

Preliminary Note on the Clifden Beds.

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IN 1921 Professor Park* published a brief account of some Tertiary localities in Southland. The most important of these so far known is at Clifden, where the Tertiary beds extend for nearly half a mile along the right bank of the Waiau River. Park states that "a rich harvest awaits the collector at Clifden," but also that "no attempt was made to make collections of fossils anywhere." Accordingly a visit was made to this locality in the hope that it might prove of interest, and the results have already far exceeded expectations.

The beds are sometimes a little difficult of access, but the fossil forms obtainable are so new and magnificent, and their preservation so fine, that the labour is well spent. Some four hundred species are now in hand, the majority of which have proved exceptionally interesting. Preliminary study of these forms shows that, though the beds from which they come are younger than the Waiarekan, they are as certainly older than the Awamoan. The very rich fauna and the exceptional preservation make comparison easy, and there is no doubt that the Clifden fauna is a peculiar one, and represents a facies not previously known in New Zealand.

Park has grouped the basal concretionary plant-beds in the Waiarekan; the limestone and overlying glauconitic sandstone in the Ototaran; the four following highly fossiliferous sand beds in the Hutchinsonian; and the two highest bands in the Awamoan. No reasons are given for this classification, and it is possible that the fossiliferous beds should be placed in a lower horizon. Much confusion has already resulted in New Zealand from the misuse of palaeontological evidence, and the reliance on lithology alone, and we consider that the only safe guide to the age of many New Zealand beds is the accurate interpretation of their palaeontology. The Clifden beds are certainly puzzling, but the problem of their age seems to admit of only two solutions—i.e., the fossiliferous sands must apparently be treated as either Hutchinsonian or Ototaran—and the hypothesis which seems most reasonable, and demands the fewest assumptions, is the one that must be accepted. If the uppermost Clifden beds be considered as Awamoan, and the intermediate beds as Hutchinsonian, then these horizons apparently contain different faunas in Southland from those they would contain in Oamaru. (It must be mentioned, however, that strong faunal *resemblances* exist—the genera are nearly all the same, though most of the species are different; but this is usual in New Zealand, where there are very few sharp distinctions in the faunas of adjacent horizons.) Though reasons may be invented to support such a possibility, it would, if adopted, allow of unlimited licence in correlating

* J. PARK, *Geology and Mineral Resources of Western Southland, N.Z. Geol. Surv. Bull. No. 23 (n.s.)*, pp. 50–52.

geographically distant beds,* and it seems to us preferable to consider that, where the lithological conditions are not totally at variance, different faunas indicate different horizons.

Thus it seems probable that the Awamoan stage—in the strict sense—is not represented at all at Clifden. The topmost bed (No. 8 of Park) has, as might be expected, most analogy with the Awamoan, and may possibly be referable to a basal Awamoan stage, such as is represented by the Target Gully and Ardgowan shell-beds, though a definite statement cannot yet be made. It seems, however, almost certain that some of the lower, richly fossiliferous beds should be placed below the Hutchinsonian, the contained fauna being unlike that of beds at present referred to the Hutchinsonian†—e.g., Otiake, Blue Cliffs, Mount Brown, &c.

The importance of this is obvious, no satisfactory store of fossils having previously been discovered in beds of this horizon. The separation between Ototaran and Hutchinsonian at Clifden is not yet clear, though there does not seem to be any reason to doubt the Ototaran age of the limestone itself; in common with the other Ototaran limestones of New Zealand, its molluscan fauna (*Pecten huttoni* Park, *Epitonium lyratum* Zitt., *Chlamys* cf. *burnetti* Zitt.) is of such a nature as to be useless for age-determination, but the brachiopods seem to be Ototaran. It cannot possibly be Atiuan. For the determination of the true ages of all the Clifden beds much will depend on the brachiopods; we have collected specimens from several of the horizons, and have to thank Dr. Thomson for identifying many of them. Some curious correlations are suggested by the brachiopod evidence, but there are several apparently anomalous facts, and consideration of these is withheld till a more complete account can be given.

Unfortunately the beds beneath the limestone seem to be unfossiliferous except for plant-remains, which, in the present state of palaeobotany in New Zealand, are not of great use. On the east coast, at Wangaloa, is a Palaeocene fauna; between this and Clifden, at Chatton, occur shells which have been examined by one of us, and which show that the beds there are almost identical in age with the Wharekuri greensands (though of a more littoral character); at Waikaia are beds (now hidden) perhaps a little

* Dr. Marshall has used this plea when investigating the Pakaurangi Point fauna, and has correlated that locality first with Target Gully (*Trans. N.Z. Inst.*, vol. 49, p. 275, 1917), then with the Oamaru limestone (*loc. cit.*, vol. 50, p. 275, 1918), and finally with the All Day Bay beds—"that is, next above the Oamaru limestone" (*loc. cit.*, vol. 50, p. 276, 1918). Subsequent writers have often assumed these beds to be Awamoan. Their true age cannot be regarded as yet settled, but they are undoubtedly not Awamoan, if by "Awamoan" is meant the horizon of the beds at Awamo Creek and Pukeuri. The fossils of the Pakaurangi Point beds do not seem like those of Target Gully or Otiake, but have many points in common with those in our Clifden collections, as will be seen from the short list at the end of this paper. There are also a few significant relations with species from the Kakanui tuffs. The Clifden beds provide a nearer approach to the Pakaurangi fauna than does any other horizon at present known, and it seems advisable to treat the Kaipara beds as part of the great Ototaran-Hutchinsonian sequence; it is even possible that they may be older than all the fossiliferous bands at Clifden, and represent part of the stage developed there as limestone or unfossiliferous sands.

† If the name "Hutchinsonian" is to be restricted to a greensand horizon definable by its brachiopods, then a new term will be necessary for beds such as those mentioned, which contain an abundant molluscan fauna. This fauna is of an older type than that found at Target Gully, so that the name "Awamoan" should not be used; there is already too much laxity in the use of that term. Morgan (*Pal. Bull. No. 8*, p. 103) would merge the Hutchinsonian with the Ototaran, but a name is needed for the stage represented at Otiake, and in the meantime it seems preferable to employ one already in use. One of us has in preparation a detailed account of stages separable from the Hutchinsonian and Ototaran, and this matter will then be more fully dealt with.

older than the Chatton sands; and at Pomahaka, not far above the coal-measures, are tuffs containing a very peculiar and apparently brackish-water fauna of about a dozen species, which give no indications of their geological age. Apart from these occurrences, Lower Tertiary beds have not been discovered in Southland; no trace has yet been found of the Bortonian or of the other stages present at Waihao.

Long and tedious work will be necessary before the Clifden faunas can be thoroughly elaborated, and till this is completed only tentative conclusions can be drawn as to their age. If, however, the suggestions here put forward prove correct, it is evident that a rich molluscan fauna already flourished in New Zealand before the Awamoan, and, if one may judge by generic similarities, evidently gave rise to the Awamoan faunas. The range of many genera and some species will be prolonged into Hutchinsonian and perhaps Ototaran times, and this will considerably weaken the theory that a connection with some land-mass at about the Awamoan stage must be postulated to account for the sudden increase in fauna. Writers have commented on the richness of the Awamoan fauna, but even the preliminary collections from Clifden show that the fauna there is equally rich.

There is still, however, the tantalizing stretch of limestone even at Clifden, during whose deposition much faunal change must have occurred. From the thickness of the Clifden section it is evident that the deposition of the Ototaran-Hutchinsonian in the Oamaru district must have occupied a very long period of time. Park gives the maximum thickness of the Oamaru stone as 110 ft., and of the Clifden limestone as 160 ft., bands 2-6 occupy another 100 ft., and band 7 is 175 ft. thick. Now, the evolutionary differences shown between successive bands of the fossiliferous beds seem to be quite as great as, for instance, between the Hutchinsonian and basal Awamoan, or Awamoan and Mokauiian, so that, the rates of evolution being assumed equal, either these stages represented quite short time-periods, or the Ototaran-Hutchinsonian period, as at present understood, was of considerable duration.

The unfossiliferous nature of the Oamaru stone has been the source of much palaeontological confusion as regards faunas above and below it, and has prevented the clear reading of the evolutionary sequence between our early and middle Tertiary faunas. Although the upper beds at Clifden will materially help in this respect, the thick basal limestone again prevents the complete solution of the problem, and at present we are still left with the apparently sudden appearance above the limestone of a rich and varied fauna, which in some respects is very like, and in others very unlike, that found in pre-Ototaran beds. It can only be said here that a careful comparison of material from Wharekuri, Clifden, and Otiake leaves the impression that the evolution of our fauna proceeded equably throughout the limestone regime, and that if a new fauna did enter by means of a shallow-water connection at that period it scarcely disturbed the hardy pioneers already in possession.

The arrival of a new fauna is generally supposed to imply increased competition, often resulting in extinction of all but the hardest members of the prior colonists. The weaker members of the invading troop would also often find the changed conditions unfavourable, and would probably perish. This may possibly account for the failure of a large number of apparently newly established species and genera to survive beyond the Awamoan: e.g., *Pollia acuticungulata* (Suter), *Merica brevirostris* (Hutt.), *Hinnites trailli* Hutt., *Erato neozelanica* Suter, &c. At the same time,

there are certain genera, such as *Natica*, *Turritella*, *Venericardia*, *Leucosyrinx*, *Pseudotoma*, *Divaricella*, *Crepidula*, *Calyptraea*, and many others, which extend in an unbroken evolutionary line of slowly changing species almost throughout our Tertiaries. It is the presence of members of such genera—generally more plentiful than the restricted forms—that gives to successive Tertiary faunas in New Zealand an appearance so strikingly (and deceptively) similar. To this also is due the statement repeatedly made by Marshall* that the ancestral counterpart of any fauna can be found in the one preceding it. This is true for such genera as mentioned above, but unless it is true for all the genera Marshall's argument does not seem to be logical. It is only to be expected that the hardy members of our original fauna would, under conditions of comparative isolation, persist with but little change for a long time; there is no need to insist on absolute isolation. Further, this fraction of our various faunas, though superficially often overwhelming, is the least important; what one must consider most is the residue of short-living species and newly appearing forms. There seems to be no doubt that the ancestors of many forms cannot be traced in earlier horizons, and it is not reasonable to suppose that this is always due to imperfect collecting. As our knowledge stands at present it is impossible to assume that the Clifden fauna was wholly derived from that found in the Waiarekan greensands at McCullough's Bridge, or that that in turn was entirely descended from the Palaeocene fauna of the Wangaloan, though in each case evolution is no doubt responsible for a certain part. The real problem to be solved is the origin of the remainder.

Dr. Marshall has so consistently urged the continual isolation of New Zealand, and the evolution of every fauna from its predecessor, that the time has come when we may expect the pendulum to swing in the opposite direction. Without, however, committing ourselves on the subject, we believe that the molluscan evidence is at present too imperfect to allow of the postulation of definite land connections. Four things must be done before this can be attempted: (1) Revision of the palaeontological work begun by Suter (this will involve the recasting of most of the published lists); (2) very much further collecting and accurate comparison and determination of species; (3) search for missing stages below the Ototaran, and for a fossiliferous facies of the part of that stage known only as "limestone"; (4) more thorough comparison with Australian and South American Tertiary faunas.

In order that our conclusions as to the age of the Clifden beds may be more readily followed, we append a brief list of some of the characteristic forms from band 6. Positive identifications are as yet made in only the few cases where no doubt can exist: "cf." indicates that the shell is very close to the species mentioned, judging from literature, but may be new; "aff." indicates that the species is certainly new, but has its nearest relative in the species mentioned.

We would also like to mention that wherever comparisons with various faunas have been mentioned our conclusions have been drawn from a study of actual specimens; we have at no time relied on lists of fossils from the localities concerned.

* See, for instance, *Trans. N.Z. Inst.*, vol. 50, p. 277, 1918; vol. 51, p. 244, 1919; vol. 52, p. 126, 1920; and vol. 53, p. 96, 1921. From the last reference the following words may be quoted: "We have, then, been forced to the conclusion that from the time the Wangaloa and Hampden beds were deposited until the present day the marine mollusca of New Zealand have shown a gradual development, without any important additions at any time from other fauna regions."

Shells from Band 6.

- Erato* aff. n. spp. from Kakanui tuffs and Chatton.
Cypraea aff. *treliassickensis* Suter.
Heliacis aff. *aucklandicus* Marshall.
Galeodea cf. *muricata* (Hect.).
Epitonium cf. *tricinctum* Marshall.
Niso cf. *neozelanica* Suter.
Fusinus several species, aff. *kai-paraensis* Suter, *solidus* Suter, and further n. spp. from Waihao.
Fusinus aff. *climacotus* Suter.
Aethocola aff. *fleusosa* Marshall.
Cominella aff. *carinata* (Hutt.).
Typhis n. sp.
 "Scaphella" aff. *elegantissima* Suter.
Lyria n. sp.
Ancilla cf. *spinigera* Marshall.
Marginella n. sp. (also from Chatton).
Gemmula cf. *bimarginata* Suter.
Turricula aff. *lutescens* (Hutt.).
Bathytoma aff. *haasti* (Hutt.).
Pseudotoma aff. *robusta* (Hutt.).
Pseudotoma *excavata* (Suter).
Borsonia aff. *rudis* (Hutt.).
Leptoconus cf. *armoricus* Suter; and several other species.
Scaphander aff. n. sp. from Chatton.
Anomia cf. *poculifera* Marshall.
Glycimeris aff. *subglobosa* Suter.
Glycimeris aff. *treliassickensis* Marwick.
Glycimeris aff. n. sp. from Otiake (*laticostata* group).
Chama n. spp.
Pecten aff. n. sp. from Wharekuri.
Propeamusium cf. *zitteli* (Hutt.).
Venericardia subintermedia Suter.*
Protocardia patula (Hutt.).
Macrocallista sculpturata Marshall.
Corbula nitens Marshall.
Tellina cf. *inconspicua* Marshall.

Besides these, there are a few further significant species from other bands, as follows:—

From Bands 7 and 8.

- Ampullina* cf. n. sp., from the Waihoa greensands.
Natica n. sp. (also from Otiake).
Fusinus aff. *maorium* M. & M.
Ventricola n. sp. (also from Otiake).
Chione cf. n. sp., from Chatton.
Chama huttoni Hect.
Olivella cf. *neozelanica* Hutt.

From Band 4.

- Mitrella* cf. *inconspicua* Marshall.
Borsonia n. sp.
Turricula aff. *marginalis* Marshall.†

The present paper must be regarded as entirely preliminary; for the moment the various lines of evidence as to the age of these beds conflict so much that a satisfactory solution seems difficult. One fact seems to be clear—that the Awamoan, Hutchinsonian, and possibly Ototaran stages as at present constituted are too comprehensive, and urgently need subdivision before the work of correlation can be carried out properly.

* The shell described by Dr. Marshall (*Trans. N.Z. Inst.*, vol. 50, p. 272, 1918) as *Cardium (Glans) kaiparaensis* from Pakaurangi Point is, from the figure and description a juvenile of the shell described by Suter from the same locality as *Venericardia subintermedia*. It is certainly a *Venericardia*, Suter's original naming of Marshall's specimen being *Cardita (Glans)*, not *Cardium*, and it appears so in the list in *Pal. Bull.* No. 8, p. 3, and in Marshall's own list (*loc. cit.*, p. 274). There are one or two other discrepancies in this list—e.g., *Epitonium tricinctum* Marshall appears as *Epitonium trilineatum* n. sp.; and there are a number of misspellings. *Dentalium pareorense* is quoted as of Ihering (in vol. 51, p. 235, it is referred to Suter), *Cardium pulchellum* Gray appears in place of *Protocardia pulchella* (Gray), and *Epitonium browni* Zitt. is given a place. *Chione auriculata* Bartrum, described from this locality (*Trans. N.Z. Inst.*, vol. 51, p. 97, 1919), is apparently a *Lucinida*, close to *L. laminata* (Hutt.). One of us (*Proc. Mal. Soc.*, vol. 16, 1924) has proposed the name *Chlamys kaiparaensis* Finlay in place of *Pecten subconvexus* Marshall, preoccupied.

† This species belongs to the group containing *torticostata*, *marginalis*, *gravidata*, *ordinaria* (all of Marshall), and *hamiltoni* (Hutt.)—a group characteristic of early Tertiary horizons in New Zealand. (See Marshall, *Trans. N.Z. Inst.*, vol. 52, p. 114, 1920.)