THE SIGNIFICANCE OF CIRRIPEDES TO THE PALEOECOLOGY OF MOTUTAPU ISLAND.

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SUMMARY

A greywacke stack, part of the Waipapa basement rocks beneath the Waitemata Group, outcrops on the Western shore of Motutapu Island in the Hauraki Gulf.

Biotic elements associated with this stack, including a locally highly concentrated cirripede fauna, can be used to determine environmental changes during the deposition of the basal Waitemata sediments (Waitakian – Otaian).

During this period, an initial phase of transgression with a rapid deepening of water is envisaged, with the greywacke stack outcropping well below wavebase when the Hexelasma rich siltstone beds were deposited. This is followed by an influx of allochthonous material resulting in the deposition of a volcanic bryozoan grit, which includes a moderately shallow water fauna. Following this, the transgressive sequence continues, with only deep water faunal elements remaining in the overlying siltstone facies.

INTRODUCTION

Motutapu Island is one of a series of small islands within the Hauraki Gulf near Auckland. (Fig. 1). Geologically, the island can be divided into two parts, the Waitemata Group, dating from the lower Miocene (Waitakian – Otaian) to the west, and the Waipapa Group basement rocks, outcropping mainly to the east and occurring as isolated stacks through the eastern Waitemata sediments.

GEOLOGIC SETTING

The Waitemata sequence of rocks is generally sparsely fossiliferous, but in the basal silty sandstones and grit horizons, a wide range of molluscan, bryozoan and cirripede remains can often be identified. On the west coast of Motutapu Island, the basal Waitematas form both wide wave cut platforms and steep cliffs, the latter occurring especially when associated with basement outcrops.

In the area studied (Figs 1,2) the basement rock is unconformably covered by an unfossiliferous coarse to fine conglomerate, overlain by a bedded siltstone which shows evidence of internal scour. This siltstone is eroded to form a wide wave cut platform which terminates against a protruding stack of the greywacke basement, forming a vertical cliff.

Post depositional settling of the siltstone has resulted in the draping of sediments around the greywacke stack. Sediment deformation continues above the stack and can be observed in an overlying bryozoan grit horizon which is gently bowed over the basement high.

The siltstone lithology is composed of a series of alternating silt and fine sand horizons. The sediments tend to be coarser near the base, grading through

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Fig. 1. Locality map showing Waitemata Group Sequences on Mototapu Island.
to a siltstone higher in the sequence. The lower horizons show some evidence of graded bedding but this often obscured by bioturbation. Higher in the sequence, the beds tend to be more regular with fewer minor unconformities and truncations, indicating that at this stage, sediments were probably deposited well below wave base, and as a consequence protected from further erosion.

The volcanic grit lithology is composed of numerous broken fragments of bryozoan and molluscan shells with varying amounts of volcanic detritus. The lithology becomes finer grained and develops more regular bedding near the top of the sequence, this probably indicating a deeper and less energetic environment.

The most striking features of the locality are the fossilised remains of an exceptionally large cirripede, *Hexelasma aucklandicum*. This species was initially described by Sir James Hector. Subsequent reference to the fauna and its setting has been made by Withers, Grant-Mackie and Mayer, the latter producing the first detailed geological description of Motutapu Island.

**CIRRIPEDES AND THEIR DISTRIBUTION**

**The Ecology of Cirripedes**

Modern shallow water cirripede assemblages are most varied in the zone
immediately above the subtidal, here referred to as the littoral fringe; species numbers rapidly decrease both above and below this zone. Modern species that are characteristic of this littoral fringe in New Zealand include *Balanus decorus*, *Balanus trigonus*, *Balanus vestitus*, *Balanus tintinabulum*, *Calantica spinosa* and *Calantica villosa*. Modern species characteristic of deeper water assemblages are, a species of *Hexelasma* (414-1600m) (Fig. 3), *Verruca halotheca* (252-896m, but down to 1680m off Hawaii), *Calantica gemma* (401-722m) and *Balanus auricoma* (85-386m) (Foster 3).

**Motutapu Waitemata Group Cirripedes**

The basal Waitematas in this locality can be divided into three distinct biotopes; the lower conglomerate, from which no cirripede remains have been recovered, the overlying siltstone which contains three species, and the volcanic grit, which contains at least six and possibly seven species of barnacles.

**FAUNAL ASSOCIATIONS AT MOTUTAPU ISLAND**

**The Siltstone Biotope**

Evidence of bioturbation is abundant in the lower horizons. There are also scattered remains of plant material, fossilised as friable lignite-like inclusions which tend to become less frequent and finally disappear higher in the sequence.

At the base, associated foraminifera indicate a shallow shelf environment characterised by benthic species such as *Amphistegina* and *Vaginulina*, but higher in the sequence there is a greater abundance of planktonics including *Globigerina woodei*, *Globoquadrina optima* and *Globoquadrina dehiscens*. 
Cirripedes Siltstone Volcanic Grit

Arcoscapellum sp. x
Balanus auricoma x
Balanus cf. acutus x
Balanus vestitus x
Calantica subplana x
Hexelasma aucklandicum x x
Lepas cf. harringtoni x x
Verruca halotheca x x

Table 1: Distribution of Motutapu Waitemata Group Cirripedes

indicating a deeper, open water environment.

The Volcanic Grit Biotope

The Volcanic Grit contains a wide variety of broken bryozoan fragments, coelenterates and molluscs.

Crabb\(^2\) describes a high percentage of flexible cellariiform; and eschariform bryozoans from the grit. These forms tend to indicate a moderate to high energy environment, which is not supported by the more fragile cirripedes such as Hexelasma aucklandicum. However, there are some low energy bryozoan forms present, which Crabb attributes to a deeper environment. This, with textural evidence suggesting that the volcanic debris initially accumulated in immediately sublittoral environments, indicates that the grit deposit is a composite lithology, having been transported, with its shallow water fauna into deeper conditions. Deeper water elements were incorporated into the sediments during transportation.

The molluscs present are also part of a shallow water assemblage and include Serripecten beethami, Lentipecten hochstetteri, Mesopeplum kaiparaense, Eucrassatella ampla and Ostreacea.

Mayer\(^6\) indicated that the grit bed was composed of a number of lahar-type flows, with the volume of successive flows decreasing. The uppermost part of the deposit shows alternating fine siltstone and volcanic sandstone beds, and was probably deposited by bottom currents.

Analysis of Faunal Associations

The basal horizons of the siltstone were deposited in shallow water, moderate energy conditions, probably close to the littoral fringe, a rapid deepening of conditions is envisaged with this sequence, resulting in the deposition of a distinctly deep water facies in the upper beds.
Volcanic activity occurred for a period during the siltstone formation, resulting in a subsequent deposition of volcanic debris on the shallow, upper
shelf. Slope instability probably developed, causing the mass submarine flows which incorporated both shallow, and later deep water elements within the matrix of the grit when it was finally deposited in relatively deep water.

DISCUSSION ON THE CIRRIPEDES PRESENT

It has been concluded by Buckeridge\(^1\) that the environmental radiation of non-pedunculate Cirripedia began during the upper Cretaceous — lower Tertiary. There has been a tendency for the less competitive species to move away from the littoral fringe, the Chthamalidae radiating into intertidal conditions and the Verrucidae and Pachyaszmaide into deeper water.

This radiation proceeded at different rates so that by the lower Miocene, *Hexelasma aucklandicum* appears established as a deep water species whilst *Verruca halotheca* is still found in both shallow and deep water environments. Unlike *Hexelasma aucklandicum*, the abundance of *Verruca halotheca* increases in the volcanic grit. The compartments of *Hexelasma aucklandicum* in the grit generally show only minor abrasion, indicating minimal transport; the verrucid compartments, however, show varying degrees of abrasion, which, coupled with their greater abundance in the grit suggests that some of them had been incorporated into the grit from other, shallower environments.

*Bal anus (Solidobalanus) auricoma* is present in the section, but restricted to the volcanic grit, suggesting that this species had a shallow water habitat during the lower Miocene.

Analysis of environmental changes using lower Tertiary cirripedes must be based on stratigraphic evidence covering a series of lithologies. Emphasis must be placed on the continued presence of taxa through a sequence, and the disappearance or reappearance of other taxa.

The siltstone facies at Motutapu show only three species of cirripede, but during the interval of volcanic grit deposition, the species number rapidly increased, many of the species present being indicative of moderately shallow water: *Bal anus (Solidobalanus) c.f. acutus, Bal anus (Austrobalanus) vestitus* (Fig. 4).

These species are not represented in the overlying siltstone, indicating the cessation in the introduction of shallow water, allochthonous material.

The energy of the environment can often be determined by the structure of the cirripedes present. *Hexelasma aucklandicum* is a large, relatively thin walled, weakly articulated barnacle and could be assumed to have lived in a relatively moderate to low energy environment. *Hexelasma aucklandicum* is found as accumulations about the stack. From this it appears likely that the barnacle lived on the stack and that upon death, specimens disarticulated, fell and were concentrated in sediments around the base.\(^4\)

The specimens appear to be concentrated to the south and southwest of the stack, and this, although possibly a result of colonisation of the south and southwest side of the stack, is more likely to be a result of current direction.

*Hexelasma aucklandicum* differs from the living deepwater species of *Hexelasma* (Fig. 3) described by Foster\(^3\) only by its greater size and in the shape of the opercular processes. The articular ridges are quadrangular in *Hexelasma aucklandicum* (Figs 5.1) rather than triangular as in the living specimens.
Fig. 5. 1. Hexelasma aucklandicum tergum, length approx. 4 cm. 2. scutum, length approx. 3.5 cm. 3. Balanus (Austrobalanus) vestitus top view, diameter 0.75 cm. 4. Verruca halotheca ?fixed tergum, length 0.5 cm. 5. Verruca halotheca rostrum, diameter 1 cm. 6. Verruca halotheca fixed scutum, diameter 0.5 cm.
Recollection and analysis of a wider range of samples of the disconnected compartments described by Withers\textsuperscript{7} as *Hexelasma* sp. has shown that the affinities of this species are with the subgenus *Austrobalanus* rather than the genus *Hexelasma*. The irregular internal ribbing, high conical shell shape, and rudimentary radii are characteristic of *Balanus (Austrobalanus) vestitus*. Associated but disarticulated opercular valves show no obvious difference from modern *B.(A.) vestitus*.

Further collection of samples indicate that the tergum, illustrated by Withers\textsuperscript{7} as doubtfully from *H. aucklandicum* (Plate IV, Fig. 14a\textsuperscript{7}), is probably part of a movable tergum of *Verruca halotetha*.

*Balbanus (Solidobalanus)* cf. *acutus* was initially described by Withers\textsuperscript{7}, as *Balanus amphitrite* var. *acutus*. The present author considers that this species has distinct solidobalanid features and should be placed within subgenus *Solidobalanus*, giving “*acutus*” full specific status. *B. acutus* differs from *B. amphitrite* by having a more equilateral tergum with the spur closer to the basiscutal margin, and by lacking the regular parietal pores developed in *B. amphitrite*.

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**REFERENCES**
