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A SUMMARY OF THE STRATIGRAPHY AND PALAEONTOLOGY OF THE LAKES ENTRANCE OIL SHAFT, GIPPSLAND, VICTORIA

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The Lakes Entrance Oil Shaft is situated in allotment 31, Parish of Colquhoun, about 2 miles north-east of Lakes Entrance township, and at an elevation of 90 feet above sea level. The Shaft was sunk with the object of developing, by means of low pressure mining methods, the oil-bearing beds known to exist in the lower portion of the Tertiary basin in the Lakes Entrance area. It is a circular construction with a diameter of 10 feet at the surface. It is concreted down to the depth of 1,156 ft; a smaller timbered shaft carried it down to 1,204 ft, and a winze, 5 ft by 4 ft, was used down to 1,212 ft when operations were suspended as it was considered that this depth was the margin of safety allowed above the underlying artesian waters.

It is estimated that, during mining operations, approximately 12,000 tons of Tertiary sediments were excavated. Consequently a unique opportunity was afforded the palaeontologist and geologist to study the stratigraphic sequence of Tertiary beds in the Lakes Entrance area. The author was fortunate enough to pay frequent visits to the scene of operations where she made extensive collections of fossiliferous material. From time to time she observed the various stratigraphic stages and substages of the Tertiary sequence *in situ* on the walls of the Shaft. The brown, Micaceous marls and fine sandstones and the glauconitic sandstone of the Janjukian Stage have not yet been found exposed elsewhere in the Gippsland area.

SCOPE OF INVESTIGATION

The methods used in collecting the samples for micro-palaeontological examination and for studying the lithologic sequence were:

1. A sample of sediment averaging 4 lb. in weight was taken by the miners at every 4 ft from below the depth of 200 ft. Unfortunately, systematic sampling was not undertaken from the surface down to the depth of 200 ft. These samples were bagged and labelled to await the arrival of the author who divided each sample, one portion being brought to Canberra, the other being retained at the Shaft. Approximately 300 samples have been subjected to micro-palaeontological examination.

2. Samples taken over a wider interval and representing each change in lithology were laid out on the ground in proper sequence, thus giving an excellent view of the character of the sediments through which the Shaft passed.

3. The bulk of the 12,000 tons of sediments excavated was dumped from platforms 30 ft high and 80 ft long, which stretched across the valley west of the Shaft. Many excellently preserved megafossils were collected from these dumps. Because of the frequent visits of the author, it was possible to know the limiting depths to within a few feet of the material exposed at the time. Also the miners and other members of the staff were on constant watch for fossils *in situ*, and were instrumental in obtaining many beautiful specimens (Crespin 1945, 1946). Samples of sediments and fossils were also collected from the kibbles as they came up from underground. Exact depths could be assigned to these.

STRATIGRAPHIC NOTES

An important result of the palaeontological investigation of the sediments from the Shaft is that it confirms the stratigraphic sequence of the marine Tertiary deposits in Gippsland

as recently put forward (Cresspin, 1943). There is little variation in the thicknesses of the Stages and Substages in the Shaft compared with those based on small cores from bores in the vicinity. The characteristic lithology of the sediments of each Stage is also confirmed.

Furthermore, the investigation of such large quantities of material revealed the extended stratigraphic range of fossils, both micro and mega-forms, previously regarded as restricted. Such a result is inevitable when it is considered that the range of certain species in the Victorian Tertiaries has been based on material collected from surface sections which are limited in vertical extent and form small bore cores.

A short account of the Stages and Substages with their characteristic lithology and fossils as developed in the Shaft is given below:

The stratigraphic sequence of the beds is as follows:

Recent to Pleistocene	Post Kalimnan	0 - 10 ft
Lower Pliocene	Kalimnan Stage	10 - 150 ft
Upper Miocene	Mitchellian Stage	150 - 208 ft
Middle Miocene	(Balcombian Stage	208 - 952 ft
	(i. Bairnsdale Substage	208 - 524 ft
	(ii. Batesford Substage	524 - 728 ft
	(iii. Longford Substage	684 - 952 ft
	(Janjukian Stage	952 - 1,212 ft.
	(i. Micaceous Marls and sandstones	952 - 1,197 ft.
	(ii. Glauconitic sandstone	1,197 - 1,212 ft. (base of Shaft)

Recent to Pleistocene (Post Kalimnan)

Ten feet of sands referable to the above age cover the marine Tertiaries at the Shaft. The rostrum of a beaked whale (Mesoplodon longirostris) was discovered at the base of this bed, but Glaessner (1945) suggested that it had been weathered out of the upper Kalimnan (Lower ~~Pleistocene~~ Pliocene) which directly underlies these sands.

Lower Pliocene (Kalimnan Stage)

Unfortunately, no systematic collection of samples was made from the beds referable to the Kalimnan Stage, but the official log book showed that rich fossiliferous sediments occurred from 10 feet down to 150 feet. Material collected from the dump shortly after this depth had been passed, tended to confirm this.

The fossiliferous sandstone of the upper bed at Jemmy's Point was not recorded in the Shaft, which passed directly from the Post-Kalimnan sands into the lower fossiliferous horizon of that locality. The first fossiliferous beds exposed were ochreous sandstone which extended down to 50 feet. These overlay greenish grey sandy marls in which glauconite was common and mega-fossils fairly abundant. Many large molluscan shells were collected including Eucrassatella kingicoloides, Venericardia gippslandica, Panopea kalimnae, Chlamys

antiaustralis, Turritella conspicabilis, Fulgoraria fulgetroides and Bathytoma pritchardi. The microfaunal assemblage was typical of the Kalimnan elsewhere.

Upper Miocene (Mitchellian Stage)

At 150 ft the Shaft passed into the Mitchellian Stage which persisted down to 208 ft. The upper portion of the Stage consisted of greenish grey marl with Balcombian species becoming common and with decomposed remains of molluscan shells chiefly referable to Kalimnan species. With progress downward the glauconite content gradually disappeared and Kalimnan molluscan species gave way to forms more characteristic of the upper part of the Miocene, such as Pteria (Melagrina) crassicardia and Lima (Limatula) ieffreysiana. The foraminifera exhibited a similar mixed Plio-Miocene assemblage.

Middle Miocene

Balcombian Stage

The Shaft afforded an excellent opportunity to study the Balcombian Stage as developed in Gippsland. It passed through 744 ft of sediments, from 208 ft down to 952 ft. The sediments consisted of bryozoal limestones, marly limestones and bryozoal marls, characteristic of the Gippsland Limestone ("Polyzoal Series"). The stratigraphic sequence of substages of the Balcombian described in Section 5 of the Bulletin (Crespin, 1943) has been substantiated by further evidence derived from the study of large quantities of sediments from the Shaft. The characteristic foraminiferal assemblage for the Balcombian was persistent throughout the 744 ft of sediments. New species have been found in the three substages which may prove of zonal value when the investigation of samples is finalised.

i. Bairnsdale Substage. This typical substage of the Gippsland Tertiaries was well developed. It extended from 208 ft down to 524 ft, and consisted of bryozoal limestones, frequently hard, and bryozoal marly limestones. The rich shelly horizon found at the top of the Substage at the type locality at Pound Swamp, Bairnsdale, at Toorloo Arm, Princes Highway and elsewhere east of Lakes Entrance, was encountered at 320 ft. Fossils such as Clypeaster gippslandicus, Stethothyris insolita, Austrolima bassi, Spondylus baileyanus, Hinnites corioensis and Serripecten yabliensis were common. Specimens of the last named species together with the varietal form semilaevis were frequently present throughout the Substage. A band of large valves of Ostrea were exposed at 372 ft. Typical Balcombian species of foraminifera were recorded. Operculina victoriensis, as usual, made its first appearance, in downward sequence, towards the base of the Substage, at 472 ft. However, except for two occurrences, at 264 and 272 ft respectively, Amphistegina was not found elsewhere in the Bairnsdale Substage.

ii. Batesford Substage. The Shaft passed through the Batesford Substage from 524 ft down to 728 ft. The passage from the Bairnsdale into the Batesford could only be determined by the foraminiferal content. The lithology of the sediments in the Substage was white to grey, bryozoal limestone and marly limestone interbedded with bryozoal marls often green in colour and roughly bedded. The first typical Batesford Substage foraminifera to appear was Hofkerina semiornata at 524 ft. The first record of Lepidocyclina was at 580 ft and the last one at 684 ft. Cycloclypeus was not as abundant as anticipated, the only records being at 660 and 670 ft. Other species characteristic of the Batesford assemblage were usually present.

Bryozoa was abundant, but not well preserved in the marls. Amongst the larger fossils were Stethothyris insolita (common at 660 feet), Brissopsis archeri (at 660 feet) and Nautilus cf. geelongensis (660 feet).

iii. Longford Substage. The Shaft penetrated the Longford Substage at 728 feet and continued in it down to 952 feet. The sediments were represented by bryozoal marls chiefly grey in colour. But at 852 to 860 feet a greenish, glauconitic, shelly, bryozoal limestone was exposed. It contained numerous specimens of echinoids (chiefly broken), Stethothyris, Limatula, and Merripecten. This glauconitic bed passed down into grey bryozoal marls in which the bryozoa completely dominated the fauna. Towards the base of the Substage fragile molluscan shells began to appear. Batesford foraminifera such as Hofkerina semiornata, Gypsina howchini and Planorbulinella plana, were present in the upper portion of the Substage, but gradually disappeared as the lower limit was approached.

Janjukian Stage

Sediments referable to this Stage occurred from 952 feet down to the base of the Shaft at 1,212 feet. The two characteristic lithological units were represented:

i. Micaceous marls and fine grained calcareous sandstones.
ii. Glauconitic sandstone.

i. The micaceous marls and fine grained calcareous sandstones extended from 952 feet down to 1,197 feet. The top portion of this lithological unit was represented by brown micaceous marls which passed downwards into brown, fine grained calcareous sandstone. Towards the base of this unit glauconite became increasingly common and foraminifera and mollusca scarcer. The zonal foraminifera, Cyclammina incisa, Lamarckina glencoensis and Vaginulina gippslandica were recorded and were associated with numerous smaller forms, including species which are of zonal importance in the overlaying Balcombian. Small molluscan shells were common but the larger forms were distributed more sparingly, and were usually found in thin bands. The shells were fragile and consequently were difficult to collect intact. Amongst the commoner forms were Volutispina anticingulata, Turritella aldingae (very common), Limopsis chapmani (very common) and Venericardia janjukiensis. A well preserved specimen of Carcharodon megalodon was collected at 1,018 feet and remains of a crab, recently described as Harpactocarcinus victoriensis, at 1,000 feet, (Crespin, 1946).

A prominent feature of this lithologic unit was the occurrence of hard bands of brown, calcareous sandstone. Similar bands had been encountered in all bores in Section 1, that had penetrated the Janjukian, but little was known of their mode of occurrence. The diameter of the Shaft was such that it permitted the study of the bands in situ. They proved to be "floaters" ranging up to 6 feet in length and varying in thickness from 2 inches up to 12 inches. Fourteen of these lenticular shaped floaters were encountered in the Shaft between the depths of 1,020 feet and 1,162 feet. The rock was richly fossiliferous, but the hard nature of the rock made extraction of the fossils difficult.

ii. The Shaft passed into the glauconitic sandstone at 1,197 feet. The thickness of this lithological unit was not proved as sinking operations were discontinued at 1,212 feet. The topmost samples consisted of fine angular, quartz grains with numerous ovoid pellets of brown and green glauconite. A few foraminifera such as Anomalina grosseru-

gosa, Eponides scabriculus and Elphidium crassatum were noted. The typical glauconitic sandstone was reached at 1,198 feet. This rock was very fossiliferous. Many large specimens of mollusca were present, Venericardia janjukiensis a small species of Ostrea and Turritella aldingae being particularly abundant. Cyclammina was recorded amongst the foraminifera.

The glauconitic sandstone was oil-bearing, but the quantity of oil available was not large enough to warrant the continuance of mining operations.

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