SEDIMENTARY AND STRUCTURAL FEATURES OF ‘GREYWACKE’ BASEMENT ON THE CHICKENS ISLANDS

by P.R. Moore
217 Riverside Drive, Lower Hutt

SUMMARY

The basement sequence (Jurassic ?) on the Chickens Islands consists predominantly of indurated, thin-bedded alternating sandstone and mudstone. Well-preserved sedimentary structures and common trace fossils (? Rhizocorallium sp.) suggest that sediments were largely deposited by traction currents in a ‘shelf’ environment. Paleocurrents may have flowed mainly towards the north-east and west, across a north-facing paleoslope.

The structure is dominated by probable north-east to east-north-east and south-east to east-south-east trending major folds, some of which may be refolded about a north-west or subvertical axis. Other structural features include mesoscopic recumbent folds and intraformational slump zones.

INTRODUCTION

The Chickens Islands, situated 40 km south-east of Whangarei (Fig. 1), consist of indurated alternating sandstone and mudstone (‘greywacke’) intruded by considerably younger, probably Miocene, diorite - granodiorite plutons, andesites, and porphyry dikes. Previous accounts of the geology have concentrated on the plutonic rocks and associated mineralisation at Coppermine Island (Brothers and Hopkins 1967, Wodzicki and Thompson 1970), and apart from a few observations by Bartrum (1936), the only significant report on the basement greywacke is that by Small (1969). He briefly described the mesoscopic structure, petrography and sedimentary features of the rocks, including the occurrence of well-preserved trace fossils.

During the Offshore Islands Research Group expedition to the Chickens Islands in December 1981—January 1982 the opportunity was taken to study the sedimentary rocks in more detail, and especially their structure, sedimentary features, and ichnofauna (trace fossils). Virtually the entire coastline of Lady Alice Island was examined, but only brief visits made to Mauitaha, western Whatupuke and Coppermine Island (Fig. 1).

The islands are covered by the metric (NZMS 260) topographic sheet R07, and fossil localities e.g. R07/f7 are those of the metricated New
Zealand Fossil Record File. Copies of fossil record forms are held at New Zealand Geological Survey, Otara, Auckland.

STRUCTURE

Available bedding attitudes (Fig. 1, 2) indicate that there are two main structural trends in the greywacke basement - north to north-east, and west to north-west (cf. Small 1969). These trends are further emphasised by construction of a form line contour map which suggests that the structure is probably dominated by major folds trending mainly north-east to east-north-east, and south-east to east-south-east (Fig. 1). The latter trend includes a possible overturned anticline in the south-east part of Lady Alice Island. Some of the inferred north-east folds may plunge 10-20° south-west.

![Form-line contour map of 'greywacke' basement on the Chickens Islands showing inferred major folds. Area of plutonic rocks, and some bedding attitudes, from Small (1969).](image)

Although there are almost certainly two generations of major folds, the lack of marker beds and likely dislocation of thick units of strata (e.g. on the north-east coast of Lady Alice Island) makes it difficult to determine which was earlier. There is also more than one reconstruction of the structure possible based on the data available. Despite this, north-east to east-north-east trending folds in the western part of Lady Alice Island appear to have been refolded about a north-west-trending or sub-vertical axis.
The earliest structures recognised are a number of mesoscopic recumbent folds and intraformational slump zones (See under 'Sedimentary Features'). Mesoscopic folds, and inferred major folds predate the intrusion of igneous dikes (Miocene?). No major faults were identified.

SEDIMENTARY FEATURES

The sedimentary basement sequence is dominated by indurated, thin bedded (mm-cm bedded) alternating fine to very fine sandstone and dark grey mudstone (argillite) containing sparse calcareous concretions (Fig. 3). Sandstone beds generally range from 2-5 cm, although beds up to 15-20 cm are not uncommon. Thicker, coarser grained sandstones up to 2 m or more are rare. Beds are dominated by parallel and ripple lamination, less commonly by convolute lamination. Many have sharp bases but are not obviously graded, and no sole marks other than a few load casts were observed.

Argillite beds rarely exceed 20-30 cm, and are characterised by very thin laminations (1-3 mm) of fine to very fine sandstone or siltstone. Trace fossils are common (Fig. 2, 4), and argillites are locally highly bioturbated.

Wavy to lenticular bedding is well-developed in places, and isolated, asymmetric sandstone ripples (mainly flat lenses) occur especially in argillite-dominated phases. No certain flaser bedding was
identified. Some small load casts or ball-and-pillow structures appear to represent foundered isolated ripples.

In terms of the classic Bouma model for turbidites, the alternating facies is characterised by B, C and E intervals with the most common sequences being B-C-E and C-E. The C interval is particularly dominant in some outcrops, and climbing ripple lamination locally preserved.

Intraformational folds are common, and in places ‘packets’ of more deformed sediments are interbedded with regular-dipping strata. Around the north-east side of Lady Alice Island the rocks are more disrupted, with pinch-and-swell, pull-apart and boudinage of sandstone beds. This sequence, which includes some thick (greater than 7 m) sandstones and a possible sandstone dike is, together with other ‘packets’ of deformed rocks, suggestive of syn-sedimentary or ‘soft rock’ deformation resulting from submarine slumping.

Fig. 3. Flysch-like, thin-bedded alternating sandstone and mudstone, western Lady Alice Island. Beds face north-east (to left of photo).

Trace fossils

Trace fossils (ichnofossils) are common, particularly in argillite dominated sequences (Fig. 2). The most abundant type consists of twir parallel tubes infilled with sandstone (Fig. 4), similar to those illustrated by Sporli and Grant-Mackie (1976) and identified as Rhizocorallium sp [However, Ballance (1976) has questioned their identification]. These tubes occur mainly in argillite beds, but also cut thin sandstone beds. They have an oval to semi-spherical cross-section, are up to 20 cm long.
and show rare internal transverse lamination. Individual tubes are up to 1 cm diameter, and where double tubes occur they are usually spaced 3-4 mm apart (Fig. 4).

Fig. 4. Typical twin-tubed trace fossil (\textit{? Rhizocorallium} sp.) in thin-bedded alternating facies, north-west Lady Alice Island (R07/f9). Note oblique orientation to thin sandstone bed.

The majority of tubes are oriented at high angles to bedding, but range from sub-parallel to sub-vertical. In places, sub-vertical tubes are dominant. At many localities tubes appear to be inclined in the down-current direction, determined from ripple cross-lamination.

Typical rhizocorallid burrows consist of a U-shaped tube with spreiten (curved growth laminae between the 2 tubes) (Seilacher 1967), but no spreiten or connecting U-junctions have been observed in Chickens Islands specimens. Nevertheless, it seems likely that the double tubes originally formed a U-shape, and that the connecting part has not generally been preserved.

Other trace fossils recorded include the hexagonal network form \textit{Paleodictyon}, which is locally abundant at the base of sandstone beds (e.g. east end Mauitaha Island); a large branching type sub-parallel to bedding, short ‘fat’ tubes, and a variety of irregular, disordered burrows.

Further study of the ichnofauna is in progress.
Paleocurrent directions and paleoslope

In sequences of less-deformed strata, ripples and ripple cross-lamination within sandstone beds provide an indication of paleocurrent direction. Directions are accurate only to quadrants as no three-dimensional measurements were made, and no tectonic correction could be applied other than a rotation to horizontal. Despite the errors involved, current directions would appear to be predominantly towards the north-east and west (Fig. 5); certainly there is no indication of important south or south-east-flowing currents.

![Diagram](image1.png)

**Fig. 5.** Paleocurrent directions derived from sedimentary structures (mainly ripple cross-lamination), and orientation of recumbent folds (interpreted as slump structures).

The orientation of mesoscopic recumbent folds, which are inferred to be syn-sedimentary slump structures, may be useful indicators of paleoslope, although again no tectonic correction has been applied. Fold axes are oriented predominantly north-west and south-west, roughly at right angles to the two dominant current directions (Fig. 5). Together with other minor evidence (e.g. orientation of convolute folds) the sedimentary structures suggest that sediments were largely transported down a north to north-east-facing paleoslope, and that there was a strong westward-flowing current. However, these directions must be treated with caution as the amount of tectonic rotation (folding) of the basement rocks is unknown.

**DISCUSSION**

Observations on sedimentary structures suggest that the flysch-like
sedimentary basement sequence was deposited mainly by traction rather than turbidity currents. Wavy to lenticular bedding, isolated ripples, and mudstones containing thin sandstone laminae are not characteristic of turbidites. Graded bedding or parallel-laminated (A) intervals are rare, and the apparent absence of flame structures and flute casts is notable. Overall, the thin-bedded sequence resembles delta-front, distal bar or distal fan facies (Reineck and Singh 1973, Sholle and Spearing 1982).

Trace fossils provide apparently contradictory information on depth of deposition of the sediments. For example, sub-vertical to oblique U-shaped tubes, such as *Rhizocorallium*, are considered typical of shallow marine conditions (Seilacher 1967, cf. Ballance 1976). Network forms such as *Paleodictyon*, on the other hand, are representative of the 'Nereites facies' which is considered to be indicative of deeper water (bathyal ?) environments. However, it is conceivable that *Paleodictyon* could occur in shallower water under suitable hydrodynamic conditions (e.g. low current activity, low sedimentation rates), and from the abundance of *Rhizocorallium* tubes it seems more likely that sediments were largely deposited at 'shelf' depths.

The age of the basement sequence on the Chickens Islands remains uncertain but from the occurrence of *Rhizocorallium* associated with Late Jurassic macrofossils in a similar facies at Tawharanui Peninsula (Sporli and Grant-Mackie 1976) the rocks are possibly Jurassic.

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**REFERENCES**


