Speleogenesis:
A brief insight into the spatial and temporal distribution of Australian karst

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In searching through past conferences for a suitable paper to write it became increasingly apparent that cavers in general very rarely consider the why, or how a particular cave, or cave locality, came to be where it is. Far easier to discuss first hand observations such as karst processes, troglobitic fauna, or surveying than to ponder how it all came about.

Introduction

In this paper I will be introducing the concept of spatial (occurrence in space) and temporal (existence in time) distribution of our major Australian caving areas, concentrating on what geological factors have lead to their deposition, prior to onset of karstification. What has this to do with caving? Not a lot. Caving is now, the origins of many of our limestones range in age to around 560 million years ago, yet if certain key events hadn't happened when and where they did, we wouldn't have the caves as we know them, nor would we have the need for cave conferences. The fact that the caves are there gives you an opportunity for a far broader understanding of the factors governing their existence in time and space. Just because they are there doesn't imply that they have always been there.

Spatial and Temporal Distribution

Broadly speaking, the major caving regions of Australia fall into four main categories dependent on age:

(I) Palaeozoic (Cambrian to Mid-Devonian; 560 to 380 million years ago) reefal limestone complexes, eg. Napier Range WA and Eastern Australian regions;

(II) Cainozoic (Mid Eocene to Early Oligocene; 50 to 35 million years ago) shallow marine shelf limestone, eg. Nullarbor Plain, Otway Basin;

(III) Quaternary (2 million years ago to the present) lava caves, eg. Western Victoria and;

(IV) Pleistocene (250 thousand years to the present) coastal dune calcarenite, eg. WA and SA.

This deposition of limestone and volcanic rocks in Australia is intimately linked with the breakup and dispersal of Gondwanaland (southern supercontinent) and, in particular, the breakup and dispersal of Australia and Antarctica.

Prior to the Upper Cretaceous (110 million years ago) Australia was firmly joined to Antarctica, with Tasmania nestled in against Victoria in what is now the northwestern Ross Sea region of Western Antarctica. This, and the subsequent breakup and dispersal of the two continents is shown in Figures 1 to 6, established from age dating of the Southern Ocean basin floor. At this time the Palaeozoic reefal limestone complexes of eastern and northwestern Australia were already in existence, long since having been uplifted and exposed to erosion and karstification by mountain building processes active between about 420 to 320 million years ago.

The Eucla Basin (Nullarbor Plain) lay well within the Eastern Gondwanaland supercontinent, essentially barred from any marine incursions, with Antarctica firmly locked in against the Southern Australian margin. Processes operating from deep within the Earth's mantle began to slowly stretch the Gondwanaland supercontinent, with breakup and dispersal of the two continents beginning in earnest around 55 million years ago. At this time the Eucla Basin, and associated Otway Basin to the east, were increasingly subjected to marine breakthroughs from the west along a narrow rift zone, possibly similar to the Red Sea rift zone between Africa and Saudi Arabia today.

During this period of Cainozoic continental dispersal successive marine ingressions led to extensive carbonate deposition in the Eucla Basin and terrestrial sedimentation, with lesser marine carbonates, in the Otway Basin. The Eucla Basin developed as a broad, arcuate, northward-shallowing ramp, the margins of which approximate the present day basin (Nullarbor Plain) margins.

Draining of the Eucla and Otway basin regions during the Lower Oligocene (approximately 35 million years ago) coincided with breaching of the south Tasman Rise, between Tasmania and Antarctica, and subsequent lowering of sea-level, estimated to be upwards of 200 to 250 m above present sea-level. This left the onshore Eucla and Otway basins emergent and subject to erosion, consolidation and karstification of the carbonates.

Volcanic activity in Victoria was fairly continuous during this period of Cainozoic continental breakup and separation. Older Volcanic activity peaked during the Palaeocene/Eocene (60 to 55 million years ago) coinciding with the period of initial breakup and rifting of Gondwanaland, while the Newer Volcanics peaked during the Pliocene/Pleistocene (2 million years ago to the present), possibly representing a period of reactivated rifting between Tasmania and the Australian mainland. The Newer Volcanics, prevalent throughout much of western Victoria, are of interest to cavers because of their lava caves, formed by draining of molten lava from beneath a solidifying crust, and/or steam bubbles.

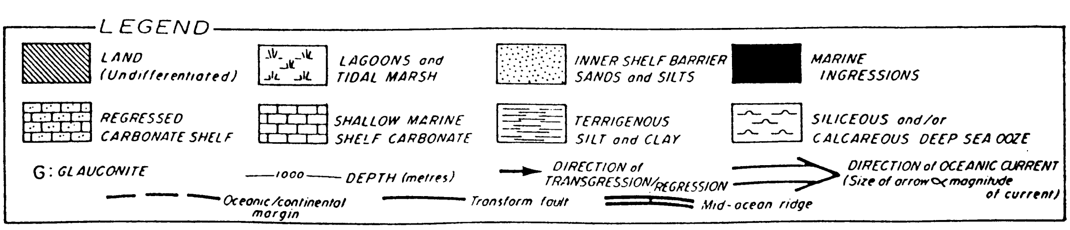
More recently, a series of rapid (geologically speaking) glacio-eustatic sea-level fluctuations, caused by periods of cyclical glaciation and glacial melting during the past 250,000 years, have given rise to extensive dune calcarenite (sandy limestone) deposition along much of our coastal regions, in particular Western Australia and South Australia. These dune systems were developed during periods of global warming and sea-level rise by the migration of foreshore beach/dune sequences, initially deposited during periods of low sea-level, and accumulating parallel to the coastline at peak sea-level. In WA, in particular, the cyclical sea-level rise and fall resulted in a stacked succession of dune ridges, whereas in SA they tend to form parallel singular dune ridges reaching well inland from the present coastline.

Conclusions

Okay, what has all this to do with caving? Palaeozoic reefal limestone complexes, outcropping in the Kimberleys and along the Australian east coast, were already uplifted and exposed to karstification long before crustal disturbances in the Late Cretaceous began fragmenting and dispersing the Gondwanaland supercontinent. Climatic conditions favoured deposition of a thick bryozoan limestone succession in the widening Eucla to Otway Basin rift zone between the Australian and Antarctic continents. Dispersal of the two continents during the Palaeocene/Eocene was marked by extensive older vulcanism in Victoria while breaching of the south Tasman Rise during the Lower Oligocene resulted in a draining of the Eucla to Otway Basin regions with exposure of the regions to erosion and karstification.

Vulcanism peaked again in Victoria during the Pliocene/Pleistocene as a result of renewed rifting between Tasmania and the mainland while, more recently, glacio-eustatic sea-level fluctuations during the Pleistocene gave rise to extensive coastal dune limestones along much of the Australian (and overseas) coastlines.

It is hoped that this necessarily brief introduction to the spatial and temporal distribution of caving areas in Australia has given you a better appreciation of why caves are where they are. It is important to realise that if these major geological events hadn't happened when and where they did, "The Earthy limestones and the Water that dissolves them, the Fiery volcanos and, in particular, the hot Air at this conference" would not be.



Legend for Figures

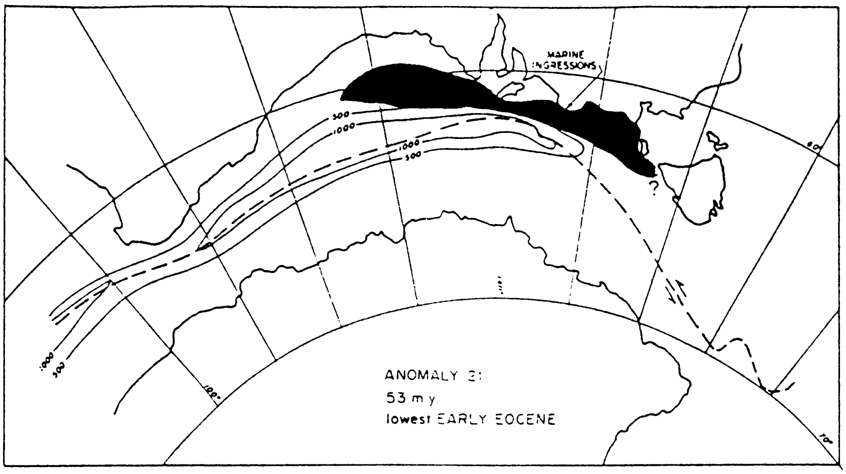


Figure 1: Paleocene to Lower Eocene marine ingressions in the Southern Ocean

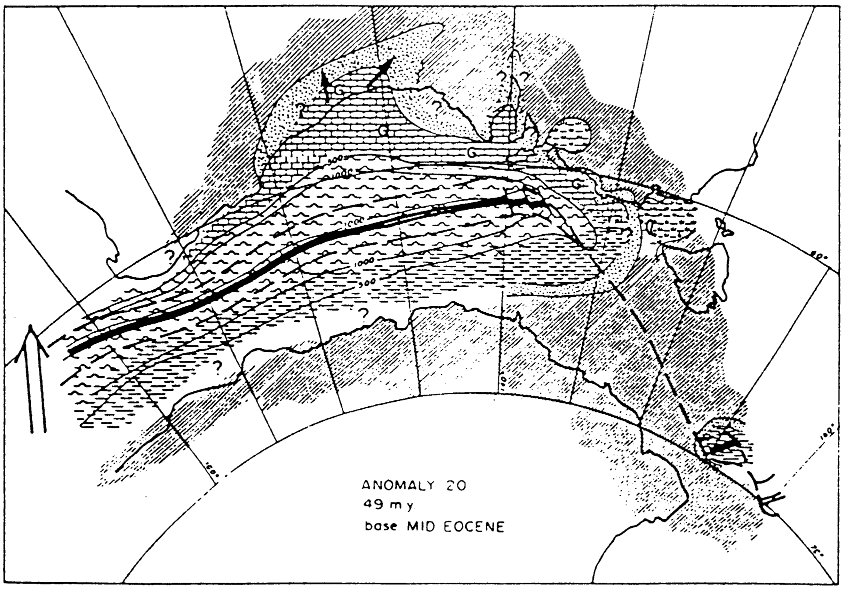


Figure 2: Lower Mid-Eocene depositional environments: Southern Ocean

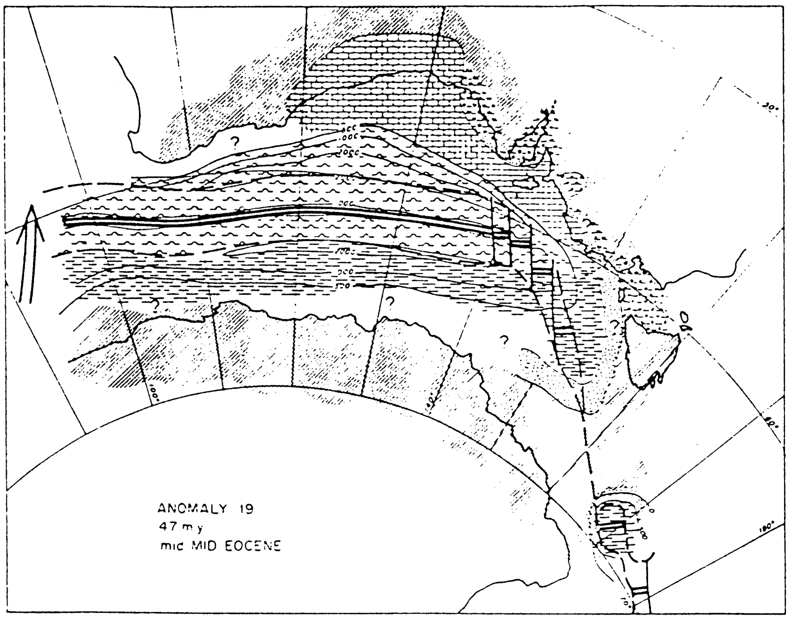


Figure 3: Upper Mid-Eocene depositional environments: Southern Ocean

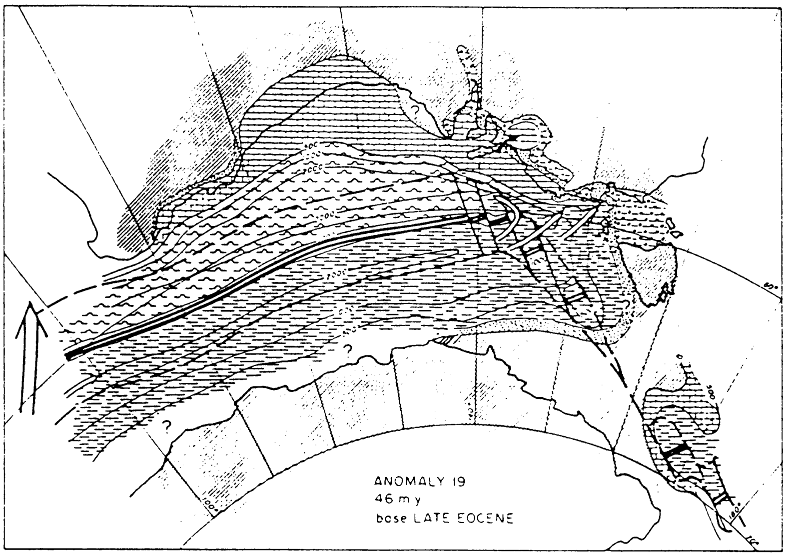


Figure 4: Late Eocene depositional environments: Southern Ocean

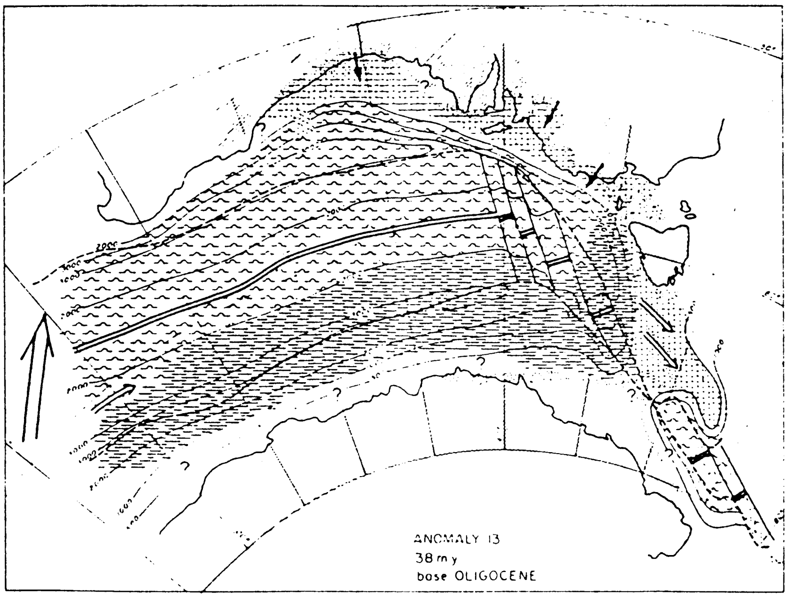


Figure 5: Lower Oligocene depositional environments: Southern Ocean

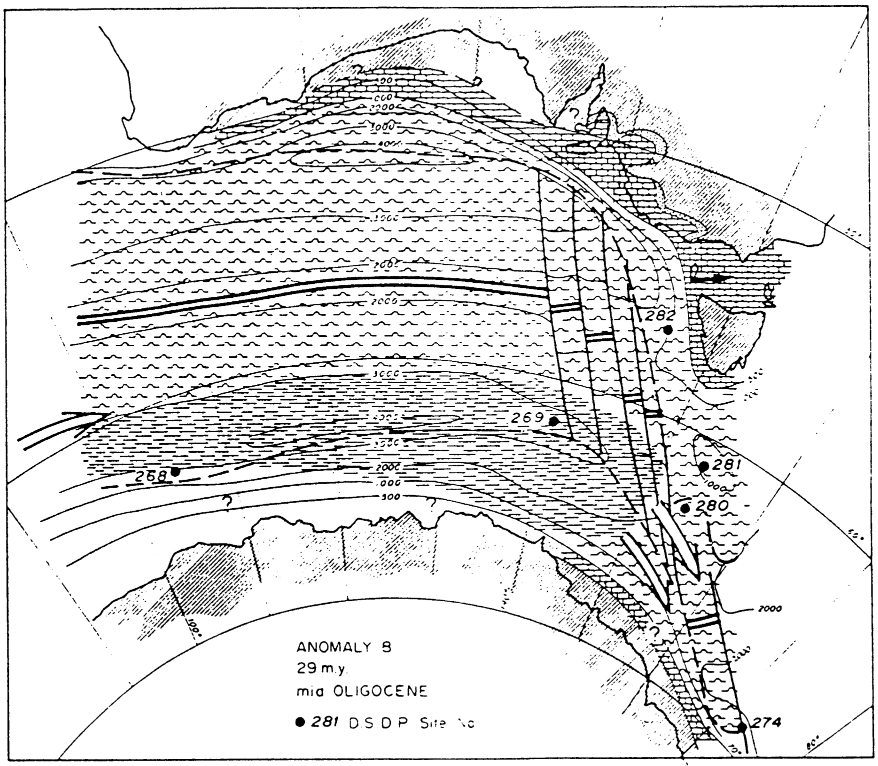


Figure 6: Upper Mid-Eocene depositional environments: Southern Ocean