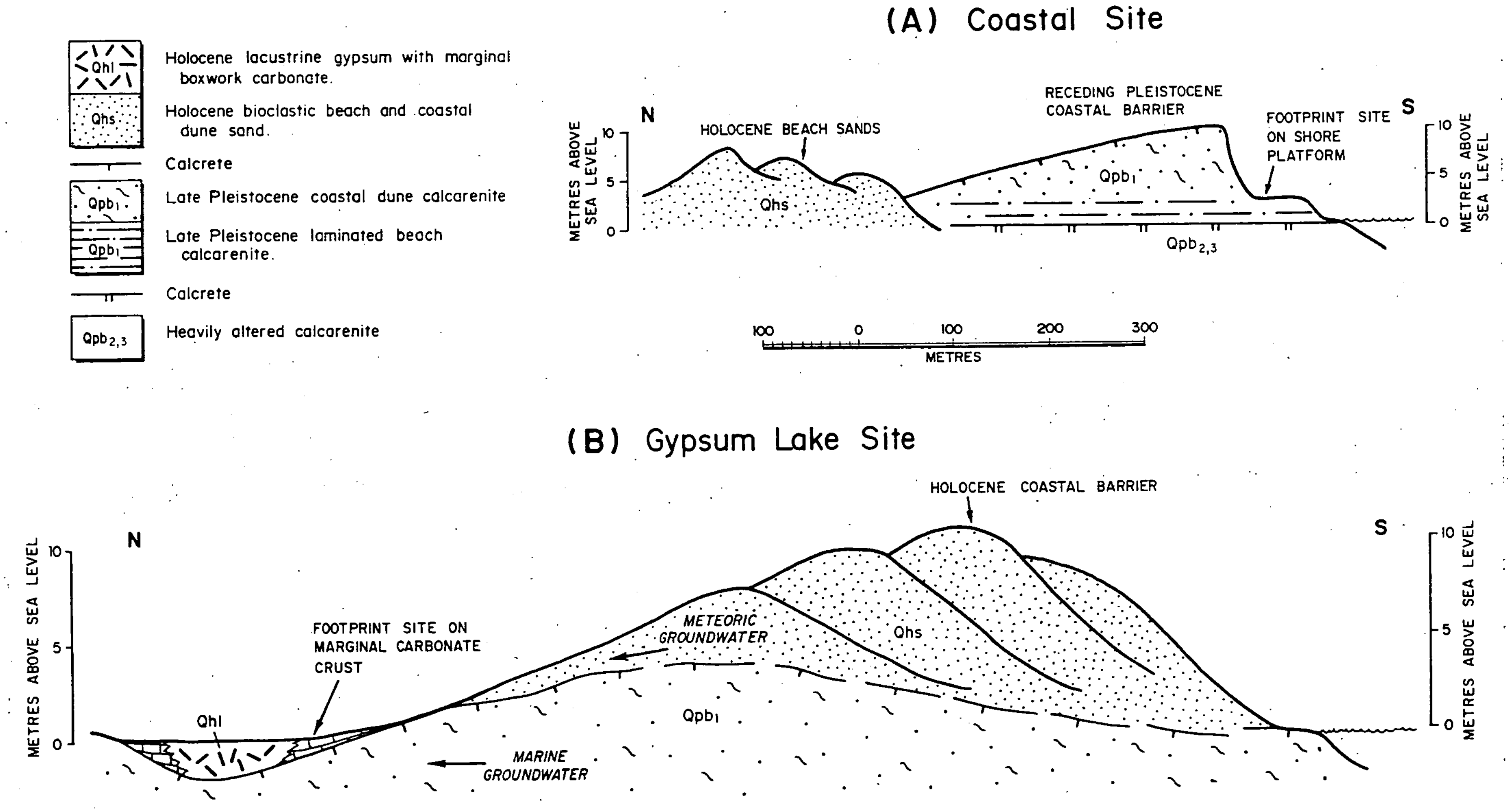


FIG. 2

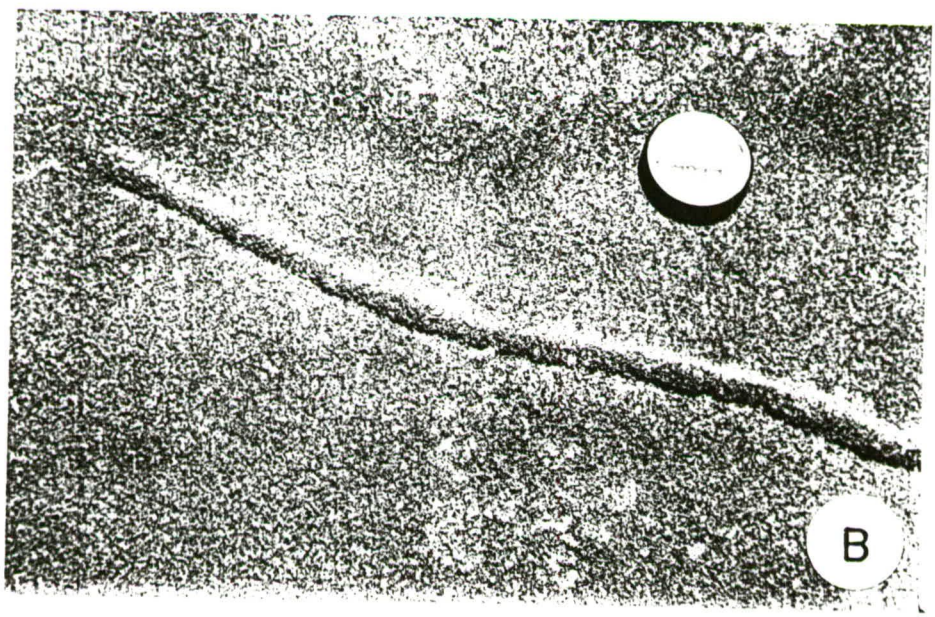
COASTAL CROSS-SECTIONS, CLARE BAY

FOOTPRINTS IN COASTAL SEDIMENTS

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

COMPILED A.B.	DRAWN R.B.	DATE Dec 1988
CHECKED		
C.D.O. 17.2.89 DATE	SCALE As shown	PLAN NUMBER S20565

MACROPOD FOOTPRINT



MOLLUSC TRAIL

FIG. 3a

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A.B.	CDO 17·2·89 DATE
FOOTPRINTS IN COASTAL SEDIMENTS	DRAWN R.B.	SCALE —
MACROPOD FOOTPRINT and MOLLUSC TRAIL	DATE Dec 1988	PLAN NUMBER S 20566
	CHECKED	

HUMAN FOOTPRINT

EMU FOOTPRINT

FIG. 3b

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A.B.	CDO 17.2.89 DATE
FOOTPRINTS IN COASTAL SEDIMENTS	DRAWN R.B.	SCALE –
HUMAN and EMU FOOTPRINTS	DATE Dec 1988	PLAN NUMBER S 20567
	CHECKED	

1225

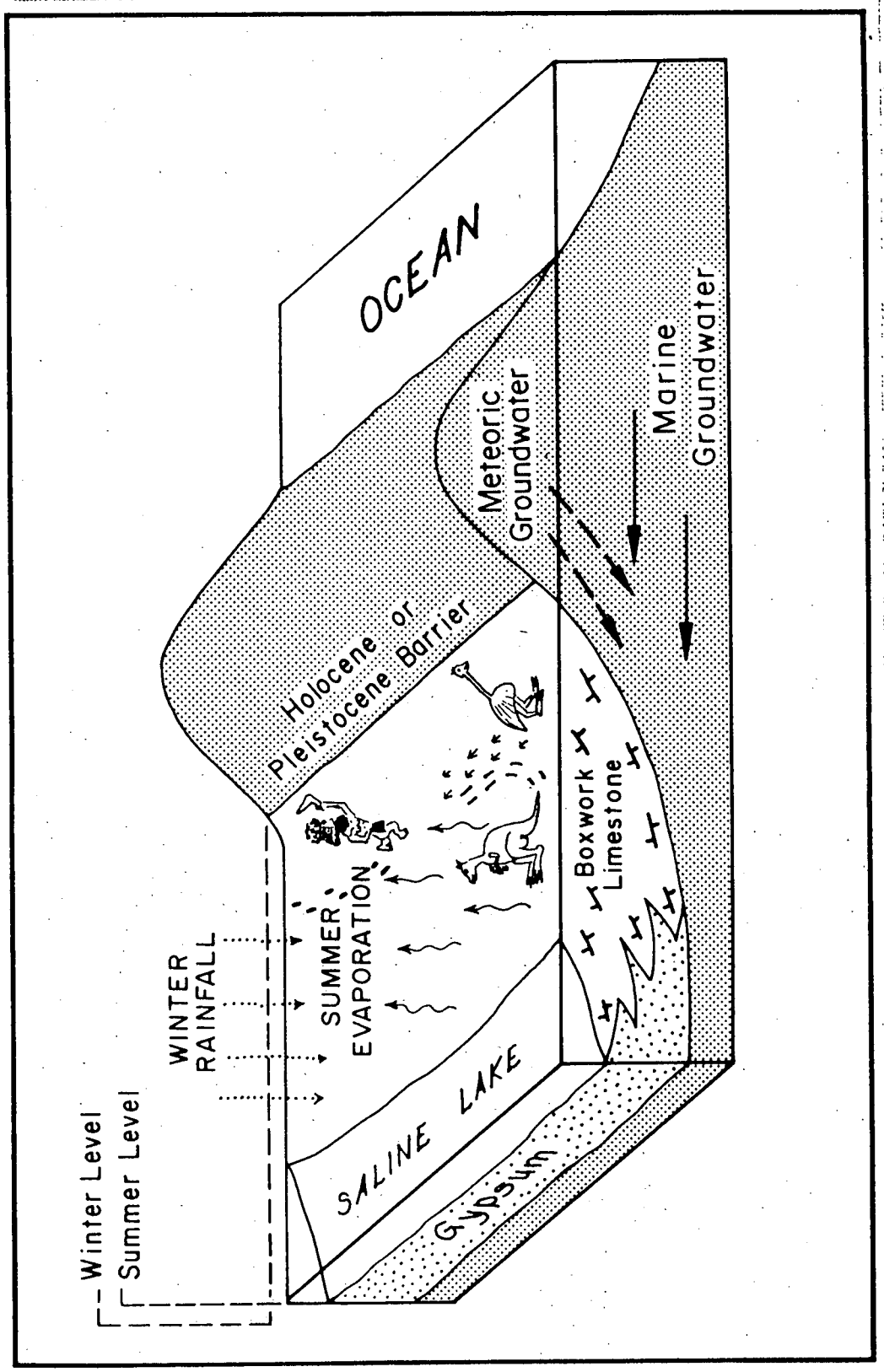


FIG. 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A.B.	C.D.O 17·2·89 DATE
FOOTPRINTS IN COASTAL SEDIMENTS	DRAWN R.B.	SCALE –
ENVIRONMENT OF FOOTPRINT FORMATION	DATE Dec 1988	PLAN NUMBER S.20568
	CHECKED	

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