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FORAMINIFERA FROM THE MAHOENUI GROUP

NORTH WANGANUI BASIN

Te Maire Bluff
S19/995484

Thesis presented in fulfilment of the requirements for the Degree of Doctor of Philosophy.

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FORAMINIFERA FROM THE MAHOENUI GROUP NORTH WANGANUI BASIN

ABSTRACT

The Mahoenui Group is a body of Oligocene and early Miocene marine clastic sedimentary rock in which two formations are recognised. The first, the Taumatamaire Formation (Happy, 1971) consists of up to 1000m of blue grey calcareous mudstone together with two minor limestones, the Awakino Limestone Member (Hay, 1967) and the Black Creek Limestone Member (new name). The second Formation, the Taumarunui Formation (Nelson & Hume, 1977) is made up of 1000m of flysch. Two facies types are seen in the flysch, the proximal and distal flysch facies.

350 species of Foraminifera are recorded in 167 samples from 47 sections. Their systematics are discussed and many are illustrated using scanning electron photomicrographs.

11 new species are recognised in the genera, Almaena, Anomalina, Epistominella, Gavelinopsis, Globocassidulina, Guttulina, Lamarckina, Lenticulina, Melonis and Verneuilina. One new subspecies of Bolivina reticulata is also recognised. These are not formally named here but will be described in papers to be published later.

An appraisal of numerical techniques in taxonomy is made while considering the Globigerina woody "group" from the Mahoenui. This supports the validity of 5 species of planktonic Foraminifera from New Zealand and illustrates the advantages and disadvantages of numerical classification.

The paleoecology and paleobathymetry of the samples is investigated using both conventional and numerical methods. These two approaches are compared, contrasted and then integrated to form a paleogeographic reconstruction.
ACKNOWLEDGEMENTS

I would like to thank the University Grants Committee for meeting my field expenses and the cost of a trip to the New Zealand Geological Survey in Lower Hutt; Messrs. Albrechtson, Fisher, Hunt and Soler for accommodation in this field; Mr. Peter McIntyre for the use of his cottage at Kakahai and for opening his house to us during sorties to Wellington.

Dr. N. de B. Hornibrook and G. S. Scott made available the micropaleontological collections at the N.Z.G.S. in Lower Hutt while Dr. J. Collen provided access to the collections at Victoria University. Shell B.P. and Todd kindly provided samples from a number of the recently drilled oil wells, both onshore and offshore in Taranaki.

I would also like to acknowledge the laboratory assistance given by Mr. Dave Pryor and the help with electron microscopy given by Mr. D. Stringer. Mr. Roy Harris gave considerable assistance with the photography and also drafted the geological map (Fig. 1.3) and Fig. 1.1. Mr. Ian Thompson also gave invaluable help with the drafting (particularly in undertaking the arduous job of drafting the dendrograms for Section 7).

I owe a particular debt of gratitude to my supervisor, Dr. Graham Gibson who freely provided guidance, encouragement and criticism and who read and re-read this manuscript:— any literary merit the manuscript possesses is entirely due to his perseverance and thorough application of normal English spelling rather than my own special brand!

Finally, I am very grateful to my wife, Lesley, who has assisted with everything from field-work to proof reading and who has tolerated my vagaries with remarkably good humour!
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<td>7.26</td>
<td>Eigenvalues (Cosine theta coefficient) P.C.A.4</td>
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Fig. 1.1 Sedimentary Basins of the North Island, New Zealand also showing the Major Physiographic Features Bordering the Study Area (After Katz, 1968).
SECTION 1
INTRODUCTION

1.1 SCOPE AND AIMS OF THIS STUDY

The North Wanganui Basin is one of a number of Tertiary basins flanking the axial basement core of New Zealand. It has a depositional history extending from Eocene to late Miocene. The Mahoenui Group was mostly deposited during the early Miocene. In the centre of the basin the Mahoenui Group exceeds 1000m in thickness and represents a substantial proportion of the Tertiary sequence.

Few macrofossils have been found in the Mahoenui but microfossils are abundant. This study investigates the foraminiferal microfauna of the group. The aim was to review the systematics of the species present, to use the abundances of the taxa in a paleoecological analysis and to trace the development of the basin during early Miocene time. The study also set out to compare and evaluate conventional and numerical methods in both taxonomy and paleoecology.

1.2 GEOGRAPHICAL SETTING (Fig. 1.1)

The area studied consists of 5000 square kilometres in Northern Taranaki (The 'King Country') lying from 38° to 40° South and 174° to 176° East. It extends from Otorohanga in the north to Raurimu in the south, and from the Herangi Ranges in the west to the Rangitoto and Hauhungaroa Ranges in the east. (See locality Map Fig. 1.1).

1.3 STRUCTURAL SETTING (Fig. 1.2)

The major structural features of the North Wanganui Basin are a number of prominent North-South striking faults which have been shown by geophysical surveys and petroleum exploration wells to border narrow, elongate basement horsts and grabens. The largest of these, the Patea - Tongaporutu - Herangi system forms the western edge of the North Wanganui Basin. This block is bordered to the west by the Taranaki Fault Zone, where the Taranaki, Manganui and Whareorino Faults each have a throw of several thousand metres (Happy, 1971; Nelson & Hume, 1977). In the east the block is bordered by the
Aria-Waipa Fault system (Nelson & Hume, 1977). The eastern margin of the basin is formed by the Hauhungaroa Fault. Between this and the Patea - Tongaporutu - Herangi High there are a number of other less prominent highs including the Ohura High.

The meridional faults are shown to have been active throughout the Tertiary and to have, at least in part controlled the deposition of the Mahoenui Group. There is, however, a second prominent fault set cutting the Mahoenui. This set of short faults that strike North-East was active from Late Miocene times.

Fig. 1.2 Major Faults and Structural Features of the North Wanganui Basin.
1.4 GEOLOGICAL SETTING

In the North Wanganui Basin the Mahoenui Group overlies the Te Kuiti Group and is itself generally overlain conformably by the Mokau Group, though near Taumarunui it is unconformably overlain by the Mohakatino Group. The exposure of the Mahoenui Group controlled by the Aria-Waipa, Ohura and Hauhungaroa Faults (See Fig. 1.3). The beds generally dip at less than 10°, and although regionally the dip is to the SW, locally the direction may vary from NW to SSW. The direction is particularly variable east of the Ohura Fault where the strata are disrupted by many small faults and a number of small folds such as the Ohura structure.

1.5 PAST WORK

Early interest in the Tertiary strata of the North Wanganui Basin centred on the coal deposits of the Mokau Group.

The Mahoenui Group was first described and mapped by Henderson and Ongley (1923). They mapped the "Mokau Subdivision" but also gave an account of the Te Kuiti area. The mapping of the North Wanganui Basin was continued by Grange (1927), who mapped the Tertiary strata of the "Tongaporutu - Ohura Subdivision", and Marwick who mapped the "Te Kuiti Subdivision".

Oil company interest in the potential of the North Wanganui Basin saw a number of exploratory surveys, and a number of reports were produced by company geologists. General geological reports included Evans, Scott & McCormick, (1942); Geiger, (1959); Glennie, (1956, 1957, 1958a, and 1958b); Van der Sijp, (1959); Stainton & Gibson, (1964) and others., while Glennie, (1958, 1959) described the distribution and nature of the graded Mahoenui beds.

Subsequent drilling of exploration wells by Shell, B.P. and Todd and the A.N.Z.P.A.C. companies provided additional data which was summarised in Well reports.

Two 1:250,000 geological maps have been published covering the area of Mahoenui Group outcrop. Kear published the first of these (Sheet (4), Hamilton) in 1960. The second (Sheet 7, Taranaki) was published by
FIG 1.2 Geological Map of Area Studied. Compiled from Hay (1967), Kear (1967) and the Authors Own Field Observations.
Hay in 1967. Further mapping has been carried out by Jamieson, (1967 Aria area); Happy, (1970 Awakino area) and Nelson, (1973, Waitomo County) as part of MSc and PhD studies.

Happy, (1970) and Nelson, (1977) outlined nomenclatural changes for the Mahoenui Group (Section 2.1),

With the recent increase in interest in oil exploration several authors have written general reviews of the Tertiary geology of the Taranaki and Wanganui Basins. Such papers include Katz, (1968); McQuillan, (1977), and Pilhaar and Wakefield, (1978), each of these has outlined aspects of Mahoenui Group geology.

Jamieson, Happy and Nelson have each recorded a number of microfaunas from the Mahoenui Group while Finlay, (1939-1940) and Hornibrook (1961) have described new species of Foraminifera from Mahoenui samples.
SECTION 2
METHODS

2.1 FIELDWORK

This study aimed to investigate general faunal trends over a large geographical area. For this reason it was impractical to attempt to record or sample all possible sections. Instead 47 relatively widely spaced sections, showing maximum exposure were selected. These provide a satisfactory cover for biostratigraphic analysis.

The columns were compiled from streams, natural inland cliffs and road cuttings. In the thinner sequences in the north and west of the basin vertical sections with nearly continuous exposure were measured using a Paulin altimeter. The sequence in the South-East of the basin is thicker and more affected by faulting. Here composite columns had to be pieced together from shorter, widely spaced vertical sections. Correlation across faults in this area was at times difficult because few marker beds are present. This made it necessary to resort to bedding thickness, bedding character and the shale/sand ratio for correlation. Because of this difficulty known faults were avoided wherever possible.

Each section was systematically sampled using normal field techniques. Particular attention was given to obtaining fresh uncontaminated material. The outcrop was first cleared of weathered rock and then a sample of about 500 cubic centimeters was taken for later processing.

2.2 PREPARATION OF SAMPLES

The physical preparation of samples followed the standard micropaleontological practice as outlined by Hornibrook, (1968). The samples were initially crushed and then oven dried before being broken down in hydrogen peroxide. When disaggregation was complete the mud was washed out over a sieve with a mesh aperture of 75 microns. The residue was then dried and split. This was then hand picked until 300 specimens were obtained or 30 trays had been examined. Occasionally, and as a last resort with sparse faunas, the residue was floated using carbon tetrachloride. The fauna was then examined and if necessary was cleaned using an ultrasonic probe. This was avoided if
possible as examination before and after ultrasonic treatment showed
that even at very low intensities there was some loss of specimens, and
intensities sufficient to remove firmly adhering matrix could
significantly alter the proportions of species in a fauna. The changes
could be quite surprising, Amphistegina an apparently robust genus is
particularly sensitive and specimens would explode at low intensities.
It is assumed that the resonant frequency of the chambers must have been
comparable to the frequency of sound used.

Following preparation the faunas were identified and the abundances
tabulated (Tables 1 - 3). These then formed the basis for later
analysis. (Tables 1 - 3 are found in the Map pocket at the back of the thesis).

2.3 NUMERICAL METHODS OF ANALYSIS

Geological data is regularly presented in tabular form, and as the
number of columns and rows in the table increase it rapidly becomes
impossible for an investigator to detect associations or trends within
the data. At this stage the use of multivariate procedures becomes
attractive. A large number of methods have been applied by the author
to paleoecological and taxonomic problems in the Mahoenui Group. Not
all methods were successful and only a selection are presented here.

2.3.1 INITIAL TREATMENT OF DATA

The table of primary data (or primary data matrix) is often manipulated
prior to the initiation of multivariate analysis. Three processes are
sometimes necessary before analysing a set of data. These are reduction,
transformation and standardisation. All three of these have been used
in the various paleoecologic analyses of the Mahoenui Group.

a) Data Reduction

An ecological analysis can often have a species list of 200 or more
taxa and a similar number of sites. Many of these species are singletons
or occur at only a few sites. This yields a sparse primary data
matrix, or one in which the majority of entries are zero.

Often these rare species are removed prior to analysis. There are two
reasons for undertaking data reduction. The first is that the computer
used may be unable to handle the volume of data presented. This may be due to the physical size of the computer memory or because of limitations imposed by language used. For example, in the FORTRAN language the largest single matrix that can be stored is 256 x 256. This means that, without resorting to extreme methods of extending an analysis, the number of sites in a site/site study may not exceed 256.

Furthermore, the time used in computation involving matrices as large as 200 x 200 (particularly in eigenanalysis) introduces another very practical limitation, expense!

The second reason for data reduction is that of accuracy. With a sparse matrix many values are low and yield low correlations. This leads to problems with both accuracy and statistical significance.

It is usually necessary to remove more than just the singletons in a fauna. The strategies used for reduction vary greatly. Generally arbitrary decisions are used, for example Scott, (1970a) excluded any species which did not attain a census count of 12 in one or more samples.

In the paleoecological analysis of the Mahoenui Group two methods of data reduction were employed. The first was to combine all species of each genus and to analyse at the generic level. The second method was to set an arbitrary cutoff level, any species that did not reach an abundance of 3% in one or more samples was excluded from the analysis.

Data reduction is generally unnecessary in taxonomic analysis.

b) Data Transformation (Ref. Clifford & Stephenson, (1975); Sneath & Sokal, (1973))

For many multivariate analyses it is important to correct or transform the data matrix to approximately normal form (though normality is only necessary in ordination if statistical tests are to be used). Transformations are manipulations applied equally to all members of the data matrix, this is in contrast to standardisation which is applied to each column or row separately. Transformation is particularly important if any statistical tests are to be carried out. Even in analyses that do not involve significance testing transformation will
be almost mandatory. This is because ecological data is generally characterised by a few abundant species together with a number of less abundant taxa. If calculation of similarity takes place on such a matrix, undue emphasis may be given to the abundant taxa. This is particularly true with the distance coefficient. Transformations in general use include \( \log n \times, \sqrt{x}, 3\sqrt{x} \) and \( \arcsin \sqrt{x} \). The \( \arcsin \) transformation is suitable when the data is measured as percentages, (Cassie and Michael, 1968), and this has been used throughout the ecological analysis of the Mahoenui Group.

c) Standardisation

Standardisation is needed when different units of measurements are used for different variables. There are a number of methods of standardisation, one of the simplest is to divide each variable element by the sum of the elements of that variable. A second common strategy is to standardise so that each variable has a mean of zero and a standard deviation of one. Standardisation is unnecessary if correlation is used as the index of similarity as this is in fact standardised covariance.

Correlation was used throughout the taxonomic analysis and so standardisation was not needed. In paleoecological analysis true abundance is unmeasurable so relative abundance must be used. For this reason the number of specimens counted was kept as constant as possible, at around 300. The counts were the standardised to a total of 100, (Scott, 1970a, corrected his totals to 200 but percentage is a much more familiar concept and therefore the present author has used it). Standardisation introduces particular problems as it gives undue emphasis to depauperate faunas. There is little one can do to avoid this apart from eliminating such faunas.

2.3.2 COEFFICIENTS OF ASSOCIATION (Ref. Klovon, 1975).

Initial ecological investigations were carried out using binary data (presence/absence) and simple matching coefficients.

a) Distance Coefficients

Distance is a measure of dissimilarity, values of \( d \) approaching zero
indicating similar means while increasing d indicates increasing dissimilarity. Distance coefficients are not bound by the limits +1 to -1 and vary from 0 to ∞. Often, however, data is manipulated to give a range from 0 to 1 so that distance is comparable to other similarity measures. d measures the distance between two multivariate means visualised as points in n dimensional space. A plethora of methods are available that calculate distance. The commonest is Euclidian distance, an extension of Pythagora's theorem into multivariate space.

In a two dimensional system, if the entities are plotted within a set of orthogonal axes the distance between them can be calculated by

\[ d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \]

if a further n - 2 dimensions are added the distance becomes

\[ d = \sqrt{\sum_{i=1}^{n} (x_{1i} - x_{2i})^2} \]

where n = the number of dimensions x_{1i} and x_{2i} are the ith variate score for entity 1 and 2. Often D^2 rather than D is used. Distance is sometimes averaged for each dimension

\[ d = \sqrt{\frac{\sum_{i=1}^{n} (x_{1i} - x_{2i})^2}{n}} \]

and this standardised Euclidian distance coefficient was used for distance calculations in the cluster analyses of paleoecological data.

This distance represents the shortest distance between two means in multidimensional space. It contrasts with the Manhattan or City Block Metric. In this distance is measured stepwise parallel to each axis (Fig. 2.1).
El1 2.L
Euclidean

Fig. 2.1 Showing the difference between the City Block (CB) and Euclidean Distance (E).

Because distance is not constrained between +1 and -1 it is particularly influenced by data where a few of the entities are very dissimilar and will tend to weight the data towards the more common variables (Davis, 1973). In paleoecological analysis this will mean that a few abundant species will tend to obscure the differences between the minor species. This may in fact be useful and produce effective dendrograms if one's object is primarily to investigate dominance. However, in general it is necessary to first standardise the data to avoid undesirable weighting.

b) Correlation Coefficient \( r \)

The Pearson product moment correlation coefficient is the most widely used measure of association

\[
 r = \frac{\sum_{i=1}^{n} (x - \bar{x})(y - \bar{y})}{\left[ \sum_{i=1}^{n} (x - \bar{x})^2 \sum_{i=1}^{n} (y - \bar{y})^2 \right]^{1/2}}
\]

This is in fact the ratio of covariance (a measure of the spread of two variables around a common mean) to the geometric mean of the variances of the two variates.

\[
 r = \frac{\text{cov} x y}{\left[ S_x^2 S_y^2 \right]^{1/2}}
\]

or the covariance divided by the product of the standard deviations

\[
 r = \frac{\text{cov} x y}{S_x S_y}
\]
In other words it is the covariance standardised so that the variance of each variable is one. This gives the correlation coefficient a range from +1 to -1 in which +1 indicates a perfect linear relationship, 0 indicates no relationship and -1 indicates a perfect inverse linear relationship. The correlation coefficient and distance coefficient are closely related when data are standardised to a mean of zero and a standard deviation of one.

Although popularly used for ecological analysis, there are a number of problems associated with the correlation coefficient. One in particular is that with a sparse data matrix (one in which there are a large number of zero values) many r values are small and inaccurate. Field, (1970) regarded 50% zero values in the primary data matrix to be the maximum proportion acceptable for the use of correlation.

In the present study correlation was found to be the most "satisfactory" measure of similarity both in taxonomic and paleoecological analysis.

c) Cosine Theta Coefficient

The cosine theta coefficient is expressed as:-

$$\cos \theta_{xy} = \frac{\sum_{i=1}^{n} x_i y_i}{\left(\sqrt{\sum_{i=1}^{n} x_i^2 \sum_{i=1}^{n} y_i^2}\right)^{\frac{1}{2}}}$$

where $x + y$ are samples

$n = \text{The number of variates}$

$i = \text{ith variate}$

Within a set of n dimensioned cartesian coordinates Cos $\theta$ represents the cosine of the angle between vectors to the two multivariate means. Cos $\theta$ is therefore a measure of the angular separation between entities and will range from one to zero (0° separation, samples identical; 90° separation samples completely unrelated).

If the primary data matrix is standardised to 0 mean and unit standard deviation the Cosine $\theta$ index and the product moment correlation coefficient are identical. Cosine $\theta$ is commonly used in Factor Analysis (Davis, 1973).
Three basic strategies are available when analysing multivariate data. These are:

1) Cluster Analysis; A hierarchical method for partitioning data.

2) Ordination methods; These involve the plotting of specimens in multivariate space. This category includes Principal Components Analysis (P.C.A.) and Factor Analysis.

Discriminant Analyses;
3) These related to Ordination methods. Included here are Multiple Discriminant Function Analysis and Canonical Variates Analysis.

The methods of analysis used in this study are briefly outlined below, but the reader is also referred to:- Everitt, (1974); Sneath & Sokal, (1973); and Davis (1973) for reviews of Cluster Analysis, Klovan, (1975); Klovan & Imbrie, (1971); and Davis, (1973) for reviews of Ordination methods, and to Bennet & Bowers, (1976) for a review of Classifactory methods. Examples showing the application of multivariate methods in paleontology include:- Scott, (1966 et seq); Valentine & Peddicord, (1967); Vilks et. al., (1970); Streeter, (1972); Barnett, (1974); and Haq and Lohmann, (1976).

a) Cluster Analysis

Cluster Analysis is a method for expressing the interrelationships and groupings seen in the similarity matrix. The results of the analysis are organised so that they can be presented in a hierarchial diagram or dendrogram with the entities linked together at progressively lower similarity levels.

There are numerous methods of Cluster Analysis available. Two of the commonest have been used during the investigation of the Mahoenui Group. These were Single Linkage Clustering and Average Linkage Clustering.

Single Linkage Clustering is the oldest clustering strategy. The
program used was written by Davies, (1971). This operates by searching the similarity matrix for pairs of entities with the highest similarity and these are used as clustering centers. The similarity level is then iteratively decreased. At each step any entity that has a similarity with any member of an extant group, that is equal or higher than the current similarity value, is linked to that group. This means that entry to any cluster is accomplished by linkage to a single individual within the cluster. As the similarity is decreased the entities join with one or other cluster. The individual clusters become linked when the similarity between two entities in different clusters exceeds the current similarity value. All the groups progressively merge until one single cluster is formed. The dendrograms produced by Single Linkage Analysis tend to have long strings of entities chained together. Such dendrograms are often uninformative and the technique is generally considered to be obsolete.

Single Linkage Clustering was only used in the preliminary assessment of the distribution of species in the Mahoenui Group. All later paleoecologic and taxonomic Cluster Analysis was carried out with Average Linkage Clustering, a technique originally developed by Sokal and Michiner in 1958. In this method an average similarity is calculated between an extant cluster and the candidate for entry to the cluster. Average Linkage Clustering covers a number of related strategies. The form used with Mahoenui Group data is known as the Weighted Pair Group method using arithmetic averages. The program used is one written by Davis, (1973). In this, operation takes place on the symmetrical similarity matrix, each column is searched for mutually highest values and these are fused. The similarity matrix is then recalculated using the average similarity for the clustered values. The process is then repeated until all the groups fuse. With Weighted Clustering the most recent addition to a cluster is given equal weighting to the extant cluster. In direct contrast to this is Unweighted Clustering where each entity is given equal weight at all stages during the analysis. This is illustrated in the following example (after Davis, 1973):
In both clustering strategies the first step is the formation of the nucleating clusters AB and DE. At the next step the similarity $S(ab, c)$ is calculated. This is

$$S(ab, c) = \frac{1}{2} \left( S(a, c) + S(b, c) \right)$$

$$S(de, f) = \frac{1}{2} \left( S(d, e) + S(e, f) \right)$$

The difference between weighted and unweighted approaches shows in the next step where the similarity between the clusters $S(abc)$ and $(def)$ is calculated.

In the unweighted analysis:-

$$S(abc), (def) = \frac{1}{9} \left( S(a, d) + S(a, e) + S(a, f) + S(b, d) + S(b, e) + S(b, f) + S(c, d) + S(c, e) + S(c, f) \right)$$

An average of all the contributing similarity.

In weighted analysis:-

$$A(abc, def) = \frac{1}{4} \left( S(ab, de) + S(ab, f) + S(c, de) + S(c, f) \right)$$

The Weighted Pair technique has the disadvantage that it may introduce distortion into the dendrogram, however, it is computationally simpler and faster than the unweighted method.
The Unweighted Pair Group method was used extensively in the paleoecological analysis with good results. It was also tried in the taxonomic analysis as a "zapping technique" (Reyment, 1972) but was not very successful and was superceded by Multiple Discriminant Function Analysis.

Two thorough reviews of Cluster Analysis are to be found in Sneath and Sokal, (1973); and Clifford and Stephenson, (1975).

b) Ordination Methods

These include Principal Components Analysis (P.C.A.) and Factor Analysis (F.A.). P.C.A. has been applied to both ecological and taxonomic problems while F.A. was applied to the paleoecology.

The aim of an ordination technique is to condense the data and to represent it by fewer variables than in its original form. These methods make no assumptions about the existence of groups, and variation is considered by be continuous. This is in direct contrast to Cluster Analysis which essentially aims to split the data into groups.

1) Principal Components Analysis

Principal Components Analysis is closely related to regression analysis. The technique can be illustrated from a simple bivariate system. When the entities are plotted with respect to x and y, a line fitted so that perpendiculars from all points to the line are minimised, defines the major axis of the ellipse, or the first principal component axis. In effect the swarm has been rotated so its major axis lies along the \(x_1\) axis (Fig. 2.3).

The second principal component axis corresponds to the second axis of the ellipse and is at right angles to the first. The direction and slope of the principal component axes are (w.r.t The original coordinate system) given by the eigenvectors of the similarity matrix (S) (normalised with zero mean and unit standard deviation). The length of each principal component axis represents the proportion of total variance it accounts for. These lengths are the eigenvalues or latent roots of (S) and they sum to the trace. This allows the contribution each principal axis makes to the system to be expressed as a percentage.
Fig. 2.3  Relationship of Original Variable Axes $x_1$, $x_2$; Principal Component Axes $c_1$, $c_2$ and Data Points in a Bivariate System.

The coordinates of the entities with respect to the new axes are then found by multiplying the original measurements by the corresponding eigenvector element and summing the products.

$$c_1 = v_1 x_1 + v_2 x_2$$

The whole process can be extended for systems with any number of variables. Each new variable is regarded as a new dimension in hyperspace and is added orthogonally to the preexisting axes.

The program used in this study was originally written by Davies, (1971) but was extensively rewritten by the present author. It first constructs a similarity matrix and finds its determinant. An eigenanalysis is then carried out to find the eigenvalues and eigenvectors of this matrix. This is done using the Hotelling, (1933) iterative method (See Davies, (1971) and Lowley & Maxwell, (1963)). The method is slow in comparison to the Givens - Householder, or the Jacobi methods but does have the advantage that it conserves computer memory. The
The program is also self-limiting in that it sets a limit of 100 iterations when determining eigenvalues. If this limit is exceeded the program will terminate and return the eigenvalues and eigenvectors previously calculated. Termination will occur when the eigenvalues are equal or small in value. This procedure is acceptable as generally the first few eigenvalues account for the larger part of the variance. Following the evaluation of the eigenvalues and eigenvectors the program derives the coordinates of the entities with respect to the principal component axes and these are used to form bivariate plots showing the location of the entities on these new axes.

Two points are important when using Principal Components Analysis. The first is that the technique uses orthogonal axes, in other words it assumes that there are no correlations between the new variables. The second point is that P.C.A. gives a faithful representation of the distance between major groups but is notorious for falsifying distance between close neighbours (Rohlf, 1968).

This second point was a problem in the paleoecological analysis in this study. P.C.A. confirmed the gross structure, outlining well the major groups determined by Cluster Analysis, but did not show the internal structure of these clusters well. A further point to be considered before applying P.C.A. (or F.A.) is whether it is necessary to correct the data for normality. This appears to be open to some debate, some authors (e.g. Seal, 1964; Cassie, 1968) point out the relationship of P.C.A. to regression and feel that normality is essential. ("Concepts of elipsoids of variation and the rotation of axes to produce uncorrelated variables is so closely linked with the multivariate normal distribution") that P.C.A. and F.A. "should only be applied to this type of data". Seal, (1964) p. 170). Other authors (e.g. Davis, 1973; Clifford & Stephenson, 1975) consider that normality is not essential and that the algebraic operations of P.C.A. can be applied to non-normal populations as long as significance testing is not being used. Clifford and Stephenson, (1975) go one step further and note that "it remains uncertain if the transformation required to produce normality is the same that will produce optimal ecological sense". In the present study the author found empirically that correction for normality produced the best "ecological sense."
2) **Factor Analysis**

This is closely related to P.C.A. but the new axes are not required to be orthogonal – in other words the new variables may be correlated. Factor analysis was tried with the paleoecological data. The program used was the CABFAC program devised and published by Klovan and Imbrie, (1971). This algorithm relies on the fact that in a system of N items and n variables the essential solution of the similarity matrix is the same for both the NxN and nxn cases. This means that the eigenvalues and eigenvectors can be calculated for the smaller matrix and once derived can be used to find the factor loadings for Q (between entities) or R mode (between attributes) analysis. Once the factor scores are established the program then rotates the matrix using the varimax scheme. This iteratively rotates the factor axes so as to maximise the variance of the factor scores.

The results obtained from using this analysis were disappointing, and as Cluster and Principal Components were more satisfactory Factor Analysis was not pursued.

c) **Discriminant Analysis**

Discriminant Analysis is a method for investigating the relationship between two or more previously established groups. Individuals defined by a number of variables can then be allocated to these groups.

1) **Canonical 'Variates' Analysis**

The aim of this analysis is to derive a set of functions of the form

\[ d_j = \sum_{i=1}^{m} w_{ij} x_i \]

Where \( d_j \) is the discriminant score, \( X \) is the individual score for each variable \( (i) \), \( w_{ij} \) is the weighting of the variable \( (i) \) on each discriminant function \( (j) \) and \( m \) is the number of variables.

The weights \( w \) are computed so as to maximise the variance between groups and to minimise the variance within each group. They are the eigenvectors of the product matrix \( W^{-1}B \) where \( W \) is the pooled within groups sums of squares and products matrix and \( B \) is the between-groups.
sums of squares and products matrix. The eigenvalues of this matrix give the amount of variance accounted for by each discriminant axis or "canonical variate."

The analysis usually results in a significant increase in parsimony. The first "canonical variate" discriminates maximally between all groups and will account for the larger proportion of the variance. Some of the groups may be poorly distinguished by the first "canonical variate" and other "canonical variates" may need to be used. These are usually added orthogonally to the first.

Individual scores calculated for each entity allow them to be plotted as scatter diagrams in terms of the canonical axes.

2) Multiple Group Discriminant Function Analysis

This is closely related to "Canonical Variates" Analysis and aims to determine the best allocation of individuals into one of a number of predefined groups. A series of classification functions are derived, one for each group. These take the form: (Bennett & Bowers, 1976)

\[
Y_j = \left( \sum_{i=1}^{m} X_i C_{ij} \right) - C_{oj}
\]

Where \( i = 1, 2 \ldots m \)

\( m = \) number of variables

\( j = 1, 2 \ldots \) number of groups

\( C_{ij} \) and \( C_{oj} \) are the coefficients and constant terms of the classification function.

These terms are obtained

\[
C_{ij} = \sum_{p=1}^{m} \left( U_{ip} \bar{X}_{pj} \right)
\]

and

\[
C_{oj} = \frac{1}{2} \left( \sum_{p=1}^{m} \bar{X}_{pj} C_{pu} \right)
\]

Where \( m = \) number of variables

\( i = 1, 2 \ldots \) number of variables (m)

\( j = 1, 2 \ldots \) number of groups

\( \bar{X}_{pj} = \) mean value variable p group j

\( U_{ip} = \) The elements of the inverse pooled within groups variance - covariance matrix.
The discriminant score for each individual for each group is calculated and the individual allocated to the group for which its score is highest. The probability that the individual was drawn from the group can also be calculated, as can the Mahalanobis distance $D^2$ of each individual from the group mean (and the contribution that each original variable made to discrimination). Discriminant Analysis has a number of underlying assumptions, including:

1) The data should be multivariate normal

2) The variance for each variable for each group should be similar

3) The covariance between pairs of variables should be similar for each group

"Canonical Variates" Analysis and Multiple Discriminant Function analysis were used extensively in the numerical appraisal of the G. Wood 'group' (Section 5). Initially a program written by Davies, (1971) was used, this preforms a "Canonical Variates" Analysis, calculates an extended Chi squared test for the equality of group means and a Chi squared test of the significance of each eigenvalue. The author then used a program contained in the U.C.L.A. BMD package, BMD07M which was written by Sampson, (1976). This program uses both the strategies described above. Sampson describes this program as a "Stepwise Discriminant Function Analysis" in which "A set of linear classification functions are computed by choosing the independant variables in a stepwise manner. The variable entered at each step is selected by one of four available criteria and a variable is deleted when its F value becomes too low. Using these functions and prior probabilities, the posterior probabilities of each case belonging to each group is computed. The program also computes the coefficients for canonical variables to give an optimal two-dimensional picture of the separation of groups." The program also plots the individual in terms of the first two canonical axes and can stratify these along the third axes.

2.3.4 CALCULATION OF FAUNAL DIVERSITY

As originally used diversity was simply the number of species present in
a particular sample. However, ecologists have come to realise that diversity relates to the parent population and should be independent of sample size. A number of indices have been developed as attempts to remove the effect of sample size.

The Fisher $\alpha$ index was an early attempt described by Fisher, Corbet and Williams, (1943)

$$S = \ln 1 + (N/\alpha)$$

or

$$\alpha = \frac{n_i}{x}$$

where $S$ is the number of species observed, $N$, the total number of individuals sampled and $n_i$ and $x$ are components of a geometric progression. $n_i$ (the number of groups with one unit) = $N (1 - x)$ and $x$ (a constant multiplier) is dependent on the size of the ratio $N/S$ ($x$ can be read from Fig. 125 in Williams, (1964). Murray, (1968) plotted a base graph that has allowed rapid determination of the index. This has led to its wide use in micropaleontology. Pielou, (1977) notes that in many cases this may be erroneous as the $\alpha$ index is based on the assumption that the species abundance data fits a logarithmic series. If this condition is not met then $\alpha$ cannot validly be applied. Pielou, (1977) also notes that it is often impossible to determine if the data do fit a logarithmic series, particularly if the number of species present is low.

The $\alpha$ index is an example of a diversity index based on the numbers of species present (Species diversity of Sanders, (1968)). Most recently developed indices of diversity are based on the concept that diversity should interrelate both the total number of species and their relative proportions. (Dominance diversity of Sanders). Some of these (such as Eddens, (1971) index) are based on an assumed theoretical distribution but there is also a group of measures which do not assume a distribution, but are instead, based on information theory. These are becoming widely used in ecological literature.

The Shannon - Weaver index is the basic information measure of diversity and is suitable for use where the sample being considered is part of an infinite population.
\[ H' = N \log N - \sum_{i=1}^{s} n_i \log n_i \]

Where \( N \) is the number of individuals in a sample, \( s \) is the number of species observed and \( n_i \) is the number of individuals in the \( i \)th species. This expression is dependant on sample size and often \( H \) is expressed as diversity per individual specimen.

\[ H' = \log N - \frac{1}{N} \sum_{i=1}^{s} n_i \log n_i \]

Alternatively if proportions, not numbers, of specimens are used

\[ H' = - \sum_{i=1}^{s} p_i \log p_i \]

where \( p_i \) is the proportion of the \( i \)th species. \( H \) can be calculated either with \( \log \) base 10 or \( \log \) base \( e \) though there is a tendency for workers to use base \( e \). The names proposed for the units of function are diverse. Those to the base 10 include "bell" (Good, 1950), "decimal digit" (Good, 1953) and "deci" (Pielou, 1966a). Those to the base \( e \) include "natural bel" (Good, 1953) and "nat" (McIntosh, 1967).

The Shannon function assumes that the sample is only part of an infinite population. If in fact the whole population is present in the sample then the Brilouin diversity index should be used (Clifford & Stephenson, 1975; Pielou, 1977)

\[ H(B) = \log N! - \sum_{i=1}^{s} \log n! \]

Clifford and Stephenson, (1975) note, however, that the use of \( H(B) \) rather than \( H' \) will have little practical effect.

The main weakness of information theory measures is that rare or singleton species are neglected.

As investigators have worked with diversity they have come to regard it as a two-fold concept involving both the number of species and the evenness of distribution. A number of attempts have been made to develop a measure of evenness. One such index of evenness is derived from information theory. This is equitability or \( E \)

\[ E' = \frac{H' - H_{(\text{min})}}{H'_{(\text{max})} - H'_{(\text{min})}} \]
as $H'(\text{min}) = 0$ and $H'(\text{max}) = \log s$ where $s =$ the total number of species in the population

Therefore, $E' = \frac{H'}{\log s}$

This index was used by Buzas and Gibson, (1968, 1973). However, Pielou, (1977) notes that it is not possible to determine the total number of species in a community as any sample cannot contain all species. Pielou therefore rejected attempts to measure $E'$ in such communities.

Scott, (1971a) used McIntosh's index of uniformity

$$U = N - (\sum n_i^2)^{\frac{1}{2}} / N - N / (K)^{\frac{1}{2}}$$

where $K =$ number of species

$N =$ total number of specimens

and $n_i =$ census count

This index measures the "Euclidean distance of the assemblage from a point with zero individuals" (Clifford & Stephenson, 1975). A sample with maximum $U$ has all species with equal abundance, a sample with minimum $U$ will have one species with $N - K + 1$ individuals and all other species with 1 individual. Scott, (1971a) compared this to a histogram. In a maximally equitable sample a histogram of species numbers will be rectangular and as $U$ decreases the histogram becomes increasingly skewed.

In this study a number of indices relating to diversity were calculated for each sample. These included:-

- $S =$ The number of species
- $G =$ The number of genera
- $B =$ The number of benthic species
- $\alpha =$ The Fisher $\alpha$ index of diversity
- $H'$ =$ \ $The Shannon index of diversity
- $U =$ The McIntosh index equitability

The values obtained for each sample are listed in Appendix 1 and discussed in Section 7.1.
SECTION 3
LITHOSTRATIGRAPHY

3.1 HISTORICAL REVIEW AND FORMATIONAL NOMENCLATURE

The Mahoenui Group in the North Wanganui Basin consists of two dominant lithotypes, massive calcareous mudstones and alternating flysch-like mudstones and sandstones. The massive mudstones have occasional intercalated limestones and sandstones.

The terminology applied to the Mahoenui Group has been confused mainly due to inadequate formal definition and also because the original type section is only known, "by inference" to be: - "in the hills east of Mahoenui" (Kear in Fleming, 1959). Henderson and Ongley proposed the Mahoenui Series as "A series of argillaceous beds in places at least 600 feet thick which overlies the claystones that form the upper part of the Te Kuiti Series". Later workers have included this "Upper Te Kuiti claystone" in the Mahoenui (Kear & Schofield, 1959).

The term series was used for lithostratigraphic units, as it is now restricted to chronostratigraphic units it is simply necessary to use "formation" or "group" when referring to the Mahoenui. Kear used "Mahoenui Formation" in the stratigraphic Lexicon (Fleming, 1959). At this time he noted that it might be warranted to raise the Mahoenui to group status and in fact referred to the Mahoenui "Group" in a paper with Schofield (Kear & Schofield, 1959). This was done without formal definition, designation of a type section or naming of formations within the group. Hay, (1967) also used the term "group" (again with no formal definition) and named the Upper and Lower Awakino Limestones together with the Upper and Lower Mahoenui Mudstones as formations within the Group. These names are informal for not only are they without type sections but they also contravene the I.S.S.C. recommendation that "A name should never be used for more than one unit even if of different rank." Hay also noted that the Mahoenui mudstones are in part made up of alternating sandstone and mudstone beds as seen near Taumarunui. Glennie had previously (1959) separated the interbedded sequence from the underlying mudstones but unfortunately did not give them a name. Happy, (1971) similarly distinguished the flysch-type sediments from the massive mudstones. He proposed the Taumatamaire Formation for the
massive mudstones and named the Bexley Bluffs section (R17/608828) as the type locality. Happy considered the Upper and Lower Awakino Limestones to be members of the Taumatamaire Formation. He excluded the flysch from the Taumatamaire Formation but did not name it as a new formation. Nelson & Hume, (1977) followed Happy's terminology but named the flysch lithotype as the Taumarunui Formation giving the "cliff section exposed on the roadside immediately north of Taumarunui" as its type section.

The upper and lower limestone units are here regarded as members of the Taumatamaire Formation but the Awakino Limestone Member is restricted to apply only to the Limestone lying at or near the base of the Mahoenui in the Awakino Gorge - Black Creek area. The type section of the Awakino Limestone Member is here nominated as the Black Creek section at the north end of Pagets dip slope (Section 4: R17/630890). The Bexley section (Section 2: R17/607826) is regarded as a reference section for the Awakino Limestone Member. The limestone consists of a number of lenses rich in algae or Foraminifera. The name Black Creek Limestone is proposed for the limestone present about 10m below the Mahoenui - Mokau contact in the Awakino - Black Creek area. (This is Hay's "Upper Awakino Limestone" renamed because of the dual use of the name 'Awakino Limestone' as outlined above). The Black Creek section (R17/630890) is here given as the type section for this member with the Bexley section again nominated as a reference section. Figs. 3.1 - 3.4 show the stratigraphic sections sampled by the author in this study.

3.2 THE BOUNDARIES OF THE MAHOENUI GROUP

3.2.1 THE LOWER BOUNDARY

The Mahoenui Group generally lies conformably on the underlying beds, be they the Te Kuiti Group Limestones or the sandstones of the Mangaotaki Formation. The commonest types of boundary between the Mahoenui Group and underlying strata are outlined below.

a) Conformable Contacts

The most common form of contact is a clean sharp junction marking a rapid change in depositional regime associated with a sudden influx
Key to lithology in following stratigraphic sections

- Sandstone
- Calcareous Sandstone
- Mudstone streaks in Sandstone
- Sandy Mudstone
- Sandstone streaks in Mudstone
- Mudstone
- Calcareous Mudstone
- Limestone
  - seam
  - Pebby Limestone
  - Alternating Sandstone/Mudstone showing proportion of Sandstone and Mudstone
- Coal
- Mesozoic basement rocks
of terrigenous debris into the North Wanganui basin. When exposed this form of contact shows few features suggesting a pause in deposition, though at a few localities, (R16/930135) there is a bored surface on the top of the Te Kuiti Group. When obscured, the junction is expressed topographically by an abrupt change in slope. The change between the calcareous Te Kuiti Group and the terrigenous muds of the Mahoenui Group is sometimes gradual, the limestone becoming more silty and sandy in its upper 1 – 3m and finally passing into calcareous mudstone.

Hopkins, (1970) illustrates an example of this at R17/725026. Here in an alternating series of soft argilaceous limestone and hard flaggy limestone bands the percentage of CaCO₃ decreases towards the Mahoenui Group (Fig. 3.5).

![Diagram](image)

Fig. 3.5 Gradational contact between the Mahoenui Group and the Te Kuiti Group at R17/725026 (from Hopkins, 1970)

b) Unconformable Contacts

Evidence for an unconformable contact between the Mahoenui and Te Kuiti Groups was presented by Kear and Schofield, (1959). This unconformity has been shown by later workers (Hopkins, 1970; Happy, 1971; Nelson, 1973) to be a local feature restricted to the Awakino Gorge – Mahoenui township area. The local unconformity in this area is related to the active tectonic movements associated with the uparching of the Herangi
basement high. In this area both inter and intraformational unconformities are seen.

Going West from Black Creek (R17/630890) towards Taumatamaire Hill the Mahoenui first overlies the Te Kuiti Group with an angular unconformity then completely oversteps it to lie directly and unconformably on the Mesozoic basement. Mahoenui Group – basement contacts are also seen on the Pipiriki basement high (Puniwhakau – 1 Oil Well) and the Ohura high (Tatu – 1 Oil Well).

In the Awakino area there are several examples where the Awakino Limestone lies on limestones of the Te Kuiti Group. The Awakau Road section (Section 1: R18/590795) illustrates this sort of contact well. Here the contact is undulating, the Awakino Limestone rests on the scoured top of the Orahiri Limestone. The limestones near the contact contain abundant well rounded greywacke pebbles of 0.5 – 2cm occasionally 4 cm diameter. Lithothamnium algal heads up to 6cm in diameter are common in the Awakino Limestone in this section (Fig. 3.6).
3.2.2 UPPER BOUNDARY

Over much of the north and west of the North Wanganui Basin the Mahoenui Group is conformably overlain by the unfossiliferous sands of the lower Mokau Group. This contact is generally a gradational one with the mudstones of the Taumatamaire Formation becoming progressively more sandy towards the contact. In the Mahoenui township - Awakino Gorge area the change from Mahoenui to Mokau Group is abrupt and almost always obscured by the debris shed by the Mokau Group sandstones. The Mokau may lie directly on the Black Creek Limestone - or may be separated from it by 5 - 10m of mudstone.

Around Te Kuiti the contact is better exposed. Here it is typically a rapid transition from the massive mudstones of the Taumatamaire Formation, through a few interbedded fine sands with carbonaceous debris, pebbles and bivalve casts into non-fossiliferous, massive sandstones of the Lower Mokau Group. The contact is completely gradational (Fig. 3.7) and is marked topographically by an abrupt change from the rolling Mahoenui country to steep bluffs typical of the Mokau Group. Further north at Waitomo the lower part of the Mahoenui Group again consists of massive mudstones typical of the Taumatamaire Formation. These soon give way to extremely bioturbated sandy mudstones with sandstone bands becoming more frequent higher in the column. This trend continues until the massive sandstones of the Mokau Group are reached. In this area the distinction between the Mahoenui and Mokau Groups is difficult to apply and of dubious significance.

To the south, in the Tangitu - Hiwi saddle region, (Columns 29-32) on the edge of the flysch basin, the alternating mudstones and sandstones of the Taumarunui Formation show a rapid decrease in the ratio of sand to mud until, a few metres below the Mahoenui - Mokau contact, only mudstone remains. Above this mudstone there is a rapid gradational change into the Mokau Group sandstone, marking the sudden onset of the Mokau sedimentary regime. A similar pattern is seen in the Mangakara valley (Column 28) near Ohura. The junction is sharp and conformable and "marked by an interbedded sandstone/mudstone layer which is carbonaceous and shows much current lamination" (Stainton and Gibson, 1964). 8 Km north of Ohura in the Waitewhena valley the Mahoenui and Mokau Groups grade imperceptibly into one another and the placement of the boundary
is purely arbitrary. East of Ohura the Mokau wedges out over a distance of 12 Km. Further east the upper part of the Mahoenui is lost so that near Taumarunui the alternating sandstones and mudstones of the Taumarunui Formation are overlaid by the Mohakatino Group at an angular unconformity of about three degrees (Fig. 3.8).

Fig. 3.7 Gradational contact between Mahoenui and Mokau Groups at column 14 (S16/988121) just south of Te Kuiti.

South of Taumarunui, near Raurimu, the Mahoenui Group is also overlain unconformably by the Mohakatino Group. In column 40 the upper surface of the Taumarunui Formation is undulating and bored. This is overlain by a 2 - 3cm thick band of shell hash in a mudstone matrix. This band is rich in neritic Foraminifera and also has abundant carbonaceous material, glauconite and occasional fish teeth. Overlying this band with a sharp contact are the brown weathered medium grained sandstones of the Mohakatino Group (Fig. 3.9).

In the Taranaki Basin west of the Patea - Tongaporutu basement high the distinction between the Mahoenui - Mokau and Mohakatino Groups fades. Here sedimentation typical of the Mahoenui Group appears to have continued with little interruption from Late Oligocene to Upper Miocene. In the Mangahewa -1 and Urenui -1 wells for example, the Tikorangi limestone (Te Kuiti Group equivalent (Pilaar & Wakefield, 1978))
is overlain by silty mudstones with occasional sandstone streaks. Apart from a few coaly bands that may represent the Mokau Group there is little change in lithology until the clastic late Miocene sands of the Waikiekie Formation.

**Fig. 3.8** Contact between Mahoenui and Mohakatino Groups in Column 46A, 10Km north of Taumarunui.

**Fig. 3.9** Contact between Mahoenui and Mohakatino Groups in Column 40.
In Inglewood -1, the Kapuni Wells and Kupe -1 the Kapuni sands are overlain by mudstones of the Mahoenui Group. These are in turn truncated by sandstones presumed to be equivalent to the Mokau Group. Above these sandstones Mahoenui style mudstones reappear and continue until overlain by The Waikiekie Formation. This upper mudstone interval could be interpreted as the Mohakatino Group but because of the close lithological similarity between upper and lower mudstone, together with the difficulty in placing the top Mahoenui boundary in the Mangahewa -1 and Urenui -1 Wells, a case can be argued for including both mudstones in the Mahoenui Group (e.g. Pilaar & Wakefield, 1978). This view is followed by the present author.

### 3.3 DESCRIPTION OF STRATIGRAPHIC UNITS WITHIN THE ONSHORE MAHOENUI GROUP

#### 3.3.1 TAUMATAMAIRE FORMATION

Two lithotypes are included in the Taumatamaire Formation, a carbonate facies and a calcareous mudstone facies.

**a) Mudstone Facies**

The mudstones are the most widespread lithotype seen in the North Wanganui Basin Mahoenui Group and the only lithotype present in the Taranaki Basin Mahoenui. In the North Wanganui Basin they are thickest in the centre of the basin where they may reach about 1000m.

On the eastern edge of the basin they are about 200m thick and are overlain by thick flysch deposits of the Taumarunui Formation. On the western rim the Mahoenui wedges out onto the Herangi High. The thin mudstones are intercalated with limestones in this area. The Taumatamaire Formation mudstones are massive blue-grey and slightly calcareous, obvious bedding is rarely seen though occasionally they appear to be well bedded with beds of between 1 and 10cm. When viewed at close quarters these apparently well bedded strata show no obvious textural or grainsize differences and the bedding only becomes obvious when the outcrop is viewed from a distance of some metres. In some areas concretionary bands may pick out the primary lamination while in other outcrops there are silt streaks or coarser layers of concentrated microfossils. The mudstones are occasionally interrupted by thin,
extremely well sorted find sandstones. These sandstones are common in the upper part of the Taumatamaire Formation from Mahoenui to Te Kuiti and grade into the distal flysch facies of the Taumarunui Formation.

The Taumatamaire Formation mudstones are generally sandier north of Te Kuiti and also to the west of the basin near Awakino and Mahoenui township.

Although generally fossiliferous, very few macrofossils are found in the mudstones except as widely disseminated shell hash. Bioturbation has been extensive and the massive beds often have obvious Tigilites burrows infilled either with sandier sediment, mud, shell hash or, occasionally, extremely microfossiliferous sand.

More commonly the mud is burrow mottled from extensive bioturbation and it is this that is responsible for the destruction of the primary lamination.

b) Carbonate Facies - Awakino and Black Creek Limestones

This facies is restricted to the western edge of the North Wanganui Basin along the edge of the Herangi basement high. Limestone development took place at two distinct levels in the Mahoenui Group.

The lower of these limestones, the Awakino Limestone Member, occurs at or near the base of the Mahoenui Group. This is a multiple unit which shows rapid vertical and horizontal changes in thickness and composition. Happy, (1971) noted that this limestone shows wide petrographic variation with few unifying features or trends to be seen. While this limestone is widely distributed the individual pods or lenses are restricted and cannot be traced far. It is generally algal-rich with Lithothamnion nodules up to 10cm in diameter. This contrasts markedly with the underlying Te Kuiti Group limestones where bryozoa are the dominant bioclasts. In the lower part of the Awakino Limestone Member pebbles of greywacke, indurated sandstone and argilite pebbles are common.

The upper or Black Creek Limestone Member is best developed in the Mahoenui Township - Black Creek region where it attains a maximum
thickness of about 7m. It is generally a single band but occasionally (R17/614826) it is separated into two bands by a fine calcareous sand. It has a blocky to flaggy form. The flags are generally 15 – 30cm thick and are separated by 2 – 3cm sandy seams. The seams are more prominent in the lower half of the limestone which is somewhat sander than the upper half. The lower boundary between the Black Creek Limestone and the Taumatamaire Formation mudstones is often undulose with bulbous protruberences of limestone. It is also often marked by a very fossiliferous sandy layer characterised by abundant Rhizothyris.

The Black Creek Limestone is a sandy, fine grained limestone, petrographically more uniform than the Awakino Limestone with fewer calcareous algae. Foraminiferal tests, generally those of *Amphistegina* and *Cibicides* form the predominant bioclasts though *Nephrolepidina orakiensis* is very abundant in some samples.

The Black Creek Limestone is the most widespread single band of limestone but is restricted to the Awakino-Mahoenui area. In comparison the individual pods of the Awakino Limestone are very restricted geographically but the overall unit extends over a wide area and is found from the Awakino Gorge to Te Kuiti.

### 3.3.2 TAUMARUNUI FORMATION

The Taumarunui Formation consists of alternating graded sandstones and mudstones. The larger part of this flysch is exposed in a narrow north-south trending zone extending from Mangapehi to Raurimu. The graded beds are underlain and overlain by calcareous mudstones of the Taumatamaire Formation. The underlying mudstones vary in thickness from 3 to 300m while the overlying mudstone is thin and usually measures between 10 and 15m. The thickness of the Taumarunui Formation is difficult to determine because of faulting and erosion, but in the thicker sequences it is at least 800m thick.

A number of sedimentological facies can be recognised within the Taumarunui Formation. These are described below using the terminology of Walker and Mutti, (1973).

a) **Proximal Flysch Facies**

This facies is characterised by alternating sandstone/mudstone couplets
where the sand:mud ratio is around one and the sandstones show a near complete Bouma sequence.

The sandstones of this facies may be up to 3m in thickness but are more often 30cm or less. They are argillaceous and grade from fine sand (125-250) at the base to very fine sand (62-88) and then mud at their top. The base of the sandstone is sharp and shows a wide variety of sole structures (see later). Also common at the base of the sandstone are pockets of shell hash, lutite clasts and plant debris. Occasional wood fragments as long as 15cm have been recovered (Glennie, 1959). Above this sharp base the sandstone may initially be massive (Bouma -A) but this is more often than not missing, the sequence beginning with plane – parallel laminae (Bouma -B). This band is followed by a layer of ripple drift bedding or, occasionally, convolute lamination (Bouma -C). The sandstone is then completed by a further layer of plane – parallel laminae before passing upwards into the interturbidite mud (Bouma -E). Occasionally the upper boundary of the sandstone will be sharp and wavy like the base. Petrographically the sandstones appear to be made up of angular quartz together with minor feldspar, glauconite and argillite. The rock is calcite – cemented when fresh.

1) Sole Structures

The structures appearing in relief on the base of the sandstones of the proximal flysch facies include flute casts, load structures and linear drag marks together with biologically derived trace fossils.

Load casts are by far the most common sole mark. These, though common, are generally small and are usually less than 3cm in diameter. Flute casts, though common, are often small, and weakly developed. However, a number of examples of excellent, well developed flutes have been seen. Tool markings are less abundant, though they are still common. These are usually casts and vary in length from a few centimetres to tens of centimetres. Glennie, (1959) noted that the linear features have a general north-south orientation. Strike measurements on these features range from 170° to 190°. On the basis of this pattern together with the sense given by ripple drift bedding and flute casts Glennie proposed a northerly source for the flysch. This view is
supported by the present authors observations.

2) **Trace Fossils**

Both the mudstones and the sandstones of the Taumarunui Formation show evidence of intense biological activity during each interturbidite phase. The mudstones are often burrow mottled from bioturbation. Occasionally simple burrows of the ichnogenus *Tigilites* are preserved in full relief within the mudstone. The base of the sandstones often carries a cast of the mudstone surface preserved in convex hyporelief. The commonest members of this fauna are simple, short, straight or slightly undulating, occasionally branching trails up to about 6cm in length. These belong to the ichnogenus *Planolites*. Simple sinuous trails of *Helminthoida* and honeycomb markings of *Paleodictyon* are characteristic of the *Nereites* facies typically found in flysch deposits and generally interpreted as typical of bathyal or abyssal water depths (Seilacher, 1964; Gregory, 1964; Hayward, 1976).

b) **Distal Flysch Facies**

This facies is characterised by sandstone mudstone couplets where the sand/mud ratio is less than one. The sandstones are thin (generally less than 5cm thick) and are characterised by sharp basal contacts with few sole markings. The Bouma sequence is still recognisable in this facies but is reduced, the beds lacking the Bouma -A layer and the B layer being very reduced. Convolute lamination (Bouma C) is often prominent in the distal flysch facies.

The flysch may grade laterally through the distal flysch facies into couplets with thin weakly laminated or structureless sandstones (the distal - exotic facies) or may grade directly into mudstones of the Taumatamaire Formation.

* Terminology of Walker & Mutti, (1973). In a very recent paper (1978) Walker uses the term 'thin bedded flysch' for this.
In this section the systematics of 319 species recorded from the Mahoenui Group are considered. Eleven new species and one new subspecies are recognised. These are not formally named but will be published later.

The classification and order of taxa in this study follows that of Loeblich and Tappan, (1974). The synonymy listed for each species includes the initial description, major name changes, most New Zealand references and any other papers found to be of significance to the present study.

Brief descriptions of specimens of most species found in the Mahoenui Group are given and many of the species are illustrated with scanning electron photomicrographs, taken using a JEOL J.S.M. - U.3 microscope.

Where possible Mahoenui Group specimens were compared with their respective type or reference specimens lodged at the N.Z. Geological Survey (Lower Hutt) and Victoria University (Wellington). Holotypes, paratypes and topotypes of most species erected by Finlay, Hornibrook, Jenkins, Vella and Gibson are available in these collections together with matched topotypes of the species described by Karrer and Stache during the NOVARA expedition (Hornibrook, (1971)).

Mounted faunal slides for all samples, S.E.M. stubs holding the illustrated specimens, holotypes and paratypes of the new species and a mounted slide with a set of hypotypes of all species recorded in this study are lodged with the Geology Department, University of Auckland. Unless otherwise noted, the measurements in the following text refer to the first specimen of each species mounted on the above mentioned reference slide.

The author's sample numbers are used throughout the text and on all diagrams. The samples have been registered in the N.Z. Fossil Record System and a list of the authors sample numbers and the corresponding Fossil Record Numbers is found in Appendix 3.

The reader is also referred to the tables of species abundance for all samples found in the map pocket at the end of this study.
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<td>Psamminopelta sp.</td>
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Order FORAMINIFERIDA
Suborder TEXTULARIINA
Superfamily AMMODISCACEA
Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1962

AMMODISCUS ARCHIMEDIS (Stache), Pl. 1, fig. 1.
Cornuspira archimedis Stache, 1864: 180, Pl. 22, figs. 1a – b.
Cornuspira elliptica Stache, 1864: 181, Pl. 22, figs. 2a – b.
Ammodiscus archimedis (Stache); Hornibrook, 1971: 30, Pl. 5,
figs. 72 – 74.

Remarks: Tests unilocular, arenaceous, evolute planispiral.
Dimensions of Hypotype: Diameter, 2.24mm, Thickness .48mm

Distribution: Occurs as rare specimens in 5 samples from columns 13, 19, 29, 29a and 35.

Recorded Stratigraphic Range: Occurs throughout most of the Tertiary in New Zealand.
Genus **GLOMOSPIRA** Rzehak, 1885

**GLOMOSPIRA CORONA** Cushman and Jarvis

*Glomospira charoides* (Jones & Parker) var. *corona* Cushman & Jarvis, 1928 : 89, Pl. 12, fig. 9, 11.

*Glomospira corona* Cushman & Jarvis ; Hornibrook, 1968 : 42, fig. 4;

Haward, 1975 : 502 (list)

Remarks: Robust, specimens are presumed to have been reworked from Cretaceous - Eocene strata.

Distribution: Occurs in only two samples from columns 14 and 44.

Recorded Stratigraphic Range: Late Clarence Series to Arnold Series (Hornibrook, 1968).

---

Superfamily **LITUOLACEA**

Family **RZEHAKINIDAE**

Genus **PSAMMINOPELTA** Tappan, 1957

**PSAMMINOPELTA SP.**

Remarks: A single large specimen of this genus has been found. The test is agglutinated, compressed in edge view with a large spherical prolocus followed by an evolute planispiral coil. Its tubular chambers are half a coil in length and its aperture is simple and terminal.

---

**Fig. 4.1** Psamminopelta sp., Sample 162, 20X.

Dimensions: Maximum diameter : 3.48mm; Minimum diameter 2.20mm;

Thickness, .66mm.

Distribution: Occurs only in one sample from Column 44.
Recorded Stratigraphic Range: I am not aware of any record of this genus from New Zealand. It has previously been recorded from the Early - Late Cretaceous of North America and Australia. The Mahoenui specimen is presumed to have been reworked from Cretaceous strata.

Family LITUOLIDAE
Subfamily HAPLOPHRAGMOIDINAE

Genus TROCHAMMINOIDES Cushman, 1910

TROCHAMMINOIDES cf. APPROXIMATUS Galloway and Heminway

cf. Trochamminoides approximatus Galloway and Heminway, 1941: 319, Pl. 6, fig. 1a - b.

Remarks: The test is of medium to large size, discoidal, partially involute, planispiral and biconcave. The shell is made up of 4 - 5 whorls with about 15 chambers in the final whorl. Specimens have depressed sutures and a low, lipped, interiomarginal aperture.

This species is close to T. cf. approximatus which Galloway and Heminway described from the Lower Miocene of Puerto Rico. They distinguished this species from the genotype T. proteus as T. approximatus lacks an early tubular portion, has a greater number of whorls, is more nearly planispiral and has a smaller aperture. Galloway and Heminway noted that many specimens recorded as T. proteus should be relocated.

Dimensions of hypotype: Diameter .55mm.

Distribution: Occurs in only one sample from column 44.

Observed stratigraphic range: Recorded from Otaian strata.

Genus CRIBROSTOMOIDES Cushman, 1910

Cribrostomoides is similar to Haplophragmoides but differs in having an areal aperture. Loeblich and Tappan, (1964) placed Labrospera as a junior synonym of Cribrostomoides. They regarded specimens with areal slit like apertures (previously regarded as Labrospera) as immature Cribrostomoides while larger individuals with a dentate aperture or a row of areal pores were interpreted as gerontic
morphotypes of *Cribrostomoides*. Krasheninnikov, (1974) disagreed with this and maintained both genera.

Mahoenui specimens have an areal slit-like aperture but following Loeblich and Tappan, (1964) these are placed in *Cribrostomoides*.

**Cribrostomoides sp.**

**Remarks:** This species resembles *C. pacifica* (Krasheninnikov, (1973)). This involute planispiral shell is of medium size, is agglutinated and has about four chambers in its final whorl. The sutures of this species are radial and incised, the periphery is lobulate and broadly rounded while the aperture is a wide areal slit.

**Dimensions of Hypotype:** Diameter .47mm; Thickness .41mm.

**Distribution:** Occurs in two samples from column 13.

**Observed Stratigraphic Range:** The genus is recorded from Late Cretaceous – Recent. However I am not aware of a previous record from New Zealand. These specimens are from the Otaian near Aria.

---

![Image of Cribrostomoides sp.](image)

**Fig. 4.2** *Cribrostomoides sp.; Sample 46, 130X.*

**Subfamily Sphaeramminae**

**Genus Sphaerammina** Cushman, 1910

**Sphaerammina cf. ovalis** Cushman

Remarks: The subspherical tests of this species are coarsely arrenaceous. They are involute and slightly asymmetrically planispiral with strongly overlapping chambers so that few chambers are visible externally. The aperture is a slit set obliquely on the apertural face and is partially blocked by a long tooth. These specimens are similar to *S. ovalis* as described by Cushman, (1910) but differ in being smaller, more coarsely agglutinated and having an obliquely set aperture.

Dimensions of Hypotype: Diameter 1.24mm

Distribution: Occurs only in one sample from column 6.

Observed Stratigraphic Range: Recorded by Cushman from Recent sediments in the Pacific. The present author is not aware of a previous New Zealand record for *S. ovalis*. It is here recorded from strata dated Waitakian to Otaian.

Fig. 4.3. Sphaerammina cf *ovalis* Cushman, Sample 31, 180X.

Subfamily CYCLAMMININAE

Genus CYCLAMMINA Brady, 1879

*CYCLAMMINA INCISA* (Stache), Pl. 1, fig. 2.

*Haplophragmium incisum* Stache, 1864 : 165, Pl. 21, fig. 1.

*Haplophragmium maoricum* Stache, 1864 : 166, Pl. 21, fig. 2.

*Cyclammina incisa* (Stache); Hornibrook, 1961 : 30; Hornibrook, 1971 : 34, Pl. 6, figs. 88-91, Text fig. 9.
Cyclammina cf. incisa (Stache); Gibson, 1967 : 14.
Haplophragmoides cf. incisa (Stache); Taylor, 1965 : 150, fig. 2a; 3(3), (4).

Remarks: Although Taylor, (1965) relegated Cyclammina incisa to Haplophragmoides as his specimens did not appear to have secondary cribrate openings, Hornibrook (1971) regarded C. incisa to be better placed in Alveolophragmium or Cyclammina on the basis of its labryinthis wall structure. Hornibrook felt that the case for transferring Cyclammina incisa to Haplophragmoides was not strong. This view is confirmed by S.E.M. observations made by Gibson (pers. com.) which showed cribrate openings on some of Taylor's Victorian specimens.

Cyclammina incisa from the Mahoenui Group also has cribrate secondary apertures above the low interiomarginal primary aperture. These specimens are large, finely arenaceous and glossy. They are involute planispiral with a rounded peripyery and about 11 chambers in the final whorl. The sutures are nearly radial, slightly recurved and somewhat incised. The shell wall is labryinthis.

Dimensions of Hypotype: Diameter 0.45mm, Thickness, .26mm.

Distribution: Cyclammina incisa is widely distributed throughout the Mahoenui Group. Occasional specimens are recorded from around Mahoeului, Te Kuiti and Waitomo. This species is commonest in the distal flysch occurring in high numbers in column 13 at Aria and columns 29 - 31 South East of Aria. It is persistent though less abundant to the North East of Aria (columns 33, 34, 35, 36 and 38). Further south around Taumarunui Cyclammina incisa occurs in numerous samples but only rarely occurs in abundance.

Recorded Stratigraphic Range: Hornibrook, (1971) gave the range Arnold - Landon Series but noted that the upper limit for the species was uncertain. Cyclammina incisa regularly occurs in Otaian strata of the Mahoenui group. Arnold Series - Otaian Stage.

Subfamily LITUOLINAE

Genus AMMOTIUM Loeblich and Tappan, 1953

AMMOTIUM SP. Pl. 1, fig. 3.
Remarks: A few specimens of a very large (up to 5mm) Ammotium are recorded. This species is very coarsely arenaceous, initially planispiral with a coil of about 5 - 6 chambers, later uncoiling with about four uniserial chambers. In the uniserial section the proximal chamber margin extends back towards the initial coil and overlaps the preceding chambers. Test compressed, sutures somewhat incised, though somewhat indistinct due to the course wall texture. Aperture simple, terminal. The length of the uniserial section and the distance the inner chamber margins extend back are variable.

Dimensions: Length 3.8mm, Thickness, .98 mm.

Distribution:Occurs in two samples from column 6.

Observed Stratigraphic Range: Otaian Stage.

Family TEXTULARIIDAE
Subfamily SPIROPECTAMMININAE

Genus BOLIVINOPSIS Yakovlev, 1891

BOLIVINOPSIS CUBENSIS (Cushman & Bermudez), Pl. 1, fig. 4.

Textularia elongata Jones; Mantell, 1850 : 330, Pl. 29, fig. 2.

Spiroplecta annectens (Parker & Jones; Brady, 1884 : 376, Pl. 45, fig. 22, 23; Chapman, 1926 : 31, Pl. 8, fig. 1 (Not of Parker & Jones).

Spiroplectoides cubensis Cushman & Bermudez, 1937 : Pl. 1, fig. 44, 45.

Bolivinopsis cubensis (Cushman & Bermudez); Finlay & Marwick, 1940 : 107; Finlay & Marwick, 1947 : 231; Hornibrook, 1961 : 15, Pl. 1, fig. 1; Gibson, 1967 : 7; Hornibrook, 1968 : 48, fig. 49;

Hornibrook, 1971 : 7 (list); Nelson, 1973 : Table following p. 183; Hayward, 1975 : 502 (list).

Remarks: This small siliceous species, with its initial planispiral coil followed by a long slender biserial stage, is rare and is generally broken when found.

Dimensions of Hypotype: Length .40mm

Distribution: Occurs rarely, generally towards the western edge of.
the basin. Sections 3, 7 and 8 near Mahoenui, 13 at Aria, 15 and 20 near Te Kuiti and 43 near Taumarunui have samples containing B. cubensis.

Recorded Stratigraphic Range: Dannevirke series to Wanganui series (Hornibrook, 1968) (Paleocene to Pliocene).

Genus VULVULINA d'Orbigny, 1826
Subgenus VULVULINA

VULVULINA (VULVULINA) PENNATULA (Batsch).

Nautilus (Orthoceras) pennatula Batsch, 1791 : Pl. 4, figs. 13a-d.
Bigenerina pennatula (Batsch); Brady, 1884 : 373, Pl. 45, figs. 5 - 8; Cushman, 1921 : 127, Pl. 25, figs. 3a, b.
Vulvulina pennatula (Batsch); Finlay & Marwick, 1940 : 108;
Finlay, 1947 : 263; Barker, 1960 : 92, Pl. 45, figs 1 - 8;
Hornibrook, 1961 : 24; Hornibrook, 1968 : 50, Table 11;
Hornibrook, 1971 : 7 (list).

Remarks: Mahoenui specimens appear to be identical to Recent V. pennatula with a rapidly expanding initial coil followed by a wide biserial stage with 4 - 5 pairs of strongly recurved chambers. The granular test later narrows and becomes uniserial for 1 - 3 chambers. Compressed, maximum thickness within biserial section, periphery with a narrow keel, sutures thick, aperture an elongate terminal slit.

Dimensions of Hypotype: Length, .98mm, breadth, .56mm.

Distribution: V. pennatula is recorded from columns 15, 18 and 20, near Te Kuiti. In each case it is recorded from samples immediately above or below the Awakino Limestone.

Recorded Stratigraphic Range: Finlay, (1947) recorded the range of this species as Waitakian - Recent. This range was extended by Hornibrook (1961) who recorded V. pennatula from mid Landon to Taranaki series. Records from Recent sediments include Brady, (1884) from the Atlantic and Cushman, (1921) from the China Sea. Mid Landon to Recent (Oligocene - Recent).
Subgenus SEMIVULVULINA Finlay

VULVULINA (SEMIVULVULINA) WAITAKIA Finlay

Vulvulina (Semivulvulina) waitakia Finlay, 1939a : 507, Pl. 68, figs. 1a - b; Hornibrook, 1961 : 24.
Semivulvulina waitakia (Finlay); Finlay & Marwick, 1940 : 115, 119; Finlay, 1947 : 264.

Distribution: Rare, occurring in only one sample from the base of the Mahoeuni in column 47a.


Subfamily TEXTULARIINAE

Genus TEXTULARIA Defrance, 1824

Five species of Textularia have been recorded in this study, four from the Mahoeuni Group. Textularia miozea is the most common species and is characterised by a rapidly expanding, moderately compressed, carinate test. Both spinose and non spinose individuals are recorded. Also placed as T. miozea are small, squat, juvenile specimens and individuals with horizontal sutures that are probably referable to T. pseudomiozea. A small rapidly expanding Textularia with few inflated chambers is placed as T. cf. awamoana. Another inflated species is T. hayi. This elongated species is initially compressed but later subcylindrical in cross section. T. semicarinata is also found in the Mahoeuni, this is very flattened, carinate with numerous chambers and straight sutures. This species is finely arenaceous except for a median coarser zone. Textularia gladizea is used for elongate, slowly expanding flattened specimens of Textularia recorded from Mokau Group sediments. Specimens of Textularia from the Mahoeuni Group were compared with their respective type specimens at the New Zealand Geological Survey, Lower Hutt.

TEXTULARIA cf AWAMOANA Hornibrook, Pl. 1, fig. 7.

cf. Textularia awamoana Hornibrook, 1961 : 18, Pl. 1, fig. 8, 9.

Distribution: Occurs sporadically and rarely throughout the Mahoeuni
Group. T cf. awamoana is recorded in 10 samples from sections 5, 6 and 7 near Mahoenui, 15, 20, 22 and 24a near Te Kuiti, section 27 in the Waitewhena Valley, and sections 46a and 47a near Taumarunui.

Observed Stratigraphic Range: Otaian Stage - Clifdenian (Early - mid Miocene).

TEXTULARIA GLADIZEA Finlay

Textularia gladizea Finlay, 1947 : 267, Pl. 3, figs. 27, 28; Hornibrook, 1968 : 72, fig. 71.

Distribution: Occurs in two samples taken from the Mohakatino Group immediately overlying the Mahoenui Group near Taumarunui.

Recorded Stratigraphic Range: Finlay recorded specimens from the Clifdenian and Lillburnian stages, figuring a specimen from "Inland Mokau". Hornibrook, (1968) gave a range of Clifdenian - Tongaporutuan (Mid Miocene - late Miocene).

TEXTULARIA aff. HAYI Karrer, Pl. 1, fig. 8.

aff. Textularia hayi Karrer, 1864 : 78, Pl. 16, fig. 7.

Dimensions of Hypotype: Length, .57mm, Breadth, .30mm.

Distribution: Rare, present in 10 samples. Generally from sections in the north and west of the basin. Sections 3 and 4 near Mahoenui, 15 - 18, 20, 21, 22, near Te Kuiti and column 47a near Taumarunui all have samples containing T. aff. hayi.

Stratigraphic Range: Otaian stage - early Miocene.

TEXTULARIA MIOZEA Finlay, Pl. 1, fig. 9.

Textularia miozea Finlay, 1939a : 509; Finlay & Marwick, 1940 : 119, 125; Finlay, 1947 : 266, Pl. 2, fig. 18 - 20; Hornibrook, 1961 : 17, Pl. 1, fig. 15; Gibson, 1967 : 8, Pl. 1, figs. 3, 4; Hornibrook, 1968 : 72, fig. 13; Scott, 1971a : fig. 2; Happy, 1971 : Table following p. 100; Hayward, 1975 : 502.

Dimensions of Hypotype: Length, .67mm, Breadth, .58mm.

Distribution: Textularia miozea is particularly abundant throughout the
north and west of the basin where it is one of the dominant faunal elements. It is also recorded from the massive mudstones underlying the Taumarunui Formation flysch. It has also been found in Mohakatino Group strata immediately above the Taumarunui Formation at Taumarunui and Raurimu.

Recorded Stratigraphic Range: Hornibrook, (1961) recorded the range of *T. miozea* as Altonian stage - Tongaporutuan stage, and *T. pseudomiozea* as ? Whaingaroan, Otaian - Altonian. Specimens of *T. miozea* sensu stricto are found from Otaian strata in the Mahoenui Group.

**TEXTULARIA SEMICARINATA** Hornibrook, Pl. 1, figs. 5, 6.

*Textularia semicarinata* Hornibrook, 1961 : 19, Pl. 1, figs. 2,3.

Dimension of Holotype: Length, .50mm, Breadth, .37mm

Distribution: Though never common, *T. semicarinata* occurs in 29 samples, generally in the Mahoenui - Te Kuiti area. However, it also occurs at the base of the Mahoenui Group in column 47a and in the overlying Mohakatino Group in column 46.

Recorded Stratigraphic Range: Otaian - Altonian (Hornibrook, (1961)). The specimens recorded in sample 153 suggest that the range of this species may extend into the Southland Series.

**Genus BIGENERINA** d'Orbigny, 1826

**BIGENERINA SP**

Specimens of a cylindrical agglutinated species that is initially biserial and becomes uniserial, are placed as *Bigenerina sp*. They occur in few samples and are never abundant.

Subfamily PSEUDOBOLIVINAE

**Genus SIPHOTEXTULARIA** Finlay, 1939

**SIPHOTEXTULARIA AWAMOANA** Finlay, Pl. 1, fig. 12.

*Siphotextularia awamoana* Finlay, 1939b : 91, Pl. 14, figs. 89, 90.
Remarks: Specimens from the Mahoenui Group were compared with the type suite and are considered to be synonymous. They have a lobulate periphery and chambers that increase rapidly in size. Initially the test is flattened but later chambers are more inflated. The aperture is lipped.

Dimensions of Hypotype: Length, .40mm, Breadth, .31mm.

Distribution: Rare, occurs in three samples from sections 14 and 17 near Te Kuiti and in two samples at the base of the Mahoenui in columns 45 and 47b near Taumarunui.


SIPHOTEXTULARIA aff. SUBCYLINDRICA Finlay, Pl. 1, figs. 10, 11.

aff. Siphotextularia subcylindrica Finlay, 1940 : 499, Pl. 62, figs. 9, 10.

Siphotextularia aff. subcylindrica Finlay; Nelson, 1973:
Table following p. 183.

Remarks: Individuals referred to S. aff. subcylindrica are small. Initially they are rapidly expanding with somewhat flattened chambers and obscure sutures. Later they have parallel sides, are more inflated and have distinct though not deeply incised sutures. The periphery is broadly rounded and the aperture is at the end of a short spout set slightly obliquely on the final chamber.

Dimensions of Hypotype: Length, .32mm, Breadth, .28mm.

Distribution: Rare, only occurring in two samples

Recorded Stratigraphic Range: Finlay, (1940) regarded S. subcylindrica as a Taranakian index species. Gibson, (1967) extended the range of this taxon to Waiauan – Kapitean, possibly Opoitian. He felt that S. subcylindrica developed from S. awamoana in the lower and mid Tongaporutuan. However, these specimens are from the Otaian and suggest an earlier separation of S. subcylindrica from S. awamoana.

SIPHOTEXTULARIA EMACIATA Hornibrook.

Remarks: Similar sized to S. subcilindrica, S. emaciata is characterised by its rhombic cross section and concave walls.

Dimensions of Hypotype: Length, .28mm, Breadth, .22mm

Distribution: Rare, occurs in one sample only.

Recorded Stratigraphic Range: Dunroonian to Waiauan (Hornibrook, (1961)), (Middle Oligocene - late Miocene).

Genus HAEUSLERELLA Parr, 1935

Haeuslerella hectori is the dominant species of Haeuslerella from the Mahoenui Group but Haeuslerella decepta and H. pukeuriensis are also recorded. H. Pukeuriensis is an easily identified species with its transition from biserial to uniserial habit. Haeuslerella hectori was originally described by Finlay (1939). This description is vague, but he distinguished it from H. pukeuriensis by its regularly biserial habit, and from H. textulariformis by its larger size, stouter form and incised sutures. H. decepta and H. hectori are more difficult to separate. When Hornibrook, (1961) described H. decepta he distinguished it from H. hectori by its coarser wall texture and "in being broader and more compressed with carinate edges". Scott (1965) recognised the difficulty of separating H. decepta and the H. pukeuriensis "group" (H. pukeuriensis and H. decepta) and attempted to reassess the two by a biometric study. He measured the proloculus diameter, maximum width and thickness of the test. Scott used these to derive the discriminant functions A(Pr) based on prolocular diameter and A(W₁,W₂,Pr) which takes into account both the diameter of the proloculus and the compression of the final chamber. Scott judged the reliability of these measures against his empirical placement of specimens on the basis of wall composition. He noted that while in the type sample H decepta has obviously coarser wall composition, this is not always so, and that reliable use of wall composition would probably require thin sectioning individuals. Scott showed a significant separation between the mean prolocular diameter of H. hectori and H. decepta.

From an evaluation of specimens from the type locality of H. decepta (S136/397,F5273A), an Altonian sample, together with two other samples,
one from the Waitakian, (S11/597, Fl5831) and one from the Otaian, (S136/768, Fl1724) Scott concluded that A(Pr) was a usable discriminator over the whole stratigraphic range of H. decepta. A(W1, W2, Pr) was found to be a reliable discriminator only in the upper Otaian and Altonian where it reflects the development of the staggered chamber form of H. pukeuriensis.

A(W1, W2, Pr) and A(Pr) have been calculated for Mahoenui group samples where Haeuslerella was abundant and well preserved. The resulting species allocation was compared with an empirical assessment of taxonomic position. As there was no obvious difference in wall composition in specimens from the Mahoenui group, empirical assessment was based on overall shape, particularly the degree of compression of the test and the development of "carinae" in Mahoenui specimens. There was an overall misclassification of 20% of specimens using A(Pr) and 23% using A(W1, W2, Pr). This compares to Scott's 7-33% misclassification for A(W1, W2, Pr) and 11-13% for A(Pr).

The status of H. decepta must be questioned, as apart from the differing prolocular diameters the shapes of H. hectori and H. decepta are very similar over much of their stratigraphic range. The differences in A(W1, W2, Pr) may simply reflect the development of H. pukeuriensis from a Haeuslerella hectori - H. decepta plexus. Such a view is supported by the stratigraphic ranges of the two species. However, the biometric analysis does not take into account the somewhat carinate edges of H. decepta. Because of this and because an inadequate number of samples have been considered, H. decepta is here maintained as a valid species. Mahoenui specimens of all three species were compared with their respective type suites to confirm these identifications.

HAEUSLERELLA HECTORI Finlay, Pl. 1, fig. 14.


Dimensions of Hypotype: Length, .84mm.
Distribution: *H. hectori* is common throughout the Mahoenui Group. It is recorded in samples from columns 1-8, 13-18, 20-22, 24a, 25, 27-29, 34, 41, 46a and 47a. It is most common in the north and west of the basin.


**HAEUSLERELLA PUKEURIENSIS** Parr, Pl. 1, fig. 13.
- *Gaudryina siphonella* Reuss; Chapman, 1926: 35, Pl. 8, fig. 8.
- *Listerella novozealandica* Cushman, 1937a: 146, Pl. 17, fig. 3.
- *Haeuslerella pukeuriensis* Parr, 1935: 83, Pl. 19, fig. 7a - b;
- Hornibrook, 1961: 21, Pl. 2, figs 32 - 33; Scott, 1965: 48pp;
- Scott, 1966a, 203 - 211; Hornibrook, 1968: 93, 94, fig. 18;
- Scott, 1971a: 126, fig. 2 (list); Scott, 1971b: 705 - 725;

Dimensions of Hypotype: Length, .74mm.

Distribution: *H. pukeuriensis* is recorded from 3 samples; two from the Mohakatino Group overlying the Mahoenui Group near Taumarunui, the other from within 10cm of the top of the Mahoenui in column 3.


**HAEUSLERELLA DECEPTA** Hornibrook
- *Haeuslerella decepta* Hornibrook, 1961: 21, Pl. 2, fig. 30;
- Scott, 1965: 203-211; Happy, 1971: Table following p. 100.

Distribution: Rare, specimens are recorded in samples from columns 1, 3, 4, 6, 13-15 and 20, all from Mahoenui to Te Kuiti on the western margin of the basin.

Recorded Stratigraphic Range: Waitakian - Altonian (Oligocene - early Miocene).
cf. Trochammina rotaliformis Wright (M.S.) in Heron-Allen and Earland, 1911 : 309.

Remarks: A small, agglutinated, low spired, concavoconvex species is recorded from the Mahoenui Group. The shell is made up of 2 to 3 whorls of $3\frac{1}{2}$ to 4 moderately inflated chambers. On the spiral side the sutures are gently recurved while they are radial on the umbilical side. The umbilicus is open with an intraumbilical aperture. These specimens are similar to T. rotaliformis which has been recorded from Recent sediments near New Zealand by Heron-Allen and Earland (1911) and Hulme (1964).

Dimensions of Hypotype: Diameter, .28mm.

Distribution: Rare, occasional specimens are found in 9 samples from throughout the Mahoenui Group.

Observed Stratigraphic Range: T. rotaliformis s.s. is a recent species. These specimens are recorded from strata of Otaian age.

Genus TRITAXIS Schubert, 1921

TRITAXIS FUSCA (Williamson)

Rotalina fusca Williamson, 1858 : 55, Pl. 5, figs. 114, 115.
Valvulina fusca (Williamson); Mestayer, 1916 : 129.
Tritaxis fusca (Williamson); Cushman, 1919, 604; Heron - Allen and Earland, 1922 : 125; Barker, 1960 : 100, Pl. 49, figs. 13, 14; Eade, 1967 : 21; Murray, 1971 : 41, figs. 6 - 9.

Remarks: Mahoenui Group specimens have an agglutinated, low trochospiral test. Spiral side raised, with gently curved indistinct sutures, umbilical side slightly concave with incised radial sutures. Test of 3 - 4 whorls, 3 - 4 chambers per whorl, these are broad and spreading on the umbilical side, crescentic on spiral side. Aperture intraumbilical with a lip.

Dimensions of Hypotype: Diameter .57mm.

Distribution: Very rare, occurring only in sample 30.

Observed Stratigraphic Range: Tritaxis fusca which is regularly recorded from Recent sediments is here recorded from the Otaian Stage. (early Miocene).
Family ATAXOPHRAGMIIDAE
Subfamily VERNEUILININAE

Genus VERNEUILINA D'Orbigny in de la Sangra, 1839

VERNEUILINA BROWNi Finlay, Pl. 1, fig. 15.

Verneuilina browni: Finlay, 1939b: 91, Pl. 14, figs. 72, 73.

Remarks: A number of specimens of a large tapering triserial agglutinated species have been recorded from the Mahoenui. These are triangular in cross section with marginal keels. The outer chamber margins are turned down and the aperture is comma shaped, lipped, and in a terminal depression. The majority of specimens are entirely triserial though occasional specimens just become biserial suggesting a strong affinity with Gaudryina. Mahoenui specimens have been compared with Finlay's type specimens of V. browni and are considered to be conspecific.

Dimensions of Hypotype: Length 1.89mm.

Distribution: This species is found in 4 samples from column 7 and one from column 6. Both columns 4 and 7 are near Mahoenui.

Recorded Stratigraphic Range: Whaingaroan to Altonian (Oligocene to early Miocene).

VERNEUILINA n.sp.A, Pl. 1, fig. 16.

Description: A small rapidly expanding triserial test, finely arenaceous with excess cement. Sides flat or slightly concave. Test triangular in cross section, with carinate edges. Outer chamber margins turned proximally. Sutures distinct, aperture a low interiomarginal arch.

Dimensions of Holotype: Length .28mm.

Types: Holotype and 5 paratypes are lodged with the Geology Dept. University of Auckland.

Type locality: RL7/f42 Sample 42, Column 7, Toroto Road, 6 Km north east of Mahoenui RL7/760920 (NZMS 260) 1 Paratype from sample 40.

Type level: Taumatamaire Formation. Lower part of the Mahoenui Group.
Remarks: V. sp. nov. resembles juvenile Gaudryina convexa and could easily be mistaken for this species. However, G. convexa is uncommon in the Mahoenui group and this species of Verneuilina is moderately common, occurring in many samples where Gaudryina is absent. No individuals of Verneuilina n. sp. A. have been observed showing any tendency towards biserial habit.

Distribution: Occurs regularly though never in abundance from samples in the Mahoenui – Te Kuiti area (Columns 1, 3-8, 12, 14-16 and 20). Not one specimen was found from the flysch sediments.


Genus GAUDRYINA D' Orbigny in de la Sagra, 1839

Three species of Gaudryina occur in the Mahoenui group. These are two large species, Gaudryina quadrazaea and G. reussi together with the medium-sized G. convexa.

Gaudryina convexa is characterised by a sharply angled triserial section that is triangular in cross section and generally has concave sides, G. quadrazaea has a subquadrate or subcylindrical biserial stage while G. reussi is triangular in cross section and carinate. Mahoenui Group specimens were compared with the type and reference specimens of Gaudryina lodged in the New Zealand Geological Survey collections.

GAUDRYINA CONVEXA (Karrer) Pl. 2, fig. 1.

Textilaria convexa Karrer, 1864 : 78, Pl. 16, fig. 8.
Gaudryina crespinæae Cushman; Hornibrook, 1961 : 26, Pl. 2, fig. 29; Happy, 1971 : Table following p. 100; Nelson, 1973 : Table following p. 183.
Gaudryina convexa (Karrer); Burdett, Hedley, Hornibrook and Hurdle, 1963 : Hornibrook, 1971 : Pl. 1, figs. 8 – 15.

Dimensions of Hypotype: Length 2.55mm.

Distribution: Rare, occurs in 7 samples from columns 5, 6 and 7 near Mahoenui and one sample from column 19 near Te Kuiti.

Recorded Stratigraphic Range: Kaiatan – Recent (Hornibrook, 1971) (Upper Eocene to Recent).
GAUDRYINA QUADRAEZA Hornibrook, Pl. 2, fig. 3,

Gaudryina quadraeza Hornibrook, 1961 : 25, Pl. 2, fig. 22, 28;
Hayward, 1975 : 502 (List).

Dimensions of Hypotype: Length 1.33mm

Distribution: Rare and sporadic generally confined to the massive Taumatamaire Formation, from Mahoenui, Te Kuiti and east of Aria (columns 1, 2, 3, 4, 14, 18, 22 and 39) one sample from the base of the Mahoenui Group near Taumarunui (column 47a) also contained G. quadraeza.


GAUDRYINA REUSSI (Stache), Pl. 2, fig. 2.

Gaudryina reussi Stache, 1864 : 171, Pl. 21, fig. 11;

Gaudryina obliquata Stache, 1864 : 172, Pl. 21, figs. 12a,b.

Gaudryina megastoma Stache, 1864 : 173, Pl. 21, figs. 13a, b.

Gaudryina novozealandica Stache, 1864 : 174, Pl. 21, figs. 14a,b.

Gaudryina capitata Stache, 1864 : 176, Pl. 21, figs. 15a,b.

Gaudryina insecta Stache, 1864 : 177, Pl. 21, figs. 16a –d.

Gaudryina (Pseudogaudryina) reussi (Stache); Cushman, 1937a : 92, Pl. 13, fig. 12, 15, 16; Finlay, 1939a : 511-513.

Pseudogaudryina anachrons Finlay, 1939c : 312, Pl. 25, figs. 36, 37.

Dimensions of Hypotype: Length 2.67mm.

Distribution: A number of specimens occur in sample 74 from the Te Kuiti Group in column 22. It is not recorded from the Mahoenui Group.

Recorded Stratigraphic Range: Kaiatan to Otaian (Hornibrook, 1971) (Late Eocene – early Miocene).
Genus TRITAXIA Reuss, 1860

TRITAXIA INSTAR (Finlay) Pl. 2, figs. 4, 5.

Clavulinoides instar Finlay, 1939b: 94, Pl. 14, fig. 77;
Nelson, 1973: Table following p. 183.
Tritaxia sp. (Clavulinoides instar of Finlay) Happy, 1971: Table following p. 100.

Remarks: Mahoenui specimens are large, finely arenaceous and glossy with excess cement. Test initially triserial followed by 3 to 4 uniserial chambers. Test triangular in cross section, carinate and has subparallel sides and a simple terminal aperture. Specimens have been compared with Finlay's types and are identical.

Dimensions of Hypotype: Length 1.11mm.

Distribution: This uncommon species is found in 8 samples, 4 from columns 6 and 7 near Mahoenui and 4 from columns 18 and 19 near Te Kuiti.

Recorded Stratigraphic Range: Finlay recorded this species from the middle Miocene. These specimens are from the Otaian Stage. (Early - middle Miocene).

Subfamily GLOBOTEXTULARIINAE

Genus DOROTHIA Plummer, 1931

DOROTHIA MINIMA (Karrer) Pl. 2, figs. 6, 7.

Textilaria minima Karrer, 1864: 79, Pl. 16, fig. 9.
Plecanium karreri Stache, 1864: 178, Pl. 21, fig. 17.
Plecanium granosissimum Stache, 1865: 179, Pl. 21, fig. 18.
Plecanium eurystoma Stache, 1864: 179, Pl. 21, fig. 19.
Dorothia karreri (Stache): Cushman, 1937a: 92, Pl. 10, fig. 9.
Dorothia minima (Karrer); Finlay & Marwick, 1940: 113, 121;
Hornibrook, 1961: 28, Pl. 2, fig. 27; Scott, 1971: Fig. 2
(1st); Hornibrook, 1971: 16, Pl. 1, figs. 16-20.

Remarks: Large specimens initially triserial becoming biserial and flaring with a low slit-like interiomarginal aperture are referred to Dorothia minima.

Dimensions of Hypotype: Length 1.47mm, Breadth 1.18mm.
Distribution: Rare specimens occur sporadically throughout the Mahoenui Group in samples from the west and north of the study area. (Columns 1, 5, 6, 13, 14 and 20). To the south east, near Taumarunui, *Dorothia minima* is only recorded in two samples both at the base of the Mahoenui in column 47a.


Genus *EGGERELLA* Cushman, 1933

*EGGERELLA BRADYI* (Cushman) Pl. 2, fig. 8.

- *Verneuillina pygmaea* (Egger); Brady, 1884: Pl. 47, figs. 4-7.
- *Verneuillina bradyi* Cushman, 1911: 54.
- *Eggerella bradyi* (Cushman); Cushman, 1933: 30; Gibson, 1967: 11, Pl. 2, fig. 21; Phleger & Parker, 1951: 6, Pl. 3, figs. 1, 2;
  - Nelson, 1973: Table following p. 183.

Remarks: *Eggerella bradyi* is used for small specimens that are finely arenaceous and glossy due to excess cement, are initially high trochospiral but later become biserial, have globular chambers separated by deeply incised sutures and a lipped aperture lying close to but not on the basal suture of the apertural face.

Dimensions of Hypotype: Length .32mm.

Distribution: *Eggerella bradyi* is uncommon in the Mahoenui area in the west and commonest in the area south from Te Kuiti and east of Aria. The sediments in this area are mostly "distal" flysch. Occurrences from further south near Taumarunui are generally from the massive mudstones of the Taumatamaire Formation underlying the flysch of the Taumarunui Formation. Columns with samples containing *Eggerella bradyi* are:- 9, 12, 15, 18, 19, 21, 22, 29, 31, 33, 34, 39, 42, 44, 45, 46a and 47b.

Recorded Stratigraphic Range: Otaian – Recent. (Early Miocene – Recent).

Genus *KARRERIELLA* Cushman, 1933

*KARRERIELLA BRADYI* (Cushman), Pl. 2, fig. 9.

- *Guadryina pupoides* Brady, 1884: 373, Pl. 46, fig. 1-4 (Not of d'Orbigny).
Gaudryina bradyi Cushman, 1911: 67, Text figs. 107a-c.
Karreriella bradyi (Cushman); Phleger & Parker, 1951: 6,
Pl. 3, fig. 4; Hornibrook, 1961: 28; Murray, 1971: 47, Pl. 16,
fig. 1-4; Nelson, 1973: Table following p. 183.

Remarks: In general appearance Karreriella bradyi and Eggerella bradyi are similar, both are initially trochoid, finely arrenaceous and glossy. However, E. bradyi remains triserial while K. bradyi becomes biserial. The two often occur together and intermediate forms are found. Phlum et al (1976) noted that Eggerella and Karreriella bradyi have similar ecological range and show morphological intergradation. It seems probable that Karreriella bradyi and Eggerella bradyi are synonymous.

Dimensions of Hypotype: Length .41mm.

Distribution: K. bradyi occurs sporadically throughout the Mahoeunui Group.

Recorded Stratigraphic Range: Occurs throughout the Tertiary.

KARRERIELLA CUSHMANI Finlay, Pl. 2, fig. 10.

Karreriella cushmani Finlay, 1940: 452, Pl. 63, figs. 38 - 42;
Hornibrook, 1961: 28; Vella, 1962: 188; Gibson, 1967: 12,
Pl. 2, fig. 26; Hornibrook, 1968: 69, fig. 12.

Remarks: Specimens from the Mahoeunui Group referred to K. cushmani are similar to K. bradyi with a glossy test and inflated chambers well defined by deeply incised sutures. However, this species differs from K. bradyi in that the test is larger and the biserial section is much more elongated.

Dimensions of Hypotype: Length .94mm.

Distribution: Occurs only in sample 49 from column 9.

Recorded Stratigraphic Range: Finlay (1940) recorded K. cushmani from Waitakian – Altonian strata and K. cylindrica from Taranakian rocks. Gibson described parallel occurrences of K. cushmani and K. cylindrica from the Tongaporutuan and Opoitian Stages. Waitakian to Opoitian (Oligocene – Pliocene).
KARRERIELLA NOVOZEALANDICA Cushman, Pl. 2, fig. 11.

Karreriella novozealandica Cushman, 1936c : 37, Pl. 5, fig. 18;
Cushman, 1937a : 133, Pl. 15, fig. 19; Finlay, 1940 : 451,
Pl. 63, fig. 35-37; Dorreen, 1948 : 286, Pl. 36, fig. 4;

Remarks: A much squatter species than K. cushmani with a coarser test and less incised sutures is referred to K. novozealandica Cushman.

Dimensions of Hypotype: Length .96mm.

Distribution: Rare, only occurring in samples 42 and 49 from columns 7 and 9.

Recorded Stratigraphic Range: Hornibrook (1961) noted that K. novozealandica is the earliest member of a lineage including K. cushmani and K. cylindrica. He recorded K. novozealandica from the Porangan Stage to the Landon Series with forms intermediate to K. cushmani occurring in the Otaian Stage. Mahoenui specimens are from the lower part of the Taumatamaire Formation near Mahoenui. These rocks are of probable Otaian age.

Subfamily VALVULININAE

Genus MARTINOTTIELLA Cushman, 1933

MARTINOTTIELLA CLARAE Gibson, Pl. 2, fig. 12.

Martinottiella clarae Gibson, 1967 : 12, Pl. 2, figs. 24, 27-29;
Nelson, 1973 : Table following p. 183.

Remarks: Martinottiella clarae is the most abundant species of Martinottiella recorded from the Mahoenui Group. It is characterised by a subangular multiserial section forming 1/3 – 1/4 of the test length and a uniserial section of 4 – 5 chambers terminated by a short spouted aperture. Mahoenui Group specimens were compared with Gibsons type suite at Victoria University and are considered to be conspecific.

Dimensions of Hypotype: Length .93mm.

Distribution: Occurs regularly throughout the northern and western parts of the study area. Towards Taumarunui M. clarae is only recorded in 4 samples. Three of these are from the massive mudstones
of the Taumatamaire Formation underlying the Taumarunui Formation, while the other is from the flysch immediately below the Mahakatino Formation in column 46a.

Recorded Stratigraphic Range: Gibson recorded M. clarae from the Waiauan to Kapitean. Specimens from the Mahoenui extend this range downwards to the Otaian and possible the Waitakian Stages. (? Late Oligocene, early Miocene – late Miocene).

MARTINOTTIELLA COMMUNIS (d'Orbigny) Pl. 2, fig. 13.

Clavulina communis d'Orbigny, 1846 : 196, Pl. 12, fig. 1 – 2; Chapman, 1926 : 36, Pl. 8, fig. 10.
Listerella communis (d'Orbigny); Cushman, 1937 : 148, Pl. 17, fig. 4 – 9.
Martinottiella communis (d'Orbigny); Hornibrook, 1961 : 29, Pl. 27, fig. 536; Hornibrook, 1971 (list); Scott, 1971a : fig. 2 (list); Nelson, 1973 : Table following p. 183; Hayward, 1975 : 502 (list).

Remarks: Specimens differing from M. clarae in having a shorter, rounded multiserial section and a uniserial section of 8 – 9 chambers are placed in M. communis.

Dimensions of Hypotype: Length 1.09mm.

Distribution: Specimens are recorded from columns 12, 14, 15, 21 and 45.

Recorded Stratigraphic Range: Dannevirke Series to Recent.

Genus ARENDOSARIA Finlay, 1939

ARENODOSARIA ANTIPODA (stache), Pl. 2, fig. 14, 15.

Clavulina elegans Karrer, 1864 : 80, Pl. 16, fig. 11.
Clavulina antipodum Stache, 1864 : 167, Pl. 21, figs. 3 – 8.
Clavulina robusta Stache, 1864 : 169, Pl. 21, figs. 9, 10.
Lingulina rimosa Stache, 1864 : 192, Pl. 22, figs. 16a, b.
Nodosaria stachei Chapman, 1926 : 53.
Liebusella antipoda (Stache); Cushman, 1937a : 167, Pl. 20, figs. 15, 16.
Listerella elegans (Karrer); Parr, 1937 : 75, Pl. 15, figs. 4 – 8.
Arendosaria antipoda (Stache); Finlay, 1939c: 95; Finlay & Marwick, 1940: 108, 119; Hornibrook, 1961: 29, Pl. 3, fig. 36; Hornibrook, 1968: 54, fig. 8; Hornibrook, 1971: 32, Pl. 5, figs. 77, 78, Text fig. 8; Nelson, 1973: Table following p. 183.

Arenodosaria robusta (Stache); Finlay, 1939a: 95.

Remarks: Following Hornibrook (1971) the name Arenodosaria antipoda is maintained even though A. elegans (Karrer) has page precedence. The name is used for large agglutinated specimens that are initially multiserial but later become uniserial. The juvenile has a slit like aperture, the adult a simple terminal aperture. Both megalospheric (A. robusta (Stache) of Finlay) and microspheric forms are recorded.

Dimensions of Hypotype: Length 2.18mm.

Distribution: Occurs regularly from columns from Mahoenui to Te Kuiti. It is also recorded from one sample in column 32. Further south near Taumarunui A. antipoda is recorded from several samples at the base of columns 44 and 47a. It is also present in sample 155 from the upper part of the Mahoenui in column 46a.


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Family PAVONITINIDAE

Subfamily PAVONITININAE

Genus TEXTULARIELLA Cushman, 1927

TEXTULARIELLA BARRETTII (Jones & Parker), Pl. 2, fig. 16.

Textularia barretti Jones & Parker, 1863: 8, 105; Mestayer, 1916: 129.

Textariella barrettie (Jones & Parker); Cushman, 1927: 24, Pl. 5, fig. 3; Renz, 1948: 171, Pl. II, figs. 13a – b; Barker, 1960: 90, Pl. 44, fig. 3, 6, 8; Eade, 1967: 22.

Remarks: Rare specimens with a coarsely arenaceous rapidly expanding conical test that is initially rounded and multiserial then triserial and finally biserial are placed as T. barretti (Jones & Parker). They
have a labyrinthic interior, indistinct sutures and an interiomarginal aperture.

Dimensions of Hypotype: Length .83mm.

Distribution: Recorded in only six samples from columns 6, 7, 9, 26 and 32.

Recorded Stratigraphic Distribution: This species has been regularly recorded from Recent sediments. Renz (1948) recorded it from late Oligocene and early Miocene strata in Venezuela. It is here recorded from Otaian strata of the Mahoenui Group.

Suborder MILIOLINA
Superfamily MILIOLACEA
Family FISCHERINIDAE

Genus CYCLOGYRA Wood, 1842

CYCLOGYRA INVOLVENS (Reuss), Pl. 3, fig. 1.

Operculina involvens Reuss, 1850 : 370, Pl. 46, fig. 30.
Cornuspira involvens (Reuss); Brady, 1884 : 200, Pl. 11, figs. 1 - 3.
Cyclogyra involvens (Reuss); Loeblich and Tappan, 1964a; Hedley, Hurdle & Burdett, 1967 : 24, fig. 16; Murray, 1971 : 53, Pl. 18, figs. 1 - 3; Topping, 1973 : 22, Pl. 5, fig. 6; Quilty, 1974 : 42, Pl. 1, fig. 22.

Dimensions of Hypotype: Diameter .26mm.

Distribution: Very rare, occurs only in samples 18 and 19 from column 3.

Observed Stratigraphic Range: A Recent species, here seen in the Otaian Stage.

Family NUBECULARIIDAE
Subfamily SPIROLOCULININAE

Genus SPIROLOCULINA d'Orbigny, 1826

SPIROLOCULINA NOVOZEALANDICA Cushman & Todd, Pl. 3, fig. 2.
Spiroloculina dorsata Reuss; Chapman, 1926 : 24, Pl. 7, fig. 5.
Spiroloculina rotundata Kreuzberg, 1930 : 276, Pl. 20, fig. 2.
Spiroloculina novozealandica Cushman & Todd, 1944 : 27, Pl. 4, fig. 23 (new name); Finlay & Marwick, 1947 : 232; Finlay, 1947 : 271; Hornibrook, 1961 : 35, Pl. 3, fig. 42.

Remarks: Large, flattened and spiroloculine with rounded chambers.

Dimensions of Hypotype: Length .98mm.

Distribution: Hornibrook (1961) recorded Spiroloculina novozealandica from the "Otaian part of the Mahoenui Formation" but found no specimens in the basal Mahoenui near Te Kuiti. S. novozealandica is uncommon in the Mahoenui Group and is recorded in only 5 samples. Two are from columns 3 and 4 near Mahoenui, two from the middle Mahoenui in columns 14 and 15 near Te Kuiti and one from the upper part of column 29.

Recorded Stratigraphic Range: Spiroloculina novozealandica first appears near, but probably a little above (Hornibrook, 1961), the base of the Otaian Stage and ranges up to the Opoitian Stage.

Family MILIOLIDAE

No stratigraphic ranges are given for the Miliolidae as they are of little stratigraphic value. Most species recorded from the Mahoenui Group have previously been recorded from Recent sediments around New Zealand.

Subfamily QUINQUELOCULININAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA cf. DELICATULA Vella, Pl. 3, figs. 3 – 6.

cf. Quinqueloculina delicatula Vella, 1957 : 26, Pl. 4, figs 77-79.

Remarks: Specimens of Q. cf. delicatula are quinqueloculine, medium sized and glossy. The chambers are subquadrate, with concave sides and rounded or subacute, almost angled edges. The aperture is on a short stout neck, circular or oval with a short bifid tooth. This tooth extends $\frac{1}{3}$ to $\frac{1}{4}$ the width of the aperture. A few specimens are close to Q. cooki with a more rectangular aperture, longer tooth and reflexed lip.
Dimensions of Hypotype: Length .57mm, breadth .32mm.

Distribution: Present in 13 samples from columns 1 - 5, 15 and 29.

QUINQUELOCULINA cf COLLEENAE Vella.

   cf. Quinqueloculina colleenae Vella, 1957 : 9, 13, 25, Pl. 5, figs. 86, 93.

Remarks: Similar to Q. cf. delicatula but much more angular.

Distribution: Occurs in sample 3 only.

QUINQUELOCULINA SEMINULA (Linne), Pl. 3, figs. 7 - 9.

   Serpula seminulum Linne, 1767 : 1264.
   Miliolina seminulum (Linne); Brady, 1884 : 157, Pl. 5, figs. 6a - c.
   Quinqueloculina incisa Vella, 1957 : 24, Pl. 6, figs. 118 - 121.
   Quinqueloculina seminula (Linne); Cushman, 1944 : 13, Pl. 2, fig. 14; Hornibrook, 1961 : Table 6, Pl. 2; Hedley, Hurdle & Burdett, 1965 : 13, Pl. 2, fig. 8; Hedley, Hurdle & Burdett, 1967 : 26; Eade, 1967 : 25; Topping, 1973 : 23, Pl. 4, figs. 3-6; Thompson, 1975 : 72, Hayward, 1975 : 504 (list).

Remarks: As outlined in Hedley et al (1967), Topping, (1975) and Thompson (1976) Q. seminulum has a wide range of variation and includes morphotypes gradational from Q. incisa to Q. triangularis Vella. Mahoenui specimens are somewhat inflated with rounded or subangular chambers, a circular aperture with a slightly reflexed lip and a short bifid tooth.

Dimensions of Hypotype: Length .54mm, breadth .35mm.

Distribution: Occurs in 13 samples from columns 2 - 5, 24, 28, 29 and 43.

QUINQUELOCULINA cf. SEMINULA Pl. 3, 10 - 12.

   cf. Serpula seminulum Linne, 1767 : 1264.

Remarks: This name is used for specimens of Quinqueloculina that are of medium to large size and are broadly triangular in apertural view. The chambers are inflated and about 4 - 5 times as long as wide.
The periphery is rounded or subacute, the aperture, circular with a simple bifid tooth. This tooth extends from 1/2 - 2/3 the width of the orifice.

Dimensions of Hypotype: Length .27mm, breadth .25mm.

Distribution: Columns 2 - 5, 13, 23, 24, 46a and 154 have samples with Q. cf. seminula present. This species generally forms between 1 and 2 percent of the total fauna but reaches 9% in one sample.

QUINQUELOCULINA DIMIDIATA Terquem

Quinqueloculina dimidiata Terquem, 1876 : 81, Pl. 81, Pl. 40, figs. 5a - c; Murray, 1971 : 61, Pl. 22, figs. 5 - 8.

Remarks: This rare species is only found in sample 27. It is characterised by its small inflated test and oblique sutures.

Dimensions of Hypotype: Length .30mm, breadth .22mm.

QUINQUELOCULINA cf. DUTEMPLEI d'Orbigny, Pl. 4, figs 1 - 4.

cf. Quinqueloculina dutemplei d'Orbigny, 1846 : 294, Pl. 19, figs. 10 - 12.

Remarks: This species is of medium size, quinqueloculine and triangular or flattened in apertural view. The periphery is acute and may develop a narrow keel. The chambers are triangular in cross section, have flat sides with ornament of fine striae parallel to their margins. This is reduced or absent in some specimens. An ellipsoid or circular aperture is partially blocked by a bifid tooth extending from 1/2 to 2/3 of its width.

Quinqueloculina striatula is similar to this species but has an aperture that is wide and almost hooded. T. striatula Parr has a similar aperture and tooth but is triloculine not quinqueloculine.

Dimensions of Hypotype: Length .48mm, breadth .33mm.

Distribution: Q cf. dutemplei occurs commonly in the northern and western parts of the study area where it often forms between 1 and 8% of the total fauna. It is also found in several samples from east of Aria. In these samples it forms less than 1% of the total fauna.
QUINQUELOCULINA cf. POLYGONA d'Orbigny, Pl. 4, figs. 5, 6.

cf. Quinqueloculina polygona d'Orbigny, 1839: 198; (Plates published separately).

Remarks: Shell quinqueloculine, elongate with subquadrate, bicarinate twisted chambers and a circular terminal spouted aperture. Apertural tooth short. Mahoenui specimens referred to Q. cf. polygona are even more contorted than those described by d'Orbigny.

Dimensions of Hypotype: Length .67mm, breadth .33mm.

Distribution: Uncommon, occurring in only 6 samples from columns 3, 4 and 5.

QUINQUELOCULINA OBLONGA (Montagu), Pl. 4, fig. 7.

Vermiculum oblongum Montagu, 1803: 522, Pl. 14, fig. 9.

Miliolinella (?) oblonga (Montagu); Brady, 1884: Pl. 5, fig. 4; Williamson, 1858: Pl. 7, figs. 186 – 187; Barker, 1961: Pl. 5, fig. 4.

Quinqueloculina oblonga (Montagu); Murray, 1971: 63, Pl. 23, fig. 4 – 8.

Remarks: A small or medium sized elongated test with rounded chambers and an aperture at the end of a short neck. Murray (1971) noted that this species was misplaced as Miliolinella and that the tooth illustrated by Williamson (1858) was an abnormal flap. Mahoenui specimens have a short stout simple tooth.

Dimensions of Hypotype: Length .43mm, breadth .16mm.

Distribution: A few specimens were found in samples 1, 23 and 139.

QUINQUELOCULINA COSTATA d'Orbigny, Pl. 4, figs. 8 – 10.

Quinqueloculina costata d'Orbigny, 1826: 301; Schlumberger, 1893: 69, Text fig. 20, Pl. 3, figs. 75, 76; Fornasini, 1905: 62, Pl. 2, figs. 6a – c; Parr, 1935: 84, Pl. 20, figs. 4a – c.

Remarks: Q. Costata and Q. striata are very similar apart from the density of the ornamentation. Mahoenui specimens best fit Q. costata. They are characterised by long narrow rounded chambers separated by distinct sutures. The chambers are ornamented with a few moderately heavy costae. The aperture is sited at the end of a short neck and lacks a prominent lip. A bifid tooth extends about half-way across
the opening.

Dimensions of Hypotype: Length .37mm, breadth .14mm.

Distribution: Occurs in 7 samples from columns 1, 2, 3 and 4 near Mahoenui. This species never exceeds 1% of the total fauna.

Genus PYRGO Defrance, 1824

PYRGO DEPRESSA (d'Orbigny).

Biloculina depressa d'Orbigny, 1826 : 298, No. 7.

Pyrgo depressa (d'Orbigny); Murray, 1895 : 604; Cushman, 1929 : 71; Parr, 1935 : 86; Vella, 1957 : 29, Pl. 7, figs. 137, 140;
Barker, 1960 : 4, Pl. 2, figs. 12, 16, 17, Pl. 3, figs. 1, 2;
Albani, 1968 : 18, fig. 52; Thompson, 1975 : 73, Pl. 6, figs. 4, 5; Hayward, 1975 : 504 (list).

Remarks: Specimens of Pyrgo with a large subcircular test that is lenticular in equatorial view and has an angular periphery are placed in P. depressa. The aperture differs from typical P. depressa in being narrower and more gaping. It is about half the width of the test, elliptical with a prominent platelike bifid tooth. The Mahoenui specimens are close to P. depressa as illustrated by Brady (1884) Pl. 2, fig. 12.

Dimensions of Hypotype: Maximum diameter .87mm.

Distribution: Rare, only in samples 17, 47 and 108.

PYRGO cf. EZO Asano.

cf. Pyrgo ezo Asano, 1938 : 93, Pl. 9, figs. 1-6.

Remarks: These specimens are very close to P. ezo recorded from the Pliocene of Japan by Asano (1938). They are medium sized with an oval test, lightly compressed in equatorial view with a narrowly rounded periphery. The aperture is arcuate, lipped, with a prominent platelike tooth.

Dimensions of Hypotype: Maximum diameter .58mm.

Distribution: Sporadic, occurs in 7 samples from columns 3, 13, 24, 31, 36 and 46a.
PYRGO SUBPISUM Parr

Pyrgo subpisum Parr, 1950: 297, Pl. 5, figs. 5a - c, 6;
Albani, 1968: 19, fig. 54; Thompson, 1975: 73, Pl. 6,
figs. 6 - 7.

Remarks: A very large inflated subglobular shell with a circular,
heavily-rimmed aperture and a prominent bifid tooth.

Dimensions of Hypotype: Maximum diameter .94mm.

Distribution: Rare (samples 17 and 69 only).

Genus PATEORIS Loeblich & Tappan, 1953

PATEORIS sp.

Remarks: Similar to Miliolinella subrotundum but with a wide gaping
aperture and no plate or tooth. The later chambers of Pateoris sp.
tend to become planispiral.

Distribution: Only recorded from sample 17.

Genus SIGMOILINA Schlumberger, 1887

SIGMOILINA TENUIS (Czjzek), Pl. 4, fig. 15.

Quinqueloculina tenuis Czjzek, 1848: 149, Pl. 13, figs. 31 - 34.
Spiroloculina tenuis (Czjzek); Heron-Allen and Earlend, 1922: 63.
Sigmoilina tenuis (Czjzek); Chaster, 1892: 56; Finlay & Marwick,
1940: 106; Cushman, 1946: 32, Pl. 5, figs. 13 - 15; Barker, 1960: 20, Pl. X, figs. 7, 8, 11; Hornibrook, 1961: 34, Pl. 27, fig. 533;
Thompson, 1975: 74, Pl. 7, figs. 2 - 4.

Remarks: A small test, matt not glossy, initially quinqueloculine
but gradually becoming planispiral. The shell is sigmoid in apertural
view and has a terminal, necked, aperture.

Dimensions of Hypotype: Length .28mm, breadth .15mm.

Distribution: Rare, occurring in samples 18, 66 and 161 only.
Subfamily MILIOLINELLINAE

Genus SCUTULORIS Loeblich and Tappan, 1953

SCUTULORIS HORNIBROOKI (Vella), Pl. 4, figs. 11 - 13.

Quinquinella hornibrookii Vella, 1953 : 21, Pl. 7, figs. 127 - 9;
Hornibrook, 1961 : 34.
Scutuloris hornibrooki (Vella); Gibson, 1967: 18, Pl. 3, fig. 47.

Remarks: Similar to Q. seminula in form but characterised by its
hooded aperture and broad platelike tooth.

Dimensions of Hypotype: Length .63mm, breadth .42mm.

Distribution: Occurs abundantly in 8 samples from columns 3 - 5 and
13.

Genus MILIOLINELLA Wiesner, 1931

MILIOLINELLA SUBROTUNDUM (Montagu), Pl. 4, fig. 14.

Vermiculum subrotundum Montagu, 1803 : 521 (figured by Walker
& Boys, 1784, Testacea minuta rariora Pl. 1, fig. 4).
Miliolina subrotundum (Montagu); Chapman, 1909 : 319.
Miliolinella subrotundum (Montagu); Mestayer, 1916 : 128;
Heron-Allen & Earland, 1922 : 65; Murray, 1971 : 73, Pl. 28,
figs. 5, 6.

Remarks: Mahoenui specimens are triloculine, of medium size and
have inflated chambers. A wide terminal aperture is almost closed by
a flap-like tooth.

Dimensions of Hypotype: Length .64mm, breadth .73mm.

Distribution: A few specimens occur in samples 9, 17, 23, 27 and 29.

Suborder ROTALIINA
Superfamily NODOSARIACEA
Family VAGINULINIDAE
Subfamily LENTICULININAE

Genus LENTICULINA Lamarck, 1804.

LENTICULINA n.sp.A, Pl. 5, figs. 1-4.
Description: Test smooth walled, medium sized, tightly coiled planispiral. Strongly compressed with a narrow peripheral keel, biumbonate with broad and translucent umbos. Early whorls visible through umbo. Final whorl with 6 - 7 chambers, sutures limbate, straight or gently recurved meeting the umbo tangentially. Aperture radiate, one limb extending down the apertural face with frilled lips.

Dimensions of Holotype: .49mm diameter, .10mm thickness.

Repository: Holotype and 6 paratypes are lodged with the Geology Department of Auckland University.

Type locality: R17/f14 Sample 14, (column 5), 1 Km south of Taumatamaire Road R17/621896. (NZMS 260). Paratypes from samples 46, 48 (column 13) and sample 30 (column 6) R17/698920.

Type level: Taumatamaire Formation, Mahoenui Group (Otaian).

Remarks: Lenticulina n.sp.A. was compared with the matched toptotypes of several species of Lenticulina described by Stache and held in the New Zealand Geological Survey collections. Lenticulina n.sp.A differs from L. gyroscalpra in being smaller, with limbate sutures and a less prominent peripheral keel. L. loculosa is much larger than the new species, with many more chambers per whorl, a much less acute periphery and a less prominent umbilical plug. However, among the topotypes of L. loculosa there are a number of smaller specimens that are quite close to L. n.sp.A.

Lenticulina calcar (Defrance) is quite similar to L.n.sp.A. in that it has straight or gently curved limbate sutures and a transparent umbo but the new species is much smaller with a less prominent keel that lacks peripheral spines. It also has more chambers per whorl.

Distribution: A common species, occurring in 45% of the samples, particularly from the north and west of the study area. This species generally forms less than 2% of the population but may reach 20%.


LENTICULINA CALLIFERA (Stache) Pl. 5, fig. 5.

Cristelaria callifera Stache, 1864 : 236, Pl. 23, figs. 15a, b.
Robulus calliferus (Stache); Hornibrook, 1971 : 42, Pl. 9, figs. 148, 149.
Lenticulina callifera (Stache); Hayward, 1975: 445, 506.

Remarks: This medium-sized species is characterised by its inflated test with 4 chambers in the final whorl, lack of a prominent umbo, limbate recurred sutures and subacute periphery which may be weakly carinate.

Dimensions of Hypotype: Diameter .32mm.

Distribution: Never abundant (generally less than 1% of the total fauna) but occurs in 29 samples from columns 1 - 4, 6, 7, 13, 14, 16, 17, 25, 29, 31, 43 and 45.

Recorded Stratigraphic Range: Runangan - Otaian. (Upper Eocene - early Miocene).

LENTICULINA GYROSCALPRA (Stache), Pl. 5, fig. 6.

Cristellaria gyroscalprum Stache, 1864: 243, Pl. 23, fig. 22.
Robulus gyroscalonus (Stache); Hornibrook, 1961: 36, Pl. 5, fig. 67; Hornibrook, 1971: 43, Pl. 9, figs. 160, 161.
Lenticulina gyroscalprus (Stache); Nelson, 1973: Table following p. 183.
Lenticulina gyroscalpra (Stache); Hayward, 1975: 441, 506.

Remarks: See Lenticulina pseudocalcarata (Stache) below.

Dimensions of Hypotype: Diameter .80mm

Distribution: L. gyroscalpra is the commonest species of Lenticulina from the Mahoeenui Group. It is found in 46% of all samples and often forms between 1 and 5% of the total fauna.


LENTICULINA PSEUDOCALCARATA (Stache)

Robulina pseudocalcarata Stache, 1864: 252, Pl. 23, fig. 31.
? Robulina oculus Stache, 1864: 247, Pl. 23, figs. 27a, b.
? Robulina cultrata antipodum Stache, 1864: 251, Pl. 23, figs. 30a, b.
Robulus pseudocalcaratus (Stache); Hornibrook, 1971: 44, Pl. 9, figs. 154 - 157.
Lenticulina pseudocalcarata (Stache); Hayward, 1975: 441, 506.
Remarks: Lenticulina pseudocalcarata and L. gyroscalpra are both large compressed species with acute carinate peripheries, 6 - 8 chambers in the final whorl, large opaque umbos and straight or gently recurved sutures. In both, the sutures are non limbate, or only lightly thickened, and are tangential to the umbo. Lenticulina gyroscalpra has a narrow keel and a very broad umbo while L. pseudocalcarata has a much less prominent umboral plug and a wide flange like keel.

Mahoenui Group hypotypes of these species were compared to the matched Topotypes of Staches' species present in the New Zealand Geological Survey collections.

Dimensions of Hypotype: Diameter .84mm.

Distribution: L. pseudocalcarata is less common than L. n. sp or L. Gyroscalpra. It is found sporadically throughout the Mahoenui Group. 29 samples from columns 3 - 5, 7 - 10, 13 - 17, 19, 22, 27, 31, 34, 39, 42, 46a and 47a contain L. pseudocalcarata.

Recorded Stratigraphic Range: Landon and Pareora Series (Oligocene and early Miocene).

LENTICULINA cf. COLORATA (Stache), Pl. 5, fig. 7.

Cristellaria colorata Stache, 1864 : 229, Pl. 23, figs. 9a - b.
Robulus coloratus (Stache); Hornibrook, 1971 : 42, Pl. 8, figs. 139 - 146.
Lenticulina colorata (Stache); Hayward, 1975 : 445.

Remarks: Mahoenui specimens are somewhat smaller than the matched topotypes of L. coloratus in the New Zealand Geological Survey collections. They are otherwise similar and are flattened with 6 - 8 chambers in the final whorl, have straight or slightly recurved limbate sutures that join at a narrow opaque umbo, and have a broad often spinose keel.

Dimensions of Hypotype: Diameter .54mm.

Distribution: Not abundant, but recorded in 26 samples from throughout the Mahoenui Group. Present in samples from columns 2 - 4, 6, 7, 11, 14 - 17, 19, 25, 29, 30, 39 and 42 - 44.

Recorded Stratigraphic Range: L. colorata ss has been recorded from the Runangan Stage to the Landon Series. Specimens recorded as L. cf. colorata are here seen in Otaian strata.
LENTICULINA MAMILLAGERA (Karrer), Pl. 5, fig. 9.

Cristellaria mamilligera Karrer, 1864 : 76, Pl. 16, fig. 5.

Lenticulina mamilligera (Karrer); Hornibrook, 1968 : 63, fig. 10; Hornibrook, 1971 : 17, Pl. 2, fig. 21.

Remarks: This large inflated species is characterised by its heavy limbate sutures with prominent tubercles.

Dimensions of Hypotype: Diameter 1.40 mm.

Distribution: Sporadic, occurs in 11 samples from columns 4, 7, 13 - 15, 19, 20, 25, 39 and 41. These are mostly from Mahoenui - Te Kuiti.

Recorded Stratigraphic Range: Waitakian Stage - lower Wanganui Series (Oligocene to Pliocene).

LENTICULINA LENTICULA (Stache) Pl. 5, figs. 10, 11.

Robulina lenticulus Stache, 1864 : 246, Pl. 23, fig. 25.

Robulus lenticulus (Stache); Hornibrook, 1971 : 43, Pl. 9, figs. 158, 159.

Lenticulina lenticulus (Stache); Hayward, 1975 : 441, 506.

Remarks: Mahoenui specimens are very close to the matched Topotypes of Lenticulina lenticula (Stache) in the New Zealand Geological Survey collections. They are similar to L. gyroscalpra in general form but have numerous narrow chambers and very recurved sutures which sweep around a narrow translucent umbo before intersection it at a low angle. The periphery carries a narrow keel.

Dimensions of Hypotype: Diameter .42 mm

Distribution: Occasional specimens recorded in 8 samples from columns 2, 14, 16, 32, 34, 42, 43 and 46a.

Recorded Stratigraphic Range: Stache (1864) recorded this species from the Whaingaroa Siltstone (Whaingaroan). These specimens are from the Otaian of the Mahoenui Group.

LENTICULINA LOCULOSA (Stache) Pl. 5, fig. 12.

Robulina loculosa Stache, 1864 : 244, Pl. 22, fig. 23.

Cristellaria larva Stache, 1864 : 232, Pl. 23, figs. 11a, b.

Cristellaria rotula Stache, 1864 : 233, Pl. 23, figs 12a, b.
Cristellaria falcifer  Stache, 1864 : 240, Pl. 23, figs. 19a, b.
Robulus loculosus  (Stache); Finlay & Marwick, 1940 : 113, 123;
Hornibrook, 1961 : 37, Pl. 4, fig. 63; Hornibrook, 1971 : 43,
Pl. 9, fig. 147; Happy, 1971 : Table following p. 100.
Lenticulina loculosa  (Stache); Hayward, 1975 : 445, 506.

Remarks: Mahoenui specimens recorded as *L. loculosa* are large, inflated,
with a rounded periphery and have about 8 - 10 chambers in the final
whorl. The sutures are gently recurved and lightly limbate or
unthickened and meet the opaque umbonal knob at a high angle.
Mahoenui specimens were compared with the Matched Topotypes in the
New Zealand Geological Survey. They are generally similar but tend
to have fewer chambers than *L. loculosa* s.s. which normally has
10 - 13 in the final whorl.

Dimensions of Hypotype: Diameter .91mm.
Distribution: Widespread, occurs in 46 samples in columns 1 - 9, 15,
16, 18 - 20, 25, 26, 30, 32, 34, 37, 38, 40, 42, 44, 46 and 47a.

Recorded Stratigraphic Range: Kaiatan Stage to lower Wanganui Series
(Eocene - Pliocene).

LENTICULINA ERRATICA  Hornibrook, Pl. 5, fig. 8.

Lenticulina erratica  Hornibrook, 1961 : 38, Pl. 4, fig. 65, 66.

Remarks: A small species with globular chambers, initially coiled
but later tending to uncoil.

Dimensions of Hypotype: Length .63mm.
Distribution: Recorded from sample 97 only.

Recorded Stratigraphic Range: Whaingaroan - Waiauan (Oligocene -
mid Miocene).

Genus DARBYELLA  Howe and Wallace, 1932

DARBYELLA sp.

Remarks: The specimens found are large, compressed and *Lenticulina-*
like. However, the test is slightly evolute on one side, making it
assymetrical or "semitrochoid". The sutures are non limbate, straight
or gently recurved, the periphery narrowly rounded without a keel and
the aperture is terminal, radiate. Hornibrook (1961) recorded a species of Darbyella from the Rifle Butts formation but these specimens had more than one whorl exposed, limbate sutures and had a peripheral keel. Darbyella tosaensis Takayanagi (1953) is similar but this species differs in being much more compressed, more assymetrical and in having more recurved sutures.

Dimensions: Diameter 1.76mm.

Distribution: Rare, occurs only in samples 29, 69 and 149.

Observed Stratigraphic Range: Otaian (early Miocene).

Genus ASTACOLUS Montford, 1808

ASTACOLUS COMPRESSUS (Stache) Pl. 6, fig. 1.

Hemiobulina compressus Stache, 1864 : 239, Pl. 23, figs. 8a, b.

Astacolus compressus (Stache); Hornibrook, 1971 : 41, Pl. 8, figs. 132 – 134; Hayward, 1976 : 504.

Remarks: Moderately compressed, planispiral specimens with a rounded periphery and narrow sloping chambers which reach down to the umbilicus are here referred to Astacolus compressus. Mahoenui specimens are close to the Matched Topotypes in the New Zealand Geological Survey collections but they have a somewhat less prominent slit in the apertural face.

Dimensions of Hypotype: Length .46mm.

Distribution: Rare, never forming more than 1% of the total fauna. Recorded in 7 samples from columns 4, 6, 13, 15, 29, 43 and 44.

Recorded Stratigraphic Range: Hornibrook recorded Astacolus compressus from the Kaiatan to the Waitakian Stage. Hayward (1976) recorded the species from as high as lower Altonian while these Mahoenui specimens are from Otaian strata. From this it seems reasonable to extend the range of A. compressus through the Pareora Series: Kaiatan – Altonian. (Late Eocene – mid. Miocene).

ASTACOLUS HAASTI (Stache)

Cristellaria haasti Stache, 1863 : 185 (fig. only); Stache, 1864 : 231, Pl. 23, figs. 10a, b.
Astacolus haasti (Stache); Hornibrook, 1971: 41, Pl. 8, fig. 135, 136.

Remarks: Specimens of a large, extremely flattened Astacolus with limbate sutures and a wide peripheral flange compare closely with the topotype specimens in the New Zealand Geological Survey collection. However, the individuals from the Mahoenui are generally smaller.

Dimensions of Hypotype: Diameter 1.09mm.

Distribution: Occurs in samples 75 and 158 only.

Recorded Stratigraphic Range: Hornibrook (1971) records the stratigraphic range of this species as "Landon". Astacolus haasti is here recorded from Otaian strata of the Mahoenui Group. Whaingaroan to Otaian. (Oligocene to early Miocene).

Genus SARACENARIA Defrance, 1824

SARACENARIA AMPLA Cushman & Todd, Pl. 5, fig. 13

Saracenaria arcuata var ampla Cushman & Todd, 1945: 31, Pl. 5, figs. 5, 6.
Saracenaria ampla Cushman & Todd; Gibson, 1967, Pl. 4, fig. 71.

Dimensions of Hypotype: Length .40mm.

Distribution: 8 samples from columns 3, 4, 8, 9, 14, 19, 43 and 47a contain Saracenaria ampla.

Recorded Stratigraphic Range: In New Zealand this species is recorded from early Miocene to Recent.

SARACENARIA ITALICA Defrance, Pl. 5, fig. 14.

Saracenaria italica Defrance, 1824: 177; (1827), Pl. 13, fig. 6; Hornibrook, 1961: 40; Gibson, 1967: Pl. 4, fig. 72.

Dimensions of Hypotype: Length .89mm.

Distribution: Recorded in 8 samples from columns 1, 4, 13, 14, 15, 32, 39 and 47a.

Recorded Stratigraphic Range: Recorded from Duntroonian to Recent. (Oligocene – Recent).
SARACENARIA ARCUATULA (Stache), Pl. 5, fig. 15.

Hemirobulina arcuatulata Stache, 1864 : 227, Pl. 23, figs. 6a, b.
Hemicristellaria pocera Stache, 1864 : 222, Pl. 23, figs. 1a, b.
? Hemicristellaria corculum Stache, 1864 : 223, Pl. 23, figs. 2a, b.
Hemicristellaria excavata Stache, 1864 : 224, Pl. 23, figs. 3a, b.
Hemicristellaria galeola Stache, 1864 : 228, Pl. 23, figs. 7a, b.

Saracenaria arcuatula (Stache); Hornbrook, 1961 : 40;
Hornibrook, 1971 : 41, Pl. 8, figs. 130, 131.

Remarks: Although Saracenaria pocera has page precedence over S. arcuatula Hornibrook (1971) chose to refer this species to S. arcuatula as it was in common usage and he wanted to maintain nomenclatural stability. Specimens from the Mahoenui are rare and variable, but are small, arcuate, initially with a compressed half coil of chambers, later becoming more inflated with a curved rectilinear series of chambers. These chambers reach back towards the proloculus.

Dimensions of Hypotype: Length .66mm.

Distribution: Recorded from samples 23, 28, 45 and 141.

Recorded Stratigraphic Range: Hornibrook, 1971 gave the range Arnold to Pareora Series, possibly higher (Eocene – Miocene) for this species.

Subfamily VAGINULININAE

Genus VAGINULINOPSIS Silvestri, 1904

VAGINULINOPSIS MOKAUENSIS Hornibrook, Pl. 6, fig. 2.

Vaginulinopsis mokauensis Hornibrook, 1961 : 42, Pl. 5, fig. 70, 76; Hornibrook, 1971 : 8 (list); Happy, 1971 : Table following p. 100; Nelson, 1973 : Table following p. 183.

Remarks: This small flattened species is characterised by its ornament of fine longitudinal ribs.
Distribution: Only occurs in three samples: 10, 30 and 69.

Recorded Stratigraphic Range: Waitakian to Lillburnian. (Late Oligocene to middle Miocene).

VAGINULINOPSIS RECTA (Karrer), Pl. 6, fig. 3.

Vaginulina recta Karrer, 1864: 74, Pl. 16, fig. 2.
Vaginulinopsis clifdenensis Hornibrook, 1961: 42, Pl. 5, 71, 72; Happy, 1971: Table following p. 100.
Vaginulinopsis recta (Karrer); Hornibrook, 1971: 17, Pl. 2, figs. 28–31.

Remarks: A large Vaginulinopsis with heavy raised sutures, a rounded periphery and lacking ornamental ribbing is placed in V. recta (Karrer).

Distribution: Recorded from four samples, 5, 10, 13, 107 and 168.

Recorded Stratigraphic Range: Waitakian to Opoitian. (Late Oligocene to Pliocene).

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA ELEGANS d'Orbigny, Pl. 6, fig. 6.

Vaginulina elegans d'Orbigny, 1826: 257, Modeles, 54;
Hornibrook, 1961: 44, Pl. 5, figs. 85, 87; Hornibrook, 1971: 8, 10 (list); Hayward, 1975: 508 (list).

Remarks: Characterised by its subcircular cross section, and straight, noninclined limbate sutures.

Distribution: Although generally forming less than 1% of the total fauna, V. elegans is recorded in 14 samples from columns 3, 4, 6, 14, 15, 17–19, 24a, 30, 34, 42, 45 and 46a.

Recorded Stratigraphic Range: Recorded throughout most of the Tertiary in New Zealand.

VAGINULINA VAGINA (Stache), Pl. 6, fig. 4.

Dentalina vagina Stache, 1864: 206, Pl. 22, fig. 34.
Vaginulina vagina (Stache); Finlay, 1946: 242 (list);
Hornibrook, 1961: 44, Pl. 5, fig. 85; Gibson, 1967: Pl. 5, fig. 73; Hornibrook, 1971: 39, Pl. 7, figs. 119–124; Happy, 1971: Table following p. 100.
Remarks: Elongate, tapering, subcircular in cross section, sutures inclined. Sutures generally little thickened. Mahoenui specimens have been compared with the Topotype specimens of *V. vagina* in the New Zealand Geological Survey collections and agree closely in form.

**Distribution:** Occurs throughout the Mahoenui Group. Found in 26 samples from columns 2, 3, 6, 8, 9, 13 - 16, 19 - 21, 24, 25, 28, 32, 33, 39, 43, 45 and 47b.

**Recorded Stratigraphic Range:** Arnold-Taranaki Series. (Late Eocene to late Miocene).

**VAGINULINA AWAMOANA** Hornibrook, Pl. 6, fig. 5.

*Vaginulina awamoana* Hornibrook, 1961 : 44, Pl. 5, fig. 77, 81, 82.

Remarks: Mahoenui specimens of *Vaginulina awamoana* are somewhat compressed with limbate sloping sutures. The Mahoenui material agrees closely with the type suit. (N.Z.G.S., T.F.1357).

**Distribution:** Recorded from seven samples: 20, 53, 67, 76, 80, 105 and 149.

**Recorded Stratigraphic Range:** Recorded in the Altonian from Oamaru (Hornibrook, 1961). These specimens are from the Otaian.

**VAGINULINA NEGLECTA** (Karrer)

*Marginulina neglecta* Karrer, 1864 : 75, Pl. 16, fig. 4;

**Distribution:** Recorded only from sample 120.

**Recorded Stratigraphic Range:** Previously only recorded from the Waitemata beds (Hornibrook, 1971). These specimens are from the Otaian of the Mahoenui Group.

**Subfamily MARGINULININAE**

**Genus MARGINULINA** d'Orbigny, 1826

**MARGINULINA SUBBULLATA** Hantken, Pl. 6, figs. 7, 8.

*Marginulina subbullata* Hantken, 1875 : 46, Pl. 4, fig. 9, 10, Pl. 5, fig. 9; Finlay, 1946 : 243 (list); Dorreen, 1948 : 288, Pl. 37, fig. 2; Hornibrook, 1961:45, Pl. 5, fig. 84; Hayward,
1975 : 506 (list).

Remarks: Used for specimens of Marginulina that are: rapidly expanding with very inflated chambers and non inclined, somewhat constricted non limbate sutures.

Distribution: Rare, only recorded in two samples from the Mahoenui Group. One at the base of column 45 and one from column 34. It is also present in the Mohakatino beds overlying the Mahoenui in column 42.

Recorded Stratigraphic Range: Occurs throughout the Tertiary in New Zealand.

MARGINULINA OBLIQUE SUTURATA (Stache)

Dentalina oblique suturata Stache, 1864 : 207, Pl. 22, fig. 36;
Hornibrook, 1961 : 46.
Marginulina oblique suturata (Stache); Hornibrook, 1971 : 38, Pl. 7, figs. 115 - 118.

Remarks: This material was compared with the matched Topotype in the New Zealand Geological Survey collection. Mahoenui specimens are small, rapidly tapering and have inclined non-limbate sutures.

Distribution: Sporadic, generally forms less than 1% of the total fauna. Found in 15 samples from throughout the Mahoenui Group. Columns 2, 3, 4, 13, 15, 16, 17, 34, 42, 44, 45, 47a and 47b all have samples containing M. oblique suturata.

Recorded Stratigraphic Range: Hornibrook (1971) recorded the range of this species as 'Arnold to Landon Series, possibly higher'. The material in this study is recorded from Otaian and Clifdenian strata.

Genus MARGINULINOPSIS Silvestri, 1904

MARGINULINOPSIS ALLANI (Finlay) Pl. 6, fig. 9.

Marginulina allani Finlay, 1939c: 318, Pl. 26, fig. 55, 56;
Finlay & Marwick, 1940 : 114, 116; Finlay, 1946 : 242 (list).
Marginulinosopsis allani (Finlay); Hornibrook, 1961 : 43, Pl. 5, fig. 69; Happy, 1971 : Table following p. 100.

Remarks: Specimens of M. allani from the Mahoenui Group are inflated and circular in cross section. The test has an open initial coil that
is followed by a uniserial section. Ornamentation consists of a few fine longitudinal ribs. The aperture is terminal and radiate.

**Distribution:** Only recorded from sample 10.

**Recorded Stratigraphic Range:** Whaingaroan to Altonian. (Oligocene to early Miocene).

**MARGINULINOPSIS HYDROPICA** Hornibrook.

Marginulinopsis hydropica Hornibrook, 1961 : 43, Pl. 5, figs. 74, 75, 79 & 80.

**Remarks:** A stout inflated species with a very large inflated initial region.

**Distribution:** Occurs only in sample 19.

**Recorded Stratigraphic Range:** Hornibrook recorded *M. hydropica* from the Runangan to Duntroonian in Omara. These specimens are from the Otaian.

**Family NODOSARIIDAE**

**Subfamily NODOSARIINAE**

**Genus DENTALINA** d'Orbigny, 1826

**DENTALINA SOLUTA** Reuss, Pl. 6, fig. 10.

Dentalina soluta Reuss, 1851 : 60, Pl. 3, fig. 4; Stach, 1865 : 203, Pl. 22, fig. 29; Chapman, 1926 : 50, Pl. 3, fig. 29, 32; Finlay, 1946 : 243 (list); Hornibrook, 1961 : 45, Pl. 6, fig. 90; Gibson, 1967 : Pl. 5, fig. 74; Hornibrook, 1971 : 8, 10 (list); Hayward, 1975 : 504 (list).

**Remarks:** Specimens of *Dentalina* with a simple curved test, globular chambers and constricted sutures are placed in *D. soluta*.

**Distribution:** Occurs in 10 samples from columns 11, 14 - 17, 19, 25, 37 and 39. All of these are in the north of the study area near Te Kuiti.

**Recorded Stratigraphic Range:** Recorded throughout the New Zealand Tertiary.
DENTALINA OBLIQUECOSTATA (Stache), Pl. 6, fig. 11.

Nodosaria obliquecostata Stache, 1864 : 197, Pl. 22, fig. 24.
Dentalina striatissima Stache, 1864 : 208, Pl. 22, fig. 38.
Dentalina substrigata Hornibrook, 1961 : 44, Pl. 6, fig. 89.
Dentalina obliquecostata (Stache); Hornibrook, 1971 : 38, Pl. 7, figs. 100-102; Hayward, 1975 : 504 (list).

Remarks: A large, arcuate, gently inflated Dentalina. Its chambers are longer than wide and are ornamented with about 12 – 14 heavy longitudinal ribs. These ribs have a slight twist over the length of the test.

Distribution: Recorded in 9 samples from columns 5, 29, 29a, 34, 41, 44, 45, 46a and 47a. These samples are generally from the flysch of the Taumarunui Formation.

Recorded Stratigraphic Range: Hornibrook (1971) recorded the range of this species as "Arnold to Landon Series and possibly higher". The material in this study is from the Otaian Stage.

DENTALINA SUBCOSTATA (Chapman).

Nodosaria (Dentalina) obliqua (Linne) var. subcostata Chapman, 1926 : 50, Pl. 11, fig. 3.
Dentalina subcostata (Chapman); Finlay, 1946 : 243 (list); Hornibrook, 1961 : 45, Pl. 6, fig. 88; Happy, 1971 : Table following p. 100; Hayward, 1975 : 504 (list).

Remarks: Individuals of this species are arcuate, with moderately inflated chambers, constricted sutures and are ornamented by short longitudinal ribs which are restricted to the sutural region.

Distribution: Recorded from sample 11 only.

Recorded Stratigraphic Range: Porangan to Altonian. (Middle Eocene to early Miocene).

Genus NODOSARIA Lamarck, 1812

NODOSARIA CALLOSA Stache

Nodosaria callosa Stache, 1864 : 197, Pl. 22, fig. 23; Hornibrook, 1971 : 37, Pl. 7, fig. 99; Hayward, 1976 : 504 (list).
Remarks: Characterised by a straight test with chambers constricted at the sutures and ornamented by 8 - 10 heavy longitudinal ribs. The aperture is centrally placed, terminal and radiate.

Distribution: Although an uncommon species that does not exceed 1% of the total fauna, N. callosa is recorded in 9 samples from columns 4, 7, 10, 15, 31, 34, 36 and 45.

Recorded Stratigraphic Range: Recorded from the Runangan to the Altonian in Oamaru (Hornibrook, 1961) and the Altonian Stage near Auckland, (Hayward, 1975).

NODOSARIA LONGISCATA d'Orbigny, Pl. 6, figs. 12, 13.

Nodosaria longiscata d'Orbigny, 1846 : 32, Pl. 1, fig. 10 - 12; Chapman, 1926 : 51, Pl. 11, fig. 7; Parr, 1937 : 73; Finlay & Marwick, 1940 : 104, 127; Dorreen, 1948 : 289; Hornibrook, 1961 : 46, Pl. 6, figs. 93, 94; Gibson, 1967 : Pl. 5, fig. 79; Hornibrook, 1971 : 8, 10 (list); Nelson, 1973 : Table following p. 183; Webb, 1973 : 134, fig. 58; Haywood, 1975 : 504 (list).

Distribution: This persistent species occurs in 46% of the samples from throughout the Mahoeunu Group. In the north and west near Mahoeunu and Te Kuiti it rarely exceeds 1% of the fauna. In the centre and south of the study area, near Hiwi Saddle and Taumarunui, Nodosaria longiscata forms a higher proportion of the fauna, often exceeding 5%.

Recorded Stratigraphic Range: Teurian to Tongaporutuan. (Paleocene to late Miocene).

NODOSARIA HOLOSERICA Schwager

Nodosaria holoserica Schwager, 1866 : 221, Pl. 5, fig. 49; Hornibrook, 1961 : 47, Pl. 6, fig. 96; Gibson, 1967 : Pl. 5, fig. 81; Hayward, 1975 : 504 (list).

Distribution: Rare, only occurs in samples 23, 24, 62 and 72.

Recorded Stratigraphic Range: Bortonian to Tongaporutuan. (Eocene to late Miocene).

NODOSARIA PYRULA d'Orbigny

Nodosaria pyrula d'Orbigny, 1826 : 253, No. 13; Cushman, 1923 : 69, Pl. 16, fig. 4.
Remarks: This species is almost always found with the chambers disaggregated. It consists of a number of elegant pyriform flasks linked by elongated necks.

Distribution: Rare, occurs in samples: 10, 18, 20, 24 and 106.

Observed Stratigraphic Range: Otaian - Recent. (Early Miocene - Recent).

Nodosaria lamnulifera Boomgaart, Pl. 6, fig. 14.

Nodosaria lamnulifera Boomgaart, 1949; Gibson, 1967: Pl. 5, fig. 78.

Remarks: Mahoenui specimens are gently and evenly expanding, straight sided, and without sutural constrictions. The chambers are wider than they are long and are separated by limbate sutures. Ornamentation consists of four prominent sharp keels, running the length of the test. These are separated by a number of minor ribs.

Distribution: Rare, recorded from samples 11 and 79.

Recorded Stratigraphic Range: Gibson recorded this species from the Tongaporutuan; these specimens are from the Otaian.

Nodosaria substrigata Stache.

Nodosaria substrigata Stache, 1864: 196, Pl. 22, figs. 22a-c; Hornibrook, 1971: 37, Pl. 7, fig. 98.

Remarks: Characterised by its heavy ribs which tend to divide into two parallel ribs.

Distribution: Recorded only in samples 24 and 29.

Genus Chrysalogonium Schubert, 1907

Chrysalogonium verticale (Stache)

Dentalina verticalis Stache, 1864: 202, Pl. 22, fig. 28.
Nodosaria (Dentalina) lorneiana d'Orbigny; Chapman, 1926: 49, Pl. 3, fig. 28.
Chrysalogonium verticalis (Stache); Finlay, 1946: 243 (list).
Chrysalogonium verticale (Stache); Hornibrook, 1961: 48, Pl. 6, fig. 102; Gibson, 1967: Pl. 5, fig. 84; Happy, 1971: Table following p. 100; Hayward, 1975: 504 (list).
Distribution: Uncommon, recorded only from samples 14, 29, 120 and 166.

Recorded Stratigraphic Range: Runagan to Tongaporutuan. (Late Eocene to late Miocene).

Genus PSEUDONODOSARIA Boomgaart, 1949

PSEUDONODOSARIA APERTA (Stache), Pl. 6, figs. 15, 16.

Glandulina aperta Stache, 1864: 188, Pl. 22, figs. 11a - c.
Glandulina erecta Stache, 1864: 189, Pl. 22, figs. 12a - c.
Lingulina propinqua Stache, 1864: 191, Pl. 22, figs. 15a - d.
Pseudonodosaria aperta (Stache); Hornibrook, 1971: 8, 10, 36, Pl. 7, fig. 95.

Remarks: The material was compared with the matched Topotype in the New Zealand Geological Survey collection and found to be identical. Mahoeuni specimens are rectilinear with no initial biserial section. They have 5 - 6 embracing chambers which increase only slowly in size. This gives a subcylindrical test which is constricted by non-limbate horizontal sutures. The final chamber tapers to a terminal radiate aperture.

Distribution: Common in the Taumatamaire Formation. Recorded in 17 samples from columns 4, 6, 9 - 11, 13 - 15, 17, 19, 20, 24 and 25. These columns are located from Mahoeuni to Waitomo. P. aperta is also recorded from three samples at the base of the Mahoeuni Group in columns 45, 47a and 47b.

Recorded Stratigraphic Range: Arnold to Taranaki Series. (Eocene - late Miocene).

Genus LAGENA Walker & Jacob In Kanmacher, 1798

Three small globular species of Lagena are recorded, Lagena striata, L. sulcata and L. laevis. Lagena striata and L. sulcata have apertures on a short neck, L. striata has numerous fine longitudinal ribs while L. sulcata has fewer heavy ribs. Lagena laevis is a smooth species with an aperture at the end of an elegant neck.

Two elongated tapering forms of Lagena are also present. Lagena gracillima and L. distoma are very similar, L. gracillima is smooth
while *L. distoma* is ornamented by a number of low ribs.

These species generally form less than 1% of the total fauna and are scattered throughout the Mahoeenui Group. Their individual distributions are not discussed separately. They are all long ranging species and their stratigraphic ranges are not listed.

LAGENA STRIATA (d'Orbigny), Pl. 6, fig. 18.

*Oolina striata* d'Orbigny, 1839c: 21, Pl. 5, fig. 12.

*Lagena striata* (d'Orbigny); Chapman, 1906: 91; Vella, 1957: 9; Barker, 1960: 118; Hornibrook, 1961: Table 6, part 1; Hulme, 1964: 326; Eade, 1967: 31; Hornibrook, 1971: 10 (list); Knudsen, 1971: 210, Pl. 16, fig. 5; Thompson, 1975: 77, Pl. 11, figs. 3, 4; Hayward, 1975: 506 (list).

LAGENA SULCATA (Walker & Jacob) Pl. 6, fig. 20.

*Serpula (Lagena) sulcata* Walker & Jacob, 1798: 634, Pl. 14, fig. 5.


LAGENA GRACILLIMA (Sequenza)

*Amphorina gracillima* Sequenza, 1862: 51, Pl. 1, fig. 37.

*Lagena gracillima* (Sequenza); Chapman, 1906: 91; Cushman, 1923: 23, Pl. 4, fig. 5; Barker, 1960: 116, Pl. 56, figs. 19 - 26; Eade, 1967: 30; Knudsen, 1971: 206, Pl. 4, fig. 1.

LAGENA LAEVIS (Montagu), Pl. 6, fig. 19.

*Vermiculum laeve* Montagu, 1803: 524.

LAGENA DISTOMA Parker & Jones, Pl. 6, fig. 17.

_Lagena distoma_ Parker & Jones (M.S.) in Brady, 1864 : 467, Pl. 48, fig. 6; Eade, 1967 : 30.

Genus AMPHICORYNA Schlumberger, In Milne-Edwards, 1881

Two species of _Amphicoryna_ commonly found in the New Zealand Tertiary are recorded from the Mahoenui, these are the hispid species _A. hirsuta_ and the costate species _A. scalaris._

AMPHICORYNA SCALARIS (Batsch), Pl. 6, fig. 21.

_Nautillus (Orthoceras) scalaris_ Batsch, 1791 : 1, 4, Pl. 2, fig. 4.

_Nodosaria scalaris_ (Batsch); Brady, 1884 : 510, Pl. 63, fig. 28 – 31; Chapman, 1926 : 53, Pl. 11, fig. 11; Finlay & Marwick, 1940 : 113.

_Amphicoryne scalaris_ (Batsch); Parr, 1950 : 328, Pl. 11, fig. 24; Hornibrook, 1971 : 8, 10 (list).

_Lagenodosaria scalaris_ (Batsch); Vella, 1957 : 9 (list); Hornibrook, 1961 : 48, Pl. 6, fig. 101; Gibson, 1967 : Pl. 5, fig. 87.

**Distribution:** Recorded in 18 samples from columns 1, 4, 6, 8, 13 – 15, 17, 26, 34, 37, 40, 41, 44, 45 and 47a. It generally forms less than 1% of the total fauna but occasionally reaches 5%.

**Recorded Stratigraphic Range:** Whaingaroan to Recent. (Oligocene – Recent).

AMPHICORYNA HIRSUTA (d'Orbigny), Pl. 6, figs. 22, 23.

_Nodosaris (Nodosaire) hirsuta_ d'Orbigny, 1826 : 252; Brady, 1884 : 507, Pl. 63, fig. 16 (In part); Chapman, 1926 : 51, Pl. 11, fig. 5.

_Langenodosaria hirsuta_ (d'Orbigny); Finlay & Marwick, 1940 : 113; Hornibrook, 1961 : 48, Pl. 6, fig. 100; Hornibrook, 1971 : 8 (list).

_Amphicoryna hirsuta_ (d'Orbigny); Gibson, 1967 : 5, fig. 90; Thompson, 1975 : 74, Pl. 8, fig. 1.

**Distribution:** Widespread, recorded in samples from columns 1 – 4, 6 – 8, 13, 14, 22, 25, 26, 29, 31, 33, 34, 37 – 39 and 43 – 45.
Recorded Stratigraphic Range: Whaingaroan to Recent (Oligocene to Recent).

Genus PALMULA Lea, 1833

PALMULA Taranakia Finlay

Palmula Taranakia Finlay, 1939: 315.

Remarks: This material best fits P. Taranakia. Mahoenui specimens are about 3mm long, palmate with a large proloculus and slight initial coil followed by about 12 uniserial chevron shaped chambers. Ornamentation consists of a few faint ribs on the proloculus and slight spines on the chamber basis. The sutures are very limbate and slightly raised. The aperture is terminal and radiate.

Dimensions of Hypotype: Length 3.87mm.

Distribution: Recorded from samples 19, 23, 75 and 93.


Genus FRONDICULARIA Defrance, 1826

FRONDICULARIA SAGITTULA Van den Broeck, Pl. 7, fig. 1.

Frondicularia alta Brady (Not d'Orbigny), 1884: 522, Pl. 65, figs. 3 - 5.

Frondicularia alta d'Orbigny var. sagittula Van den Broeck, 1876: 113, Pl. 2, figs. 12, 14.

Frondicularia alta d'Orbigny var. lanceolata Van den Broeck, 1876: 117, Pl. 2, fig. 13.

Frondicularia sagittula Van den Broeck, var lanceolata Van den Broeck; Cushman, 1923: 143, Pl. 20, fig. 4, Pl. 21, fig. 1.

Frondicularia sagittula Van den Broeck; Cushman, 1923: 143, Pl. 21, fig. 2; Barker, 1960: 138, Pl. 65, fig. 20 - 23, Pl. 66, figs. 3 - 5.

Remarks: A small form with lanceolate outline, numerous, high arched, uniserial, chevron-shaped chambers and a terminal radiate aperture is placed in Frondicularia sagittula.

Dimensions of Hypotype: Length .56mm (broken specimen).
Distribution: Present only in sample 159.

Observed Stratigraphic Range: This species recorded commonly from Recent sediments, is here recorded from Otaian strata.

Subfamily PLECTOFRONDICULARIINAE

Genus PLECTOFRONDICULARIA Liebus, 1902

Specimens of Plectofrondicularia from the Mahoenui Group were compared with the type suites in the New Zealand Geological Survey collections. The majority of individuals are referable to \textit{P. proparri}, with their strong lateral ribs, short median rib and steep chevron-shaped sutures. A few specimens with acute angled sutures and multiple fine ribs are placed in \textit{P. awamoana}.

\textbf{PLECTOFRONDICULARIA PROPARRI} Finlay, Pl. 7, figs. 2, 3.

\textit{Plectofrondicularia parri} Finlay, 1939: 516 (in part);
Finlay & Marwick, 1940: 118 (in part).

\textit{Plectofrondicularia proparri} Finlay & Marwick, 1947: 232
(nomen nudum); Finlay, 1947: 276, Pl. 4, fig. 46 - 48;
Hornibrook, 1961: 81, Pl. 12, fig. 246; Hornibrook, 1968:
34, 107, Table 5, Text fig. 23.

Dimensions of Hypotype: Length .65 mm.

Distribution: Seen in 12 samples from columns 2 - 4, 6, 8, 24a, 27, 44, 45 and 46a.

Recorded Stratigraphic Range: Whaingaroan to Otaian. (Oligocene to Miocene).

\textbf{PLECTOFRONDICULARIA AWAMOANA}

\textit{Plectofrondicularia awamoana} Finlay, 1939a: 100;
Finlay, 1939b: 319, Pl. 27, fig. 109; Finlay & Marwick,
1940: 115, 121; Hornibrook, 1961: 83, Pl. 12, fig. 243;
Hayward, 1975: 508 (list).

Dimensions of Hypotype: Length .62 mm.

Distribution: Very rare, recorded only in sample 45.

Recorded Stratigraphic Range: Early Landon Series to Altonian Stage. (Oligocene - mid. Miocene).
Genus Bolivinella Cushman, 1927

Bolivinella elegans Parr, Pl. 7, fig. 4.

Textularia folium (Parker & Jones); Brady, 1884: 357, Pl. 42, fig. 3, 3b, 4, 5 (not fig. 1, 2) (not of Parker & Jones).

Bolivinella elegans Parr, 1932: 223, 224; Hornibrook, 1961: 84, Pl. 12, fig. 238.

Remarks: Mahoenui specimens are biserial and flabelliform. The early part of the test is fairly inflated, while the later part is flattened. Ornament consists of a central ridge and parallel rows of tubercles in the median region of the test. The whole test surface is covered with fine papillae. In some specimens the ends of the chambers are spinose, other have no spines.

Dimensions of Hypotype: Length .56mm

Distribution: Present in 12 samples from columns 2 - 7 near Mahoenui and 2 samples from column 14 near Te Kuiti.

Recorded Stratigraphic Range: Whaingaroan to Altonian. (Oligocene to early Miocene).

Bolivinella sp. Pl. 7, fig. 5.

Remarks: Used for occasional palmate flattened specimens of Bolivinella with 10-12 biserial, narrow, recurved chambers. The test has a heavy, thickened median rib and is covered with fine papillae. The sutures are limbate and covered with heavy tubercles.

Distribution: Only present in sample 14.

Observed Stratigraphic Range: Otaian.

Subfamily Lingulinae

Genus Lingulina d'Orbigny, 1826

Two species of Lingulina are recorded from the Mahoenui Group. L. bartrumi is a large globose form with numerous vertical striae while L. decipiens is a large subovate, flattened, carinate species with poorly developed vertical ribbing. These ribs are restricted to a narrow zone around the periphery and the median part of the first and
occasionally second chambers. The median part of the test is left smooth and glossy.

LINGULINA DECIPIENS Stache, Pl. 7, fig. 17.

Lingulina decipiens Stache, 1864 : 193, Pl. 22, figs. 17a, b; Hornibrook, 1971 : 37, pl. 7, figs. 96, 97.
Lingulina carinata var semilineata Chapman, 1926 : 54, Pl. 12, fig. 1.

Dimensions of Hypotype: Length 1.60 mm.

Distribution: Recorded in two samples, samples 108 and 144.

Recorded Stratigraphic Range: Previously recorded from ? Runangan, Whaingaroan to Duntroonian. These specimens are from Otaian strata and do not appear to be reworked. The range of this species is therefore extended to :- ? Runangan, Whaingaroan to Otaian.

LINGULINA BARTRUMI Chapman.

Lingulina bartrumi Chapman, 1926 : 54, Pl. 11, fig. 12;

Dimensions of Hypotype: Length .78 mm

Distribution: Very rare, recorded only in sample 144.

Recorded Stratigraphic Range: Whaingaroan to Tongaporutuan. (Oligocene to late Miocene).

Family POLYMORPHINIDAE

Subfamily POLYMORPHININAE

Genus GUTTULINA d'Orbigny, 1839

Subgenus SIGMOIDINA

GUTTULINA (SIGMOIDINA) PACIFICA (Cushman & Ozawa), Pl. 7, figs. 8, 9.

Sigmoidella pacifica Cushman & Ozawa, 1928 : 19, Pl. 2, fig. 13; Loeblich & Tappan, 1964 : C534, fig. 418, 2a - c. Hayward, 1975 : 508 (list).
Guttalina (Sigmoidina) pacifica (Cushman & Ozawa); Cushman & Ozawa, 1930: 50, Pl. 37, figs. 3 - 5; Barker, 1960: 150, Pl. 72, fig. 14, 15.

Remarks: Mahoenui specimens are flattened, pyriform with overlapping chambers that reach the base of the test. Five chambers visible externally. Test somewhat sigmoid in basal view (at least in early stages). Later chambers added 140 to 150° apart.

Dimensions of Hypotype: Length .44mm.

Distribution: Recorded in 10 samples from columns 3, 4, 6, 9, 13, 15, 16, 33 and 34. This species never forms more than 1% of the total fauna.

Recorded Stratigraphic Range: In New Zealand G. pacifica is recorded from the Otaian Stage to Recent.

GUTTULINA (SIGMOIDINA) SEGUENZANA (Brady).

Polymorphina seguenzana Brady, 1884: 567, Pl. 72, fig. 16,17.
Guttulina (Sigmoidina) seguenzana (Brady); Cushman & Ozawa, 1930: 50, Pl. 37, figs. 8, 9; Barker, 1960: 150, Pl. 72, fig. 16, 17.
Guttulina seguenzana (Brady); Parr & Collins, 1937: 196, Pl. 12, fig. 10; Albani, 1968: 21, fig. 66.

Remarks: Specimens of Guttulina seguenzana from the Mahoenui Group are almost fusiform with a basal spine, the region of maximum inflation is located at a little under half the test length from the proloculus. The shell is strongly tapering at both ends. The chambers are strongly overlapping.

Dimensions of Hypotype: Length .41mm.

Distribution: Recorded in 8 samples from columns 29, 30, 34, 43, 44, 45 and 47b. These are located from Hiwi Saddle to Taumarunui.

Recorded Stratigraphic Range: Bortonian to Recent. (Mid Eocene to Recent).

GUTTULINA (SIGMOIDINA) sp. Pl. 7, fig. 7.

Description: A smooth glossy test, bulbous basally with a maximum width at about one third of its length. From this point the shell tapers upwards to a radiate aperture. In basal view this species is
subtrigonal (somewhat sigmoid) and in axial view the periphery is rounded. Four overlapping chambers are visible externally, the last two extend well below the earlier chambers. Weakly incised sutures separate the chambers.

Dimensions: Length .28mm.

Remarks: This species is similar to some specimens of *G. fissurata* Stache but bears closest resemblance to *G. caudriae* Peters & Sarmiento.

Distribution: Recorded from samples 19 and 25.

Observed Stratigraphic Range: Otaian.

Subgenus GUTTULINA

**GUTTULINA (GUTTULINA) YAEI** Cushman & Ozawa

*Guttulina yabei* Cushman & Ozawa, 1929 : 68, Pl. 13, fig. 6; Parr & Collins, 1937 : 192, Pl. 12, fig. 3, 4; Finlay & Marwick, 1940 : 115; Vella, 1957; Barker 1960 : 152, Pl. 73, fig. 2, 3; Hornibrook, 1961 : 55, Pl. 7, fig. 117; Hornibrook, 1971 : 8 (list); Thompson, 1975 : 79, Pl. 13, figs. 1, 2.

Remarks: An uncommon, large species with overlapping chambers and incised sutures. It has a higher spire and longer, less globular chambers than *G. fissurata* Stache.

Dimensions of Hypotype: Length .73mm.

Distribution: Recorded in sample 105 alone.

Recorded Stratigraphic Range: Recorded throughout the New Zealand Tertiary.

**GUTTULINA (GUTTULINA) FISSURATA**, Stache, Pl. 7, fig. 6.

*Guttulina fissurata* Stache, 1864 : 263, Pl. 24, figs. 10a, b; Hornibrook, 1971 : 48, Pl. 10, figs. 178, 179, text fig. 12; Happy, 1971 : Table following p. 100.

*Guttulina problema* d'Orbigny; Hornibrook, 1961 : 54, Pl. 7, fig. 118 (Not of d'Orbigny).

Remarks: Mahoenui specimens of *G. fissurata* are large and inflated with their maximum inflation at 1/3 to 1/2 of the test length from the
proloculus. The inflated, overlapping chambers are arranged in a quinqueloculine spiral, each chamber is inserted further away from the base, and separated from its neighbour by deeply incised sutures. The test is normally made up of a single whorl of chambers.

Dimensions of Hypotype: Length .57mm.

Distribution: This is the most widely distributed species of Guttulina in the present study. It is present in 23 samples from throughout the Mahoenui Group. Columns 1, 3, 4, 6, 7, 15, 17 – 19, 33, 34, 43 – 45, 47a and 47b.

Recorded Stratigraphic Range: Bortonian – Altonian. (Mid Eocene to early Miocene).

Genus PYRULINA d'Orbigny In de la Sagra, 1939.

Most Mahoenui specimens of Pyrulina are fusiform, spirally coiled tending biserial with slightly depressed sutures. These are placed in P. fusiformis. There are also more elegant species with fewer, more overlapping chambers. In this species the biserial later chambers reach well down towards the base of the test and cover much of the initial coiled stage.

PYRULINA FUSIFORMIS (Roemer), Pl. 7, fig. 10.

Polymorphina (Globulinen) fusiformis Roemer, 1838 : 386, Pl. 3, fig. 37.

Pyrulina fusiformis (Roemer); Cushman & Ozawa, 1930 : 54, Pl. 13, fig. 3 – 8; Parr & Collins, 1937 : 197, Pl. 13, fig. 2, 3, Pl. 14, fig. 5; Parr, 1950 : 334; Hornibrook, 1961 : 61, Pl. 7, fig. 127.

Dimensions of Hypotype: Length .95mm.

Distribution: Recorded from 4 samples: 15, 83, 132 and 142.

Recorded Stratigraphic Range: This Recent species has been recorded from the Duntroonian and Waitakian at Oamaru by Hornibrook (1961). These specimens are from the Otaian.

PYRULINA GUTTA (d'Orbigny)

Polymorphina (Pyruline) gutta d'Orbigny, 1826 : 267, 310.
Pyrulina gutta (d'Orbigny); Barker, 1960: 148, Pl. 71, fig. 11, 12.

Dimensions of Hypotype: Length .45 mm.

Distribution: Only recorded from sample 107.

Observed Stratigraphic Range: This Recent species is here recorded from Otaian strata of the Mahoenui Group.

Genus GLOBULINA d'Orbigny In de la Sagra, 1839

GLOBULINA GIBBA d'Orbigny

Globulina gibba d'Orbigny, 1826: 266, 10, Modeles 63;
Hornibrook, 1961: 60, Pl. 7, fig. 124; Hayward, 1975: 508.

Dimensions of Hypotype: Length .52 mm.

Distribution: Uncommon, single specimens are recorded in 6 samples from columns 6, 13, 15, 31 and 45.

Recorded Stratigraphic Range: Long ranging, originally recorded from Recent sediments. Hornibrook (1961) recorded this species from the Bortonian to Waitakian in Oamaru. Mahoenui specimens are from Otaian strata.

Genus SIGMOIDELLA Cushman & Ozawa, 1928

SIGMOIDELLA ELEGANTISSIMA (Parker & Jones)

Polymorphina elegantissima Parker & Jones, 1865: 438,
Table 10.

Sigmoideilla elegantissima (Parker & Jones); Cushman & Ozawa,
1930: 140, 141, Pl. 39, fig. 1; Parr & Collins, 1937: 206,
Pl. 14, fig. 9; Vella, 1957: 10 (list); Hornibrook, 1961:
61, Pl. 7, fig. 119; Hedley, Hurdle & Burdett, 1965: 20,
Pl. 6, fig. 20; Thompson, 1975: 79, Pl. 13, figs. 3, 4.

Remarks: Only small specimens of this species are recorded, they
are initially sigmoid, later biserial with overlapping chambers that
reach the base.

Dimensions of Hypotype: Length .37 mm, breadth .31 mm.

Distribution: Recorded in sample 61 only.

Recorded Stratigraphic Range: Recorded through much of the New Zealand Tertiary.
Genus POLYMORPHINA d'Orbigny, 1826

POLYMORPHINA AFF. LINGULATA Stache.

aff. Polymorphina lingulata Stache, 1864 : 255, Pl. 24, fig. 1.

Remarks: This species resembles P. lingulata, a species with an upper age limit of Waitakian. Specimens are large, robust, twisted biserial, with steeply sloping chambers and a row of alternating tubercles along the median line of the test.

Dimensions of Hypotype: Length 1.64mm.

Distribution: Recorded in 4 samples from columns 3, 19, 21 and 37.


Subfamily RAMULININAE

Genus RAMULINA Jones, In Wright, 1875.

RAMULINA GLOBULIFERA, Brady.

Ramulina globulifa Brady, 1879 : 272, Pl. 8, figs. 32, 33;
Barker, 1960 : 158, Pl. 76, figs. 22 - 28; Thompson, 1975 : 80, Pl. 13, fig. 5.

Remarks: Material from the Mahoenui Group has a central globular chamber with numerous tubular extensions. These extensions have flared ends. The test is covered by numerous pustules and short spines.

Dimensions of Hypotype: Length 1.18mm.

Distribution: Rare, recorded from 3 samples: 47, 68 and 107.

Observed Stratigraphic Range: This species, originally described from Recent sediments, is seen in the Otaian Mahoenui Group.

Family GLANDULINIDAE

Subfamily GLANDULININAE

Genus GLANDULINA d'Orbigny, 1839
GLANDULINA SYMMETRICA Stache.

Glandulina symmetrica Stache, 1864: 187, Pl. 22, figs. 9a - b; Hornibrook, 1961: 61, Pl. 8, fig. 132.
Lingulina intustriata Stache, 1864: 190, Pl. 22, figs. 13a - b.
Pseudonodosaria symmetrica (Stache); Hornibrook, 1971: 36, Pl. 10, fig. 172.

Remarks: Mahoenui specimens are tapering, initially biserial, later uniserial. The test is circular in cross section, with 6 - 7 overlapping chambers and a terminal radiate aperture.

Dimensions of Hypotype: Length .75mm.

Distribution: Though this species is never abundant, it is found in 20 samples from columns 2, 3, 4, 6, 9, 13, 19, 22, 24, 26, 33, 36, 37, 43, 44, 46a and 47a.

Recorded Stratigraphic Range: Recorded from throughout the New Zealand Tertiary.

Genus SIPHOGLOBULINA Parr, 1950

SIPHOGLOBULINA sp. Pl. 7, fig. 11.

Description: Test pyriform, triserial, chambers strongly overlapping. Each successive chamber is inserted further away from the base than its predecessor. The sutures are flush or slightly depressed and the aperture is terminal, radiate, with one particularly prominent branch. This branch is parallel to an entosolenian tube which runs against the inner wall of the test and opens as a short slit just above the basal suture of the final chamber.

Dimensions: Length .55mm.

Remarks: This species is more globular than S. siphonifera Parr, and it has a more obvious external depression along the line of the entosolenian tube.

Distribution: Very rare, only seen in sample 165.

Observed Stratigraphic Range: Otaian.
Subfamily OOLININAE

Members of the Subfamily Oolininae are often long-ranging forms and are generally of little stratigraphic value. They are widespread and, while never abundant, they are recorded from throughout the Mahoenui Group. Two species of Oolina and thirteen species of Fissurina are recorded. The distribution and stratigraphic range of these species is not discussed further.

Genus OOLINA d'Orbigny, 1839

Oolina cf. MELO d'Orbigny

cf. Oolina melo d'Orbigny, 1839: 20, Pl. 5, fig. 9.

Remarks: Specimens differ from O. melo d'Orbigny in that the transverse ribs are more curved, and in having netlike ornament around the aperture. Murray (1971: 93, Pl. 37, figs. 4 - 6) illustrates individuals as Oolina melo. However, the transverse ribs of the Mahoenui specimens are more extremely curved.

Dimensions of Hypotype: Maximum diameter .32mm, Minimum diameter, .25mm.

Oolina APICULATA Reuss

Oolina apiculata Reuss, 1851a: 22, Pl. 1, fig. 1; Haeusler, 1887: 200; Barker, 1960: 116, Pl. 56, figs. 15, 16.

Remarks: A simple smooth unornamented Oolina.

Dimensions of Hypotype: Maximum diameter .28mm. Minimum diameter .23 mm.

Oolina spp.

Remarks: Solitary individuals of several indeterminate species are placed together as Oolina spp.

Genus FISSURINA Reuss, 1850.

Fissurina ORBigNYANA Seguenza, Pl. 7, fig. 12.
Lagena orbignyana  (Seguenza); Chapman, 1909 : 337, Pl. 15, fig. 10.

Remarks: Material referred to F. orbignyana is compressed and pyriform, with multiple peripheral keels. The main keel bifurcates around the aperture which is on an elongated neck. An internal entosolenian tube is present. The test is densely perforated.

Dimensions of Hypotype: Maximum diameter .34mm, minimum diameter .29mm.

FISSURINA sp. B
Description: The test consists of a subspherical chamber extended into an ovate shape by a prominent broad, smooth, apertural neck. This neck is a little more compressed than the main chamber and forms about half the test length. The periphery has a weak keel which bifurcates around the lipped aperture. An internal entosolenian tube is present.

Dimensions: Maximum diameter .37mm, minimum diameter .26mm.

FISSURINA sp. C, Pl. 7, fig. 13.
Description: Test pyriform, carinate, with a single flange of varying width (often extended and indented) at the aboral end and bifurcating around the aperture at the oral end. The aperture has reflected lips, and opens into a long entosolenian tube. This runs close to the test surface and extends about 2/3 the length of the test.

Dimensions: Maximum diameter .32mm, minimum diameter .28mm.
Remarks: Similar to F. marginata (Montagu).

FISSURINA sp. D, Pl. 7, fig. 14.
Description: Test compressed, subcircular with several strong peripheral ribs. The outer ribs fuse in the apertural region forming a heavy apertural neck and lips. The innermost rib forms an almost complete ring and is buttressed against the smooth central part of the test by about 20, spoke-like, radial ribs. An entosolenian tube is present;
this runs about 1/3 the length of the test. The aboral end of the test is ornamented by a short spine.

Dimensions: Maximum diameter .39mm, minimum diameter .30 mm.

FISSURINA MARGINATA (Montagu), Pl. 7, fig. 20.

Vermiculum marginatum Montagu, 1803: 524.
Fissurina marginata (Montagu); Loeblich & Tappan, 1953: 77, Pl. 14, figs. 6 - 9; Knudsen, 1971: 230; Murray, 1971: 97, Pl. 39, figs. 4 - 6.

Remarks: Specimens of Fissurina referred to Fissurina marginata are simple, flattened, pyriform flasks with a narrow keel or no keel at all. The aperture is at the end of a flattened and slightly flexed apertural neck. An entosolenian tube is present. This extends about half the length of the test.

Dimensions of Hypotype: Maximum diameter .21mm
Minimum diameter .18mm.

FISSURINA sp. F, Pl. 7, fig. 16.

Description: The test is a flattened pyriform flask, carinate, with a narrow peripheral keel. The aperture is on a short neck. The test is ornamented by a single stout median rib. This rib extends from the base of the test and runs about 1/3 the length of the test.

Dimensions: Maximum diameter .14mm, minimum diameter .12mm.

FISSURINA FASCIATA CARINATA (Sidebottom)

Lagena fasciata var. carinata Sidebottom, 1906: 7, Pl. 1, fig. 17.
Fissurina fasciata var. carinata (Sidebottom); Sidebottom, 1913: 184, Pl. 16, figs. 14 - 16; Eade, 1967: 36; Thompson, 1975: 81, Pl. 15, figs. 1 - 3.

Remarks: Simple flattened, subcircular tests with one main peripheral keel flanked either side by an additional weaker keel, and a heavily lipped aperture on a short neck.

Dimensions of Hypotype: Maximum diameter .22mm, minimum diameter .18mm.
FISSURINA sp. H, Pl. 7, fig. 18.

Description: Test subspherical, somewhat flattened in the apical region and truncated by a wide flat apertural face. The aperture is slit like and opens into an entosolenian tube which extends about 2/3 the length of the test. The periphery is ornamented by a number of weak keels.

Dimensions: Maximum diameter .20 mm, minimum diameter .19 mm.

FISSURINA QUADRATA (Williamson) Pl. 7, fig. 15.

*Entosolenia marginata var. quadrata* Williamson, 1858: 11,
Pl. 1, figs. 27, 28.
*Lageno quadrata* (Williamson); Chapman, 1909: 339.
*Fissurina quadrata* (Williamson); Sidebottom, 1913: 185;
Thompson, 1975: 81, Pl. 15, fig. 6.

Remarks: This species is compressed, ovoid - subquadrate, in outline with three very heavy costae on the periphery. These costae fuse at the oral end to form a short apertural neck.

Dimensions of Hypotype: Maximum diameter .25 mm.

FISSURINA sp. J.

Description: Test subspherical, aperture slit like, terminal with low lips, opening into a very short entosolenian tube. The aboral end has a striated basal flange.

Dimensions of Holotype: Maximum diameter .18 mm
minimum diameter .17 mm.

FISSURINA sp. K.

Description: This species has a flattened subspherical test with a number of low peripheral ribs. The aperture is at the end of a long heavy subcylindrical neck.

FISSURINA sp. L.

Description: Test identical with *F. fasciata carinata* but with 6 to 8 fine longitudinal striae running over the central part of the test.

Remarks: This species may well be a varietal form of *F. fasciata carinata*. 
Dimensions of Holotype: Maximum diameter .26mm
minimum diameter .22mm.

FISSURINA sp. M, Pl. 7, fig. 19.

Description: A subcircular flattened test with a single very wide
peripheral flange which is particularly strongly developed aborally.
This flange is flanked by one of more low secondary ribs. The aperture
is lipped, opening into an internal entosolenian tube which may
extend about 1/3 to 1/2 the length of the test.

Remarks: This species is very close to Fissurina sp. C but is more
flattened with a much wider peripheral flange and a shorter entosolenian
tube.

Dimensions of Holotype: Diameter .14mm.

Superfamily BULIMINACEA

Family TURRILINIDAE

Subfamily TURRILININAE

Genus BULIMINELLA Cushman, 1911.

BULIMINELLA MISSILIS Vella, Pl. 8, figs. 1, 2.

Buliminella missilis Vella, 1963 : 6, Pl. 1, fig. 3.

Remarks: Buliminella missilis is characterised by its raised limbate
sutures. Two forms are recognised, the majority of specimens are close
to Vella's type specimens and are small fusiform shells (about 4 times
as long as wide) made up of 1 to 3 whorls. A slightly larger, more
elongate cylindrical form (about 6 or 7 times as long as it is wide)
is also included in B. missilis. This form usually has a test made
up of 3 to 4 whorls.

Dimensions of Hypotype: Length .76mm.

Distribution: Present in 9 samples from columns 2 to 6 near Mahoenui
and 2 samples from columns 15 and 21 near Te Kuiti.

Observed Stratigraphic Range: Otaian to Kapitean (Early Miocene to
late Miocene).
BULIMINELLA MADAGASCARIENSIS (d'Orbigny), Pl. 8, figs. 3 - 5.

Bulimina madagascariensis d'Orbigny, 1826:270, No. 17.
Buliminella madagascariensis (d'Orbigny); Cushman & Parker, 1946 : 68, Pl. 17, figs. 15-17; Gibson, 1967 : 23, Pl. 6, fig. 103.

Remarks: Used for a small glossy inflated fusiform shell, made up of 2-3 whorls, generally with about 7 chambers in the final whorl. The aperture is circular but is partially closed by an apertural tooth leaving a crescentic opening. The base of the shell is often ornamented by a short stout basal spine. The presence of this spine suggests that these specimens could be placed in Cushman & Parker's B. madagascariensis var spicata. However Mahoenui specimens are not always spinose, and are generally smaller than those of Cushman & Parker (1946).

Dimensions of Hypotype: Length .45mm.

Distribution: Found only in samples 19 and 23 from columns 3 and 4.

Recorded Stratigraphic Range: This Recent species has been recorded from The Tongaporutuan by Gibson (1967) it is also present in the Otaian of the Mahoenui Group.

Family SPHAEROIDINIDAE

Genus SPHAEROIDINA d'Orbigny, 1826.

SPHAEROIDINA BULLOIDES d'Orbigny, Pl. 8, fig. 14.

Sphaeroidina bulloides d'Orbigny, 1826 : 267, Modeles 65, 3 me livr; Chapman, 1926 : 74 (not Pl. 15, fig. 2) (in Part); Finlay, 1946 : 244 (list); Finlay & Marwick, 1947 : 232; Dorreen, 1948 : 298; Vella, 1957 : 10 (list); Hornibrook, 1958: 27; Hornibrook, 1961 : 90, Pl. 11, fig. 210; Hedley, Hurdle & Burdett, 1965 : 22; Gibson, 1967 : 45; Hornibrook, 1971: 9, 11 (list).

Dimensions of Hypotype: Diameter .31mm.

Distribution: Present in 61% of samples Sphaeroidina bulloides generally forms less than 1% to 3% of the fauna but can form 10 to 20% of the fauna.
Family BOLIVINITIDAE

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA RETICULATA "GROUP"

Three subspecies of Bolivina reticulata are recorded from the Mahoenui Group: B. reticulata reticulata, B. reticulata pontis and B. reticulata new subspecies. B. reticulata reticulata and B. reticulata pontis are both subrhomboidal, about half as wide as long with the widest portion in the adult part of the test. Both are characterised by steeply sloping sutures, a sub-acute periphery and coarse reticulate ornament covering the lower part of the test. Finlay (1939) noted the similarity between B. anastomosa and B. reticulata, B. byramensis and B. retiformis but distinguished them on details of ornamentation. Hofmann in his 1971 review regarded B. anastomosa to be a junior synonym of B. reticulata Hantken, and B. pontis Finlay was considered to be a subspecies of B. reticulata. Hofmann based his review on a biometric analysis in which he showed that with respect to shell shape B. anastomosa and B. reticulata were completely overlapping. In contrast B. pontis and B. anastomosa only partially overlapped.

Finlay's original descriptions of B. pontis and B. anastomosa laid emphasis on details of sculpture and he stated that in comparison with B. anastomosa the ornament of B. pontis is "a more open network with no intermediate sculpture, the vertical lines mostly not reaching the upper suture." Hofmann, however, claimed that discontinuous ribbing could also be observed in B. anastomosa. Of the 8 characters considered by Hofmann, only two relate to sculpture. The first of these is the percentage of the test covered by closed reticulate sculpture. Using this, Bolivina pontis and Bolivina anastomosa were shown to have a similar percentage cover while B. reticulata has a lower coverage. The second character is the maximal rib spacing seen in the closed network. With regard to this character, B. anastomosa and B. reticulata were shown to be similar while B. pontis was shown to have a different spacing. Hofmann considered that the similarity in rib spacing supported the synonymy of B. anastomosa and B. reticulata and he regarded the difference in the percentage cover as insignificant.

However, empirically it does appear that the ribbing pattern of
B. anastomosa is distinct. The ribbing cell shape is less regular on B. anastomosa and this is wholly missed by the measurement of rib spacing or percentage cover. A character that might better quantify the sculpture would be an estimate of the density of ribbing intersections. Further study may reestablish B. anastomosa as a subspecies of B. reticulata but at this stage the author maintains Hofmann's usage.

BOLIVINA RETICULATA RETICULATA Hantken, Pl. 8, fig. 8.

Bolivina reticulata Hantken, 1875 : 65, Pl. 15, fig. 6a - b; Chapman, 1926 : 40, Pl. 9, fig. 5; Cushman, 1937b : 50, Pl. 6, fig. 24 - 27.
Bolivina anastomosa Finlay, 1939c : 320, Pl. 27, fig. 75 - 77, 103, 111; Hornibrook, 1961 : 72, Pl. 10, fig. 188; Vella, 1966 : 92, Pl. 26, fig. 11.
Bolivina (Latibolivina) anastomosa Finlay; Hornibrook, 1968 : 68, fig. 10.
Latibolivina anastomosa (Finlay); Srinivasan, 1966 : 240, Pl. 2, fig. 9.
Bolivina (Latibolivina) reticulata reticulata Hantken;
Hofmann, 1971 : 304, fig. 13, No's. 1, 3, 8, 9, Table 1;
Haywood, 1975 : 510 (list).
Dimensions of Hypotype: Length .37mm, breadth .23mm.

Distribution: Found in the north and west of the study area. Recorded in 37 samples from columns 1 - 4, 6 - 8, 14 - 17, 20, 22, 30, 34 and 43.

Recorded Stratigraphic Range: Whaingaroan to Tongaporutuan. (Oligocene to late Miocene).

BOLIVINA RETICULATA PONTIS Finlay

Bolivina pontis Finlay, 1939c : 320; 71, Pl. 10, fig. 189.
Hornibrook, 1961 : 71, Pl. 10, fig. 189; Vella, 1966 : 92, Pl. 26, fig. 10.
Latibolivina pontis (Finlay); Srinivasan, 1966 : 240, Pl. 2, fig. 12.
Bolivina (Latibolivina) pontis Finlay; Hornibrook, 1968 : 57, fig. 8.
Bolivina (Latibolivina) reticulata pontis Finlay; Hofmann, 1971: 309, fig. 13, No's. 2, 7, 10; Table 10.

Distribution: Recorded in samples 29 and 105.

Recorded Stratigraphic Range: Runangan to Whaingaroan. The specimens from the Mahoenui Group appear to be reworked and occur in the Otaian Stage.

BOLIVINA RETICULATA new subspecies. A Pl. 8, figs. 6, 7.


Description: Specimens have the general form of B. reticulata though they expand more gradually, tapering to maximum width at about 2/3 the test length. The periphery is acute, often with a narrow keel. The chambers seem to slope less than B. reticulata. The test is fairly coarsely punctate and has only rudimentary reticulate ornament. This consists of low ribs running along the sutures of the early chambers and some incipient longitudinal ribbing. Some individuals have a prominent median rib.

Dimensions of Holotype: Length .32mm, breadth .21mm thickness .10mm.

Repository: Holotype and 8 paratypes are lodged with the Geology Department, University of Auckland.

Type locality: R17/f19 Sample 19 (column 3) Black Creek, R17/630882 (N.Z.M.S. 260); Paratypes from samples 3 (column 2) 24126, 27 (column 4) and 44 (column 7).

Type level: Taumatamaire Formation, Mahoenui Group (Otaian).

Remarks: Hornibrook (1961) noted a similar species in association with B. anastomosa in Oamaru - Hayward (1975) recorded a similar species from the Waitakere ranges.

Distribution: Occurs in 52 samples, or 31% of samples in the study area. It is commonest in the Mahoenui - Te Kuiti and Tangitu regions. Columns 1 - 4, 6 - 10, 14 - 17, 19, 21, 25, 30, 34, 41, 43, 44 and 46a have samples containing B. reticulata n. subsp.

BOLIVINA FINALYI Hornibrook, Pl. 8, fig. 9.

Bolivina finlayi Hornibrook, 1961 : 75, Pl. 9, fig. 169 - 171; Hayward, 1975 : 510 (list).

Remarks: Mahoenui specimens were compared to the type suite and are similar. The shell is characterised by its rounded periphery, coarse punctation, sinuous limbate sutures and test with fine longitudinal ribs.

This species is similar to B. punctatostiata but differs in having more thickened sutures and are somewhat more parallel sided.

Dimensions of Figured Specimen: Length .31mm, breadth .12mm.

Distribution: A common species, almost completely restricted to the Mahoenui - Te Kuiti area. Present in 33 samples from columns 1 - 5, 12, 15 - 17, 20, 24 and 28.

Recorded Stratigraphic Range: Whaingaroan to Lilburnian. (Oligocene to mid. Miocene).

BOLIVINA LAPSUS Finlay, Pl. 8, fig. 11.

Bolivina lapsus Finlay, 1939b: 98, Pl. 11, fig. 9; Finlay & Marwick, 1940 : 113, 123; Hornibrook, 1961 : 73, Pl. 10, fig. 184; Gibson, 1967 : 34, Pl. 8, fig. 130; Hornibrook, 1971 : 8, 11 (list); Hayward, 1975 : 510 (list).

Brizalina lapsus (Finlay); Happy, 1971 : Table following p. 100; Nelson, 1973 : Table following p. 183.

Remarks: An abundant and variable species of Bolivina characterised by a very smooth, glossy, very finely punctate shell. The test expands gently often with a half twist in the early stages. The periphery is rounded, the sutures are straight, limbate along the median line but becoming unthickened on the periphery. Specimens from the Mahoenui were compared with the type material and they are similar.

Dimensions of Hypotype: Length .32mm.
Distribution: As noted by Finlay (1939) B. lapsus is common in the Mahoenui Group. It is most abundant in the area from Mahoenui to Te Kuiti and is recorded in columns 2 - 4, 6 - 9, 12, 15 - 20, 24, 30, 42, 45 and 46a.

Recorded Stratigraphic Range: Whaingaroan to Tongaporutuan. (Oligocene to late Miocene).

BOLIVINA MAHOENUICA Hornibrook, Pl. 8, fig. 10.

Bolivina mahoenuica Hornibrook, 1961: 75, Pl. 10, fig. 178, 179; Hayward, 1975: 510 (list).

Remarks: Mahoenui specimens were compared to the type suite. They are coarsely punctate, slightly twisted, often with a short terminal spine. This may extend up the centre line of the test as a short median rib. The sutures are strongly recurved, steeply inclined and limbate, joining a clear, marginal, imperforate keel on the periphery. This keel often takes the form of a blunt non projecting edge to the test.

Dimensions of Hypotype: Length 0.32 mm.

Distribution: Sporadic, occurs in 12 samples from columns 1 - 4, 16, 28 and 43.

Recorded Stratigraphic Range: Waitakian to Lillburnian. (Oligocene to mid. Miocene).

BOLIVINA SEMITRUNCATA Hornibrook, Pl. 8, fig. 12.

Bolivina semitruncata Hornibrook, 1961: Pl. 10, fig. 180, 181; Gibson, 1967: 36, Pl. 9, fig. 148, Hornibrook, 1971: 11 (list); Hayward, 1975: 510 (list).

Brizalina semitruncata (Hornibrook); Nelson, 1973: Table following p. 183.

Remarks: Material from the Mahoenui Group is very similar to the type suite. Specimens are flattened and rectangular in cross section. The early portion of the shell is rapidly expanding with a few heavy ribs. Later the test is less rapidly expanding and is without ribs. The sutures are very limbate, particularly in the later part of the shell.
Dimensions of Hypotype: Length .39mm.

Distribution: Found in 25 samples from columns 1 - 4, 14 - 17, 21 and 42 where it normally forms less than 2% of the fauna.

Recorded Stratigraphic Range: Landon and Southland Series. (Oligocene and Miocene).

BOLIVINA SUBCOMPACTA Finlay.

Bolivina subcompacta Finlay, 1947 : 278, Pl. 5, fig. 64 - 69; Hornibrook, 1961 : 73, Pl. 9, fig. 177; Hayward, 1975 : 510 (list).

Brizalina subcompacta (Finlay); Happy, 1971 : Table following p. 100.

Distribution: Rare, only recorded from 4 samples : 1, 24, 62 and 99.

Recorded Stratigraphic Range: Waitakian to Waiauan. (Oligocene to mid. Miocene).

BOLIVINA ZEDIRECTA Finlay.

Bolivina zedirecta Finlay, 1947 : 278, Pl. 5, fig. 70 - 72; Hornibrook, 1961 : 73, Pl. 9, fig. 176; Hayward, 1975 : 510 (list).

Distribution: Occurs in 5 samples from columns 8, 15, 17 and 34.

Recorded Stratigraphic Range: Hornibrook (1961) recorded B. zedirecta from the Hutchinsonian to the Taranaki Series. Specimens from the Mahoenui Group extend this range into the Otaian.

Family ISLANDIELLIDAE

Genus CASSIDULINOIDES Cushman, 1927.

CASSIDULINOIDES ORIENTALIS (Cushman), Pl. 8, fig. 13.

Cassidulina bradyi Norman; Brady, 1884 : Pl. 54, fig. 10 (not of Norman); Chapman, 1926 : 42, Pl. 9, fig. 11.

Cassidulina orientalis Cushman, 1922a : 129.
Cassidulinoides orientalis (Cushman); Finlay & Marwick, 1940: 121; Vella, 1957: 10 (1st); Hornibrook, 1961: 86, Pl. 10, fig. 201; Gibson, 1967: 43, Pl. 10, fig. 162; Eade, 1967a: 39. Evolvocassidulina orientalis Eade, 1967b: 431, fig. 4, No's. 1, 2.

Remarks: Coiled biserial, later unrolling with a well developed internal toothplate.

Dimensions of Hypotype: Maximum diameter .27mm, minimum diameter .20mm.

Distribution: Never abundant, found in 13 samples from columns 2 - 4, 7, 15, 17, 20, 24, 24a, 30 and 37.

Recorded Stratigraphic Range: Waitakian to Recent. (Oligocene to Recent).

Family EOVICERINIDAE

Genus STILOSTOMELLA Guppy, 1894.

STILOSTOMELLA VERNEUILII (d'Orbigny), Pl. 8, figs. 15, 16.

Dentalina verneuilii d'Orbigny, 1846: 48, Pl. 2, figs. 7, 8.
Dentalina aequalis Karrer, 1864: 74, Pl. 16, fig. 1.
Dentalina consobrina d'Orbigny; Chapman, 1926: 48, Pl. 1, fig. 1. (in part).

Ellipsonodosaria verneuilii (d'Orbigny); Finlay & Marwick, 1940: 114, 127.

Stilostomella aequalis (Karrer); Hornibrook, 1971: 16, Pl. 2, figs. 34 - 42.
Stilostomella verneuilii (d'Orbigny); Hornibrook, 1961: 50, Pl. 6, fig. 109; Scott, 1970a: Fig. 7 (list); Hornibrook, 1971: 17; Hayward, 1975: 454, 512 (list).

Remarks: Specimens of an elongate, gently curved Stilostomella of moderate size, with flush limbate sutures, a terminal aperture and a basal spine are placed in Stilostomella verneuilii. In 1961 Hornibrook noted that S. verneuilii and S. aequalis were probably synonymous, but he still retained both species in 1971. Hayward (1975) regarded S. aequalis as a junior synonym of S. verneuilii. This is
supported by specimens from the Mahoenui Group which show complete gradation between S. aequalis and S. verneuilii. Hornibrook (1961) also drew attention to the similarity between S. verneuilii and S. pomuligera. A number of specimens of S. verneuilii from the Mahoenui Group resemble S. pomuligera. These become constricted at the sutures in the adult test. Because these specimens tend to be considerably larger than S. pomuligera and are generally without a heavy neck S. pomuligera is maintained as a separate species.

Distribution: This is a very common species and is present in 38% of samples from the study area. It is commonest in the west and north of the basin.

Recorded Stratigraphic Range: Whaingaroa to Waitotaran. (Oligocene to Pliocene).

STILOSTOMELLA POMULIGERA (Stache), Pl. 8, fig. 17.

Dentalina pomuligera Stache, 1864 : 204, Pl. 22, fig. 31.
Dentalina deformis Stache, 1864 : 205, Pl. 22, fig. 32.
Nodosaria (Dentalina) annulata (Reuss); Chapman, 1926 : 48, Pl. 3, fig. 31, Pl. 10, fig. 18.
Elipsonodosaria globulifera (Krezberg); Finlay & Marwick, 1940 : 125.
Neogenerina pomuligera (Stache); Finlay, 1946 : 243 (list).
Stilostomella pomuligera (Stache); Hornibrook, 1961 : 49, Pl. 6, fig. 110; Hornibrook, 1971 : 38, Pl. 7, figs. 103 - 108; Hayward, 1975 : 512 (list).

Remarks: Used for a small elegant curved Stilostomella. Initially the sutures are unthickened and flush, later becoming constricted and thickened.

Distribution: This species is found throughout the Mahoenui Group. It is present in 25% of samples in the study area.

Recorded Stratigraphic Range: Dannevirke to Taranaki Series. (Eocene to Miocene).

STILOSTOMELLA cf FINLAY Hornibrook, Pl. 8, figs. 18, 19.

cf. Stilostomella finlayi Hornibrook, 1961 : 50, Pl. 6, fig. 108.
Stilostomella finlayi Hornibrook; Happy, 1971: Table following p. 100.

Description: Test uniserial, gently arcuate. Initially the sutures are unthickened and flush, later they are limbate and constricting. In the adult part of the test the chambers are inflated and separated by a short neck. The chamber bases are ornamented by one, or occasionally two, rows of 20-25 short spines. The aperture is terminal, spouted, and has a simple unfrilled rim.

Remarks: Stilostomella finlayi is a similar species but differs in that the chambers are never separated by necks. Also the early chambers of S. finlayi may have a number of longitudinal striae, the apertural spout is longer, and the rim of the aperture is crenulated. Stilostomella basicarinata Hornibrook, is also similar but has a basal keel rather than a rim of spines. The adult section of S. joculator Finlay also resembles S. cf. finlayi but its early chambers are very different.

Distribution: Found throughout the Mahoeenui Group though commonest in the north and west of the study area. Occurs in 22% of the samples.

Family BULIMINIDAE

Subfamily BULIMINAE

Genus BULIMINA d'Orbigny, 1826.

BULIMINA PUPULA Stache, Pl. 9, figs. 1, 2.

Bulimina pupula Stache, 1864: 265, Pl. 24, fig. 13;
Cushman & Parker, 1947: 101, Pl. 24, fig. 7, 8; Dorreen, 1948: 292, Pl. 38, fig. 10; Hornibrook, 1961: 63, Pl. 8, fig. 141; Scott, 1970a: 322, 330, 332, figs. 6, 7, 8, 13, Table 1; Scott, 1971a: fig. 2 (list);

Bulimina aperta Stache, 1864: 266, Pl. 24, fig. 15.
Bulimina propinqua Stache, 1864: 267, Pl. 24, fig. 16.

Dimensions of Hypotype: Length .39mm.
Distribution: This common species is recorded in 30% of the samples. It is recorded in samples from columns 2 – 6, 10, 13 – 15, 17 – 19, 21, 24, 24a, 27 – 30, 32, 34, 40, 41, 44, 45, 47a and 47b.

Recorded Stratigraphic Range: Bortonian to Altonian. (Eocene to early Miocene).

BULIMINA MIOLAEVIS Finlay.

Bulimina miolaevis Finlay, 1940: 454, Pl. 64, fig. 70, 71; Finlay & Marwick, 1940: 115, 119; Hornibrook, 1961: 62; Hornibrook, 1968: 63, fig. 10, Table 11; Hornibrook, 1971: 8 (list); Nelson, 1973: Table following p. 183 (list).

Remarks: This large tapering form with inflated chambers is only occasionally recorded and these specimens are badly recrystallised.

Dimensions of Hypotype: Length .39mm.

Distribution: Only recorded in 6 samples from columns 18, 25, 26 and 30.

Recorded Stratigraphic Range: Landon Series to Taranaki Series. (Oligocene to late Miocene).

BULIMINA STRIATA d'Orbigny; Pl. 9, fig. 3.

Bulimina striata d'Orbigny, 1826: 269; Cushman & Parker, 1947: 119, Pl. 28, figs. 1 – 3.

Bulimina cf. striata d'Orbigny; Gibson, 1967: 25, Pl. 6, fig. 110; Scott, 1970a: 327, fig. 6.

Description of Mahoenui Specimens: A small to medium sized, strongly tapering Bulimina. The chambers are inflated, sometimes undercut, ornamented with low costae that extend as short stout tubercles. Many specimens also have a short apical spine. The aperture is typically bulimine with a lip. The test is coarsely punctate.

Remarks: Specimens vary considerably in size, rate of expansion and in the development of the terminal spine. This species is closely related to B. inflata Seguenza and the two have at times been considered synonyms (e.g. Cushman & Parker, 1938). B. senta is also closely
related to B. striata but it is larger, more tear-drop shaped and lacks undercut chambers. B. senta is probably directly descended from B. striata (Gibson, 1967), though Finlay considered it to be derived from B. inflata.

Dimensions of Hypotype: Length .20mm.

Distribution: Recorded in 14 samples from columns 4, 29, 30, 34, 40, 43, 44, 45 and 46a.

Recorded Stratigraphic Range: B. striata is present through the greater part of the New Zealand Tertiary. It has been recorded from the Paleocene (Newman & Scott, 1968), the early Miocene, (Scott, 1970) and the late Miocene (Gibson, 1967).

Genus VIRGULOPSIS Finlay, 1939.

VIRGULOPSIS COSTATA Hornibrook, Pl. 9, fig. 4.

Virgulopsis costata Hornibrook, 1961 : 80, Pl. 9, fig. 167; Hornibrook, 1968 : 33, 61, fig. 10, table 11; Hornibrook, 1971 : 8 (list).

Remarks: Specimens from the Mahoeñui Group have been compared with the type suite and are generally similar though somewhat smaller. They are cylindrical, densely punctate, have heavy thickened sutures and are without chamber ornament. The initial 1/4 to 1/3 of the test is triserial. It then becomes biserial.

Dimensions of Hypotype: Length .29mm.

Distribution: Present in 7 samples from columns 2, 14 – 17 and 31.

Recorded Stratigraphic Range: Waitakian to Lillburnian. (Oligocene to mid. Miocene).

VIRGULOPSIS RETICULATA Hornibrook, Pl. 9, fig. 5.

Virgulopsis reticulata Hornibrook, 1961 : 79, Pl. 28, fig. 542, 543.

Remarks: The material was compared with the type suite and is considered to be conspecific. They are small, characterised by fine reticulate sculpture and incised sutures. The initial quarter or third of the test is triserial the later part is biserial.
Dimensions of Hypotype: Length .40mm

Distribution: Occurs in 16 samples from columns 2 - 4, 6, 7, 14 - 16 and 43.

Recorded Stratigraphic Range: Waitakian - Altonian. (Oligocene to early Miocene).

VIRGULOPSIS PUSTULATA Finlay, Pl. 9, fig. 7.

Virgulopsis pustulata Finlay, 1939a: 321, Pl. 27, fig. 72 - 74, Pl. 104, 106; Finlay & Marwick, 1940: 119, 122; Hornibrook, 1961: 78, Pl. 9, fig. 165, 166; Hornibrook, 1968: 34, 68, fig. 12, Table 11; Happy, 1971: Table following p. 100.

Remarks: The Mahoenui material is identical with the primary types of Virgulopsis pustulata. Specimens are small with incised sutures. They are characterised by coarse pustulose ornament. The ratio between the triserial and biserial sections of the shell is variable.

Dimensions of Hypotype: Length .22mm.

Distribution: Only present in three samples, 3, 20 and 27.

Recorded Stratigraphic Range: Otaian to Waiauan. (Early Miocene to mid. Miocene).

VIRGULOPSIS TURRIS (Heron-Allen and Earland), Pl. 9, fig. 6.

Verneuilina turris Heron-Allen & Earland, 1922: 124, Pl. 4, figs. 8 - 12.

Virgulopsis turris (Heron-Allen & Earland); Hornibrook in Fleming, 1952: 82; Hulme, 1964: 331; Hedley, Hurdle & Burdett, 1967: Pl. 9, fig. 5; Eade, 1967: 41; Hornibrook, 1968: 36, 76, Table 8, 11, fig. 14; Happy, 1971: Table following p. 100; Thompson, 1975: 85, pl. 19, figs. 4, 5.

Remarks: A small, stout, cylindrical form that is coarsely punctate with smooth, flush, or slightly raised limbate sutures. Triserial chambers make up three-quarters of the shell. The aperture is loop shaped.
Dimensions of Hypotype: Length .25mm.

Distribution: Recorded in sample 76 only.

Recorded Stratigraphic Range: Virgulopsis turris is a Recent species. It is here recorded from Otaian strata of the Mahoenui Group.

Subfamily PAVONININAE

Genus REUSSELLA Galloway, 1933

REUSSELLA SPINULOSA LAEVIGATA Cushman, Pl. 9, fig. 8.

Reussella spinulosa var. laevigata Cushman, 1945: 34, Pl. 6, fig. 10.

Reussella aff. spinulosa (Reuss); Hornibrook, 1961: 78.

Description of Mahoenui Specimens: Test coarsely punctate, triserial, triangular with acute edges and a basal aperture. The sutures are thickened, raised and may be papillose. A row of large pores is often found just above and parallel to the sutures.

Remarks: These specimens resemble R. spinulosa but lack the peripheral spines of that species. They appear to be best placed in the non spinose R. spinulosa var laevigata which was described by Cushman (1945) from the Miocene of France.

Dimensions of Hypotype: Length .36mm.

Distribution: Present in 7 samples from columns 1, 3, 4 and 5, all from near Mahoenui.

Recorded Stratigraphic Range: Hornibrook notes similar species occurring from Otaian and Altonian strata.

Family UVIGERINIDAE

Genus EUUVIGERINA Thalmann, 1952.

Using internal morphology Hofker (1951) divided Uvigerina d'Orbigny into the genera Aluvigerina Euuvigerina and Neouvigerina. Thalman (1952) subsequently designated type species for these. Vella
(1961) introduced a much more intricate classification based on sculpture, size, and inferred phylogeny but this was not upheld by Loeblich and Tappan (1964). Loeblich and Tappan felt that the features of chamber arrangement, aperture and internal morphology (particularly the tooth plate) should be used for generic separation. They considered that ornament and size should be used for discrimination at the species level. Loeblich and Tappan also upheld *Uvigerina* as senior synonym of *Aluvigerina* (fide Ellis and Messina) and regarded *Neouvigerina* to be a junior synonym of *Siphouvigerina*.

Hornibrook (1968) still retained some of Vella's new taxa but demoted them to subgenera. Since then, however, these subgenera have dropped out of common New Zealand usage (e.g. Scott, 1971) and Hornibrook (1971)). The present author regards a phenetic rather than phylogenetic approach to be desirable. For this reason the classification used by Loeblich and Tappan is adopted here.

**EUUVIGERINA MIOZEA** (Finlay), Pl. 9, fig. 10.

- *Uvigerina miozea* Finlay, 1939b: 102, Pl. 12, fig. 12-14; Finlay & Marwick, 1940: 118, 127; Hornibrook, 1961: 65, Pl. 8, fig. 144.
- *Hofkeruva (Trigonouva) miozea* (Finlay): Vella, 1961: 477, Pl. 1, figs. 5, 8-9; Pl. 2, fig. 6.
- *Euuuvigerina (Hofkeruva) miozea* (Finlay); Hornibrook, 1968: 33, 34, 36, 103: Table 4, 6, 11, fig. 22, Hayward, 1975: 512 (list).
- *Euuuvigerina miozea* (Finlay); Scott, 1971a: 126, 128, 130, fig. 2 (list); Hornibrook, 1971: 8 (list).

**Remarks:** Material from the Mahoenui Group has been matched with Finlays' type material. They are small or medium sized, triserial specimens with inflated, lobulate chambers and incised sutures. The test varies from being moderately to very rapidly expanding and is ornamented by a number of rounded ribs, about 20 on the final chamber. These ribs are generally interrupted at the sutures and are built out from the test at their lower ends to form blunt spines. They are strongest on the early chambers and weaken towards the final chamber. The area around the aperture is generally smooth. The
aperture is on a short stout neck and has a phialine lip. *E. miozea* is a variable species, especially with regard to the rate of expansion and the degree of inflation. Some specimens approach *E. zeacuminata*, as indeed, do some of Finlays' paratypes.

Dimensions of Hypotype: Length .45mm.

Distribution: An extremely common species, present in 51% of samples from the study area.

Recorded Stratigraphic Range: Hornibrook (1968) notes that while *E. miozea* is most typically developed in the Southland Series less inflated examples occur in the Waitakian and Pareora Series.

**EUUVIGERINA ZEACUMINATA** (Vella), Pl. 9, fig. 9.

*Hofkeruva (Trigonouva) zeacuminata* Vella, 1961 : 476, Pl. 1, figs. 15, 16; Gibson, 1967 : 31, Pl. 7, fig. 125.

Remarks: Individuals of this species were matched to Vella's type specimens and are very similar in form. Mahoenui specimens are generally smaller than the types, though they are still of moderate size. They are triserial, tapering, with moderately inflated chambers, separated by weakly incised sutures. Ornament consists of numerous fine ribs (20 - 30 on the final chambers). The ribs tend to cross the sutures and bifurcate. They also generally follow the form of the shell, rather than being built out from it. The aperture is on a short broad spout and has a phialine lip.

This species is generally larger than *E. miozea*, has less prominent non spinose, uninterrupted bifurcating ribs.

Dimensions of Hypotype: Length .55mm.

Distribution: Less abundant than *E. miozea* but still present in 18% of samples. Recorded in samples from columns 1 - 5, 7, 13 - 17, 19, 24, 24a, 25, 29, 29a, 30, 37, 42 and 46a.

Recorded Stratigraphic Range: Previously recorded from the Altonian to Kapitean, these specimens are from the Otaian.

**EUUVIGERINA cf PICKI** (Vella)

Remarks: Occasional large, heavily ribbed specimens are placed in E. cf. picki.

Distribution: Only recorded in samples 29 and 30.

Genus SIPHOUVIGERINA Parr, 1950

SIPHOUVIGERINA PLEBEJA (Vella), Pl. 9, fig. 12.

Neouvierina plebeja s.l. Vella, 1961 : 470, Pl. 2,
fig. 19, Text fig. 4d - g.

Remarks: Used for very small uvigerine forms, that are initially triserial but later tend uniserial. The sutures are deeply incised and the chambers are inflated and lobulate. The aperture is on a broad spout and has a phaline lip. The test is apparently papillate when examined with a light microscope however, under the S.E.M. the "papillae" appear to be a secondary overgrowth. Because it is uncertain if this overgrowth occurs at the sites of pre-existing papillae, these specimens were not allocated to either of Vella's subspecies, as these are most easily distinguished by the presence or absence of papillae.

Dimensions of Hypotype: Length .31mm.

Distribution: Rare, occurs in samples 3, 17, 19, 22, 35, 52, 66 and 71.

Recorded Stratigraphic Range: Otaian to Lillburnian. (Early Miocene to middle Miocene).

Genus RECTUVIGERINA Mathews, 1945

RECTUVIGERINA RERENSIS (Finlay), Pl. 9, fig. 11.

Siphogenerina reensis Finlay, 1939b, 108, Pl. 11,
fig. 8; Finlay & Marwick, 1940 : 118, 119.

Rectuvigerina reensis (Finlay); Mathews, 1945 : 596,
Pl. 82, fig. 15; Hornibrook, 1961 : 66, Pl. 8, fig. 146;
Vella, 1961 : 480, Pl. 2, figs. 22 - 23; Hornibrook,
1968 : 104, Table 4, 6, fig. 22; Hornibrook, 1971 : 8
(list); Nelson, 1973 : Table following p. 183; Hayward,
1975 : 512 (list).
Remarks: The majority of specimens of Rectuvigerina from the Mahoenui Group have the prominent triserial stage and uniserial stage made up of, rarely 3, but usually 4 or 5 elongate, somewhat inflated chambers, characteristic of R. rerensis. Mahoenui specimens have been compared with the type suite and they are generally similar.

Dimensions of Hypotype: Length .63mm.

Distribution: Present in 21 samples from columns 1, 6, 7, 9, 12, 20, 21, 25, 31, 34, 35, 40, 43 and 47b.

Recorded Stratigraphic Range: Waitakian to Southland Series. (Oligocene to mid. Miocene).

Genus TRIFARINA Cushman, 1923.

Following Loeblich and Tappan (1964) Angulogerina is synonymised with Trifarina as the less regularly triangular form of Angulogerina is an inconsistent feature and is considered to be inadequate criterion for generic separation. Hofker (1951) placed Trifarina as a subspecies of Angulogerina but Trifarina must take precedence as senior synonym. There are four species of Trifarina present in the Mahoenui Group. Of these T. bradyi and T. parva are regularly triangular with sharp keels. T. parva is distinguished from T. bradyi by its smaller size, and by carinae which bifurcate and rejoin on the early triserial part of the shell. Trifarina ototara is the most abundant species of Trifarina in the Mahoenui Group. This is characterised by its roughly triangular shell with a broad periphery ornamented by double blunt keels. Trifarina tortuosa is only rarely found. This species has a distinct early triserial stage followed by a very twisted uniserial stage. Specimens of T. parva, T. ototara and T. tortuosa were compared with their respective type suites and this confirmed the identifications.

TRIFARINA PARVA Hornibrook, Pl. 9, fig. 14.

Trifarina parva Hornibrook, 1961: 71, Pl. 9, fig. 161, 162.

Dimensions of Hypotype: Length .32mm.

Distribution: Recorded in 11 samples from columns, 2, 8, 15 - 17, 20, 22, 36 and 45.
Recorded Stratigraphic Range: Bortonian to Altonian (Eocene to lower Miocene).

TRIFARINA OTOTARA (Hornibrook), Pl. 9, fig. 15.

Angulogerina ototara Hornibrook, 1961 : 70, Pl. 9, figs. 158 - 160.

Trifarina ototara (Hornibrook); Hayward, 1975 : 514 (list).

Dimensions of Hypotype: Length .30mm.

Distribution: Particularly common in the west and north of the study area. T. ototara is recorded in 38 samples from columns 1-10, 14-17, 20, 22, 41, 45, 46a and 47a.

Recorded Stratigraphic Range: Previously recorded as Runangan to Whaingaroan. These records from the Mahoenui extend this range into the Otaian.

TRIFARINA BRADYI Cushman.

Rhabdogonium tricarinatum (d'Orbigny); Brady, 1884 : 525, Pl. 67, fig. 1 - 3 (not of d'Orbigny).

Trifarina bradyi Cushman, 1923 : 99, Pl. 22, fig. 3 - 9; Finlay & Marwick, 1941 : 107; Hornibrook, 1961 : 70, Pl. 9, fig. 163 - 164; Belford, 1966 : 88, Pl. 9, figs. 16 - 17; Gibson, 1967 : 32; Scott, 1970a : fig. 8 (list); Hornibrook, 1971 : 8, 11 (list); Happy, 1971 : Table following p. 100 (list); Hayward, 1976 : 514 (list).

Distribution: Rare only seen in samples 32, 49, 50, 85, 142 and 166.

Recorded Stratigraphic Range: Recorded throughout most of the New Zealand Tertiary.

TRIFARINA TORTUOSA Hornibrook, Pl. 9, fig. 13.

Angulogerina tortuosa Hornibrook, 1961 : 68, Pl. 9, fig. 151, 152.

Trifarina tortuosa (Hornibrook); Hayward, 1975 : 514 (list).
Dimensions of Figured Specimen: Length .54mm.

Distribution: Only recorded in sample 19.

Recorded Stratigraphic Range: Waitakian to lower Southland Series (Oligocene to mid. Miocene).

Genus KOLESNIKOVELLA Bykova, 1958

KOLESNIKOVELLA AUSTRALIS (Heron-Allen & Earland), Pl. 9, fig. 16.

_Uvigerina canariensis_ d'Orbigny var _australis_ Heron-Allen & Earland, 1924: 164, Pl. 11, figs. 67 - 70.
_Angulogerina australis_ (Heron-Allen & Earland);
_Finlay & Marwick, 1940: 107, 123; Hornibrook 1961: 67, Pl. 9, fig. 157; Nelson, 1973: Table following p. 183.
_Kolesnikovella australis_ (Heron-Allen & Earland);
_Srinivasan, 1966: 245, Pl. 6, fig. 11; Hornibrook, 1971: 8 (list).

Remarks: Mahoenui specimens are very similar to those recorded by Srinivasan (1966) and Hornibrook (1961). Mahoenui individuals have a test which is roughly triangular in cross section and has rounded margins. The shell is made up of about 15 chambers, these are initially triserial but become uniserial. The aperture is at the end of a short spout and is lipped, the proximal chamber margins are extended as retral processes.

Dimensions of Hypotype: Length .32mm.

Distribution: Seen in 18 samples from columns 4, 6, 8, 9, 16 - 18, 20, 36, 41 and 42.

Recorded Stratigraphic Range: Bortonian to Tongaporutuan. (Eocene to late Miocene).

Superfamily DISCORBACEA

Family DISCORBIDAE

Subfamily DISCORBINAE
Genus DISCORBIS Lamarck, 1804.

DISCORBIS BALCOMBENSIS Chapman, Parr & Collins, Pl. 10, figs. 1, 2.

**Discorbis balcombensis** Chapman, Parr & Collins, 1934:
Pl. 8, fig. 10; Hornibrook, 1961: 98, Pl. 13, fig. 252;
Scott, 1976: fig. 7, 8 (list); Happy, 1971: Table following p. 100; Hornibrook, 1971: 8 (list); Nelson, 1973: Table following p. 183; Hayward, 1975: 514 (list).

**Discorbis finlayi** Dorreen, 1948: 293 - 4, Pl. 38, fig. 12a - c.

**Rotorbinella finlayi** Bermudez, 1952: 75.

Remarks: This very common species has generally been placed in **Discorbis** though with its prominent umbilical boss it would probably be better placed in **Gavelinopsis**.

Mahoenui specimens are trochoid with a raised conical dorsal surface of 2 - 2½ whorls. Each whorl is made up of about 7 - 8 chambers with recurved limbate sutures. Ventrally the test is involute, umbilicate with radial excavated sutures. The ventral chamber bases are built out and lap onto a large central boss which completely fills the ventral central area. The aperture is a low interiomarginal, extraumbilical slit, the periphery is acute.

Dimensions of Hypotype: Diameter .35mm.

Distribution: Particularly common in the west and north of the study area. It generally forms less than 5% of the fauna, but in several samples **D. balcombensis** exceeds 10%. This species is found in 52 samples from columns 1 - 8, 14 - 17 and 21.

Recorded Stratigraphic Range: Runangan to Waiauan. (Late Eocene to mid Miocene).

DISCORBIS SEMIOPERCULARIS

**Discorbis semiopercularis** Hornibrook, 1961: 100, Pl. 13, figs. 260 - 2.

Remarks: Occasional small discoidal specimens of **Discorbis** with
strongly recurved sutures are placed in *D. semiopercularis*.

Dimensions of Hypotype: Diameter .27mm.

Distribution: Only samples 44 and 62 contain *D. semiopercularis*.

Recorded Stratigraphic Range: Recorded from the Altonian by Hornibrook. These specimens are from the Otaian.

Genus *DISCORBINELLA* Cushman & Martin, 1935

*DISCORBINELLA BERTHELOTI* (d'Orbigny), Pl. 10, figs. 3, 6, 7.

Rosalina bertheloti d'Orbigny, 1839b : 135, Pl. 1, figs. 28 - 30; Albani, 1968 : 28, fig. 122; Thompson, 1975 : 87, Pl. 21, figs. 3 - 5. Discorbia bertheloti (d'Orbigny); Chapman, 1909 : 356; Heron-Allen & Earland, 1922 : 202. Discopulvinulina bertheloti (d'Orbigny); Hofker, 1951 : 359; Vella, 1957 : 10, Hornibrook, 1961 : 106, Pl. 14, fig. 286. Hanzawaia bertheloti (d'Orbigny); Bandy, 1961 : 21, Pl. 3, figs. 10a - c. Discorbinella bertheloti (d'Orbigny); Belford, 1966 : 90, Pl. 12, figs. 15 - 22, text fig. 8, 1 - 2, text fig. 9, 1 - 2; Eade, 1967a : 42, Scott, 1970a : fig. 8 (list); Hayward, 1975 : 455, 514, fig. 31 - 33.

Remarks: This species has been placed in a variety of genera by different authors. It is here placed in *Discorbinella* because of its flattened test, simple umbilical flaps and interiomarginal aperture. *D. bertheloti* is a very variable species particularly with respect to the degree of involution on the convex spiral side, the thickening of the sutures and in the development of the keel.

The Mahoenui specimens of *D. bertheloti* are normally almost involute on the spiral side, often with a glossy central knob; however, occasional specimens become obviously evolute. The flat or concave opposite side is partially evolute with an umbilicus surrounded by simple umbilical flaps extending from the chamber bases. The sutures are limbate, recurved and the periphery is often weakly carinate.
Dimensions of Hypotype: Diameter .20mm.

Distribution: Present in 47 samples from columns 1 - 9, 13 - 17, 20 - 22, 24a, 29, 38, 46a and 47a. These are predominantly from the north and west of the study area.

Recorded Stratigraphic Range: Landon - Recent. (Oligocene to Recent).

DISCORBINELLA COMPLANATA (Sidebottom) Pl. 10, fig. 12.

Discorbina bertheloti (d'Orbigny) var. complanata
Sidebottom, 1918 : 253, Pl. 6, fig. 1 - 3.
Planulina cf. sinuosa (Sidebottom); Finlay & Marwick, 1940 : 118, 125.
Discorbinella cf. complanata (Sidebottom); Vella, 1957 : 10, Hornibrook, 1961 : 117, Pl. 27, fig. 532.
Discorbinella complanata (Sidebottom); Hayward, 1975 : 455, 514, figs. 34 - 36.

Remarks: This flattened concave-convex species is characterised by its very recurved, "hooked", limbate sutures. Although specimens are generally about .30mm in diameter occasional specimens are much smaller and resemble those described by Hornibrook (1961) as D. cf. complanata.

Dimensions of Hypotype: Diameter .28mm.

Distribution: Uncommon, only recorded in samples 43, 45 and 121.

Recorded Stratigraphic Range: Hornibrook recorded this species from the Runangan to Waiauan in Oamaru. It is also present in Recent sediments in New Zealand. Runangan-Recent. (Late Eocene to Recent).

DISCORBINELLA cf. SCOPOS (Finlay)

cf. Discorbis scopos Finlay, 1940 : 466, Pl. 67, figs 212, 213.

Remarks: This material was compared with the type suite and is similar in all respects apart from size. The Mahoenui specimens are very much smaller than the types.
Distribution: Rare, recorded from samples 4, 5, 140 and 144.

Recorded Stratigraphic Range: Whaingaroan to Altonian. (Oligocene to early Miocene).

DISCORBINELLA TURGIDA (Finlay), Pl. 10, figs. 10, 11.

Discorbis turgidus Finlay, 1940: 467, Pl. 67, fig. 214 - 216; Finlay & Marwick, 1940: 114, 118.
Discopulvinulina turgida (Finlay); Hornibrook, 1961: 105, Pl. 14, fig. 287, 291, 295; Happy, 1971: Table following p. 100 (list).
Discorbinella turgida (Finlay); Hayward, 1975: 514 (list).

Remarks: This species is related to D. bertheloti. Mahoeunui specimens have about 6 chambers in the final whorl, a flat, umbilical side, high raised involute side and a peripheral flange. The umbilicus is surrounded by simple flaps. The aperture is interromarginal and equitorial in position.

Dimensions of Hypotype: Diameter .29 mm.

Distribution: Rare, only recorded from samples 1 and 76.

Recorded Stratigraphic Range: Whaingaroan to Altonian. (Oligocene to early Miocene).

DISCORBINELLA TIMIDA Hornibrook. Pl. 10, figs. 8, 9.


Remarks: Specimens from the Mahoeunui Group are small, delicate, concavo-convex with a gently raised spiral side. There are about 4 - 5 slightly depressed, gently recurved indistinct sutures on this side. The opposite side is somewhat concave and has more recurved, slightly limbate, sutures. An umbilicus is present but this is closed by a number of prominent plates. The primary aperture is interiomarginal, equitorial in position.

Dimensions of Hypotype: Diameter .28mm.

Distribution: Uncommon, present only in samples 29, 41 and 65.
Recorded Stratigraphic Range: Hornibrook (1961) recorded specimens of D. timida from the Altonian and Castlecliffian. Mahoenui specimens are from the Otaian.

Genus EPISTOMINELLA Husezima & Maruhasi, 1944.

EPISTOMINELLA IOTA Hornibrook, Pl. 10, figs. 13 - 15.

Epistominella iota Hornibrook, 1961: 122, Pl. 17, fig. 359, 361, 363; Hayward, 1975: 514 (list).

Remarks: Material from the Mahoenui Group has been compared with the type suite in the New Zealand Geological Survey collections. The Mahoenui specimens are very close to the types but are almost always strongly recrystallised.

Dimensions of Hypotype: Diameter .14mm, thickness .08mm.

Distribution: Uncommon, but occurs in large numbers in some samples. Samples 3, 23, 96, 137 and 139 contain E. iota. In samples 137 and 139 it forms more than 30% of the total fauna.

Recorded Stratigraphic Range: Waitakian to Waiauan. (Oligocene to mid. Miocene).

EPISTOMINELLA n. sp. A, Pl. 10, figs. 16, 19.

Description: Test of medium size, trochospiral, biconvex and finely perforate. 1½ to 2 whorls are exposed on the evolute side. The opposite side is involute with 8 - 9 chambers showing. The sutures on both sides are non limbate and flush, the periphery is subacute with a rounded keel. The aperture is lipped, elongated in the direction of coiling and set in an infundibulum.

Dimensions of Holotype: Maximum diameter .26mm thickness .09mm.

Repository: Holotype and Paratypes are lodged with the Geology Department, University of Auckland.

Type Locality: R17/f35 ; Sample 35, (Column 8) Mangaorino Road, R17/729930 (N.Z.M.S. 260); Paratypes, sample 50 (Column 9).
Type level: Taumatamaire Formation, Mahoenui Group (Otaian).

Distribution: Present in 5 samples: 35, 50, 79, 92 and 129.

Observed Stratigraphic Range: Otaian. (Early Miocene).

Genus GAVELINOPSIS Hofker, 1951

GAVELINOPSIS n. sp. A, Pl. 11, figs. 1, 2.

Description: Test planoconvex, nearly involute on both sides with about 8 chambers visible. The umbilical side is flat or slightly concave with excavate, almost petalloid, papillate sutures. The umbilicus is filled by a 'star shaped' plug. On the opposite side the shell is raised, conical and about half as high as wide with unthickened, slightly depressed, gently recurved sutures. The slit like aperture is situated near the periphery on the umbilical side, the periphery acute.

Dimensions of Holotype: Diameter .25mm, thickness .10mm.

Repository: Holotype and 3 Paratypes are lodged with the Geology Department, University of Auckland.

Type locality: S16/f13 Sample 62, (Column 17) Bluffs west of Te Kuiti, S16/979151 (N.Z.M.S. 260); Paratype, sample 59 (column 17).

Type level: Taumatamaire Formation, Mahoenui Group (Otaian).

Distribution: Never abundant, recorded in samples 62, 75 and 76.

Observed Stratigraphic Range: Present in the Otaian of the Mahoenui Group near Te Kuiti.

GAVELINOPSIS PUKEURIENSIS Hornibrook, Pl. 10, figs. 17, 18.

Remarks: Material from the Mahoenui Group was compared to the type suite. The specimens are smaller than Hornibrooks' types and have more chambers per whorl. Otherwise they are very similar, having a coarsely and densely punctate, inflated trochoid shell with a rounded periphery. On the evolute side there are about \(2\frac{1}{2}\) whorls of 6 - 7 chambers exposed. The sutures on this side are non limbate and depressed. On the opposite side the test is involute, and umbilicate. The sutures on this side are nearly radial and are deeply incised, particularly on their inner ends. The umbilicus usually has a central plug and is bordered by triangular apertural flaps which extend from the chamber bases. The aperture is an umbilical - extraumbilical slit beneath these flaps.

Dimensions of Hypotype: Diameter .22mm.

Distribution: Forms 2 - 3% of the total faunas in samples 24 and 134.

Recorded Stratigraphic Range: Otaian to Clifdenian. (Early Miocene to mid. Miocene).

Genus ROSALINA d'Orbigny, 1826

ROSALINA cf. SQUAMATA (Parker), Pl. 11, figs. 3, 4.

cf. Discorbis squamata Parker, 1952 : 418, Pl. 6, figs. 10, 11.

Description of Mahoenui Specimens: Low, trochospiral, coarsely and densely punctate tests with a rounded periphery. The dorsal side is evolute, gently raised and conical, with about 6 - 8 chambers per whorl. Ventrally the test is umbilicate, involute and slightly concave, with simple imperforate umbilical flaps protruding into the umbilicus.

Dimensions of Hypotype: Diameter .21 mm.

Distribution: Rare, only present in samples 23 and 42.

ROSALINA sp. Pl. 11, fig. 7.

Description: Medium sized, low trochospiral shell. The dorsal side is completely evolute, with 2 - 3 whorls exposed. There are 5 - 6 chambers in the final whorl. Ventrally the test is partially evolute and umbilicate. The umbilicus is occasionally filled by a boss.
The periphery is rounded and imperforate while the remainder of the shell is coarsely and densely punctate. The sutures are gently recurved, slightly depressed and thickened. The aperture is an interiomarginal arch with a lip and is restricted to the umbilical side of the test. It also extends along the spiral suture for 2 - 3 chambers but is covered by a flap.

Dimensions: Diameter .38mm.

Distribution: Present in 8 samples from columns 2 - 7 and 19.

Observed Stratigraphic Range: Present in the Otaian of the Mahoenui Group.

ROSALINA VITRIZEA Hornibrook, Pl. 11, figs. 5, 6.

Rosalina vitrizea Hornibrook, 1961: 101, Pl. 13, fig. 264, 266, 269.

Remarks: This is a characteristic vitreous species. The spiral side is a low cone with numerous short chambers arranged in about 3 - 4 whorls. The umbilical side is flat or slightly concave with 5 - 6 chambers exposed. Ventral sutures radial, umbilicus small, periphery acute and carinate. Test coarsely punctate.

Dimensions of Hypotype: Diameter .28mm.

Distribution: Uncommon, occurs in 5 samples from columns 4, 6, 7, 8 and 17.

Recorded Stratigraphic Range: Waitakian to Castlecliffian.

Genus PARVICARININA Finlay, 1940

PARVICARININA ALTOCAMERATA (Heron-Allen & Earland) Pl. 11, fig. 8.

Truncatulina tenuimargo Brady, 1884: 662, Pl. 93, fig. 2 (Not fig. 3); Chapman, 1926: 78, Pl. 16, fig. 1.

Truncatulina tenuimargo var. altocamerata Heron-Allen & Earland, 1922: 209, Pl. 7, figs. 24 - 27.

Parvicarinina altocamerata (Heron-Allen & Earland); Finlay, 1940: 467, Pl. 62, fig. 30 - 34; Finlay & Marwick, 1940: 111; Barker, 1960: 192, Pl. 93,
figs. 2a - c; Hornibrook, 1961: 118, Pl. 14, figs. 296, 299, 301, 302 and 305; Belford, 1966: 93 - 94, Pl. 14, figs. 14 - 16; Scott, 1971a: Fig. 2 (list); Hornibrook, 1971: 11 (list).

Laticarinina altocamerata (Heron-Allen & Earland);
Loeblich & Tappan, 1964a: C.580, 581, fig. 457 (2 - 4).

Dimensions of Hypotype: Diameter .45mm.

Distribution: Present in 20 samples from columns 2 - 7, 19, 29, 33, 34, 37, 40, 43, 45, 47a and 47b.

Recorded Stratigraphic Range: Recorded from Kaiatan to Recent.
(Eocene to Recent).


BUCCELLA LOTEULLA Hornibrook.


Remarks: This very small biconvex trochoid species is characterised by its petalloid, papillae filled sutural depressions. Material from the Mahoeinui Group is very similar to the Type specimens.

Dimensions of Hypotype: Diameter .15mm.

Distribution: Rare, only recorded from samples 4, 49 and 94.

Subfamily BAGGININAE

Genus BAGGINA Cushman, 1926

BAGGINA AMPLA (Finlay), Pl. 11, fig. 9.

Cancris amplus Finlay, 1940: 463, Pl. 64, fig. 92 - 4;
Finlay & Marwick, 1940: 119, 125; Finlay & Marwick, 1947: 233.

Baggina ampla (Finlay); Hornibrook, 1961: 120, Pl. 16, fig. 335 - 337; Hornibrook, 1968: 33, 36, 64; Table 4, 8; Text fig. 10; Hornibrook, 1971: 8 (list).
Remarks: A large, inflated, densely perforate Baggina with a rounded periphery and characteristic large imperforate area above a low, lipped aperture. The umbilical area is characterised by incised sutures which leave the chamber bases projecting into the umbilicus.

Dimensions of Hypotype: Maximum diameter .42mm, minimum diameter .30mm.

Distribution: Rare, recorded in samples 4, 49 and 94.

Recorded Stratigraphic Range: Waitakian Stage to Opoitian.

Family GLABRATELLIDAE

Genus BUENINGIA Finlay, 1939

BUENINGIA CREEKI Finlay, Pl. 11, figs. 10, 11.

Remarks: This small inflated species is characterised by its thick imperforate flange. Mahoenui specimens are identical to the type suite.

Dimensions of Hypotype: Diameter .22mm.

Distribution: This species is particularly common in the area from Mahoenui to Te Kuiti. It is present in 38 samples from columns 1 - 8, 17, 19 - 22, 25, 29a, 30 and 46a.

Recorded Stratigraphic Range: Landon to Taranaki Series.

Genus HERONALLENIA Chapman & Parr, 1931.

HERONALLENIA LAEVIS Parr, Pl. 11, figs. 12, 13.

Remarks: Mahoenui specimens are compressed and umbilicate with 7 - 8
chambers in the final whorl. The aperture opens into the umbilicus but
it is partially obscured by a toothlike flap. The raised umbilical
side is radially grooved and is only sparsely punctate, while the lower
spiral side is densely perforate. On the umbilical side the sutures
are radial and incised while they are strongly recurved and somewhat
limbate on the spiral side. Most specimens of Heronallenia from the
Mahoenui Group are similar to Parr's illustrations of H. laevis.
However, a few specimens are somewhat more inflated and approach
H. pulvinulinoides Parr.

Dimensions of Hypotype: Maximum diameter .55 mm,
minimum diameter .46.

Distribution: Uncommon, occurs in 10 samples from columns 1, 5, 7, 8,
17 and 43.

Recorded Stratigraphic Range: Parr recorded H. laevis from Recent
sediments. These specimens are from the Otaian of the Mahoenui
Group.

Genus CANCRIS de Montfort, 1808

CANCRI S LATERALIS Finlay.

Cancris lateralis Finlay, 1940 : 463, Pl. 4, fig.
105 - 7; Finlay & Marwick, 1940 : 114, 122;
Hornibrook, 1961 : 120, Pl. 15, fig. 329, 333 - 334;
Hornibrook, 1968 : 68, fig. 12; Hornibrook, 1971 :
8 (list); Nelson, 1973 : Table following p. 183.

Distribution: Present in 6 samples from columns 3, 4, 6, 17 and 37.

Recorded Stratigraphic Range: Runangan to Kapitean. (Late Eocene to
late Miocene).

CANCRI S LAEVINFLATUS Hornibrook.

Cancris laevinflatus Hornibrook, 1961 : 120, Pl. 15,
fig. 328, 331 & 332.

Distribution: Rare, only recorded in 3 samples : 65, 76 and 96.

Recorded Stratigraphic Range: Whaingaroan to Waiauan. (Oligocene to
mid Miocene).
Genus GLABRATELLA Dorreen, 1948.

Four species of Glabratella are recorded from Mahoenui Group faunas. Three of these (G. radiata, G. calcarata and G. zealandica) are planoconvex species with acute peripheries and a flat umbilical side ornamented with radial striae and papillae. These three species all have low arched basal slits for apertures. In contrast G. crassa is a small distinct subglobular species.

GLABRATELLA RADIATA (Vella), Pl. 11, figs. 15 - 17.

Pileolina radiata Vella, 1957: 36, Pl. 8, fig. 170,171.
Discorbis radiata (Vella); Hornibrook, 1961: 100.
Glabratella radiata (Vella); Hedley, Hurdle & Burdett, 1967: 36, 38; Eade, 1967a: 44.

Remarks: This species is higher spired than either G. calcarata or G. zealandica. The high domed involute side has numerous recurved chambers. Sutures on the umbilical side are almost totally obscured by radial ornament of heavy tubercles. This taxon often forms plastogamic pairs.

Dimensions of Hypotype: Diameter .39mm.

Distribution: This is the commonest species of Glabratella in the Mahoenui Group. It occurs in 29 samples from columns 1 - 10, 14 and 17. Most of these are from near Mahoenui. It generally forms less than 3% of the fauna.

Observed Stratigraphic Range: This Recent species has been recorded from the Altonian in Oamaru. It is present in the Otaian of the Mahoenui Group.

GLABRATELLA ZEALANDICA (Vella), Pl. 12, figs. 1, 2.

Pileolina zealandica Vella, 1957: 37, Pl. 8, fig. 175, 176.
Discorbis zealandica (Vella); Hornibrook, 1961: 99, Pl. 13, fig. 254 - 256; Happy, 1971: Table following p. 100; Hornibrook, 1971: 9 (list); Hayward, 1975: 514 (list).
Glabratella zealandica (Vella); Hedley, Hurdle & Burdett, 1967: 38, 39; Eade, 1967a: 45.
Remarks: This is a low spired species. The test is constructed of 2 - 4 whorls, each with 5 - 8 recurved chambers. The umbilical side of the shell is involute with recurved sutures. The opposite side is evolute and conical. The umbilicus is obscured by rows of fine papillae, centrally there are often a number of plate like nodules and occasionally an umbilical boss.

Dimensions of Hypotype: Diameter .20mm.

Distribution: Present in 25 samples from columns 2 - 5, 7, 8, 14, 16 and 17, from the Mahoenui and Te Kuiti areas. This species usually forms less than 1% of the fauna.

Recorded Stratigraphic Range: Whaingaroan to Recent. (Oligocene to Recent).

GLABRATELLA CALCARATA (Heron-Allen & Earland), Pl. 12, figs. 4, 5.

Discorbina calcarata Heron-Allen & Earland, 1922: 204, Pl. 7, figs. 12 - 16.

Discorbis calcarata (Heron-Allen & Earland);


Glabratella calcarata (Heron-Allen & Earland); Eade, 1967: 44.

Remarks: Mahoenui Group specimens of this low spired species have an evolute side showing 2 - 3 whorls of 6 - 8 chambers per whorl. On the umbilical side the shells are involute with radial incised sutures. These are somewhat obscured by radially arranged rows of papillae. The umbilicus is open though somewhat obscured by expanded chamber bases. The peripheral ends of the sutures are extended as short spines. Although placed in Discorbis by Hornibrook (1961) this species is better placed as Glabratella because of its flat ventral surface with radiating papillae.

Dimensions of Hypotype: Diameter .25mm.

Distribution: Rare, only present in samples 2, 9, 14, 17, 19, 22.

Recorded Stratigraphic Range: Duntroonian to Recent. (Oligocene - Recent).
GLABRATELLA CRASSA  Dorreen, Pl. 11, fig. 14.

Glabratella crassa  Dorreen, 1948: 294, Pl. 39, fig. 1; Hornibrook, 1961: 108, Pl. 14, fig. 289;
Happy, 1971: Table following p. 100.

Remarks: G. crassa is characterised by a test constructed of a few globular chambers and its wide umbilicus which is ornamented by radial lines of tubercles. Occasional specimens of G. crassa are found as plastogamie pairs.

Dimensions of Hypotype: Diameter .28mm.

Distribution: Present in 17 samples from columns 1, 2, 4 - 8, 14, 17, 22 and 30.

Recorded Stratigraphic Range: Present through most of the New Zealand Tertiary.

Family SIPHONINIDAE

Genus SIPHONINA Reuss, 1850

SIPHONINA AUSTRALIS  Cushman, Pl. 12, figs. 3, 6.

Siphonina australis  Cushman, 1927b: 8, Pl. 2, fig. 6, Pl. 3, fig. 7 - 8; Hornibrook, 1961: 121, Pl. 16, fig. 353; Hornibrook, 1968: 58, Table 4, text fig. 9; Hornibrook, 1971: 9, 11 (list).

Remarks: Specimens from the Mahoeuni Group are translucent, trochosphiral, lenticular and carinate. The keel is wide and frimbriate, perforated by large pores perpendicular to the periphery. These pores remain obvious along the spiral suture. The test is composed of 2 - 3 whorls with 4 - 5 chambers in the final whorl. The sutures are limbate, depressed and straight or slightly recurved, radiate on the involute side, tangential, straight and flush on the spiral side. The aperture is on a short heavy oval spout with a heavy phialine lip. Ornamentation consists of a few heavy tubercles on the final chamber. Siphonina australis was originally described from the middle Tertiary of Australia. In 1924, Cushman described a very similar species from Recent sediments of the South Pacific. This species (S. tubulosa)
has also been recorded on the modern New Zealand shelf (Thompson, 1975). These specimens were compared with those of *S. australis* from the Mahoenui Group and they appear to be extremely similar. A comparison between the types of *S. tubulosa* and *S. australis* may well show the two to be synonyms.

Dimensions of Hypotype: Diameter .30mm.

Distribution: Present throughout the Mahoenui Group. Occurs in 39 samples from columns 3, 6 - 12, 15 - 22, 26, 29, 35, 37, 42 - 46a and 47a.

Recorded Stratigraphic Range: Upper Arnold to Wanganui Series. (Late Eocene to Pleistocene).

**Family EPONIDIDAE**

**Genus EPONIDES d'Montfort, 1808**

**EPONIDES BROECKHIANUS** (Karrer), Pl. 12, figs. 7 - 9.

*Rotalia broeckhianus* Karrer, 1878 : 98, Pl. 5, fig. 26; Brady, 1884 : 705, Pl. 107, fig. 4.

*Eponides cf. broeckhianus* (Karrer); Finlay & Marwick, 1940 : 114.

*Gyroidina broeckhiana* (Karrer); Hofker, 1951b: 403, fig. 281 – 2; Barker, 1960 : 220, Pl. 107, figs. 4a - c; Belford, 1966 : 167, Pl. 27.

*Eponides broeckhianus* (Karrer); Hornibrook, 1961 : 109, Pl. 15, fig. 321, 322; Hornibrook, 1971 : 8 (list); Happy, 1971 : Table following p. 100; Scott, 1971a : fig. 2 (list); Nelson, 1973 : Table following p. 183; Hayward, 1975 : 516 (list).

Remarks: Specimens of a large glossy *Eponides* are placed in *Eponides broeckhianus*. Mahoenui specimens are biconvex with a subacute periphery. The involute side has about 6 chambers exposed, arranged about a central umbilical depression. The sutures on this side are nearly radial, limbate and slightly depressed. On the opposite side there are about 3 whorls visible and the sutures are tangential and limbate. The aperture is a low interiomarginal arch.
Dimensions of Hypotype: Diameter .71mm, Thickness .45mm.

Distribution: Recorded in 16 samples from columns 1, 3, 4, 6, 15, 16, 22, 28 and 30.

Recorded Stratigraphic Range: Bortonian to Waitotaran. (Eocene to Pliocene).

EPONIDES REPANDUS (Fichtel & Moll), Pl. 12, fig. 10.

Nautilus repandus Fichtel & Moll, 1798 : 35, Pl. 3, fig. a - d.

Pulvinulina repandus (Fichtel & Moll); Chapman, 1926 : 84, Pl. 17, fig. 1.

Eponides repandus (Fichtel & Moll); Chapman, Parr & Collins, 1934 : 565, Pl. 9, fig. 18; Finlay, 1939a : 521; Finlay, 1939b : 122; Finlay & Marwick, 1940 : 119; Parr, 1950 : 360; Vella, 1957 : 10 (list); Carter, 1958 : 45, Pl. 6, fig. 51 - 53; Hornibrook, 1961 : 109, Pl. 15, fig. 324; Scott, 1970a : fig. 7; Hornibrook, 1971 : 8 (list); Murray, 1971 : 173, Pl. 72, fig. 1 - 4.

? Eponides repanda (Fichtel & Moll); Hofker, 1951b : 330, fig. 225 - 6.

Remarks: Specimens from the Mahoenui Group are large, unequally biconvex; nearly planoconvex. The spiral side has 1½ to 2 whorls of 6 chambers and extremely limbate recurved sutures. The involute side is raised, often with a central depression. The sutures on this side are radial, incised and unthickened. The acute periphery is often bluntly keeled, the aperture is a low interiomarginal arch.

Dimensions of Hypotype: Diameter .40mm, Thickness .29mm.

Distribution: Uncommon, found in 10 samples from columns 1, 6, 7, 15 - 17 and 39.

Recorded Stratigraphic Range: Kaiatan to Recent. (Eocene to Recent).

EPONIDES n. sp. A, Pl. 12, figs. 11, 12, 15.

Description: A small trochoid, low spired, equally biconvex species. The test is very finely punctate, the periphery rounded. On the evolute side there are 2½ to 3 whorls visible. On this side the
sutures are slightly limbate, tangential and gently recurved. On
the spiral side there are about 8 chambers exposed in the last whorl.
The sutures on this side are nearly radial and are little thickened.
The aperture is a low interiomarginal slit that is entirely restricted
to the involute side.

Dimensions of Holotype: Diameter .32mm, Thickness .15mm.
Repository: Holotype and 5 Paratypes are lodged with the
Geology Department, University of Auckland.
Type locality: R17/f50 ; Sample 50, (Column 9) Te Kuiti -
New Plymouth highway, 7 Km N.E. of Mahoenui R17/758948
(N.Z.M.S.260), Paratypes from sample 158 (column 43).
Type level: Taumatamaire Formation, Mahoenui Group
(2taian).

Remarks: This species differs from E. broeckhianus in being smaller,
with a more rounded periphery, and more nearly biconvex. It is quite
similar to E. regularis of Phleger & Parker but the periphery is much
more rounded and the profile is less compressed.

Distribution: Occurs sporadically, recorded in 13 samples from:
columns 9, 14, 19, 24a, 29a, 30, 32, 34, 37, 43 and 47a.


Family AMPHISTEGINIDAE

Genus AMPHISTEGINA, d'Orbigny, 1826.

AMPHISTEGINA CAMPBELLI Karrer, Pl. 12, figs. 13, 14.

Amphistegina campbelli Karrer, 1864 : 84, Pl. 16,
fig. 18; Hornibrook, 1968 : 56; Hornibrook, 1971 :
22, Pl. 4, figs. 22, Pl. 4, figs. 57 - 60, Text
fig. 5.
Amphistegina aucklandica Karrer, 1864 : 85, Pl. 16,
fig. 19; Hornibrook, 1968 : 56; Hornibrook, 1971 : 22,
Pl. 4, figs. 61 - 63, text figs. 4, 5; Hayward, 1975 :
516 (list).
Amphistegina sp. Dorreen, 1948: 298, Pl. 40, fig. 6; Hornibrook, 1961: 167, Pl. 27, fig. 525; Scott, 1970a: 316–341, fig. 7, 8, 13 (lists), fig. 6; Happy, 1971: Table following p. 100; Nelson, 1973: Table following p. 183.

Remarks: New Zealand lower Tertiary specimens of Amphistegina have been separated into the strongly biconvex A. aucklandica and an extremely flattened form, A. campbelli. Specimens from the Mahoenui Group show a complete intergradation between these forms and they are considered to be synonyms. A campbelli is regarded as the senior synonym as it has page precedence over A. aucklandica. Mahoenui specimens placed in this species are of medium to large size, planispiral and biconvex. They vary from being flattened, discordal, to being strongly inflated. The test is constructed of about 5 whorls each of up to 24. greatly recurved chambers with secondary chamberlets near the periphery. The aperture is a low interiomarginal slit, and is often surrounded by papillate ornament. The shell is densely punctate, but the umbos are often thickened forming a glassy knob.

Amphistegina campbelli closely resembles A. lessoni and it is likely that most New Zealand early Miocene specimens are conspecific with A. lessoni.

Dimensions of Hypotype: Diameter .55mm.

Distribution: This species is present in 30% of samples. It is particularly common in the west and north of the study area where it is present in almost every sample. In many samples A. campbelli forms more than 10% of the total fauna.

Recorded Stratigraphic Range: Miocene.

Family CIBICIDIDAE

Genus CIBICIDES de Montfort, 1808

A number of the species here placed as Cibicides have been placed as Cibicidoides by Hayward (1975) and others. Cibicides and Cibicidoides are very similar in general morphology, both are completely involute on
one side, evolute and coarsely punctate on the other side. Both have imperforate keels, and both are very variable in form. In Cibicidoides the interiomarginal aperture is restricted to the periphery, while in Cibicides the aperture crosses the periphery and extends along the spiral suture. Loeblich and Tappan recorded Cibicides as an attached form with a radial wall and Cibicidoides as a free living form with a granular wall. However, the criterion "free living vs. attached" is subjective and unsatisfactory for generic separation and the difference between radial and granular walls has also been shown to be unreliable (Towe & Cifelli).

This leaves only the apertural details for generic separation. Because of the range of variation seen in specimens from the Mahoenui Group this was not considered significant at the generic level and Cibicidoides and Cibicides were placed together.

CIBICIDES PERFORATUS (Karrer), Pl. 13, figs. 1 - 3.

Rotalia perforata Karrer, 1864 : 81, Pl. 16, fig. 13.
Rotalia maculata Stache, 1864 : 278, Pl. 24, figs. 28a - c.
Truncatulina haidingeri (d'Orbigny); Chapman, 1926 : 77, Pl. 1.
Cibicides perforatus (Karrer); Finlay & Marwick, 1940 : 111, 119; Dorreen, 1948 : 299; Carter, 1958 : 46, 47, Pl. 6, figs. 57 - 59; Hornibrook, 1961 : 161, Pl. 25, figs. 503 - 505; Hornibrook, 1971 : 21, Pl. 4, figs. 69 - 71; Scott, 1971a : fig. 2 (list); Happy, 1971 : Table following p. 100 (list); Nelson, 1973 : Table following p. 183.
Cibicidoides perforatus (Karrer); Hayward, 1975 : 522 (list).

Remarks: Cibicides perforatus is characterised by its medium to large sized, equally biconvex test with about 12 chambers in the final whorl, coarse punctuation, recurved, somewhat limbate sutures, iridescent, somewhat blotchy appearance and a spiral side with the central area obscured by "umbilical callus." Although Finlay (1940) regarded C. maculatus as a synonym of C. perforatus, Hornibrook (1971)
retained the species for specimens, resembling C. perforatus, but differing in being less strongly biconvex, with a less prominent umbo, fewer chambers per whorl and more recurved sutures on the spiral side. Specimens referrable to C. maculatus are here placed in synonymy with C. perforatus.

Dimensions of Hypotype: Diameter .34mm, Thickness .25mm.

Distribution: Extremely abundant. Occurring in 72% of samples taken from the study area. This species regularly forms more than 20% of the total fauna.

Recorded Stratigraphic Range: Kaiatan to Tongaporutuan. (Late Eocene to Recent).

CIBICIDES NOTOCENICUS (Dorreen), Pl. 13, figs. 5, 6.

Cibicides vortex Dorreen, 1948 : 299, Pl. 41, fig. 5; Hornibrook, 1961 : 160, Pl. 24, fig. 490 - 492.

Cibicides perforatus (Karrer) var. notocenicus Dorreen, 1948 : 299, Pl. 41, fig. 4.

Cibicides notocenicus Dorreen; Hornibrook, 1961 : 158, Pl. 25, fig. 496, 498.

Description: Trochoid, small to medium sized, planoconvex. Involute side high domed with a pseudoumbilical depression which is generally filled by a callus plug. There are about 10 chambers exposed on the involute side, and the sutures are limbate and recurved. The spiral side is flat or gently domed, partially involute, with 1½ to 2 whorls showing. Centrally the chamber detail is obscured by "umbilical callus." Specimens with flat dorsal sides often have a well developed umbilical plug delineated by a deeply incised spiral suture. The periphery is sharply rounded and generally carinate. The aperture is an interiomarginal slit extending from just below the equator, across the periphery, and along the spiral suture for 1 to 2 chambers. The test is coarsely punctate on the spiral side, often having a blotchy iridescent appearance.

Dimensions of Hypotype: Diameter .30mm, Thickness .23mm.

Remarks: Although particular individuals could be identified as
C. vortex or C. notocenicus they are not separated and they are seen as members of a plexus of high domed planoconvex forms. Within this plexus specimens show wide morphological variation. Size, inflation, peripheral angle, the presence of a pseudoumbilical depression or callus knob, and the form of the dorsal umbilical callus all vary. Dorreen (1948) regarded C. notocenicus to be closely related to C. perforatus only differing in "the possession of more prominent sutures and in being much more conical ventrally." The blotchy iridescent appearance, similar number of chambers, central indistinct area dorsally, and the presence of occasional forms apparently intermediate between C. notocenicus and C. vortex tends to support this view.

Distribution: Less widespread than C. perforatus but still present in 39% of samples. This species is commonest in the west and north of the study area.


CIBICIDES MEDIOCRIS Finlay, Pl. 13, figs. 4, 7, 8.

Cibicides mediocris Finlay, 1940 : 464, Pl. 67, fig. 198, 199; Finlay & Marwick, 1940 : 115, 120.

Remarks: Mahoenui specimens are flattened with an acute, often carinate periphery. The spiral side is flat or somewhat domed with limbate, recurved sutures. There are usually ½ to 2 whorls exposed on the spiral side. The central region is obscured by umbonal callus. This is delineated by a deeply incised spiral suture. The involute side is domed with a large prominent boss. There are 9 - 12 chambers exposed on this side and these are separated by gently recurved, slightly depressed sutures.

The spiral surface is densely and coarsely punctate while the involute side is smooth and glossy with much finer perforation. A low, lipped interiomarginal aperture extends from just below the periphery across the margin and along the spiral suture.

Dimension of Hypotype: Diameter .34mm, Thickness .15mm.

Distribution: Present in 45% of the samples, particularly from the west of the basin.
Recorded Stratigraphic Range: Duntroonian to Tongaporutuan. (Oligocene to late Miocene).

CIBICIDES ROBERTSONIANUS (Brady), Pl. 13, figs. 9 - 11.

Truncatulina robertsonianus Brady, 1881 : 65;
Brady, 1884 : 664, Pl. 95, fig. 4.
Cibicides robertsonianus (Brady); Phleger & Parker, 1951 : 31, Pl. 16, figs. 10 - 13;
Cibicides cf. robertsonianus (Brady); Gibson, 1967 : 67, Pl. 19, fig. 277.

Remarks: Mahoenui specimens of C. robertsonianus are small, approximately equally biconvex with a rounded, subacute, lobulate, periphery. There is often a weak peripheral keel. The involute side has 6 - 10 chambers exposed and is a little depressed centrally. The evolute side has about 4 - 5 slowly expanding whorls visible. The sutures are somewhat limbate and incised. Those on the involute side are radial or gently curved while those on the spiral side are more recurved. The spiral suture may be thickened. The test is coarsely and densely punctate on the spiral side, while the involute side is markedly less perforated. The aperture is a low, interiomarginal, lipped, slit, which extends from the equator to the spiral suture. It extends only a short distance along the spiral suture. Mahoenui specimens generally have fewer chambers and tend to be less completely involute, having somewhat more recurred sutures, than the specimens illustrated by Brady (1884).

Dimensions of Hypotype: Diameter .15mm.

Distribution: Present in 40 samples from columns 3, 5 - 9, 11 - 13, 20, 22, 24a - 27, 29 - 32, 34, 40, 43 - 47b.

Recorded Stratigraphic Range: Present throughout the Tertiary in New Zealand.

CIBICIDES MOLESTUS Hornibrook, Pl. 13, figs. 15, 19.

Cibicides molestus Hornibrook, 1961 : 163, Pl. 24, figs. 478, 479, 483; Vella, 1952a : 192 (list); Gibson,
1967: 67, Pl. 19, figs. 275, 276; Hornibrook, 1968: 76, fig. 14; Happy, 1971: Table following p. 100 (list); Scott, 1971a: fig. 2 (list); Hornibrook, 1971: 9, 11 (list); Nelson, 1973: Table following p. 183 (list).

*Cibicidoides molestus* (Hornibrook); Hayward, 1975: 522 (list).

**Remarks:** This species is characterised by its unequally biconvex form and its wavy, recurved, non limbate, somewhat incised sutures on the involute side. The spiral side inflation of the Mahoenui Group specimens is variable, some specimens are flattened and nearly biconvex while others are highly arched. The sutures are also variable, the majority of individuals having the typical wavy sutures, while others have sutures that are simply recurved.

Dimensions of Hypotype: Diameter .39mm, Thickness .20mm.

**Distribution:** Present in 65 samples (38%) from throughout the Mahoenui Group.

**Recorded Stratigraphic Range:** Bortonian to Waitotaran. (Eocene to Pliocene).

**CIBICIDES NOVOZEALANDICUS** (Karrer), Pl. 13, fig. 14.

*Rotalia novo-zealandica* Karrer, 1864: 80, Pl. 16, fig. 12.

*Pulvinulina novo-zealandica* (Karrer); Chapman, 1926: 83, Pl. 1, fig. 12.

*Cibicides novozealandicus* (Karrer); Finlay & Marwick, 1940: 114, 123; Hornibrook, 1961: 158, Pl. 24, fig. 480, 481, 484; Hornibrook, 1971: 9, 21, Pl. 4, figs. 64 - 68; Scott, 1971a: fig. 2 (list); Nelson, 1973, Table following p. 183.

*Cibicidoides novozealandicus* (Karrer); Hayward, 1975: 522 (list).

**Remarks:** Specimens placed in *C. novozealandicus* (Karrer) are characterised by an unequally biconvex test with an involute side that is much higher somed than the spiral side, coarse dense punctation, limbate recurved sutures and a subacute carinate periphery.

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*Remarks:* This species is characterised by its unequally biconvex form and its wavy, recurved, non limbate, somewhat incised sutures on the involute side. The spiral side inflation of the Mahoenui Group specimens is variable, some specimens are flattened and nearly biconvex while others are highly arched. The sutures are also variable, the majority of individuals having the typical wavy sutures, while others have sutures that are simply recurved.

**Dimensions of Hypotype:** Diameter .39mm, Thickness .20mm.

**Distribution:** Present in 65 samples (38%) from throughout the Mahoenui Group.

**Recorded Stratigraphic Range:** Bortonian to Waitotaran. (Eocene to Pliocene).

**CIBICIDES NOVOZEALANDICUS** (Karrer), Pl. 13, fig. 14.

*Rotalia novo-zealandica* Karrer, 1864: 80, Pl. 16, fig. 12.

*Pulvinulina novo-zealandica* (Karrer); Chapman, 1926: 83, Pl. 1, fig. 12.

*Cibicides novozealandicus* (Karrer); Finlay & Marwick, 1940: 114, 123; Hornibrook, 1961: 158, Pl. 24, fig. 480, 481, 484; Hornibrook, 1971: 9, 21, Pl. 4, figs. 64 - 68; Scott, 1971a: fig. 2 (list); Nelson, 1973, Table following p. 183.

*Cibicidoides novozealandicus* (Karrer); Hayward, 1975: 522 (list).

**Remarks:** Specimens placed in *C. novozealandicus* (Karrer) are characterised by an unequally biconvex test with an involute side that is much higher some of than the spiral side, coarse dense punctation, limbate recurved sutures and a subacute carinate periphery.
Dimensions of Hypotype: Diameter .68 mm, Thickness .42 mm.

Distribution: Recorded in 32 samples from columns 2, 4, 6 - 9, 12, 13, 15, 16, 18 - 20, 22, 26, 34, 39, 43, 46a and 47a.

Recorded Stratigraphic Range: ? Whaingaroan, Duntroonian to Tongaporutuan. (Oligocene to late Miocene).

CIBICIDES LOBATULUS (Walker & Jacob), Pl. 13, figs. 17, 18.

Nautilus lobatulus Walker & Jacob, 1798: 642, Pl. 14, fig. 36.
Truncatulina lobatulus (Walker & Jacob); d'Orbigny, 1846: 168, Pl. 9, figs. 18 - 23.
Dyocibicides biseriatus Cushman & Valentine, 1930: 31, Pl. 10, fig. 1, 2; Vella, 1957: 11 (list), 41; Hornibrook, 1961: 165, Pl. 26, 516.
Dyocibicides sp. Scott, 1970a: fig. 7, 8 (list), fig. 5 (8); Scott, 1971a: fig. 2 (list); Happy, 1971: Table following p. 100.

Remarks: This species occurs as two distinct morphological forms. The first is regularly trochoid, flattened, planoconvex or concavo-convex with an acute periphery. In this form 1 - 1½ whorls are exposed on the spiral side with 8 - 10 densely punctate chambers exposed in the final whorl. The sutures are recurved, flush and limbate on the spiral side, incised and less limbate on the higher domed ventral side. The aperture is an interiomarginal arch
extending from just below the equator, across the periphery and along the spiral suture for 2 - 3 chambers.

The second form is initially trochoid but becomes biserial or irregularly chambered. These forms have been previously recorded as Dyocibicides biserialis or D. primitiva.

Kaasschieter (1955) regarded Dyocibicides and Cibicidella as variants of C. lobatulus. This view was supported by Nyholm (1961) who studied the life cycle of C. lobatulus and found morphotypes resembling a wide range of genera. Cibicides, Rectocibicides and Dyocibicides were seen within this range. A number of other authors have supported this view (e.g. Butt, 1966) while some have continued to use Dyocibicides but have noted variation from regularly trochoid specimens to biserial or irregular specimens. In this work, Dyocibicides irregularis and D. primitiva are considered to be synonyms of C. lobatulus.

Dimensions of Hypotype: Diameter .27mm.

Distribution: Widespread, though not abundant, in the north and west of the study area. Present in 28% of samples.

Recorded Stratigraphic Range: Whaingaroan to Recent. (Oligocene to Recent).

CIBICIDES PSEUDOJINGERIANUS (Cushman), Pl. 13, figs. 12, 13, 16.

Truncatulina pseudoungerianus Cushman, 1922b : 97, Pl. 20, fig. 9.
Cibicides pseudoungerianus (Cushman); Barker, 1960 : 194, Pl. 94, figs. 9a - c; Gibson, 1967 : 67, Pl. 19, fig. 278; Murray, 1971 : 177, Pl. 74, figs. 1 - 6; Knudsen, 1971 : 260.

Remarks: Specimens from the Mahoenui Group have a test that is unequally biconvex (the involute side is higher arched than the gently domed spiral side) and a subacute periphery that often has a rounded keel. On the spiral side there are 2 - 3 whorls exposed, the early whorls are often raised above the rest of the test, and may be obscured by callus. Ventrally, only one whorl of 9 - 12 chambers is exposed. This often has a central callus knob or a pseudoumbilical depression.
The sutures are thickened and recurved on both sides. The test is coarsely and densely punctate on the spiral side but is very finely punctate and glossy on the involute side. The aperture is a low, lipped, interiomarginal slit which extends from midway along the base of the apertural face, across the equator, and back along the spiral suture for 1 or 2 chambers.

Dimensions of Hypotype: Diameter .25mm, Thickness .14mm.

Distribution: Present in 51 samples from columns 1 - 5, 7, 10, 13, 15 - 20, 25, 26, 29 - 31, 34, 41 - 44 and 46a.

Recorded Stratigraphic Range: Otaian to Opoitian. (Early Miocene to Pliocene).

CIBICIDES spp.

Cibicides is an extremely variable genus. A number of unidentified species that occur occasionally or as singletons are lumped together as Cibicides spp. These are not further discussed.

Family PLANORBULINIDAE

Genus PLANORBULINA d'Orbigny, 1826

PLANORBULINA sp. Pl. 14, fig. 2.

Description: A flat initial coil is followed by chambers added in a rough irregular spiral. Each chamber has one or two low interiomarginal apertures. The shell is densely and coarsely punctate.

Dimensions: Maximum diameter .19mm, minimum diameter .15mm.

Distribution: Rare, occurs in samples 14 and 47 only.

Genus PLANORBULINELLA Cushman, 1927

PLANORBULINELLA PLANA Heron-Allen & Earland, Pl. 14, fig. 1.

Planorbulinella plana Heron-Allen & Earland, 1924: 174, Pl. 12, fig. 92 - 95; Finlay & Marwick, 1940: 118;
Remarks: Specimens of a medium or large sized Planorbulinella occurring in the Mahoenui Group are placed in P. plana. In this species the somewhat globular chambers are arranged in an annular series. The chambers of adjacent whorls alternate giving the shell a somewhat scalloped margin.

Dimensions of Hypotype: Diameter .49mm.

Recorded Stratigraphic Range: Otaian to Waiauan. (Lower to mid. Miocene).

Family HOMOTREMATIDAE

Genus VICTORIELLA Chapman & Crespin, 1930

VICTORIELLA CONOIDEA (Rutlen)

Carpenteria conoidea Rutten, 1914 : 47, Pl. 7, figs. 6 - 9.
Carpenteria proteiformis Goës var. plecte Chapman, 1926 : 320, Pl. 51, fig. 3.
Victoriella plecte (Chapman); Chapman & Crespin, 1930 : 320, Pl. 51, fig. 3.
Victoriella aff. plecte (Chapman); Finlay & Marwick, 1940 : 95, 117; Hornibrook, 1953 : 439.
Victoriella conoidea (Rutlen); Glaessner & Wade, 1959 : 199, Pl. 1, fig. 1 - 5; Pl. 2, fig. 1 - 5, 7 - 10, Pl. 3, fig. 3, text. fig. 1 - 4; Hornibrook, 1961 : 168, Pl. 26, fig. 520; Hornibrook, 1968 : 64, fig. 11; Hayward, 1975 : 518 (list).

Remarks: Mahoenui specimens are large, trochospiral, initially multiserial with a low spire, later high spired and roughly triserial with thick walled globular chambers. The test is densely punctate and heavily tuberculated. The aperture is umbilical and lipped.
Dimensions of Hypotype: Length 1.65mm.

Distribution: Only present in sample 40.

Recorded Stratigraphic Range: Waitakian - Otaian. (Late Oligocene to lower Miocene).

Genus WADELLA Srinivasan, 1966

WADELLA GLOBIFORMIS (Chapman), Pl. 14, fig. 4.

Carpenteria globiformis Chapman, 1926: 81, Pl. 16, fig. 6; Hornibrook, 1961: 169, Pl. 26, fig. 518, 519; Hornibrook, 1968: 58, fig. 9.

Wadella globiformis (Chapman); Srinivasan, 1966: 250.

Remarks: Specimens of a large, coiled globose species that is densely punctate, and has an umbilical aperture with a tooth, are placed in Wadella globiformis.

Dimensions of Hypotype: Diameter 1.18mm.

Distribution: Recorded in samples 29, 30, 32 and 40.

Recorded Stratigraphic Range: Kaiatan to Altonian. (Eocene to early Miocene).

Superfamily SPIRILLINACEA

Family SPIRILLINIDAE

Subfamily SPIRILLININAE

Genus SPIRILLINA Ehrenberg, 1843

SPIRILLINA sp. Pl. 14, fig. 5.

Description: The test is small, and is made up of a proloculus followed by a simple undivided tube arranged in an asymmetric planispiral coil. The test is convex on one side and slightly concave on the other. The spiral suture is depressed, the margin of the shell is squarish, and often has a weak keel. Both sides of each whorl are ornamented with simple radial ribs.
Dimensions of Hypotype: Diameter .20mm.

Remarks: These specimens are close to *S. decorata* Brady, but they have a more rectangular periphery and are asymmetrical.

Distribution: Rare, found in samples 13, 14 and 69.

Observed Stratigraphic Range: Otaian. (Early Miocene).

Subfamily PATELLININAE

Genus PATELLINA Cushman, 1928

PATELLINA CORRUGATA Williamson, Pl. 14, fig. 3.

*Patellina corrugata* Williamson, 1858 : 46, Pl. 3, fig. 86 - 89; Chapman, 1926 : 75, Pl. 15, fig. 5; Parr & Collins, 1930 : 90, Pl. 4, fig. 1 - 5; Finlay & Marwick, 1940 : 111; Vella, 1957 : 10 (list); Hornibrook, 1961 : 97, Pl. 13, fig. 250; Hedley, Hurdle & Burdett, 1967 : 46.

Description of Mahoenui Group Specimens: A small, conical, planoconvex test with a circular profile. The proloculus is followed by a simple tube for one or more whorls. This gives way to biserially arranged chambers. The sutures are limbate, upstanding and the chambers are coarsely punctate. The aperture is a low arch at the base of the final chamber.

Dimensions of Hypotype: Diameter .37mm.

Distribution: Rare, recorded from samples 3, 13, 14 and 74.

Recorded Stratigraphic Range: Occurs throughout the New Zealand Tertiary.
Genus PARAROTALIA Le Calvez, 1949

PARAROTALIA MACKAYI (Karrer), Pl. 14, fig. 6.

Rosalina mackayi Karrer, 1864 : 82, Pl. 16, fig. 14.
Calcarina mackayi (Karrer); Finlay, 1939d :
387 - 9; Finlay, 1939b : 527 - 8; Finlay, 1947 :
Neorotalia mackayi (Karrer); Hornibrook, 1968 : 63,
fig. 10.
Pararotalia mackayi (Karrer); Hornibrook, 1971 : 19,
Pl. 3, figs. 55 - 57, Pl. 13, figs. 3 - 7, Text figs.
2a - g.

Remarks: Specimens from the Mahoenui Group are large, trochospiral,
and have a prominent tuberculated umbo on the involute side. On this
side the sutures are incised, radial, and marked by parallel rows of
tubercles. The spiral side is glossy and has straight, limbate, sutures.
The surface of the shell is densely and coarsely punctate. The periphery
is carinate and tuberculated while the aperture is interiomarginal and
partitioned internally. There are about 10 - 11 chambers in the final
whorl.

As in the Waitamata Group, P. mackayi, generally occurs in conjunction
with Lepidocyclina and Miogypsina.

Dimensions of Hypotype: Diameter .47mm.

Distribution: Occurs in samples 5, 24, 25, 31, 59 and 83.

Recorded Stratigraphic Range: Whaingaroan to Clifdenian. (Oligocene to
mid. Miocene).

Family ELPHIDIIDAE

Subfamily ELPHIDIINAE

Genus ELPHIDIIDUM de Montfort, 1808

The genera Elphidium Montfort and Cribroelphidium Cushman & Bronnimann
are not separated in this study. Species of *Elphidium* from New Zealand have long been masquerading under provincial names. Although an attempt has been made to resolve this problem, it is made difficult by the wide ecophenotypic variation of the species, and additionally clouded by conflicting, and often confused views expressed in Northern Hemisphere literature.

**ELPHIDIUM ADVENUM** (Cushman), Pl. 14, figs. 7, 8.

*Polystomella subnodosa* Brady, 1884 : 734, Pl. 110, figs. 1a, b (Not of Von Münster).

*Polystomella advena* Cushman, 1922c : 56, Pl. 9, figs. 11, 12.

*Elphidium advenum* (Cushman); Cushman, 1930 : 25, Pl. 10, figs. 1, 2; Cushman, 1939 : 60, Pl. 16, figs. 31 - 35.

*Elphidiononion charlottensis* Vella, 1957 : 38, Pl. 9, figs. 187, 188.

*Cribroelphidiurn charlottensis* (Vella); Hedley, Hurdle & Burdett, 1967 : 50, Pl. 12, fig. 3a, b.

*Elphidium charlottensis* (Vella); Hulme, 1964 : 338; Topping, 1973 : 31, Pl. 11, figs. 4, 5;

Thompson, 1975 : 88.

Description of Mahoenui Group Specimens: Lenticular, involute, planispiral, with an acute, carinate, periphery. Bicornicate with a glossy umbilical plug. This plug may be smooth but is generally perforated by one or two circlletts of pores. The chambers gradually increase in size with about 15 - 16 in the final whorl. The sutures are gently recurved and are crossed by 6 - 9 retral processes. These are about 1/3 to 1/2 the width of each chamber. Shallow depressions lie between each retral process and these are filled numerous pustules. The aperture is a row of pores at the base of the imperforate apertural face.

Dimensions of Hypotype: Diameter .41mm.

Remarks: Cushman (1939) described *E. advenum* as being strongly compressed with subparallel sides and with "umbilical regions depressed, often with a small central boss." Vella (1957) erected *E. charlottensis* for specimens that lacked the depressed umbilicus, and had more inflated
chambers than *E. advenum*. Vella felt that Recent Pacific specimens recorded as *E. advena* by Cushman (1939) were probably synonyms of *E. charlottensis*. However Cushman's (1939) illustrations show very similar forms from both the Pacific and the Atlantic oceans. These are blunthonate and lecticular in form.

The degree of inflation in specimens of *E. advenum* illustrated by Cushman is very variable. The individuals he illustrates from the Pacific are more compressed than the Holotype of *E. charlottensis* but those from Florida are more inflated! It seems that the degree of inflation cannot be regarded as sufficiently constant to allow discrimination between these two species. If this is accepted then the continued separation of *E. charlottensis* and *E. advenum* must depend entirely on details of umbilical morphology. Both species have a somewhat flattened umbilical region with an umbilical boss that does not extend beyond the normal profile of the test. *E. charlottensis*, however, has a boss that completely fills any umbilical depression while *E. advenum* tends to have a smaller boss incompletely filling the umbilical depression.

The overall morphological variation in New Zealand Tertiary and Recent specimens of *E. charlottensis* is considerable and overlaps *E. advenum*. The differences in the structure of the umbilicus are not considered to be sufficient to separate the two and *E. charlottensis* is here considered to be a local variant of *E. advenum*.

**Distribution:** Common in the north and west of the study area. Recorded in 42 samples from columns 1 - 8, 14 - 18, 20, 28, 30, 40, 46a and 47a.

**Observed Stratigraphic Range:** ? Waitakian, Otaian and Recent. (? Late Oligocene, early Miocene and Recent).

**ELPHIDIIUmut cf. HAMPDENENSIS** Finlay, P1. 14, figs. 9, 13.

cf. Elphidium hampdenensis Finlay, 1939b: P1. 12, fig. 31 - 3; Finlay, 1940: 457.

**Description of Mahoenui Group Specimens:** Test small to medium sized, moderately inflated, with about 12 - 13 chambers in the final whorl. The umbilical region is slightly depressed, the periphery subacute
and often carinate. The aperture is a row of pores at the base of the apertural face. This is triangular with slightly concave sides.

Dimensions of Hypotype: Diameter .31mm

Remarks: A number of similar species are recorded from the Oligocene and Miocene of Australia and New Zealand. These species include:

- **E. subinflatum** Cushman
- **E. pseudoinflatum** Cushman
- **E. hampdenensis** Finlay
- **E. Hornibrooki** Srinivasan

These species may form a plexus. The specimens from the Mahoenui Group most closely resemble **E. hampdenensis** with its recurved limbate sutures and almost reticulate network of retral processes, however they are smaller and tend to be somewhat more inflated.

Distribution: Recorded in 26 samples from columns 1 - 5, 7, 14 - 17 and 36.

Recorded Stratigraphic Range: **E. hampdenensis** is an index for the Heretaungan. **E. cf. hampdenensis** is recorded from the Otaian of the Mahoenui Group.

ELPHIDIUM EXCAVATUM (Terquem) sensuo lato, Pl. 14, figs. 10 - 12.

- **Polystomella excavata** Terquem, 1876 : 429, Pl. 2, fig. 2a - d.
- **Elphidium striatopunctata** var. **selseyensis** Heron-Allen & Earland, 1911 : 448.
- **Polystomella striatopunctata** (Fichtel & Moll);
- **Elphidium incertum** var. **clavatum** Cushman, 1930 : 20, Pl. 7, figs. 10a, b; Cushman, 1939 : 57, Pl. 16, figs. 1, 2; Parker, 1952 : 412, Pl. 5, fig. 11.
- **Elphidium (Polystomella) excavatum** (Terquem); Heron-Allen and Earland, 1932 : 439, Pl. 16, figs. 22 - 23.
- **Elphidium lidoensis** Cushman, 1936a : 80, Pl. 15, fig. 6; Cushman, 1939 : 62, Pl. 17, fig. 17.
Elphidium argenteum  Parr, 1945: 216, Pl. 12, fig. 7a, b.

Elphidium excavatum  (Terquem); Parker, 1952: 412, Pl. 5, fig. 8; Murray, 1971: 159, Pl. 66, figs. 1 - 7.

Elphidium clavatum  Cushman; Loeblich & Tappan, 1953: 98, Pl. 19, figs. 8, 10; Buzas, 1966: 585 - 594, Pl. 71, figs. 1 - 8; Knudsen, 1971: 273, Pl. 11, figs. 10 - 13, Pl. 20, figs. 5 - 8.

Ciliophidium argenteum  (Parr); Hedley, Hurdle & Burdett, 1967: 48, Pl. 12, figs. 2a, b.

Elphidium excavatum  (Terquem); forma clavata  Cushman; Feyling-Hanssen, 1974: 339, Pl. 1, figs. 1 - 9; Pl. 2, figs. 1 - 9.


Elphidium excavatum  (Terquem) forma selseyensis  (Heron-Allen & Earland); Feyling-Hanssen, 1974: 341, Pl. 4, figs. 1 - 7, Pl. 5, figs. 1 - 7.

Elphidium excavatum  (Terquem) forma lidoensis  Cushman: Feyling-Hanssen, 1974: Pl. 6, figs. 1 - 7.

Description of Mahoenui Group Specimens: Test small to medium sized, involute planispiral with 11 - 15 chambers in the final whorl. The sutures are gently recurved, somewhat incised, limbate, and crossed by 4 - 8 stout retral processes. The periphery is broadly rounded and a little lobulate. The test may be compressed with sub-parallel sides or it may be much more inflated. The umbilical region often has a small boss. A row of pores at the base of the apertural face forms the aperture.

Dimensions of Hypotype: Diameter .27mm.

Remarks: Considerable confusion exists over the status of E. incertum, E. clavatum and E. excavatum. Williamson described Polystomella umbilicata var incerta in 1858. Cushman (1930, 1939 and others) recorded and described E. incertum var clavatum. Loeblich and Tappan (1953), and Buzas (1966), have shown that E. incertum Cushman is distinct
from *E. incertum* (Williamson). Buzas (1966) also showed that *E. incertum* Cushman and *E. incertum* var. *clavatum* Cushman were inseparable. Later workers have included both forms as *E. clavatum*. For example, Feyling-Hanssen (1973) regarded *E. clavatum* as a synonym of *E. excavatum*. He also included *E. lidoensis* and *E. selseyensis* in *E. excavatum*. Feyling-Hanssen felt that he could recognise four ecophenotypic varieties of *E. excavatum*:

1) *E. excavata* forma *clavata*, which he felt was characteristic of arctic regions.

2) *E. excavata* forma *alba* - characteristic of boreal/subarctic regions.

3) *E. excavata* forma *selseyensis* - characteristic of boreal regions.

4) *E. excavata* forma *lidoensis* - characteristic of Lusitanian regions.

*E. excavatum* from the Mahoenui Group can be divided into two intergrading morphological groups:

1) Compressed forms resembling *E. excavatum* as originally described by Terquem and similar to those placed as *E. excavatum* forma *selseyensis* by Feyling-Hanssen (1973).

2) More inflated forms best fitting *E. excavatum* forma *clavata* of Feyling-Hanssen. This form has been previously recorded from New Zealand Recent sediments as *E. argenteum* (Parr) (Hedley et al., 1967; Topping, 1973).

These forms are not separated on the distribution charts and they are considered together in the paleoecological analysis.

**ELPHIDIIUM FICHTELLIANUM** (d'Orbigny), Pl. 14, fig. 14.

*Polystomella fichtelliana* d'Orbigny, 1846 : 125, Pl. 6, figs. 7, 8.

*Elphidium fichtellianum* (d'Orbigny); Cushman, 1939 : 42, Pl. 11, fig. 12.
Description of Mahoenui Group Specimens: Discoidal, involute planispiral with 17 - 18 chambers in the final whorl and an aperture that consists of a row of pores at the base of the apertural face. The umbilical region is depressed, ornamented with a fine network of ribs. The limbate sutures are interconnected by about 7 - 8 retral processes.

Dimensions of Hypotype: Diameter .33mm.

Remarks: E. crespinae Cushman, E. fichtellianum (d'Orbigny) and E. novozealandicum Cushman are very similar, differing only in details of the umbilical region. E. crespinae has a flattened and non-excavate umbilicus, E. fichtellianum has a slightly depressed umbilicus with a fine covering ornamental network while E. novozealandicum has a depressed umbilicus with an open network of ribs and a somewhat less acute periphery. These three species form a distinct group and may well be shown to be synonyms. They are similar to E. macellum but are more compressed, carinate and have fewer, heavier retral processes.

Discoidal specimens of Elphidium from the Mahoenui Group are closest to E. fichtellianum but differ from E. fichtellianum s.s. in having a more rounded periphery and a somewhat less compressed test.

Distribution: Rare, only recorded in samples 40 and 42.

Recorded Stratigraphic Range: E. fichtellianum is commonly recorded in the Miocene and Pliocene of Europe. These specimens are from the Otaian of the Mahoenui Group. The similar species E. crespinae is recorded from the Oligocene and early Miocene of Australia (Cushman, 1939; Lindsay, 1969) while E. novozealandicus is present from the late Miocene to Recent in New Zealand (Cushman, 1939; Hornibrook, 1968).

Subfamily NOTOROTALIINAE

Genus DISCOROTALIA Hornibrook, 1961

DISCOROTALIA TENUISSIMA (Karrer), Pl. 14, fig. 15.

Polystomella tenuissima Karrer, 1864 : 83, Pl. 16, fig. 16.

Notorotalia tenuissima (Karrer); Finlay & Marwick, 1940 : 114, Vella, 1957 : 45.

Remarks: This small discoidal species is characterised by being just trochospiral, by its strongly recurved limbate sutures and interconnecting, slightly irregular and occasionally anastomosing retral processes.

Dimensions of Hypotype: Diameter .34mm.

Distribution: Never abundant, recorded in 14 samples from columns 4, 6 – 8, 14 – 17, 20 and 43.


Genus NOTOROTALIA Finlay, 1939a.

Notorotalia spinosa is the most abundant Notorotalia present in the Mahoenui Group. This species is characterised by its large size, depressed biconvex test and an acute, often flanged periphery. The limbate sutures are very strongly recurved dorsally, and somewhat recurved ventrally. There are between 8 and 11 chambers in the final whorl of the test.

A larger, non-spinose Notorotalia with more numerous chambers (12 – 13 in the final whorl), less recurved dorsal sutures and a dorsal umbilical knob has been placed in N. targetensis. Occasional specimens are recorded as N. cf. stachei. These are small, with irregular ornament and a strong peripheral keel. Very strongly inflated, biconvex specimens have been recorded as N. biconvexa.

NOTOROTALIA SPINOSA (Chapman), Pl. 14, figs. 16, 19.

Rotalia clathrata var. spinosa Chapman, 1926: 85, Pl. 17, fig. 6.

Dimensions of Hypotype: Diameter .58mm.

Distribution: Common, exceeds 10% of the fauna in a number of samples. Recorded in 35 samples from columns 3 - 7, 9, 13 - 17, 20, 22 - 24, 30, 34, 40, 42, 44 - 47b.

Recorded Stratigraphic Range: Duntroonian to Altonian with forms intermediate with N. stachei in the Whaingaroan. (Oligocene - early Miocene).

NOTOROTALIA cf. STACHEI Finlay
cf. Notorotalia stachei Finlay, 1939a: 519, Pl. 69, fig. 3.

Dimensions of Hypotype: Diameter .23mm.

Distribution: Occurs in samples 52, 60 and 145.

Observed Stratigraphic Range: N. stachei is recorded from the Whaingaroan to the Duntroonian. These specimens of N. cf. stachei are recorded from the Otaian.

NOTOROTALIA TARGETENSIS Hornibrook, Pl. 14, fig. 18.

Notorotalia targetensis Hornibrook, 1961: 137, Pl. 20, figs. 418, 419, 422, Pl. 28, fig. 553; Hayward, 1975: 516 (list).

Dimensions of Hypotype: Diameter .72mm.

Distribution: Very abundant in sample 168, also recorded in sample 64.

Recorded Stratigraphic Range: Hornibrook records this species as being restricted to the Altonian, Mahoenui specimens of N. targetensis are from the Otaian.
NOTOROTALIA BICONVEXA Hornibrook

Notorotalia biconvexa Hornibrook, 1961 : 137,
Pl. 18, fig. 402 - 404; Happy, 1971 : Table
following p. 100.

Dimensions of Hypotype: Diameter .67mm.

Distribution: Rare, only recorded from sample 30 and sample 88.

Recorded Stratigraphic Range: Otaian. (Early Miocene).

Genus CRIBROROTALIA Hornibrook, 1961

CRIBROROTALIA ORNATISSIMA (Karrer), Pl. 14, fig. 17.

Amphistegina ornatissima Karrer, 1864 : 85,
Pl. 16, fig. 20.

Criborotalia ornatissima (Karrer); Hornibrook,
1971 : 8, 20, Pl. 3, figs. 47 - 49, Text fig. 3.

Remarks: A large characteristic Criborotalia. Mahoenui specimens are
biconvex, but are sometimes flattened. The periphery is acute, the
sutures pustulose. These pustules tend to fuse into raised ridges.
Both the spiral and involute side sutures are nearly straight,
coalescing centrally on the spiral side. The shell has a prominent
tuberculated dorsal umbo, 13 - 18 chambers in the final whorl and
is coarsely punctate.

Dimensions of Hypotype: Diameter 1.09mm.

Distribution: Present in 23 samples from columns 1, 4, 6 - 8, 15,
17, 20, 29a, 30, 45 and 47a.

Recorded Stratigraphic Range: Waitakian to Waiauan. (Oligocene to
mid Miocene).

CRIBROROTALIA cf. DORRENI Hornibrook.

cf. Criborotalia dorreeni Hornibrook, 1961 : 139,
Pl. 18, fig. 396, 398, Pl. 28, fig. 556.

Remarks: A few poorly preserved, small, biconvex specimens of
Notorotalia with an umbonal plug and weak granular ornament are placed
as N. cf. dorreeni.

**Distribution:** Present in 8 samples: 1, 28, 29, 39, 61, 62, 76 and 145.

**Recorded Stratigraphic Range:** Landon to Southland Series. (Oligocene to mid. Miocene).

**Family MIOGYSINIDAE**

*Genus MIOGYSINA* Sacco, 1893

**MIOGYSINA INTERMEDIA** Drooger.

*Miogysina intermedia* Drooger, 1952: 35, 36, 54, 55, Pl. 2, figs. 30 - 34, Pl. 3, fig. 4;
Drooger (In Von Koenigswald et al, 1963): 325;
Hornibrook, 1968: 108, fig. 24 (3, 4);
Hayward, 1975: 516.

**Remarks:** Specimens of this species have a large subtriangular to subovate test composed of an apically situated embryonic whorl, and an equitorial layer of rhombic chambers flanked by upper and lower lateral layers of irregular chambers.

The test is inflated in the prolocular region, otherwise it is flattened. The shell surface is coarsely pustulose.

**Dimensions of Hypotype:** Maximum diameter 2.25mm.

**Distribution:** Recorded only in sample 30.

**Recorded Stratigraphic Range:** Otaian to Altonian. (Early Miocene).

**Family NUMMULITIDAE**

*Genus HETEROSTEGINA* d'Orbigny, 1926

**HETEROSTEGINA BORNEENSIS** Van der Vlerk

*Heterostegina borneensis* Van der Vlerk, 1930: 16, Pl. opp. p. 34, fig. 6, Pl. opp. p. 36, fig. 25;
Remarks: Specimens of this species from the Mahoenui Group have a large flattened planispiral test. They are discoidal apart from the initial region which is somewhat inflated. Their chambers are long, narrow, recurved and internally partitioned to form rectangular chamberlets. The shell is constructed of 2 – 3 whorls with about 16 chambers in the final whorl. The outer surface is smooth and imperforate.

Dimensions of Hypotype: Maximum diameter 1.96mm.

Distribution: Only found in samples 28, 30.

Recorded Stratigraphic Range: Otaian to Tongaporutuan. (Early - mid Miocene).

Superfamily GLOBIGERINACEA

Family GLOBOROTALIIDAE

Subfamily GLOBOROTALIINAE

Genus GLOBOROTALIA Cushman, 1927a

Subgenus TURBOROTALIA Cushman & Bermudez, 1949

GLOBOROTALIA (TURBOROTALIA) OPIMA Bolli

Three subspecies of G. opima Bolli are recorded from the Mahoenui Group:–

G. (T.) opima nana Bolli
G. (T.) opima pseudocontinuosa (Jenkins)
G. (T.) opima semivera (Hornibrook)

These species are characterised by a tight trochospiral test with a sublobulate equatorial periphery, 4 – 5 embracing chambers in the final whorl, radial, somewhat incised sutures, a narrow umbilicus and a lipped, interiomarginal, umbilical to extraumbilical aperture.

Although these three taxa have been regarded as subspecies of G. nana by Jenkins (1971) and others, they are closely related to G. opima.
and are better placed as subspecies of this taxon. Throughout its Oligocene range G. opima s.s. overlaps and integrates with G. opima nana (Jenkins & Orr, 1972, Blow, 1969) and the sole ground for distinguishing the two is size. (Bolli, 1957). Blow (1969) suggested that G. opima opima and G. opima nana might be ontogenetic or ecophenotypic variants of a single taxon. However, if this were so one would expect the stratigraphic range of the two species to be similar, where in fact G. opima nana has a considerably longer range than G. opima.

GLOBOROTALIA (TURBOROTALIA) OPIMA NANA Bolli, Pl. 15, figs. 1 - 3.

Globorotalia opima nana Bolli, 1957b : 118, Pl. 28, fig. 3a - c.
Globorotalia nana Bolli; Postuma, 1971 : 340,
Jenkins & Orr, 1972 : 1101, Pl. 28, figs. 7 - 9;
Nelson, 1973 : Table following p. 183.
Globorotalia (T.) nana Bolli; Palmieri, 1975 : 35,
Pl. 3, figs. 23 - 25, 29.
Globorotalia (T.) nana nana Bolli; Jenkins, 1971 :
123, Pl. 11, figs. 303 - 308; Jenkins, 1975 : 462;
Hayward, 1975 : 396.

Dimensions of Hypotype: Maximum diameter .29mm.

Distribution: This is the commonest species of Globorotalia from the Mahoenui Group. It is present in 72% of samples where it regularly forms 5% and often 10% of the total fauna.

Recorded Stratigraphic Range: Globorotalia opima nana is the longest ranging subspecies of G. opima. Originally Bolli gave its range as "G. ampliapertura zone to G. ciperoensis zone" in Trinidad. Blow (1969) regarded specimens recorded from the Oligocene to be probable homeomorphs and gave the restricted range of Upper P14, P15 to N3 (P22). Postuma (1971) again extended this to the G. kugleri zone (N4). In New Zealand it has been recorded from Kaiaran to Clifdenian. (Mid Eocene to mid. Miocene).

GLOBOROTALIA (TURBOROTALIA) OPIMA SEMIVERA (Hornibrook) Pl. 15, figs. 6,9.

Globorotalia mayeri Bolli, 1957b : 118, Pl. 28,
fig. 4a - c (In part).
Globigerina semivera Hornibrook, 1961: 149 - 150,
Pl. 23, fig. 23, fig. 455 - 457; Jenkins, 1966a: 10,
Pl. 2, fig. 12a - c.
Globorotalia (Turborotalia) nana semivera (Hornibrook);
Jenkins, 1971: 125, Pl. 12, fig. 342 - 4; Hayward,
1975: 396.

Remarks: Similar to G. opima pseudocontinuosa but distinguished by
its wide arched aperture and by having 4½ - 5 chambers in the final
whorl. Hornibrook’s original description of G. semivera noted 4 - 4½
chambers in the final whorl. There are 4½ chambers in the final whorl
of the holotype but many of the paratypes have 4½ and occasionally 5
chambers in the last revolution. Because of this, Jenkins (1971)
restricted G. semivera to include only specimens with 4½ or 5 chambers
and regarded those with 4 chambers to be G. pseudocontinuosa. The
present author has examined the type suite for this species and confirms
and follows Jenkins’s interpretation. Jenkins also noted a complete
intergradation between G. pseudocontinuosa and G. semivera in the type
suite of G. semivera.

Dimensions of Hypotype: Maximum diameter .31mm.

Distribution: Present in 28% of samples from the study area. This
species generally forms less than 2% of the total fauna.

Recorded Stratigraphic Range: Whaingaroan to Clifdenian. (Oligocene
to mid. Miocene).

GLOBOROTALIA (TURBOROTALIA) OPIMA PSEUDOCONTINUOSA (Jenkins)
Pl. 15, figs. 4, 5.

Globorotalia opima Bolli subsp. continuosa Blow;
Jenkins, 1960: 366, Pl. 5, fig. 4a - c. (Not 5a - c).
Globorotalia nana pseudocontinuosa Jenkins, 1967:
1074, fig. 4, 20 - 5; Jenkins, 1971: 124, Pl. 12,
fig. 336 - 341; Hayward, 1975: 396.

Remarks: G. opima pseudocontinuosa is closely related to G. opima
semivera but is distinguished from this species by its quadrilobate
equatorial periphery and from Globorotalia opima nana by its high arched
lipped aperture.
Dimensions of Hypotype: Maximum diameter .25mm.

Distribution: Present in 47% of samples from the study area. This species generally forms less than 3% of the total fauna.

Recorded Stratigraphic Range: In New Zealand and Australia this species is recorded from Oligocene to mid Miocene. (Whaingaroan to Lillburnian).

GLOBOROTALIA (TURBOROTALIA) OBESA Bolli, Pl. 15, fig. 7.

Globorotalia obesa Bolli, 1957b: 119, Pl. 29, fig. 2a - 3; Jenkins, 1960: 304, Pl. 5, fig. 2a - c; Postuma, 1971: 34.
Globorotalia (Turborotalia) obesa Bolli; Jenkins, 1971: 127, Pl. 13, fig. 348 - 350;

Remarks: A small, low trochospiral Globorotalia of few whorls with rapidly expanding, strongly inflated chambers (4 – 4½ in the final whorl) a lobulate equatorial periphery, rounded axial profile, an umbilical – extrumbilical aperture, a wide umbilicus and ornamented by fine pustulose ornament, is placed in Globorotalia (T.) obesa.

Dimensions of Hypotype: Maximum diameter .26mm.

Distribution: Present in 65% of samples, generally forms less than 5% of the total faunas but often reaches 8 – 10%.

Recorded Stratigraphic Range: Bolli recorded Globorotalia obesa from the Catapsydrax dissimilis zone to the Globorotalia menardii zone (early to late Miocene). Blow (1969) extended the range from zone P21 (N2) to zone N23. In New Zealand and Australia the recorded range of G. obesa (Otaian stage – Waiauan, early to late Miocene) is close to that given by Bolli. Jenkins also recorded a similar species as G. cf. obesa from the Oligocene of New Zealand (Whaingaroan and Waitakian). He distinguished this species by its smoother walled test.

GLOBOROTALIA (TURBOROTALIA) ZEALANDICA Hornibrook, sensu lato.

Remarks: Rare specimens of *Globorotalia zealandica* are recorded. These specimens are probably *G. zealandica incognita* Walters (Walters, 1965 : 120, figs. 6A - J).

Distribution: Present only in sample 86.

Recorded Stratigraphic Range: *G. zealandica s.l.* is present in New Zealand from the Otaian Stage to the Altonian. (Early Miocene).

Subgenus GLOBOROTALIA Cushman, 1927a

GLOBOROTALIA (GLOBOROTALIA) MIOZEA Finlay, Sensu lato.

*Globorotalia miozea* Finlay, 1939c : 326, Pl. 29, fig. 159 - 161.

Remarks: A single specimen of a compressed and carinate *Globorotalia* was recovered from the Mokau Group overlying the Mahoeunui in Column 30. The specimen is poorly preserved and not allocated to any of Walters (1965) subspecies.

Recorded Stratigraphic Range: *G. miozea s.l.* is present from the Altonian to Kapitean Stage. (Early to late Miocene) in New Zealand.

Family GLOBIGERINIDAE

Subfamily GLOBIGERININAE

Genus GLOBIGERINA d'Orbigny, 1826

Subgenus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA (GLOBIGERINA) CIPEROENSIS Bolli.

Bolli (1954) described *G. ciperoensis* for small to medium sized, low
trochospiral species of *Globigerina* with 2 - 2½ whorls of globular chambers arranged around a central umbilicus. He compared this Oligocene species to *G. concinna* Reuss and considered that the size, rate of chamber expansion and stratigraphic positions distinguished these two species. In a later paper, Bolli (1957) recognised three subspecies of *G. ciperoensis*:-

*G. ciperoensis ciperoensis* for specimens with a large open umbilicus and simple sutures.

*G. ciperoensis angustiumbilicata* for specimens with a small umbilicus and a tendency for the aperture to become umbilical - extraumbilical.

*G. ciperoensis angulisuturalis* which is characterised by deep "U" shaped sutures.

*G. ciperoensis ciperoensis* and *G. ciperoensis angustiumbilicata* are present in the Mahoenui Group. A six chambered form of *G. ciperoensis* is also present. This is recorded as *G. (G.) cf. ciperoensis angustiumbilicata*.

Blow and Banner (1962) and Blow (1969) considered *G. concinna* to be a 5 chambered subspecies of *G. bulloides* and *G. ciperoensis ciperoensis* to be a 5 chambered subspecies of *G. ouachitaensis*. They regarded *G. angustiumbilicata* and *G. angulisuturalis* to be of full specific rank and to be descended from *G. officinalis*.

*G. ciperoensis* has a lower spire than *G. ouachitaensis*. It also has a shallower umbilicus, more rounded equatorial periphery and 5 rather than 4 chambers in the final whorl. These are considered adequate grounds to maintain *G. ciperoensis* as a full species. Furthermore, *G. ciperoensis*, *G. angustiumbilicata* and *G. angulisuturalis* intergrade over much of their stratigraphic range (Bolli, 1957, Jenkins, 1971) and are therefore better considered as subspecies. Bolli's usage is followed by the present author.

*G. ciperoensis* "Group" and *G. ouachitaensis* appear to have been iteratively derived from *G. officinalis*. 
GLOBIGERINA (GLOBIGERINA) CIPEROENSIS CIPEROENSIS Bolli, Pl. 15, fig. 8.

Globigerina cf. concinna Reuss; Cushman & Stainforth, 1945 : 67, Pl. 13, fig. 1a - b.
Globigerina ciperoensis Bolli, 1954 : 1;

Globigerina ciperoensis ciperoensis Bolli; Bolli, 1957b : 109, Pl. 22, figs. 10a - b; Jenkins, 1971 : 145, Pl. 14, figs. 411 - 413; Hayward, 1975 : 396 (list).
Globigerina ouachitaensis ciperoensis (Bolli);
Blow & Banner (in Eames et al. 1962); 90, Pl. IX, figs. E - G; Blow, 1969 : 320, Pl. 2, figs. 4 - 6, Pl. 17, figs. 7, 10, 11.

Dimensions of Hypotype: Maximum diameter .29mm.

Distribution: Present in 46% of samples. It generally forms less than 5% of the total fauna but exceeds 10% in a number of samples.

Recorded Stratigraphic Range: Blow (1969) records G. (G.) ciperoensis ciperoensis from late Eocene (P19) to Miocene (N5). In Australia it is recorded from early Oligocene to Miocene (Palmeri, 1975), while in New Zealand G. ciperoensis ciperoensis ranges from the Whaingaroan Stage to the Tongaporutuan. (Oligocene to late Miocene).

GLOBIGERINA (GLOBIGERINA) CIPEROENSIS ANGUSTIUMBILICATA Bolli, Pl. 15, figs. 10, 11.

Globigerina ciperoensis angustiumbilicata Bolli, 1957b : 109, Pl. 22, figs. 12a - 13c; Jenkins, 1971 : 144, Pl. 15, figs. 451 - 3; Hayward, 1975 : 396 (list); Jenkins, 1975 : 454.
Globigerina angustiumbilicata Bolli; Blow, 1969 : 316; Jenkins & Orr, 1972 : 1085, Pl. 4, figs. 5, 6, Pl. 5, figs. 6 - 8; Palmeri, 1975 : 5, Pl. 1, fig. 31 - 33.

Dimensions of Hypotype: Maximum diameter .22mm.
Distribution: A common species present in 52% of samples; it generally forms less than 5% of the total fauna but may exceed 10% and occasionally 20% of the fauna.

Recorded Stratigraphic Range: G. (G.) ciperoensis angustiumbilicata is longer ranging than G. (G.) ciperoensis ciperoensis. It has been recorded from Eocene (P16) to Quaternary (N22) by Blow (1969). In New Zealand and Australia the first occurrence of this species is somewhat later. Here it appears in the Oligocene and ranges through to late Miocene. (Whaingaroan to Tongaporutuan in New Zealand).

GLOBIGERINA (GLOBIGERINA) cf. CIPEROENSIS ANGUSTIUMBILICATA
Pl. 15, fig. 12.

cf. Globigerina ciperoensis angustiumblicata
Bolli, 1957b: 109, Pl. 22, figs. 12a - 13c.

Description: A medium sized low trochospiral test composed of 2 to 3 whorls of globular chambers. There are 6 chambers in the final whorl, separated by simple sutures and arranged about an open umbilicus. The periphery is lobulate, and the aperture is umbilical to extraumbilical.

Dimensions: .27mm diameter.

Remarks: Similar to G. ciperoensis angustiumbilicata but distinguished by having 6 chambers in the final whorl, a somewhat higher spire and (in some specimens) a more open umbilicus. Jenkins (1971) recorded similar specimens in Otaian and Waitakian samples.

Distribution: Uncommon, recorded from 8 samples (52, 56, 84, 92, 106, 107, 110 and 115).

Observed Stratigraphic Range: Otaian. (Early Miocene).

GLOBIGERINA (GLOBIGERINA) OUACHITAENSIS Howe & Wallace, Pl. 15, figs. 13 - 15.

Globigerina ouachitaensis Howe & Wallace, 1932:
74, Pl. 10, fig. 7a - b; Srinivassan, 1968: 147, Pl. 15, figs. 4 - 8; Jenkins, 1971: 153, Pl. 16, figs. 489 - 490; Jenkins & Orr, 1972: 1089;
Palmieri, 1975: 8, Pl. 3, figs. 9 - 11.
Globigerina ouachitaensis ouachitaensis. Howe & Wallace; Blow & Banner (In Eames et al. 1962): 90, Pl. IX, D, H - K, fig. 9 (VI).

Remarks: Specimens from the Mahoeouui Group referred to G. ouachitaensis have small or medium sized high trochospiral tests with a lobulate periphery and a broadly rounded axial periphery. The chambers are subspherical and arranged in 3 - 4 whorls around an open subquadrate umbilicus. The aperture is a low umbilical arch and the test is covered by pustulose ornament.

G. ouachitaensis is very similar to G. officinalis (Bolli 1957, Banner et al. 1952, Postuma, 1971) and these two species have on occasion been synonymised (Postume 1971, as G. parva). They are distinguished on the height of the spire, the width of the umbilicus and the tightness of coiling. Occasional Mahoeouui specimens are similar to G. officinalis but these are placed in G. ouachitaensis.

Dimensions of Hypotype: Maximum diameter .23mm.

Distribution: Recorded from 54% of samples. It generally forms less than 3% of the total fauna but makes up 5 or 6% of the fauna in some samples.

Recorded Stratigraphic Range: In New Zealand, G. ouachitaensis is recorded from Bortonian to Altonian. (Eocene to early Miocene).

GLOBIGERINA PRAEBULLOIDES "GROUP"

Globigerina aff. bulloides d'Orbigny; Stainforth, 1948 (in part) : 118, Pl. 25, figs. 14, 15 (not figs. 16 - 18).

Globigerina praebulloides Blow, 1959 : 180, Pl. 8, figns. 47a - c, Pl. 9, fig. 48; Jenkins, 1960 : 352, Pl. 2, figs. 1a - c; Postuma, 1971 : 268 - 626;

Palmieri, 1975 : 8, Pl. 1, figs. 1 - 6.

Globigerina praebulloides praebulloides Blow;
Blow & Banner (in Eames et al. 1962) : 92, Pl. IX, figs. 0 - Q.

Globigerina bulloides d'Orbigny; Jenkins, 1971 : 141, Pl. 14, figs. 488 - 410.
Remarks: This is a plexus of small or medium sized species of Globigerina. They have a low trochospiral test with 4, occasionally 5, chambers in the final whorl, a lobulate periphery, small umbilicus and pustulose ornament. Blow (1959) was able to subdivide G. bulloides d'Orbigny into three species: G. bulloides, G. praebulloides and G. parabulloides. Blow and Banner (1962) later erected a number of subspecies within G. praebulloides. Jenkins (1971) reduced G. praebulloides to a junior synonym of G. bulloides but many later workers (e.g. Palmieri, 1975) have not accepted Jenkins' view and have maintained G. praebulloides. This usage is followed by the present author.

G. praebulloides differs from G. bulloides in having a somewhat elongate rather than subcircular equatorial profile, looser coiling around a smaller umbilicus, more embracing, ovate rather than spherical chambers and a less highly arched aperture.

G. praebulloides shows extreme phenotypic variation, this combined with its simple morphology, leads to considerable homeomorphy and means that species boundaries are obscure. For example, specimens from the Mahoenui Group show an intergradation between G. praebulloides and Globorotalia obesa. A similar intergradation was reported by Butt (1966) and Jenkins (1971).

Three morphological groups can be distinguished within G. praebulloides from the Mahoenui Group. These are not considered to warrant species or subspecies rank, but they are distinct forms and are separately recorded. These three groups are:

1) G. (G.) praebulloides forma typica Blow.

2) G. (G.) praebulloides forma A.

3) G. (G.) praebulloides forma B.

GLOBIGERINA (GLOBIGERINA) PRAEBULLOIDES Blow forma typica, Pl. 16, fig. 3.

Remarks: Specimens are normalform and closely resemble G. praebulloides Blow.
Dimensions of Hypotype: Maximum diameter .30mm.

Distribution: Extremely abundant, present in 79% of samples from the study area, where it regularly forms 10% or more of the total fauna.

GLOBIGERINA (GLOBIGERINA) PRAEBULLOIDES Blow forma A, Pl. 16, figs. 1,2.
Remarks: Specimens assigned to G. praebulloides forma A are normalform with a somewhat more spherical equatorial profile, less closely appressed more spherical chambers and a higher arched aperture than G. praebulloides forma typica. G. praebulloides forma A approaches G. bulloides sensu stricto in morphology.

Dimensions of Type: Maximum diameter .25mm.

Distribution: Common, occurs in 52% of samples. It is less abundant than either of the other forms of G. praebulloides and it generally forms less than 3% of the fauna.

GLOBIGERINA (GLOBIGERINA) PRAEBULLOIDES Blow forma B, Pl. 16, figs. 4-6.
Remarks: Specimens assigned to this form are characterised by Kummerform final chambers but are otherwise identical to G. praebulloides forma typica. This form is similar to G. bulloides quadrilatera Galloway & Wissler.

Dimensions of Type: Maximum diameter .30mm.

Distribution: This is the most abundant form of G. praebulloides in the Mahoenui Group. It is present in 77% of samples from the study area. It regularly forms 20% and often 40% or more of the total fauna.

GLOBIGERINA WOODI "GROUP"

Globigerina woodi woodi, G. woodi connecta, G. cf. woodi and G. brazieri are abundant and widespread in the Mahoenui Group. The similar species G. labiacrassata and G. cf. apertura are also present but are much less abundant.

G. woodi woodi is characterised by its low trochospiral globular test, its coarse reticulate ornament and high arched aperture. The apertural height varies greatly and shows a complete intergradation into the lower apertured, and more compact species, G. woodi connecta.
G. brazieri is a somewhat more robust form, and was primarily distinguished from G. woodi woodi by having a higher arched, more nearly circular, aperture with a smoother rim. The juvenile of G. brazieri has a slightly extraumbilical aperture which becomes umbilical in the adult. It also has a more rapid rate of increase in chamber size than G. woodi woodi.

G. labiacrassata is very close in form to G. woodi woodi but differs in having extremely thick apertural lips. Jenkins noted that the thickness of the apertural rim decreases towards the Miocene. He felt that this species became similar to G. bulloides in the early Miocene. The present author, however, regards G. labiacrassata to be an ancestral form of G. woodi.

G. apertura is a late Miocene and Pliocene species and has a much higher arched aperture and a higher spired test than G. woodi. Specimens from the Otaian of the Mahoenui Group resembling G. apertura have a spire of much the same height as G. woodi and are probably just extreme morphotypes of this species. They are recorded as G. cf. apertura.

G. woodi woodi, G. woodi connecta and G. labiacrassata all show a wide range in the size of their final chamber. These, while rarely forming a true bulla often develop a bulla-like kummerform final chamber with less pronounced ornament which partially obscures the umbilicus.

The interrelationships and phylogeny of G. woodi, G. labiacrassata, G. brazieri and G. apertura are further discussed in section 6.

GLOBIGERINA (GLOBIGERINA) WOODI WOODI Jenkins, Pl. 16, figs. 8 - 11.

Globigerina apertura Cushman; Hornibrook, 1958b : 28 - 9; Carter, 1959 : 52 - 3, fig. 43;
Hornibrook, 1961 : 148, Pl. 21, fig. 432 - 3, 435;
Carter, 1964 : 104, Pl. 9, fig. 177 - 179.
Globigerina woodi Jenkins, 1960 : 352, Pl. 2, fig. 2a - c; Takayanagi & Saito, 1962 : 91,
Pl. 25, fig. 6a - c; Jenkins, 1964 : 29, Table 1 (list); Gibson, 1967 : 58, Pl. 15, figs. 227 - 229;
Hornibrook, 1968 : 85, fig. 16; Hornibrook, 1971 : 9
(list); Jenkins & Orr, 1972 : 1090, Pl. 11, figs. 10-12;
Nelson, 1973 : Table following p. 183.
Globigerina woodi woodi Jenkins; Jenkins, 1971: 159, Pl. 18, fig. 548-50; Happy, 1971: Table following p. 100.

Dimensions of Hypotype: Maximum diameter .38mm.

Distribution: Extremely abundant, present in 77% of samples. This species generally forms less than 5% of the total fauna but may form 10 or 20% of the fauna.

Recorded Stratigraphic Range: Middle Waitakian Stage to Wanganui Series. (Late Oligocene - Pliocene).

GLOBIGERINA (GLOBIGERINA) WOODI CONNECTA Jenkins, Pl. 16, fig. 12.

Globigerina woodi connecta Jenkins, 1964a: 72, Text fig. 1a - c; Jenkins, 1965e: 117, Pl. 17;
Jenkins, 1971: 157, Pl. 18, figs. 545-547;
Happy, 1971: Table following p. 100; Nelson, 1973: Table following p. 183.

Globigerina connecta Jenkins; Palmieri, 1975: 6, Pl. 2, figs. 23-25, 30.

Dimensions of Hypotype: Maximum diameter .30mm.

Distribution: Abundant, recorded in 67% of samples. G. woodi connecta generally forms less than 5% of the total fauna.

Recorded Stratigraphic Range: Late Waitakian Stage to the Altonian Stage. (Late Oligocene - early Miocene).

GLOBIGERINA (GLOBIGERINA) cf. WOODI, Pl. 16, figs. 13-15.

cf. Globigerina woodi Jenkins, 1960: 352,
Pl. 2, fig. 2a - c.

Description: A medium sized umbilicate low trochospiral shell with coarse reticulate ornament. There are four globular chambers in the final whorl. The final chamber is reduced in size and may resemble a bulla. This is often much less strongly sculptured than the test of the test and partially obscures the umbilicus. The aperture is an umbilical arch of varying height.

Dimensions of Type: Maximum diameter .32mm.
Remarks: Because of the difficulty in trying to establish their parent species, small globigerines with reticulate ornament and kummerform chambers are all placed together in Globigerina cf. woodi. The author considers that this placement, though unsatisfactory, is less so than attempting to allocate these specimens to G. woodi woodi, G. woodi connecta or G. brazieri.

Distribution: This species is extremely abundant, present in 75% of samples where it normally forms less than 5% of the fauna. However, it may reach 10% to 20% occasionally 30% of the total fauna.

GLOBIGERINA (GLOBIGERINA) BRAZIERI Jenkins, Pl. 17, figs. 1 - 4.

Globigerina brazieri Jenkins, 1965b : 1098, fig. 6 (43 - 51); Jenkins, 1971 : 140, Pl. 15, fig. 433 - 441.

Dimensions of Hypotype: Diameter .33mm.

Distribution: Never abundant but present in 45 samples from columns 1 - 5, 7, 11 - 13, 15 - 21, 24 - 26, 28, 29, 31, 35, 36 and 44.

Recorded Stratigraphic Range: Jenkins recorded this species from the Waitakian Stage to the Lower part of the G. woodi connecta Zone. (Late Oligocene - early Miocene).

GLOBIGERINA (GLOBIGERINA) LABIACRASSATA Jenkins, Pl. 17, figs. 5,6,8,9.

Globigerina reticulata Stache; Hornibrook, 1961 (In part):
146, Text fig. 4a, d, e (not b or c).
Globigerina labiacrassata Jenkins, 1965b : 1102, fig. 8, No. 64 - 71; Jenkins, 1971 : 151, Pl. 16, fig. 474 - 484; Palmieri, 1975 : 7, Pl. 3, fig. 12.

Dimensions of Figured Specimen: Maximum diameter .29mm.

Distribution: Rare, specimens are recorded only in samples 14, 20, 21 and 26.

Recorded Stratigraphic Range: Jenkins (1971) recorded G. labiacrassata from the Whaingaroan Stage to the early part of the Waitakian Stage (Oligocene). Palmieri (1975) recorded this species from "Early Miocene beds, above the G. kugleri datum" (Upper Zone N3 or Lower Zone N4). The New Zealand range is here extended into the Otaian (approximately Zone N4).
GLOBIGERINA (GLOBIGERINA) cf. APERTURA Pl. 17, fig. 7.

cf. Globigerina apertura Cushman, 1918 : 57,
Pl. 12, fig. 8a - c (fide Ellis & Messina, 1940 et. seq.).

Dimensions of Hypotype: Maximum diameter .35 mm.

Distribution: Present only in samples 52, 67, 95, 105 and 125.

Recorded Stratigraphic Range: G. apertura sensu stricto is recorded from late Miocene and Pliocene. The Mahoenui Group specimens are from the Otaian Stage and this is well outside the range normally accepted for this species. Although they have the high arched aperture characteristic of G. apertura, they may only be extreme morphotypes of Globigerina woodi woodi. These specimens are recorded as G. cf. apertura.

Subgenus SUBBOTINA Brotzen & Pozaryska, 1961

GLOBIGERINA (SUBBOTINA) cf. ANGIPOROIDES Hornibrook.

cf. Globigerina angiporoides Hornibrook,
1965 : 834, fig. 1, 2.

Description: Test very small, a neat low trochospiral coil with 4 closely appressed chambers in the final whorl. The final chamber is bulla-like though it is of approximately the same size as the penultimate chamber. The shell has somewhat incised, radial sutures and fine, reticulate ornament.

Dimensions of Hypotype: Maximum diameter .19 mm.

Remarks: Differs from G. angiporoides in that the final chamber is of approximately the same size or slightly larger than the penultimate chamber.

Distribution: Rare, recorded in 11 samples from throughout the Mahoenui Group. It is present in samples from columns 15, 25, 29, 30, 32, 35, 36 and 43.

Recorded Stratigraphic Range: Hornibrook (1968) records this species from the upper Arnold Series to the lower part of the Whaingaroan Stage.
These specimens of G. cf. angiporoides are recorded from rocks of Otaian age. (Early Miocene). They may be reworked but there is no supporting evidence for this.

Genus GLOBIGERINOIOIDES Cushman, 1927

GLOBIGERINOIOIDES TRILOBUS ALTIAPERTURUS Bolli.

Remarks: Jenkins (1971) examined several Otaian samples from Northland and found a continuous variation from low apertured forms resembling G. primordius to high apertured forms like G. altiaperturus. He thus regarded these two species as probable synonyms. The present author has had similar experience and the two are therefore placed together for the purposes of this study.

Mahoenui specimens are trochospiral, lobulate with incised sutures, have reticulate ornament, a medium-arched, umbilical, primary aperture and one or more prominent sutural secondary apertures of variable height.

Dimensions of Hypotype: Maximum diameter .28mm.
Distribution: Uncommon, recorded in 15 samples from columns 2, 6, 8, 9, 15, 17 - 19, 22, 25 and 37.

Recorded Stratigraphic Range: This is a very short ranged species, Blow (1969) gave the range of G. altiaperturus as Zone N4 to early Zone N5 and G. altiaperturus as N5 to early N7. (Early Miocene).

In New Zealand G. altiaperturus is present from the Otaian Stage to Altonian Stage. (Early Miocene).

GLOBIGERINOIDES TRILOBUS TRILOBUS (Reuss)

Globigerina triloba Reuss, 1850 : 374, Pl. 47, figs. 11a - e; Chapman, 1926 : 73, Pl. 14, fig. 18 (in part).
Globigerinoides triloba (Reuss); Finlay & Marwick, 1940 : 119; Blow, 1956 : 62, Text fig. 1 (1 - 3);
Globigerinoides triloba triloba (Reuss); Bolli, 1957b : 112, Pl. 25, fig. 2a - c, Text fig. 21(1);
Jenkins, 1960 : 353, Pl. 2, fig. 5 a - c.
Globigerinoides trilobus trilobus (Reuss);
Jenkins, 1971 : 180, Pl. 19, fig. 571 - 81.
Globigerinoides quadrilobatus Banner & Blow, 1960 : 17, Pl. 4, fig. 3.
Globigerinoides triloba immatura Jenkins, 1960 : 354, Pl. 2, fig. 7a - c.

Distribution: Occasional poorly preserved specimens of G. trilobus trilobus are recorded. This species is only found in samples 120 and 121.

Recorded Stratigraphic Range: Altonian - Wanganui Series. (Early Miocene to early Pleistocene).

GLOBIGERINOIDES APERTASUTURALIS Jenkins

Globigerinoides apertasuturalis Jenkins, 1960 :
352, Pl. 2, fig. 3a - c; Jenkins, 1964 : 29, Table 1;
Remarks: Occasional specimens of a small species of Globigerinoides with distinct globular chambers, a low primary aperture and very small secondary sutural apertures are placed in Globigerinoides apertasuturalis.

Dimensions of Hypotype: Maximum diameter .29mm.

Distribution: Rare, recorded in 15 samples from columns 6, 7, 11, 19, 24a, 25, 26, 29a, 30 and 43.

Recorded Stratigraphic Range: Jenkins recorded sporadic occurrences of G. apertasuturalis from the Oligocene (Whaingaroan - Duntroonian Stages) to late Miocene (Tongaporutuan). He suggested that this species is a polyphyletic "end member developed from a number of species of Globigerina."

Genus GLOBOQUADRINA Finlay, 1947

GLOBOQUADRINA DEHISCENS (Chapman, Parr & Collins) Pl. 17, figs. 11, 12.

Pulvinulina crassa (d'Orbigny); Chapman, 1926 : 82, Pl. 16, fig. 10 (not of d'Orbigny).

Globorotalia dehiscens Chapman, Parr & Collins, 1934 : 569, Pl. 11, fig. 36a - c; Finlay, 1946 : 341.

Globigerina dehiscens (Chapman, Parr & Collins); Finlay & Marwick, 1940 : 114, 123.

Globoquadridra subdehiscens Finlay, 1947 : 291.

Globoquadridra dehiscens (Chapman, Parr & Collins); Finlay, 1947 : 290, 291; Carter, 1958 : 56, Pl. 8, fig. 85 - 7; Hornibrook, 1961 : 153, Pl. 22, fig. 446 - 447, 449; Hornibrook, 1968 : 84, fig. 16; Hornibrook, 1971 : 9, 10; Jenkins, 1971 : 165, Pl. 20, fig. 595 - 7; Jenkins & Orr, 1972 : 1094, Pl. 17, figs. 8 - 10; Happy, 1971 : Table following p. 100; Kennett & Srinivasan, 1973 : 5 - 14; Nelson, 1973 : Table following p. 183; Jenkins, 1975 : 455; Palmieri, 1975 : 17, 18, Pl. 4, figs. 21 - 3, 28 - 33, Pl. 5, figs. 1 - 24, 33 r 7, 40, Pl. 6, figs. 14 - 19, Pl. 16, figs. 4 - 12, Pl. 17, figs. 1 - 7; Hayward, 1975 : 396 (list); Scott, 1976 : 311 - 325, figs 1 - 3, 7 - 13, 20 - 22, 26, 28, 30, 32 & 34.
Globoquadrina dehiscens (Chapman, Parr & Collins); subspecies dehiscens Jenkins, 1960: 354, Pl. 3, fig. 3a - c; Blow, 1969: 341, Pl. 28, fig. 1.
Globoquadrina dehiscens (Chapman, Parr & Collins); subspecies advena Jenkins, 1960: 355, Pl. 3, fig. 4a - c.

Dimensions of Hypotype: Maximum diameter .42mm.

Distribution: An abundant and widely distributed species. Present in 76% of samples. It generally forms between 1 and 3% of the total fauna but often forms 10% and occasionally 20%.

Recorded Stratigraphic Range: Blow (1969) recorded G. dehiscens dehiscens from Zone N4 to Zone N19. (Early Miocene to Pliocene). In New Zealand this species is present from the base of the Waitakian Stage to the Tongaporutuan Stage, and possibly ranges into the Opoitian Stage. (Late Oligocene to late Miocene, possibly Pliocene).

GLOBOQUADRINA VENEZUELANA (Hedberg), Pl. 17, fig. 10.

Globigerina venezuelana Hedberg, 1937: 681, Pl. 92, figs. 7a - b; Bolli, 1957b: 110, Pl. 23, fig. 6a - 8b; Blow, 1969: 322; Jenkins, 1971: 156, Pl. 16, fig. 498 - 501; Palmieri, 1975: 9, Pl. 4, figs. 14-16; Quilty, 1976: 639, Pl. 4, figs. 13 - 14.
Globoquadrina venezuelana (Hedberg); Blow, 1959: 186, Pl. 22, fig. 58a - c, 59; Jenkins & Orr, 1972: 1095, Pl. 18, figs. 4 - 6.

Description of Mahoenui Group Specimens: Test medium to large sized, with a spire of medium height. There are 4 inflated chambers in the final whorl, these are arranged around a relatively narrow umbilicus. The last chamber is somewhat flattened and overhanging, often with a small projecting "tooth". The aperture is umbilical and the sutures are depressed. Sculpture is coarse and reticulate.

Dimensions of Hypotype: Maximum diameter .37mm.
Remarks: Bolli (1957) noted that this species is very variable and Mahoenui Group specimens also vary greatly, particularly with regard to chamber size and shape. On the whole they appear to be similar to Bolli's illustration Pl. 23, figs. 6a - c but tend to have a narrower umbilicus. Blow (1969) noted that G. venezuelana tends to have a narrow umbilicus in the early part of its range.

Distribution: Rare, present in samples 52, 54, 81, 93, 95 and 99.

Recorded Stratigraphic Range: Blow (1969) recorded G. venezuelana from Zone N3 to Zone N19. (Late Oligocene to Pliocene). Quilty (1976) extended the range into the Quaternary (Zone N23). In New Zealand G. venezuelana has previously only been recorded from the Altonian Stage by Jenkins (1971). The New Zealand stratigraphic range is here extended into the Otaian Stage. (Lower Miocene).

GLOBOQUADRINA cf. LARMEUI Akers.

cf. Globoquadrina larmeui Akers, 1955 : 661,
Pl. 65, figs. 4a - c.

Remarks: Mahoenui specimens are subquadrate in outline with 3½ to 4 chambers in the final whorl. The chambers are subspherical and separated by deeply incised sutures. The final chamber is overhanging and somewhat flattened. The aperture opens into a prominent umbilicus. Below the overhanging final chamber there is a tooth-like lip which projects into the umbilicus. The Mahoenui specimens differ from G. larmeui sensu stricto in that this tooth is not nearly as well developed.

Dimensions of Hypotype: Maximum diameter .29mm.

Distribution: Rare, only recorded in samples: 52, 81, 93 and 95.

Recorded Stratigraphic Range: Blow (1969) recorded this species from Zone N6 to Zone N18. (Early Miocene to late Miocene). In New Zealand G. larmeui has previously been recorded from the Altonian Stage (Jenkins, 1971). G. cf. larmeui is here recorded from Otaian strata. (Lower Miocene).
Subfamily CATAPSYDRACINAE

Genus GLOBIGERINITA Bronnimann, 1951

Globigerinita was erected by Bronnimann (1959) for bullate Globigerines. Tinophodella Loeblich & Tappan, and Catapsydrax Bolli, Loeblich & Tappan were subsequently erected and were based on details of their bullae. Blow & Banner (in Eames et al 1961) later described complete intergradation in the morphology of the bulla in Catapsydrax, Tinophodella and Globigerinita and consequently they synonymised all three as Globigerinita. This usage is followed by the present author who uses Globigerinita for all Globigerina like forms whose primary aperture and umbilicus is covered by a bulla with secondary infralaminal apertures. Globigerinita is here regarded as a specialised end form of Globigerina and it is a polyphyletic group, developed by a number of different species of Globigerina. Furthermore each species may form the Globigerinita morphotype repetitively. An example of this is noted by Blow (1969) who regarded G. incrusta to have been formed heterochronously and iteratively from Globigerina juvenilis. The author maintains this genus with trepidation and does so for two reasons. The first is the stratigraphic value of some species of Globigerinita and the second is the difficulty inherent in establishing the parent Globigerina for any species of Globigerinita.

Two species of Globigerinita are present in the Mahoenui Group: G. dissimilis and G. incrusta.

GLOBIGERINITA DISSIMILIS (Cushman & Bermudez), Pl. 17, fig. 14.
Globigerina dissimilis Cushman & Bermudez, 1937 : 25, Pl. 3, fig. 4 - 6.
Catapsydrax dissimilis (Cushman & Bermudez); Bolli, Loeblich & Tappan, 1957 (Part) : 36, Pl. 7, figs. 6a - c (refigured holotype), 7a - b, 8a - c; Jenkins, 1964b : 181, fig. 1 (list);
Hornibrook, 1968 : 84, fig. 16; Postuma, 1971 : 256, 257; Jenkins, 1971 : 182, Pl. 21, fig. 625 - 7;
Hornibrook, 1971 : 9 (list); Nelson, 1973 : Table following p. 183; Hayward, 1975 : 396 (list).
Globigerinita dissimilis dissimilis (Cushman & Bermudez); Blow & Banner (in Eames et al 1962): 106, Pl. 14, fig. D; Blow, 1969: 327, Pl. 25, figs. 6, 7.


Catapsydrax dissimilis dissimilis (Cushman & Bermudez); Quilty, 1976: 641, Pl. 7, figs. 12, 13.

Globigerinita dissimilis (Cushman & Bermudez); Jenkins & Orr, 1972: 1093, Pl. 16, figs. 10, 11, 12.

Description of Mahoenui Group Specimens: A low spired trochoid species with four globular, partially embracing chambers in the final whorl, depressed sutures, and reticulate ornament. The primary umbilical aperture is covered by a prominent umbilical bulla with one or more infralaminar apertures on each side of the bulla.

Dimensions of Hypotype: Maximum diameter .21mm.

Remarks: Blow & Banner (1962) distinguished Globigerinita dissimilis ciperoensis from G. dissimilis dissimilis, the latter having only one infralaminar aperture at each end of the bulla. These two subspecies are not separated in this study. G. stainforthi is similar to G. dissimilis but this species is smaller and has a more complex and closely appressed bulla which extends along the sutures.

Distribution: Occurs sporadically throughout the Mahoenui Group, recorded in 25 samples from columns 2, 7, 13, 19, 24a, 25, 29 - 31, 33, 35, 36, 39, 40, 42 - 44 and 47b.

Recorded Stratigraphic Range: Cushman & Bermudez (1937) originally recorded G. dissimilis from the Eocene of Cuba. Blow (1969) gives the range of G. dissimilis as Zone P15 to the top of Zone N6. (Late Eocene to early Miocene). In New Zealand G. dissimilis ranges from the Whaingaroan Stage to the Otaian Stage. (Oligocene to early Miocene).

GLOBIGERINITA INCRUSTA Akers, Pl. 17, fig. 13.

Globigerinita incrusta Akers, 1955: 655, Pl. 65, fig. 2a - d; Gibson, 1967: 60, Pl. 15, figs. 232, 233, 238; Blow, 1969: 328, Pl. 24, fig. 3;
Description of Mahoenui Group Specimens: A small, low or medium trochospiral test with dense pustulose ornament, depressed sutures and four subspherical chambers in the final whorl. The primary umbilical aperture is closed by a bulla. This is rectangular, elongated across the umbilicus and has 4 infralaminal apertures situated at the primary sutural positions, one at each corner of the bulla. The secondary apertures may have short tunnel-like extensions along the sutures.

Dimensions of Hypotype: Maximum diameter 19mm.

Distribution: Present in 29 samples from columns 8, 14, 15, 19 - 22, 26, 29 - 31, 33 - 36, 43 - 45 and 47a.

Recorded Stratigraphic Range: This is a very long ranging species. Blow (1969) recorded G. incrusta from Zone N4 to Zone N23. (Early Miocene to Holocene). In New Zealand it is recorded from the Waitakian Stage to the Castlecliffian Stage. (Late Oligocene to Pleistocene).

Superfamily ORBITOIDACEA

Family LEPIDOCYCLINIDAE

Genus LEPIDOCYCLINA Gumbel, 1870

LEPIDOCYCLINA (NEPHROLEPIDINA) ORAKEIENSIS (Karrer), Pl. 18, fig. 1.

Orbitoides orakeiensis Karrer, 1864 : 86, Pl. 16, fig. 21.

Miogypsina orakeiensis (Karrer); Chapman, 1926 : 94, Pl. 1, fig. 21, Pl. 20, fig. 2, Pl. 18, fig. 6.

Nephrolepidina orakeiensis (Karrer); Finlay & Marwick, 1940 : 118; Finlay & Marwick, 1946 : 330, 331, 351.

Lepidocyclina (Nephrolepidina) orakeiensis (Karrer); Hornibrook, 1968 : 108, fig. 24, (6, 7), fig. 25, fig. 26 (1); Hornibrook, 1971 : 24, 25, Pl. 12, figs. 1 - 5, Pl. 13, fig. 1, Text fig. 6.
Remarks: Mahoenui specimens are large, circular, and flattened peripherally but are somewhat inflated and biconvex centrally. An equatorial layer of subovate to hexagonal chambers is overlain by several layers of lateral chambers.

Externally the shell is finely though densely punctate and heavily tuberculated. The tubercles overlie vertical internal pillars.

Dimensions of Hypotype: Diameter 2.22mm.

Distribution: Present in samples 30 and 39.

Recorded Stratigraphic Range: Upper Waitakian or Otaian to Altonian. (? Late Oligocene, early Miocene).

Superfamily CASSIDULINACEA

Family PLEUROSTOMELLIDAE

Genus PLEUROSTOMELLA Reuss, 1860

PLEUROSTOMELLA BREVIS Schwager, Pl. 18, figs. 4, 5.

Pleurostomella brevis Schwager, 1866 : 239,
Pl. 6, fig. 81; Brady, 1884, Pl. 51, fig. 20.

Remarks: Used for specimens of Pleurostomella that are stout, fusiform and rapidly expanding with few chambers. The final chamber forms about half the test and has a 'T' shaped aperture in a hood-like terminal depression. The upper bar of the "T" is wide while the descending bar is thin and elongate.

The larger specimens of this species from the Mahoenui Group bear close resemblance to P. bierigi Palmer & Bermudez but the final chambers are less inflated and overlapping. Hayward (1975) recorded P. bierigi from the Waitemata beds.

Dimensions of Hypotype: Length .45mm.

Distribution: Rare, occurs only in samples 52 and 105.

Recorded Stratigraphic Range: A Recent species, here recorded from
the Otaian. (Lower Miocene – Recent).

PLEUROSTOMELLA ALTERNANS Schwager, Pl. 18, figs. 2, 3.

Pleurostomella alternans Schwager, 1866 : 238, Pl. 6, fig. 79, 80; Chapman, 1926 : 41, Pl. 9, fig. 9, 10;
Finlay, 1946 : 243 (list); Hornibrook, 1961 : 88.

Remarks: Used for small or medium sized specimens of Pleurostomella that are fusiform, initially biserial and just become uniserial.

Individuals from the Mahoenui Group agree well with Schwagers fig. 80, but they differ from P. tenuis Hantken (recorded from the Waitakere ranges Miocene by Hayward (1975)) in being larger and by becoming uniserial in the adult.

Also included in P. alternans are a number of smaller, more elongate and staggered specimens which correspond to Schwagers fig. 79.

Dimensions of Hypotype: Length .73mm.

Distribution: Found in 16 samples from columns 7, 14, 19, 22, 25, 29, 29a, 33, 34, 37, 43, 44, 45 and 47a. These columns are in general located from Te Kuiti to Taumarunui.

Recorded Stratigraphic Range: Recorded from the Whaingaroan and Duntroonian by Hornibrook (1961), from the Otaian and Altonian by Hayward (1975) and from Recent sediments by Brady (1884). Mahoenui Group specimens occur in the Otaian.

Family CAUCASINIDAE

Subfamily FURSENKOININAE

Genus FURSENKOINA Loeblich & Tappan, 1961

FURSENKOINA SCHREIBERSIANA (Czjzek), Pl. 18, fig. 6.

Virgulina schreibersiana Czjzek, 1848 : 11,
Pl. 13, fig. 18 – 21; Cushman, 1937b : 13,
fig. 11 – 20; Hornibrook, 1961 : 64, Pl. 8,
fig. 138.
Fursenkoina schreibersiana (Czjzek); Belford, 1966: 136, Pl. 9, figs. 18 - 21; Srinivasan, 1966: Pl. 6, fig. 2; Eade, 1967: 51; Hornibrook, 1971: 11 (list).

Description of Mahoenui Group. Specimens: Test medium sized, elongate, and somewhat flattened. Biserial throughout. A short, very strongly twisted initial section is followed by 8 - 9 less twisted chambers. The sutures are strongly inclined, somewhat depressed, and limbate. A tall, lipped, slit-like aperture extends up the apertural face from the base of the chamber. The test may have a short apical spine.

Dimensions of Hypotype: Length .33mm.

Remarks: Although on first examination the early part of the test appears to be triserial, close examination reveals this to be very strongly twisted and biserial. Most specimens recorded were juveniles.

Distribution: Sporadic, occurs in 7 samples from columns 2, 4, 13, 17, 21, 24 and 45.

Recorded Stratigraphic Range: Throughout the Tertiary in New Zealand.

Family LOXOSTOMIDAE

Genus LOXOSTOMUM Ehrenberg, 1854.

LOXOSTOMUM sp.

Description: Test elongate, compressed, biserial to uniserial and finely perforate with a weak peripheral keel, depressed, non-limbate sutures and no sculpture. The aperture is subterminal, ovate and lipped. There is often a short apical spine.

Dimensions of Type: Length .56mm.

Distribution: Rare, occurs only in samples 1, 35 and 75.

Observed Stratigraphic Range: Otaian. (Early Miocene).
Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA LAEVIGATA d'Orbigny, Pl. 18, fig. 7.

Cassidulina laevigata d'Orbigny, 1826 : 282,
Pl. 15, fig. 4 - 5; Cushman, 1921 : 171, Pl. 31,
fig. 7; Finlay, 1946 : 243 (list); Renz, 1948 :
125, Pl. 9, figs. 9a - b; Hornibrook, 1961 : 85,
Pl. 10, fig. 199; Belford, 1966 : 138, Pl. 24,
figs. 1 - 4; Text fig. 16 (1 - 2); Gibson,
1967 : 42.

Cassidulina laevigata d'Orbigny var. carinata
Cushman, 1922 : 124, Pl. 25, fig. 6 - 7 (not
Cassidulina laevigata d'Orbigny var. carinata
Silvestri (1896)).
Cassidulina neocarinata Thalman, 1950 : 44;
Hornibrook, 1961 : 86, Pl. 10, fig. 200.

Remarks: The interpretation of C. laevigata presented by Belford (1966)
is adopted here. Both keeled (C. neocarinata) and unkeeled (C. laevigata)
forms are included in C. laevigata.

Dimensions of Hypotype: Diameter .30mm, Thickness .15mm.

Distribution: Sporadic, present in 10 samples from columns 3, 6, 8, 16,
17, 21, 28 and 30.

Recorded Stratigraphic Range: Occurs throughout the Tertiary in
New Zealand.

CASSIDULINA DELICATA Cushman, Pl. 18, fig. 8.

Cassidulina delicata Cushman, 1927c : 168,
Pl. 6, fig. 5; Renz, 1948 : 125, Pl. 9,
figs. 10a - b; Belford, 1966 : 140, Pl. 24,
figs. 5 - 10, text fig. 16 (3 - 4).

Remarks: Mahoenui specimens agree with Cushman's description and type
figures. In particular, this species, is characterised by its subacute
periphery, the withdrawal of chamber pairs to the margin as small,
triangles, its depressed sutures, and its ovate form. The aperture is long and extends the full length of the apertural face.

In comparison, C. laevigata, has a much more restricted aperture.

Dimensions of Hypotype: Diameter .30mm, Thickness .15mm.

Distribution: Present in 11 samples from columns 6, 7, 10, 15, 16, 17, 19 and 30.

Recorded Stratigraphic Range: Not previously recorded from New Zealand. This species was originally described by Cushman (1927) from Recent sediments in the Pacific near Panama. It has since been recorded from early Oligocene to late Miocene in North America (Renz, 1948) and from the late Miocene of Papua New Guinea (Belford, 1966). Mahoenui specimens are from the Otaian. (Early Miocene).


GLOBOCASSIDULINA CRASSA (d'Orbigny), Pl. 18, figs. 10 - 12.
Cassidulina crassa d'Orbigny, 1839c : 56, Pl. 7, figs. 18 - 20; Brady, 1884 : 429, Pl. 54, figs. 4a - c, 5a - c.
Globocestulina crassa (d'Orbigny); Belford, 1966 : 151, Pl. 26, figs. 5 - 9, Text fig. 17 (9 - 10).


Dimensions of Hypotype: Maximum diameter .27mm.

Distribution: This species is present in 31 samples from columns 2 - 5, 7, 8, 10, 13, 15, 17, 19, 29, 31, 36, 41, 42 and 46a.

Observed Stratigraphic Range: This Recent species occurs in the Otaian (Early Miocene) of the Mahoenui Group.

GLOBOCASSIDULINA n.sp. A. Pl. 18, figs. 13 - 16.

Description: A small, globose, enrolled biserial test with about 4 chamber pairs in the final whorl. The aperture is trifid, with a prominent, lipped branch extending slightly obliquely up the apertural
face. There are two branches along the basal suture but one of these tends to be poorly developed. The shell is sculptured, and the ornament consists of irregular raised ribs with smooth areas between. The ribs are on the whole continuous and netlike, well developed on the lower part of the shell, but weak on the final chamber. Shell finely punctate.

Dimensions of Holotype: Diameter .44mm.

Repository: Holotype and 6 Paratypes are lodged with the Geology Department, University of Auckland.

Type locality: R17/119; Sample 19 (column 3), Black Creek, R17/630892 (N.Z.M.S.260) Paratypes sample 27 (column 4).

Type level: Taumatamaire Formation, Mahoenui Group (Otaian).

Remarks: Similar in general form to G. oriangulata but differs in ornament and in being less coarsely punctate. Differs from G. arata in having raised ornament rather than being "ploughed in the direction of growth by fine and numerous irregular bifurcating furrows."

Distribution: Recorded in 21 samples from columns 1 - 4, 6, 8, 9, 15, 17, 22, 30 and 47a.

Observed Stratigraphic Range: ? Waitakian, Otaian. (? Late Oligocene, early Miocene).

GLOBOCASSIDULINA MURRHYNA (Schwager), Pl. 18, fig. 9.

Sphaeroidina murrhyna Schwager, 1886 : 250, Pl. 7, fig. 97.
Cassidulina cuneata Finlay, 1940 : 456, Pl. 63, fig. 62 - 6; Hornibrook, 1968 : 51, fig. 9.
Globocassidulina murrhyna (Schwager); Belford, 1966 : 152, Pl. 26.

Remarks: Finlay felt that the aperture of C. cuneata was very different from C. murrhyna which he considered to have a "chink like" aperture "set in a produced beak like final chamber". Belford later regarded the apertural characters quoted by Finlay as a product of the orientation of the original illustration of C. murrhyna. He stated that if C. cuneata
was similarly oriented the two appeared to be identical. This is supported by the present author's own observations of the types of C. cuneata and Belfords interpretation is followed.

Dimensions of Hypotype: Maximum diameter .36mm.

Distribution: Occurs occasionally in the Mahoenui Group. Specimens are recorded in 14 samples from columns 2, 3, 6, 7, 10, 19, 22, 24 and 46a.

Recorded Stratigraphic Range: Landon to early Wanganui Series. (Oligocene to Pliocene).

GLOBOCASSIDULINA ORIANGULATA Belford, Pl. 18, figs. 17, 18.

Globocassidulina oriangulata Belford, 1966:
148, Pl. 25, figs. 1 - 5, text fig. 16 (13 - 14).

Description of Mahoenui Specimens: Test small, biserial, globular with about 4 chamber pairs in the final whorl. Circular in front and edge view though the final chamber is extended and somewhat "beak like" in profile. The chambers are slightly lobulate with somewhat depressed sutures. In the apertural region the sutures are particularly incised and are often accompanied by a number of weak striations which radiate from the aperture. However, these are much less prominent than those in G. gemma. The aperture is strongly lipped and trifid, the outer branch along the basal suture is generally poorly developed. This leaves an "t" shaped opening but even this tends to be obscured by the lips. The shell is coarsely and densely punctate.

Dimensions of Hypotype: Maximum diameter .21mm.

Remarks: Many specimens recorded from the New Zealand as G. subglobosa are probably better placed in G. oriangulata.

Distribution: A common species, particularly in the Mahoenui and Te Kuiti regions. It is present in 37 samples from columns 1 - 11, 14 - 17, 19, 25 and 30.

GLOBOCASSIDULINA SUBGLOBOSA (Brady)

Cassidulina subglobosa Brady, 1881: 60;
Brady, 1886: 430, Pl. 54, fig. 17; Cushman,
1925: 54, Pl. 8, fig. 48–50; Chapman, 1926:
42, Pl. 9, fig. 14; Finlay, 1939: 112; Finlay
& Marwick, 1940: 107; Finlay, 1946: 245;
Finlay & Marwick, 1947: 232; Vella, 1957: 10
(list); Hornibrook, 1961: 85, Pl. 10, fig. 198;
Gibson, 1967: 42, Pl. 10, fig. 163.
Globocassidulina subglobosa (Brady); Belford,
1966: 149, 150, Pl. 25, figs. 11–16, Text
fig. 17 (1–6), 18 (1–4).

Description of Mahoenui Group Specimens: A subspherical species of
Globocassidulina with about 4 chamber pairs in the final whorl, weakly
incised sutures and somewhat inflated chambers giving a lobulate
periphery. The final chamber is about 2 times as wide as it is high and
has a simple elongate slit like aperture set obliquely on the apertural
face. (The two lateral limbs of the aperture that run along the basal
suture in G. sp. nov and G. oriangulata are not developed in G. subglobosa).

Distribution: Uncommon, occurs in 12 samples from columns 2, 4, 7, 8,
15–17, 20 and 30.

Recorded Stratigraphic Range: Present throughout the New Zealand
Tertiary.

Genus EHRENBERGINA Reuss, 1850

Finlay erected E. marwicki in 1939. In 1947 he separated E. willeti
and E. healyi from E. marwicki. The features he used for this included
the overall size, the ratio of length to width, details of the apertural
face, the proloculus, spinosity, the morphology of the ventral ridge,
details of the dorsal surface and the stratigraphic range of each
species.

Hornibrook (1961) maintained both E. willeti and E. marwicki as
separate species but remarked that while separate at their respective
type localities, specimens from other areas are difficult to distinguish. Hornibrook felt that *E. willetti* would prove to represent an extreme morphotype of *E. marwicki*. Scott (1973) considered most of Finlay's criteria in a numerical evaluation. He investigated the ratio of length to width, length to inflation, the diameter of the proloculus and the stratigraphic range.

Scott (1973) placed *E. healyi* in synonymy with *E. marwicki*. He also considered *E. willetti* to be a subspecies of *E. marwicki* but remarked that this placement was equivocal. Scott noted that although there is little difference between *E. marwicki* and *E. willetti* in overall inflation, the two show at least partial separation in the ventral inflation. Similarly, the ratio between length and width, is different in *E. willetti* and *E. marwicki*. These were combined by Scott and presented as the discriminant function:

\[
L_3 = 0.369 t - 0.334w - 0.564V
\]

where \( L_3 \) is greater than 6.3 for admission to *E. willetti*

\( t \) = the length of the shell
\( w \) = the width of the shell
\( v \) = the ventral inflation

This was applied to specimens of *Ehrenbergina* from the Mahoenui Group and it placed almost all specimens as *E. willetti*. Those that are placed in *E. marwicki* are distinct, much less inflated ventrally, with lower ventral ridge, are less spinose, and differ in the details of the apertural face.

Because of this strong demarcation *E. willetti* and *E. marwicki* are here considered as full species. Specimens of both species have been compared with their respective type suites and are similar in most respects.

**EHRENBergina marwicki** Finlay, Pl. 19, fig. 3.

*Ehrenbergina marwicki* Finlay, 1939c : 322, Pl. 28, figs. 112 - 118; Finlay & Marwick, 1940 : 118, 122; Finlay & Marwick, 1947 : 233; Finlay, 1947 : 284, Pl. 7, fig. 118; Hornibrook, 1961 : 87, Pl. 10,
EHRENBERGINA WILLETTI Finlay, Pl. 19, figs. 1, 2.

Dimensions of Hypotype: Length .22mm, Thickness .15mm.

Distribution: Present in 15 samples from columns 3, 4, 6 - 8, 13 and 41.

Recorded Stratigraphic Range: Otaian to upper Tongaporutuan. (Early Miocene to mid. Miocene).

Superfamily NONIONACEA

Family NONIONIDAE

Subfamily CHILOSTOMELLINAE

Genus CHILOSTOMELLOIDES Cushman, 1926.

CHILOSTOMELLOIDES OVIFORMIS

Lagina (Obliquina) oviformis Sherborn & Chapman, 1886:
745, Pl. 14, fig. 19.
Chilostomella oviformis (Sherborn & Chapman);
Sherborn & Chapman, 1889 : 485, Pl. 11, fig. 13.
Chilostomelloides oviformis (Sherborn & Chapman);
Cushman, 1926 : 77, Ph. 11, figs. 17, 21; Hayward,
1975 : 487, figs. 88, 89.

Remarks: Specimens resembling Chilostomella ovoidea but differing in
having a protruding circular aperture are placed in Chilostomelloides
oviformis.

Dimensions of Hypotype: Length .30mm.
Distribution: Rare, occurs in sample 46.

Observed Stratigraphic Range: This Recent species is here recorded
from Otaian, (Early Miocene) strata.

Genus CHILOSTOMELLA Reuss, 1850

CHILOSTOMELLA OVOIDEA Reuss, Pl. 19, fig. 4.
Chilostomella ovoidea Reuss, 1850 : 380, Pl. 48,
fig. 12a – e; Cushman, 1926 : 74, Pl. 11,
figs. 1a – e; Hornibrook, 1961 : 89, Pl. 11,
fig. 209; Gibson, 1967 : 45, Pl. 10, fig. 166.

Remarks: Forms that approach C. czizeki Reuss are included in C. ovoidea.
This is justified by the comment made by Cushman (1935) that C. czizeki
"may be a varietal form of C. ovoidea." I do not synonymise C. czizeki
and C. ovoidea as I have viewed too few specimens and have not seen
the types.

Dimensions of Hypotype: Length .40mm.
Distribution: Never abundant, recorded in 16 samples from columns 4,
13 – 16, 19, 27, 30, 31, 34, 38 and 45.

Recorded Stratigraphic Range: Occurs throughout the New Zealand
Tertiary.
Subfamily NONIONINAE

Genus FLORILUS de Montfort, 1808.

FLORILUS STACHEI (Cushman), Pl. 19, fig. 5.

? Nonionina boueana d'Orbigny; Chapman, 1926: 87, Pl. 17, fig. 10.
Nonion stachei Cushman, 1936b: 66, Pl. 12, fig. 7; Cushman, 1939: 16, Pl. 3, fig. 18.
Pseudononion stachei (Cushman); Finlay & Marwick, 1940: 112, 114; Hornibrook, 1961: 93, Pl. 11, fig. 216, 220; Scott, 1970a: fig. 8 (list).
Florilus stachei (Cushman); Hornibrook, 1971: 8 (list); Hayward, 1975: 520 (list).

Remarks: Large assymetrical shells with numerous recurved chambers and thickened sutures are placed in F. stachei.

Dimensions of Hypotype: Maximum diameter 1.89mm, Thickness .30mm.

Distribution: Recorded in samples 59, 61, 91, 100, 153 and 167.

Recorded Stratigraphic Range: Duntroonian to Lillburnian. (Oligocene to mid. Miocene).

Genus NONION de Montfort, 1808.

Two species of Nonion have been recorded. A small, involute planispiral lenticuline test with an acute periphery, recurved sutures, and central umbonal boss is placed in N. cassidulinooides. A more inflated test with a rounded periphery, only slightly recurved, slightly incised, non-limbate sutures, and a depressed umbilical region ornamented with small pustules, is recorded as Nonion deceptrix.

NONION CASSIDULINOIDES Hornibrook.

Nonion cassidulinooides Hornibrook, 1961: 92, Pl. 11, fig. 214, 215.

Dimensions of Hypotype: Maximum diameter .23mm, Thickness .10mm.
Distribution: Only present in sample 65.

Recorded Stratigraphic Range: Whaingaroan to Waitotaran. (Oligocene to Pliocene).

NONION DECEPTRIX Hornibrook.

Nonion deceptrix Hornibrook, 1961: Pl. 11, fig. 218, 219.

Dimensions of Hypotype: Maximum diameter .31mm, Thickness .14mm.

Distribution: Only present in sample 63.

Recorded Stratigraphic Range: Whaingaroan to Waitotaran. (Oligocene to Pliocene).

Genus ASTRONONION Cushman & Edwards, 1937

Five species of Astrononion are recorded from the Mahoenui Group. Three of these, A. australae, A. italicum and A. parki are similar in general test form. They are somewhat compressed with a lobulate, broadly rounded, periphery and an open umbilicus. These species differ primarily in details of their sutural modifications. A. australae has sutural tubes in the juvenile but these change to irregularly rhomboid plates in adult specimens. This species has narrow oval ports opening obliquely on the rear of the sutural tubes. Astrononion parki and A. italicum both have long narrow sutural tubes, but while A. parki has simple circular supplementary apertures, A. italicum has small, obliquely set, oval apertures.

A. pusillum and A. fijiensis are quite distinct, A. pusillum is small and inflated with a broadly rounded periphery and a small or closed umbilicus. The sutural tubes of A. pusillum are very narrow and short, ending in small simple circular ports. A. fijiensis is a large flattened species that has large triangular plates covering the umbilicus.

Hornibrook's (1964) classification of Astrononion into 3 subgenera
is followed here. Specimens of A. parki and A. pusillum were compared with their primary types and are considered to be identical.

ASTRONONION (ASTRONONION) AUSTRALAE Cushman & Edwards, Pl. 19, fig. 6.

Astrononion (Astrononion) australae Cushman & Edwards;
Hornibrook, 1964: 335.
Astrononion (Astrononion) aff. australae Cushman &
Edwards; Hayward, 1975: 492, 493, 520, fig. 99.

Dimensions of Figured Specimen: .49mm.

Distribution: Present in 47 samples (28% of samples) from columns 1 - 9 in the Mahoenui region, 13 - 18 and 22 from Aria and Te Kuiti and columns 27, 28 and 30 from Ohura to Tangitu.

Recorded Stratigraphic Range: A. australae, present in the Miocene of Victoria (Cushman and Edwards) and the Altonian of Auckland (Hayward, 1975) is here recorded in the Otaian and possibly the lower Altonian.

ASTRONONION (ASTRONONION) ITALICUM Cushman & Edwards, Pl. 19, fig. 8.

Astrononion (Astrononion) italicum Cushman & Edwards;
Hornibrook, 1964: 333, 335.
Astrononion (Astrononion) aff. italicum Cushman &
Edwards; Hayward, 1975: 492, 520, fig. 100.

Dimensions of Hypotype: Diameter .25mm, thickness .10mm.

Distribution: Occurs sporadically throughout the Mahoenui Group in the north and west of the study area. Present in 17 samples from columns 1, 4, 7, 15 - 17, 19, 20, 22, 29a, 37 and 38.

Observed Stratigraphic Range: Present in the Otaian of the Mahoenui Group. (Early Miocene).

ASTRONONION (ASTRONONION) PUSILLUM Hornibrook, Pl. 19, fig. 9.

Astrononion pusillum Hornibrook, 1961: 96, Pl. 12,
fig. 229, 236; Vella, 1962: 288.
Astrononion (Astrononion) pusillum Hornibrook, 1964: 334, Pl. 1, fig. 4.
Astrononion (Astrononion) cf. pusillum Hornibrook; Hayward, 1975: 493, 520.

Dimensions of Hypotype: Diameter .22mm, thickness .15mm.

Distribution: Present in 15 samples from columns 4, 14 - 16, 24a, 29, 37, 40 - 43 and 46a.

Recorded Stratigraphic Range: Occurs throughout the Tertiary of New Zealand.

ASTRONONION (ASTRONONION) PARKI Hornibrook, Pl. 19, fig. 7.
Astrononion parki Hornibrook, 1961: 95, Pl. 12, fig. 230, 237; Scott, 1970a: 330, 333, figs. 6, 7, 8, 13; Scott, 1971: 128, fig. 2; Happy, 1971: Table following p. 100.
Pacinonion parki (Hornibrook); Vella, 1962b: 290, fig. 8, 9; Gibson, 1967: 47, Pl. 11, fig. 176.
Astrononion (Astrononion) parki Hornibrook, 1964: 335.

Dimensions of Hypotype: Diameter .36mm, Thickness .13mm.

Distribution: Rare, occasional specimens present in samples 9, 12, 16, 47, 48, 91 and 147.

Recorded Stratigraphic Range: Occurs from Runangan to Altonian.
(Late Eocene to early Miocene).

ASTRONONION (FIIJINION) FIJIENSE Cushman & Edwards, Pl. 19, fig. 10.
Nonionina asterizans Brady, 1884 (Not of Fichtel & Moll): Pl. 109, fig. 1, 2.
Astrononion fijiense Cushman & Edwards, 1937: 35, Pl. 3, figs. 15, 16; Barker, 1960: Pl. 109, fig. 1, 2; Vella, 1962: 288.
Astrononion (Fijinonion) fijiensis Cushman & Edwards; Hornibrook, 1964: 335, 338, Pl. 1, fig. 1 - 3; Hornibrook, 1971: 8 (list); Hayward, 1975: 493, 520.
Dimensions of Hypotype: Diameter .29mm, Thickness .14mm.

Distribution: Present in samples: 12, 14, 37 and 81.

Recorded Stratigraphic Range: Otaian to Recent. (Early Miocene to Recent).

Genus NONIONELLA Voloshinova, 1958.

NONIONELLA NOVOZEALANDICA Cushman, Pl. 19, fig. 11.

Nonionella novozealandica Cushman, 1936a : 88,
Pl. 13, figs. 16a - c; Cushman, 1939 : 31, Pl. 8,
fig. 10; Finlay & Marwick, 1940 : 119, 122;
Hornibrook, 1961 : 94, Pl. 11, fig. 217, 221;
Scott, 1970a : 327, fig. 6, 7; Hayward, 1975 :
520 (list).

Description of Mahoenui Group Specimens: Small, inflated, slightly
trochospiral shells with chambers that increase rapidly in size. There
are about 9 chambers in the final whorl. Dorsally the shell is partially
evolute with a central boss and gently recurved sutures. Ventrally the
test is involute with somewhat depressed, recurved sutures. (Particularly
in the umbilical region). The final chamber is assymmetrical with a
flap extending over the umbilicus. The aperture is an interiomarginal
arch on the periphery, running into the umbilicus below the flap.

Dimensions of Hypotype: Maximum diameter .26mm, thickness .11mm.

Distribution: Present in 22 samples from columns 2, 4, 6, 14 - 17, 20,
22, 24, 28, 29, 34, 38, 42 and 43.

Recorded Stratigraphic Range: Whaingaroan to Tongaporutuan. (Oligocene
to late Miocene).

NONIONELLA MAGNALINGUA Finlay, Pl. 19, figs. 12, 16.

Nonionella magnalingua Finlay, 1940 : 456, Pl. 65,
fig. 144, 146; Finlay, 114, 127; Hornibrook, 1961 :
94, Pl. 12; fig. 226, 232 - 3; Gibson, 1967 : 48,
Pl. 11, figs. 181, 182; Happy, 1971 : Table
following p. 100; Hornibrook, 1971 : 8 (list);
Hayward, 1975 : 520 (list).
Remarks: This slightly trochospiral species is characterised by a strongly asymmetrical, swollen final chamber that overlaps one side of the test.

Dimensions of Hypotype: Maximum diameter .30mm
Thickness .16mm.

Distribution: Recorded in only 5 samples: 9, 47, 65, 158 and 163.

Recorded Stratigraphic Range: Duntroonian to Wanganui Series.
(Oligocene to Pleistocene).

Genus PULLENIA Parker & Jones, In Carpenter, Parker & Jones, 1862.

Two species of Pullenia have been recorded from the Mahoeunui Group. These are the inflated Pullenia bulloides and the less inflated species P. quinqueloba. Following Phleger and Parker (1951), no distinction is made between P. quinqueloba and P. quadriloba as the range of variation includes specimens with 4, 5, and occasionally 5½ or 6 chambers in the final whorl.

PULLENIA BULLOIIDES (d'Orbigny), Pl. 19, figs. 13, 14.

Nonionina bulloides d'Orbigny, 1846: 107, Pl. 5, fig. 9 - 10.
Pullenia sphaeroides (d'Orbigny); Chapman, 1926: 74, Pl. 15, fig. 1.
Pullenia bulloides (d'Orbigny); Finlay, 1946: 243 (list); Vella, 1957: 10 (list); Hornibrook, 1961: 90, Pl. 11, fig. 205 - 206; Vella, 1963: 12, 13, Pl. 1, figs. 7, 8; Gibson, 1967: 45, Pl. 10, figs. 168, 169; Hornibrook, 1971: 11 (list); Nelson, 1973: Table following p. 183.

Dimensions of Hypotype: Diameter .41mm, Thickness .39mm.

Distribution: Present in 36% of samples, occurs throughout the Mahoeunui Group.

Recorded Stratigraphic Range: Occurs from Upper Cretaceous to Recent.
Pullenia quinquedoba (Reuss), Pl. 19, fig. 15.

Pullenia quinquedoba Reuss, 1851b: 71, Pl. 5, fig. 31; Finlay, 1946: 243 (list); Phleger & Parker, 1951: 29, Pl. 15, fig. 12, 13; Vella, 1957: 10 (list); Hornibrook, 1961: 90, Pl. 11, fig. 207 - 108; Vella, 1963: 12; Gibson, 1967: 46, Pl. 10, figs. 172, 173; Hornibrook, 1971: 11 (list).

Pullenia compressiuscula Reuss var quadriloba; Reuss, 1867: 55, Pl. 3, fig. 8.

Pullenia quadriloba Reuss; Cushman & Todd, 1943: 15, Pl. 2, figs. 20, 21; Vella, 1963: 12, Pl. 1, figs. 9, 10; Gibson, 1967: 46, Pl. 10, figs. 170, 171.

Dimensions of Hypotype: Diameter .32mm, thickness .21mm.

Distribution: Present in 23 samples from columns 1, 2, 4, 6, 7, 10, 14 - 20, 25, 36, 37, 46a and 47b.

Recorded Stratigraphic Range: Upper Cretaceous to Recent.

Family ALABAMINIDAE

Genus ALABAMINA Toulmin, 1941

Alabamina tenuimarginata (Chapman, Parr & Collins) and A. acutimarginata (Finlay) are recorded from the Mahoenui Group. These species are morphologically similar, both are almost equally biconvex with a test comprising 2 - 3 whorls with 5 - 6 chambers in the final whorl. The spiral side sutures are straight, tangential and thickened. Those on the involute side are slightly depressed, less limbate, only slightly recurved and meet at a shallow central depression. The aperture is a low lipped interiori marginal arch enclosed in an infundibulum.

According to Finlay A. acutimarginata is somewhat larger than A. tenuimarginata with a more compressed test and a more narrowly rounded marginal flange. Finlay also felt that A. acutimarginata lacked the central ventral depression but the paratypes show this
feature clearly.

A. tenuimarginata is a very variable species and the test varies from specimens close to A. obtusa or A. creta with an obtuse periphery, high domed involute side, somewhat pentagonal outline and gaping infundibulum to specimens very close to A. tenuimarginata. Mahoenui specimens tend to lack the peripheral flange.

ALABAMINA ACUTIMARGINATA (Finlay), Pl. 19, figs. 19, 20.

Pulvinulinella acutimarginata Finlay, 1940 : 462, Pl. 66, figs. 184 - 186.

Alabamina acutimarginata (Finlay); Happy, 1971: Table following p. 100.

Dimensions of Hypotype: Diameter .35mm, thickness .15mm.

Distribution: Occurs in 31 samples from columns 1, 3, 4, 7, 8, 14 - 17, 19 - 22, 34, 36, 37 and 44.

Recorded Stratigraphic Range: Bortonian to Opiotian. (Eocene to Pliocene).

ALABAMINA TENUIMARGINATA (Chapman, Parr & Collins), Pl. 19, figs. 17,18.

? Pulvinulinella tenuimarginata Chapman, Parr
& Collins, 1934 : 565, Pl. 9, fig. 19.

Pulvinulinella tenuimarginata Chapman, Parr
& Collins; Finlay, 1940 : 463; Finlay & Marwick,

Alabamina tenuimarginata (Chapman, Parr & Collins);
Finlay, 1946 : 244 (list); Hornibrook, 1961 : 123,
Pl. 17, fig. 365 - 366; Gibson, 1967 : 54; Scott,
1970a : fig. 7 (list), fig. 5; Scott, 1971a : fig. 2
(list); Hornibrook, 1971 : 8 (list); Happy, 1971 :
Table following p. 100; Nelson, 1973 : Table
following p. 183; Hayward, 1975 : 522 (list).

Dimensions of Hypotype: Diameter .37mm, thickness .19mm.

Distribution: Occurs in 41% of samples. This species often exceeds
2% of the total fauna and forms 30% of the fauna in occasional samples.