THE SEDIMENTARY STRUCTURES OF THE UPPER SCAMANDER SEQUENCE AND THEIR SIGNIFICANCE

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(With 2 Plates)

ABSTRACT

A number of sedimentary structures, which have previously not been described anywhere in Tasmania, are developed in the Scamander Slates and Quartzites, near Upper Scamander. These structures include markings made in muds that have been preserved as casts on the soles of graded sandstones and coarse-grained siltstones. It is well known that certain sole markings, such as flute casts, indicate the direction of the current responsible for their erosion and infilling. This is confirmed at Upper Scamander, for the distribution of the directions incated by these sole markings is similar to that obtained from an examination of current bedding developed in some sandstones and coarse-grained siltstones. A study of the rock types in the Upper Scamander sequence shows that the deposit " normal " to the area was of muds, whilst sands, coarse silts, and fragments of plants and a marine fauna were brought into the locality by turbidity currents, which probably originated to the south-west. The only evidence of life that existed at the site of deposition is the presence of worm-like grooves that were made on the surface of the muds.

INTRODUCTION

Near Upper Scamander, in the north-east of Tasmania, a well-exposed sequence of rocks occurs in road cuttings. During a recent visit to the road section, a number of sedimentary structures developed in the rocks were noted, which hitherto have not been reported anywhere in Tasmania. Apart from the general interest of recording these structures, which are the subject of many present-day researches in America and particularly Europe, a study of the road section has proved profitable in that a great deal more information has been obtained on the depositional history of these rocks. The results of the investigation point a way as to how the isolated sections of their correlates in north-east Tasmania may be made to yield far more information than they have to date.

THE UPPER SCAMANDER ROAD SECTION

The Upper Scamander road section is a type locality of the " Scamander Slates and Quarzites " (Walker, 1957). From the fossils recovered and from a general consideration, Walker expresses the belief that this formation ranges in age between the Middle Silurian and Middle Devonian and considers it to be a part of the Mathinna Group (Hills and Carey, 1949).

Because faults are present not all the road cuttings of the road section are considered, for parts of what has been mapped may be repeated in the remaining road cuttings. The section investigated extends 382 metres in the direction S 16° W along the road from the point of co-ordinates 892,000N-603,830E on the International Grid on Sheet No. 4 of the 4-mile state map of Tasmania. Although faults may occur where soil and rubble obscure parts of the outcrop in the mapped section, a comparison of the intact sequences has indicated no repetition.

The beds in the section mapped dip at 30°-50° in the direction W. 17°-32° N., and are very gently corrugated at a number of points. The axes of these tectonic corrugations trend at N 20° E to S 20° W, which agrees with the direction inferred by Walker (1957) for the regional folding, and their plunge, although difficult to assess, is considered to be about 8 degrees in the direction S 22° W. Thus, with the aid of a stereogram, all sedimentary structural directions have been rotated to the geographical horizontal about the fold axis direction, given by the corrugations, after corrections were made for the fold plunge.

The Scamander sequence exposed in the mapped road section is approximately 177 metres thick, and from a study of the compositions, textures and sedimentary structures the rocks can be divided into two distinct groups consisting of (1) mudstones and (2) sandstones and coarse-grained siltstones. Descriptions of the groups follow immediately, but the significance and the discussion of many of the various features developed in the rocks are given in the concluding section.

DESCRIPTION OF THE ROCK TYPES

1. Mudstones

Layers of mudstones occur in the section examined, and they vary from a few millimetres to 3.7 m. in thickness. Commonly, these mudstones, which break with a sub-conchoidal fracture, are banded and the bands, which are from 0.4 mm. to about 5 cm. in thickness, are coloured usually light to dark grey and occasionally purple or brown.

The mudstones are composed of varying proportions of mica laths, orientated parallel to the bedding planes, and sub-angular grains of quartz, which may be up to 0.02 mm. in size.

Sedimentary structures are lacking and no fossils were found.

2. Sandstones and Coarse-Grained Siltstones

These rock types are characterised by a number of features, noted below, which are entirely absent from the mudstones.

The layers of sandstone and coarse-grained siltstones, which vary from 2 cm. to approximately 3 m. in thickness, are usually massive. Lamination, when it occurs, is restricted to the sediment of the coarse siltstone grade.

By inspection with a hand-lens a number of layers are seen to be graded. Commonly, the gradation within a layer is from a median size grade of 0.25 mm. to 0.4 mm. at the base, to a median size grade of 0.03 mm. to 0.1 mm. at the top. However, examples occur of layers of sandstone or coarse siltstone grade only.

The sediments are poorly sorted, for even in the coarser horizons the particle size varies from that of the largest grain to clay grade. The grains are angular to sub-angular, and most of the larger ones are of quartz, but fragments of quartzite, chert, mica and occasionally feldspar occur. The fine material, of clay and fine silt grade, is of quartz grains and mica laths with subordinate amount of chlorite flakes. Many quartz particles show a little recrystallisation at their margins.

The poor sorting of the sediments (Plate 1 A) is significant, for it suggests that material as fine as clay size grade was deposited with the largest grains associated with it. In one layer occur chunks of dark grey mudstone, which are up to 16 cm. in length, and they are contorted in such a way as to suggest that they were not consolidated when they were deposited with grains of mainly coarse siltstone grade.

Fossils are not common, but Walker (1957) has recorded the recovery of a stunted marine fauna which included bryozoans, corals, brachiopods, and moulds of crinoid columnals. The fossils are often fragmentary, and their occurrence suggested to Walker that they indicated a place of burial and not of growth. Rare plant remains, which include the primitive plant *Hostimella* (?) described by Cookson (1936), have also been found.

A host of markings in muds have been preserved as casts on the soles of the sandstones and coarse siltstones. Walker (1957, p. 25) reported their occurrence and described them as "depositional rolls and corrugations", which he considered to have developed at right angles to the prevalent current direction. In recent years several types of sole marking have been described and a classification has been proposed (Kuenen, 1957). This classification and the terminology adopted by Kuenen is used in the following description of the markings occurring in the Upper Scamander road section.

Pre-current markings are rare and they are casts of meandering worm-like grooves (Plate 1 B). These occur on the soles of thin coarse-grained siltstone layers, and their absence from the soles of the sandstones is presumed to be due to their obliteration by later current erosion. The worm-like casts are the only evidence of life that existed on the depositional floor during the accumulation of the mudstones.

A profusion of current markings occurs. Flute casts, which are elongated parallel bulges, vary greatly from sole to sole both in size and shape. Usually the oblong bulges are bulbous at one end and flared at the other. They may be wide apart or crowded together to form numerous patterns. The flute casts vary in size from 12 cm. in breadth and 30 cm. in length to minute examples barely visible to the unaided eye. Photographs of some of the types observed are shown in Plates 1 and 2. Usually the same type occurs over a single sole, but exceptions are present and in one case flute casts of the usual shape are seen to develop in the direction of elongation into flat-topped parallel ridges. Only small and weak examples occur on the soles of the coarse-grained siltstone layers.

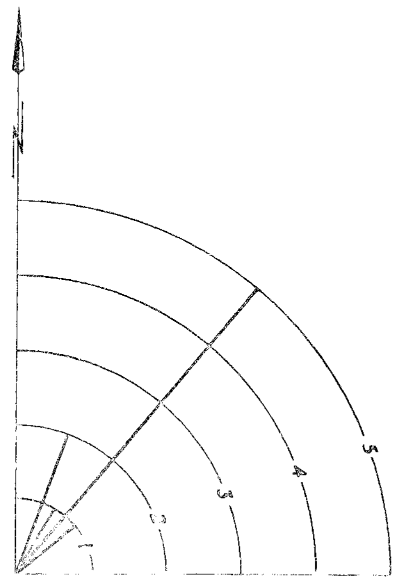

FIG. 1.—Rose diagram showing the distribution of down-current directions indicated by flute casts of nine horizons in the Upper Scamander road section.

It is well known that the direction from the bulbous to the flared end of a flute cast is in the direction of the current that was responsible for its erosion and infilling (Rich, 1950; Kuenen, 1953, 1957; and others). At Upper Scamander the direction of well-developed flute casts was determined for nine horizons, well spaced in the road section examined. These directions were then rotated to the horizontal about the regional fold axis by means of a stereogram, and plotted in the rose diagram of Fig. 1, which indicates that the currents responsible for the transportation and deposition of the sandstones and coarse-grained siltstones remained fairly constant in direction from the south-west throughout the time of accumulation of the sediments of the section mapped. On a sole of one coarse-grained siltstone, small and poorly-developed flute marks appear to indicate a current opposite in direction to those recorded above, however this anomaly may result from the effect on the marks of the depositional phenomenon of load casting, described later.

Drag marks, which are long even ridges, are developed on some soles. Plate 2 C is the photograph of the cast of a drag mark some 3.4 cm. in breadth occurring on the sole of a sandstone bed. Many of the other marks are much smaller and are only just visible to the naked eye. In all cases the drag marks, which are characterised by a constancy of shape, size and direction, extend beyond the limit of the exposed sole. Their orientation, as is well known, tends to be in the current direction which was deduced by other features developed in adjacent layers of sandstone and coarse-grained siltstone.

All the pre-current and current sole markings have been exaggerated to varying degrees by load casting, which is a depositional feature. Load casting is the vertical adjustment resulting from the unequal loading of sands on the irregular surface of soft muds, and in the Upper Scamander road section structures caused by load casting are most apparent on the soles of the coarsest and thickest beds of sandstone. In many cases (Plate 2 D) load casting has produced overhanging edges to the flute marks and also "flame structures" (Walton, 1956, p. 267), which are irregular blade-like penetrations of mudstone into overlying sandstone.

Small-scale current bedding, with laminations rarely thicker than 0.5 mm., is sometimes developed in the top 10 cm. or so of a graded layer of sandstone, particularly where there is an upward gradation to a coarse siltstone, and in some layers of coarse-grained siltstone. The current bedding, which is generally of the type described as "festoon" by Pettijohn (1957, p. 169), occasionally shows the effect of current drag by the bending of the tops of the forset laminations in the direction of the current. Four current bedded horizons, which are well spaced along the mapped road section, have been examined, and the direction of current bedding has been calculated to within about 10 degrees by viewing the same lamination along at least three intersecting planes approximately perpendicular to the bedding plane. The directions so determined have been rotated about the regional fold axis to the horizontal by means of a stereogram. The direction of current bedding for the four horizons, is N 32°-52° W, which is similar to that obtained from the flute casts of soles, confirming the use of the latter in determining current direction.

Post-depositional sedimentary structures are rare, but gentle folding occurs in some sandstone layers. The layers themselves are not folded and are of uniform thickness throughout . Walker (1957, p. 26) considers the deformation to be due to slumping resulting from the slope of the depositional floor to the west. In the affected beds the folds are complete and are observed to flatten against the margins. In Plate 2 E the current bedded upper part of a sandstone layer has been gently folded and the flattening of the folds against the upper margin is clearly seen. Such folding would apear to be due to intrastratal flowage. Of significance is the coincidence in direction of the axes of these folds and the trend of regional folding, which suggests a tectonic control over their formation.

CONCLUSIONS

The mudstones have the characteristics of sediments formed by quiet deposition from dilute fluid suspensions, for they are of even grain size, the mica laths are invariably parallel to the bedding planes and they lack features which may indicate any other mode of transportation and deposition.

On the other hand, turbidity currents appear to be the only agents able to produce the combination of features found in the sandstones and coarse-grained siltstones at Upper Scamander. The significant features are poor sorting and grading (Kuenen and Migliorini, 1950; Kuenen, 1953), the profusion of current sole markings (Kuenen, 1957, pp. 232-3), and the fairly constant direction of the currents which transported and deposited these sediments (Kuenen, 1953, p. 1,045).

Current bedding and sole markings show that the turbidity currents came from an area to the southwest of Upper Scamander. The sediments of this source area must have been deposited in a sufficiently unstable attitude for masses of the material to slide down slope and become density currents by mixing with water. Under the influence of gravity these currents continued to travel down the sloping floor through clear water, with the coarser grades of their load of each current moving to their nose. The suspended material carried by the turbidity currents was usually of sand, silt, and fragments of plants and a marine fauna, but it is evident that there was a variation in the material available, for there are variations in the composition, and in the sorting of the sandstones and coarse siltstones (see Walker, 1957, p. 27).

When the turbidity currents reached a decrease in gradient they slowed and started depositing their load. The surface of the muds, over which the currents passed, was scoured and occasionally disturbed to such an extent that fragments of it became incorporated into the suspended material of the currents. Rarely, the surface of the muds was eroded only to a small degree, and worm-like grooves, the tracks of bottom living organisms, were not obliterated. Immediately behind the eroding nose of the current however, there was deposition, which began with the coarser grades of material and ended with the finer detritus of the tail.

Undoubtedly, not all the sediment carried by the currents was in suspension, for the drag marks found on some soles at Upper Scamander indicate traction. However, traction was of more importance during deposition from the tail of a current for the coarse silt grade material of the tops of some sandstone beds is current bedded, and examples are found of current laminations bent in the direction of the current.

Between the arrivals of turbidity currents at Upper Scamander fine silt and clay, which are the "normal" type of sediment to the area, were deposited. The only evidence of life that existed at the site of deposition is the presence of worm-like grooves that were made on the surface of the muds.

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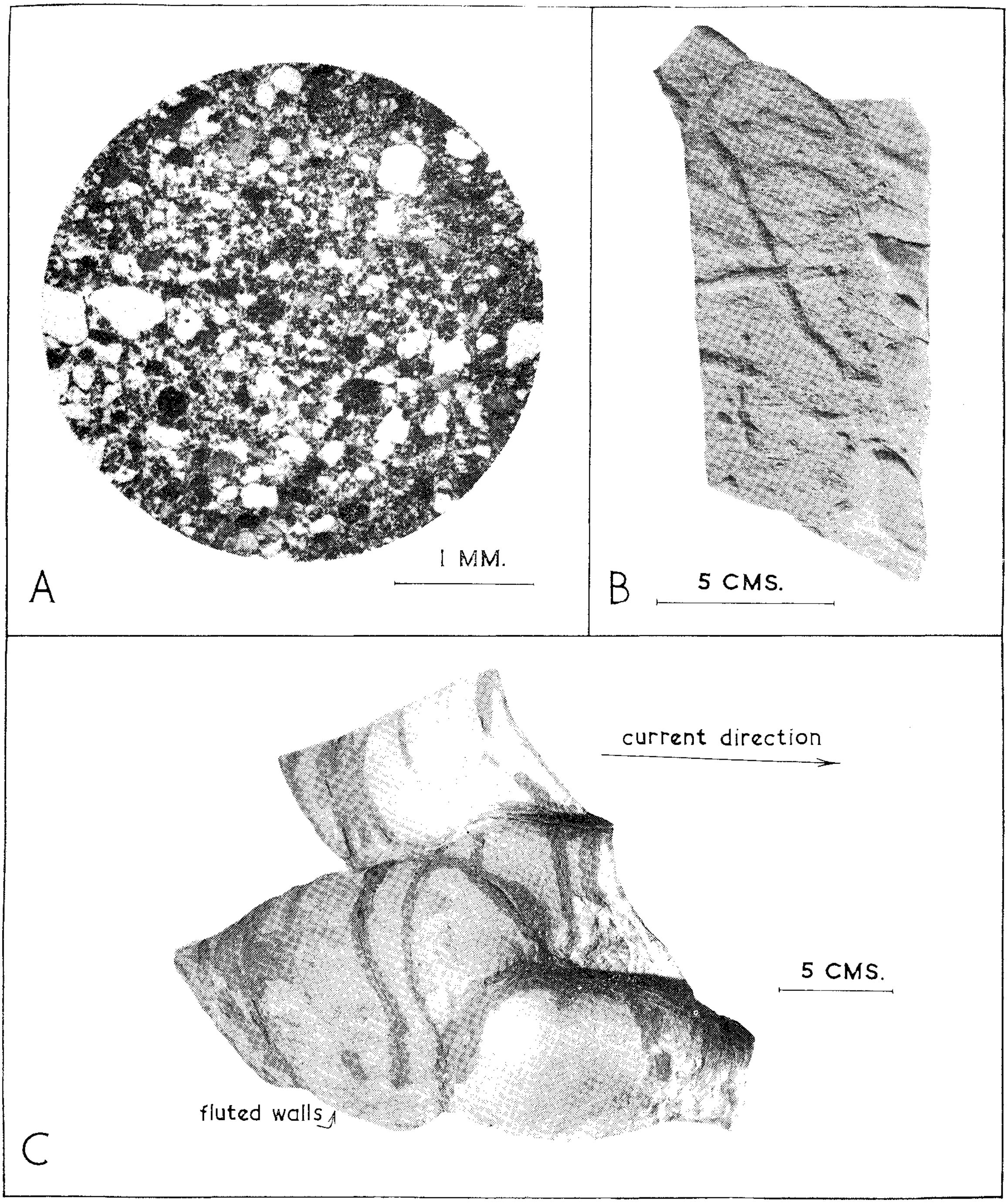

Plate 1.

A. Upper Scamander sandstone, crossed nicols. Sorting is poor.
B. Casts of meandering worm-like grooves on the soles of a thin coarse-grained siltstone.
C. Large flute casts with fluted walls.

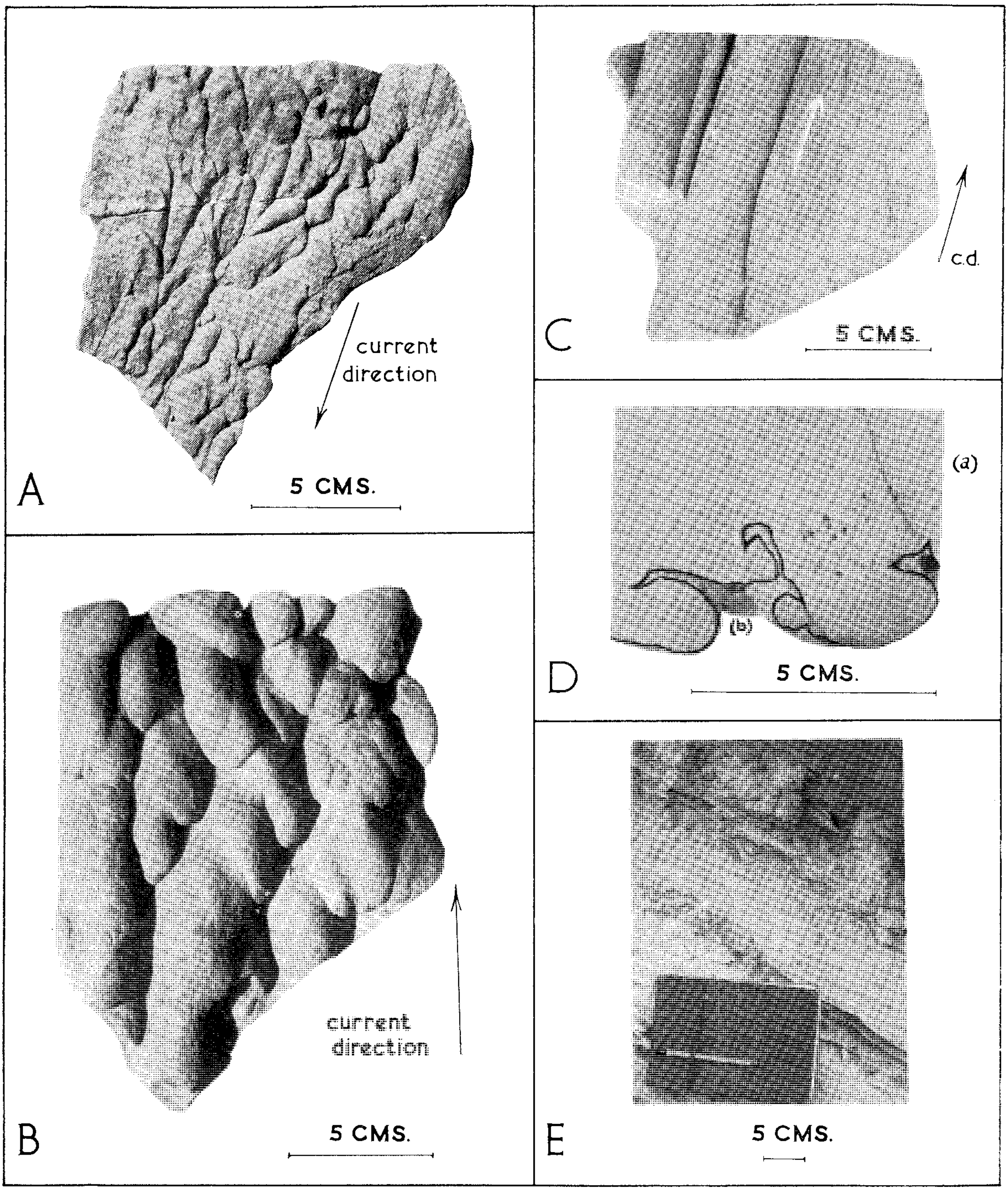

PLATE 2.

A. Crowded flute casts.
B. Well developed flute casts.
C. Part of a cast of a drag mark.
D. Load casted flutings (plans shown in B) with overhanging walls and flame structures. Black line indicates boundary between sandstone (*a*) and mudsone (*b*). The photograph is of a section cut normal to bedding and current direction.
E. Folding produced by intrastratal flowage in a sandstone layer, current bedded at the top.