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Art. VIII.—*On the Age of the Bairnsdale Gravels; with a note on the included Fossil Wood.*

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(With Plate X., and 1 text figure).

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Occurrence.

The uplifted coastal plain, which extends from the hill-ranges of South Gippsland on the west to Cape Howe on the east, is covered with a sheet of coarse gravel and sand, in which are frequently found silicified tree-trunks with their structure excellently preserved.

Some two or three years ago, whilst travelling from Bairnsdale to Orbost by the new railway line then in course of construction, I was impressed with the enormous extent of these gravel beds which were met with along the greater part of the country traversed. On examination, the gravels were found to contain many kinds of hard rock, both quartzitic and igneous, undoubtedly derived from the high lands to the north. Dr. T. S. Hall has remarked upon this gravel sheet, in its occurrence in the western area, as follows:—[1]

"A striking feature of the Tertiary plateau to the north of the lakes is the presence of a great sheet of gravel and sand which covers the district, as seen on the railway line from Flynn's Creek to Bairnsdale. West of Sale sands predominate, but from Sale to Stratford coarse gravels are common, and the same may be said of the country from there to Bairnsdale. The same gravel plateau, deeply trenched by streams, extends along the Buchan road, with but a slight intermission, as far as Stony Creek. The rocks composing the deposit vary considerably, in places rounded quartz predominates, but in others quartzites and ferruginous hardened sandstones are very common. They evidently represent a waste sheet from the mountains to the north."

In a traverse from Bairnsdale to Neumerella I noticed these torrent gravels usually rested on, or passed into, fine sand; more-

1 Some Notes on the Gippsland Lakes. Vict. Nat., vol. xxxi., June, 1914, p. 33.

over, the beds were especially developed (as seen in excavations along the railway line) from Bairnsdale to the Nicholson River. They again became predominant from Mossiface to Bruthen. From Stony Creek through Nowa Nowa to Tostaree as far as Hospital Creek they appeared in sheets of considerable thickness, whilst in nearing the Snowy River basin they were again seen. At 23 miles 18 chains east of Nowa Nowa the Bairnsdale Limestone reappeared and the section in the cutting shewed torrent gravel 3 feet, resting in a great thickness of limestones and marls of Janjukian or Miocene age. The gravel bed near Neumerella shows a thinning out owing to uplift and denudation in this district.

The thickness of the gravels varies greatly according to local position, and, as we might expect, they are thickest in those areas which, during their deposition, were subject to subsidence and estaurine influence. Thus, in the trend of the old valleys of the Macallister and Mitchell Rivers, we have such evidence from the borings put down in search for water. At Paynesville a pebble bed was met with at 100 feet which, in all probability is the same as the gravel bed now under discussion; at 160-260 feet Kalimnan fossils from the same boring were identified by the writer, whilst deeper still the Janjukian strata were in evidence.[1] And here must be explained an apparent discrepancy of opinion regarding the much greater thickness of these gravel beds which Dr. Hall[2] was led to assume from data given to the Conference on Artesian Water in 1913, since he remarks that "At Paynesville water was struck at 520 feet in terrestrial gravels." The deposit in question belongs to the older series, and is Miocene or Janjukian, the mistake having arisen from the bore-foreman describing the silty, shelly (marine) deposit as "terrestrial gravel." This curious error shows the necessity of a palaeontological examination of the deposits before any accurate conclusion as to origin can be arrived at. It is also extremely probable that the same results would obtain from an examination of the boring products of Sale and Fernbank, also alluded to by Dr. Hall.

As we pass over to the eastern border of the ancient Gippsland Bight we notice that much of the coastal plain has again disappeared beneath the sea, and we get only the inner border of the deposit, naturally with coarser boulders, and lying against the flanks of the old rocky coast-line. This character is maintained

1 Chapman. Cainozoic Geology of the Mallee and other Victorian Bores. Rec. Geol. Surv. Vict., vol. iii., pt. iv., 1916, p. 402.

2 Vict. Nat., vol. xxxi., June, 1914, p. 33.

on to Cape Howe, where it disappears against the truncated rocks of the Pacific Coast.

Age of the Gravel Bed.

From the geological evidence of the formation of a peneplain with leaf-beds and Miocene, or "older basalt," lava flows in the mountain regions of Gippsland, it may be concluded that the great uplift of this fairly mature area, geographically speaking, took place at the close of the Miocene and Lower Pliocene (Kalimnan) times, named by E. C. Andrews "The Kosciusko Period."[1] A range of high land running more or less parallel to the south-eastern coast of Australia was then elevated to heights varying from 2000 to 7300 feet above sea-level. Following upon this, along the Gippsland Lakes district, there is evidence of a secondary subsidence, which is progressing even down to the present time. This Late Pleistocene to Recent downward movement is proved by the drowned ends of river valleys, as pointed out by Dr. Hall,[2] which are seen at the North Arm of Lake Cunninghame, Lake Bunga and Lake Tyers. Further proof of this subsidence is met with in the great depths of the river valleys near the coast; and in that district in 1915, I had the opportunity of seeing the pile driving for the Nicholson River Bridge, where 80 ft. of alluvium had been penetrated without reaching bedrock. That this subsidence, however, is intermittent, is proved by finding not very far away, low cliffs of Kalimnan sands well above sea-level and surrounded by the torrent gravel.

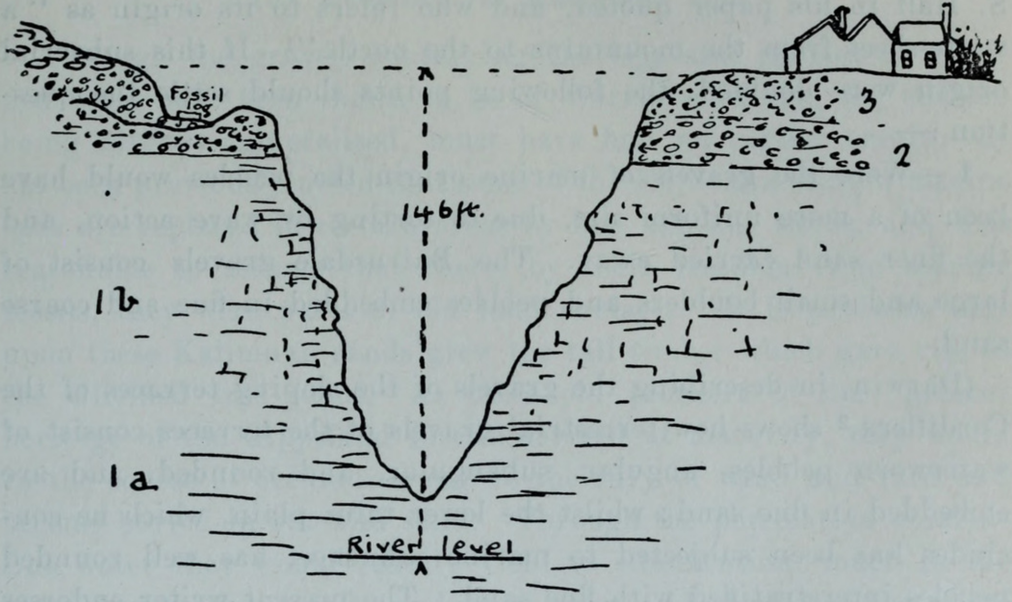
So far as my own observations go, the torrent gravels with their large boulders and rounded fragments of silicified wood seem to rest on or pass downwards into fine sand; at other times to rest on older rocks (Janjukian). The lower sands are undoubtedly of Kalimnan age, as they represent the Moitun and Boggy Creek ironstone series of McCoy, and also the Jimmy's Point shell-marl. This sequence is supported by evidence already published by Messrs. Dennant and Clarke,[3] for in a section of Underwood's Cliff at Bellevue, N.W. of Bairnsdale (see woodcut), we have a ferruginous sandy conglomerate pasing upwards into heavy gravel wash (=torrent gravel) with a fossil log; this is underlain by fourteen feet of ferruginous fossil blocks (containing Kalimnan fossils),

1 Geographical Unity of Eastern Australia. Journ. and Proc. R. Soc. N. S. Wales, vol. xlix., pt. iv., 1910, pp. 420-480.

2 Vict. Nat., vol. xxxi., 1914, p. 32.

3 Proc. Roy. Soc. Victoria, vol. xvi. (n.s.), pt. i., 1903, p. 22, pl. iv.

then four feet of clay, eighteen feet of limestones with fine gravel, four feet of yellow limestone and one hundred feet of alternating hard and clayey limestones. Seeing that the ferruginous bed at Underwood's contains Lower Pliocene fossils, the torrent gravel which rests upon it, on acount of its different lithological structure, will be post-Kalimnan. Allowing for the great physiographic



Section at Underwood's, Lower Mitchell River. After Dennant and Clark, with additions. Showing relative position of Gravels with Silicified Wood.

1a—Janjukian marls; 1b—Janjukian limestone; 2—Kalimnan fossiliferous ironstone; 3—Gravels (Werrikooian), with silicified wood.

changes which have taken place since Kalimnan times, the beds of gravel immediately following could hardly be younger than Upper Pliocene or Werrikooian. That Dr. Hall was inclined to regard these gravel beds as older, that is, of Kalimnan age, can be gathered from his remarks in the paper on the Gippsland Lakes,[1] where he says: "Clear evidence of the age of the gravels is shown at Red Bluff, near the mouth of Lake Tyers. The cliffs here consist of yellow and grey sands crowded with *Arachnoides incisa*, Tate, and are of Kalimnan (? Miocene) age. The sandstones contain a few quartz pebbles, which form intercalated sheets in the upper part of the cliff." If, however, we regard this upper bed as distinct from the lower yellow and grey sands, we must necessarily conclude that they are of later age than the echinoid-bearing sands,

1 Loc. supra cit., 1914, pp. 33, 34.

and therefore Post-Kalimnan or Werrikooian, and this conclusion appears to agree with the evidence from Bellevue and the general sections along the Orbost railway line. Moreover, these lower sands with echinoids are, *prima facie*, marine, whilst the torrent gravel by the nature of its composition, as the débris of mountain streams, is undoubtedly of terrestrial origin.

This term "terrestrial gravels," was previously used by Dr. T. S. Hall in his paper quoted, and who refers to its origin as "a waste-sheet from the mountains to the north."[1] If this subaerial origin were doubted, the following points should settle the question :—

1.—Were the gravels of marine origin the pebbles would have been of a more uniform size, due to sorting by wave action, and the finer sand carried away. The Bairnsdale gravels consist of large and small boulders and pebbles embedded in fine and coarse sand.

(Darwin, in describing the gravels of the sloping terraces of the Cordillera,[2] shows how terrestrial gravels of the terraces consist of waterworn pebbles, angular, subangular, and rounded, and are embedded in fine sand; whilst the lower talus plain, which he concludes has been subjected to marine influence, has well rounded pebbles interstratified with fine sand. The present writer endorses these distinctive points from observations made on raised beach deposits both round the British Islands and on the Australian coast.)

The same physical structure is seen in the case of glacial tills, where sorting by levigation has had no chance to work.

2.—In a marine beach or littoral deposit, sea-shells, shell-fragments or encrusting organisms would almost invariably be present. For example, the gravelly marine beds (Janjukian and Kalimnan) of the Paynesville Bore *do* contain marine shell-fragments. The Patagonian beach gravels have the pebbles frequently encrusted with marine organisms.

3.—The presence of silicified (derived) blocks of fossil wood clearly point to a terrestrial origin, for if drifted wood it must have been silicified subsequently to deposition, yet there is no trace of the siliceous cementation of the bed containing the wood. Moreover, all drift wood in fossil deposits seen by the writer showed traces of attack by marine organisms as *Teredo* and worms.

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1 Victorian Naturalist, vol. xxxi., 1914, p. 33.

2 Darwin. Geol. Observations on the Volcanic Islands and parts of South America, visited during the voyage of H.M.S. Beagle, 2nd ed., 1876, pp. 286-9 and pp. 290-92.

4.—The unconformable relation of this gravel bed to the underlying shallow marine deposits, and its aspect in regard to the present physiography of the coast allow of no other conclusion than that it is terrestrial.

Age of the Fossil Wood.

(a) *Evidence for Kalimnan Age.*

Although the gravels containing the logs and pebbles of silicified wood have been shown to be of Werrikooian age, the timber, being already mineralised, must have had an earlier origin. It has been previously noted that some of the Kalimnan shallow marine beds are replaced in certain areas by fine silicious sands, and it is reasonable to assume that there, by their freedom from marine fossils, they were parts of old land surfaces. It is probable that upon these Kalimnan sands grew the tall timber which gave rise to the silicified tree stems. As these old pioneers of our present heritage of the Gippsland forests arrived at maturity, they would in the course of events succumb to the fury of wind and rain and become buried in silt and sand. Through the percolation of alkaline water they would readily yield to silicification, much in the same way as the *Acacias* and other trees and shrubs of the Cairo petrified forests were formed.

That these trees did not grow in any profusion on the slopes of the northern ranges is an inevitable conclusion, seeing that at that time, as now, there must have been a great deal of vertical erosion on the sides of the hills, and that the natural home for the forests would be along the foothills and flats. There the accumulated remains of logs and branches would be gathered, where quieter conditions of deposition would obtain, inducing fairly rapid silicification. The same forces which would break up the surface of the older beds to form the Werrikooian gravels would also bring down the fragments of volcanic rocks and quartzites from the high lands to the north.

(b) *Evidence for Janjukian Age.*

On the other hand it might even be proved by the collection of further evidence from stratigraphical relationship, that the silicified wood was derived from quartzitic deposits under the older (Miocene) basalt-lavas, of which there are numerous remnants along the upper reaches of the Dargo and Tambo Rivers. This could only be arrived at by a careful search of valley sections in those areas, for evidence of silicified tree-stems *in situ*.

With regard to the silicification of loose sand overlain by basalt, it is, for example, well known that the sands of Kalimnan age in the Melbourne area which would otherwise be of loose texture, where covered by the newer basalt, are consolidated and silicified, it may be assumed, by alkaline waters from the overlying lavas, which either contained dissolved silica or dissolved it during percolation; and frequently pieces of wood are found in the sands which have been preserved through the reactions from the lava above. It is therefore easy to conceive that in the same way the thorough silicification of logs of wood might occur in the Miocene deposits of the uplands and plateaus of Gippsland, where leaves of Eucalypts and fronds of ferns have been found, as at Dargo and Bogong.

Up to the present no information regarding the occurrence of silicified wood in the Dargo district has been furnished, the wood there found being merely lignified. Thus, Reginald A. F. Murray, in his "Report on the Geological Survey of Portions of Dargo and Bogong,"[1] mentions gravels, sands and clays with impure lignites of Miocene age, resting on the bedrock and overlain by Miocene basalt (op. cit. p. 98). The same author (p. 102) says, "In a head of the Bundarrah, on the south-western margin of the basalt, are exposed beds of yellowish brown laminar clay containing fossil leaves"; and again (p. 106), referring to the beds exposed on the Mayford Spur at Synnot's claim, he states that "here also are siliceous conglomerates and ferruginous bands containing fossil leaves."

Description of Fossil Wood.

Specimen A. *Eucalyptus* aff. *melliodora*, Cunningham.

This specimen is a slab of silicified wood measuring about 15 cm. × 9 cm. × 3 cm. It was presented to the Museum collection by Mr. G. S. Rees, of the Construction Branch of the Victorian Railways, and was obtained by Malcolm S. Moore, B.E., in 1915, from Bruthen, during the construction of the Orbost railway line. The following is a note on its occurrence kindly supplied by Mr. Moore at my request:—

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1 Prog. Rep. Geol. Surv. Vict., No. V., 1878, pp. 96-117.

"This fossil wood is found in the coarse gravel beds which overlie the limestone and finer drift sands, and which appear to mark the course of the creeks in late Tertiary times. They frequently form the resistant material which has determined the position of the ridges. The fossil wood occurs with pebbles of quartzite, milky quartz and various volcanic rocks. The wood is always rounded and waterworn, and appears to have been petrified in some deposit previous to the one in which it is now found. The pebbles come from rocks which form the hills northwards from Omeo. There is abundance of Yellow Box growing in these hills at present."[1]

The general appearance of this specimen of fossil wood is closely like that of Yellow Box (*Eucalyptus melliodora*). Sections were cut in three directions, microphotographs of which accompany these notes.

Annual rings.—These average about 2 mm. apart in the fossil. In the Yellow Box specimen before me they average about 2.5 mm. This difference might of course be due to dryness of soil in the case of the fossil specimen, and in any case there is always a large amount of variation even in individual examples.

Pores.—In the fossil specimen these are thin-walled and rather densely packed. In *E.melliodora* they are moderately thin-walled and slightly less densely packed. In *E.obliqua* (Messmate), the pores are large and more dispersed. In *E.hemiphloia* (Grey Box) and its variety, *albens* (White Box), the pores are very dense. In *E.regnans* (Mountain Ash Gum), the pores are large, and more widely dispersed than in the fossil specimen, and the walls are thicker. *E. Sieberiana* (Silver Top) shows a closely similar structure to the fossil in transverse section. In *E.macrorhyncha* (Victorian Stringy Bark) the pores are less numerous than in the fossil.

Tangential Section.—The cross sections of the medullary rays in the fossil as compared with *E. Sieberiana* are shorter and more irregularly curved and tapering, whilst it closely agrees with those in *E.melliodora*. In *E.regnans* the fibres are denser and the medullary rays more numerous.

Radial Section.—The bundles of cells forming the rays in the fossil wood are much coarser in structure than in *E.hemiphloia*, and are exactly similar to those in *E.melliodora*. In *E.leucoxylon* and *E.regnans* the rays are more closely arranged.

1 This last statement was in reply to a question as to whether Yellow Box was found in the district.

Upon submitting microphotographs of the wood to Mr. R. T. Baker, of the Sydney Technological Museum, who is a recognised authority on this subject, I have received the following interesting notes :—

"The weathered surface rather favours a coarse-grained timber, but such is not brought out in the other three. Your placing it near *E.melliodora* is a very good one, although the walls of the pores are much thinner than my specimens, otherwise I think it will do. In tangential section the rays are rather too small for that species than in my sections, but the radial is satisfactory. The other nearest Eucalypt is *E.albens.*"

The Eucalypt, *E.albens* referred to is the White Box, sometimes regarded as a variety of *E.hemiphloia;* but as already pointed out, the pores are much denser in *E.hemiphloia,* and its rays are smaller and more finely cellular.

From the above comparison I think one is justified in placing specimen A nearest *E.melliodora,* but evidently an ancestral form of that species. During the time elapsing between the Upper Miocene or Lower Pliocene and the present (at a low estimate of about one and a-half to two million years), there was ample opportunity for a species like that of the genus *Eucalyptus* to vary. This is not a bold assumption, seeing that within the scope of very modern physiographic changes, variations in the genus have undoubtedly happened.

Specimen B. *Eucalyptus* sp. aff. *piperita,* Smith.

This specimen of fossil wood is of an entirely different character of Eucalypt to the preceding. It was obtained from the same gravel beds, but at Baker's Bight, Mallacoota Inlet, by Mr. P. H. Bond, who presented it to the Museum. The specimen measures about 31 cm. x 5 cm. x 5 cm. It is similarly silicified, though not so completely, and shows the burrows of a longicorn beetle traversing part of the wood; this burrow is about 6 mm. in diameter, and resembles those commonly found in such wood at the present time.

From a comparison of the wood structure this specimen comes nearest to *E.piperita* (White Stringy Bark). The radial section shows the same characters in having the compressed cells of the rays in perfectly straight series and of the same dimensions; while the marked fissile character of the liber cells is more like that species than *E.obliqua.* The latter species, moreover, has larger radial tubes, and the pitted structure of the walls of the vertical ducts or pores is more conspicuous.