THE MARINE ORIGIN OF WATER-LAIN VOLCANIC SEDIMENTS OF SOUTH-WEST ADELAIDE ISLAND

By M. R. A. THOMSON

ABSTRACT. The presence of trace fossils (vermicular structures), sponge spicules and (?) Radiolaria in some water-lain tuffaceous sediments of Upper Jurassic age in south-west Adelaide Island is indicative of their deposition in a marine environment.

THE small area of ice-free rock in south-western Adelaide Island, which is the site of the British Antarctic Survey station (Fig. 1), is composed of sedimentary rocks of largely volcanic composition intruded by an intermediate to basic dyke swarm. These sediments have been referred to the Upper Jurassic Volcanic Group by Dewar (1969). Most of the sediments are very coarse-grained and contain a high proportion of crystal fragments. Frequently they are distinctly bedded and their water-lain origin is clearly indicated by the presence of well-developed false bedding. In one small outcrop (T.360.21) at the back of the beach, about 350 m. north of the station area, a small lensoid bed of fine-grained tuff up to 1·2 m. thick is interbedded with the coarser sediments. In the hand specimen these tuffs are mainly black in colour but a few thin greenish white bands are also present. They are highly indurated and, like all the rocks in the station area and forming the offshore islands, cut by large numbers of narrow quartz and quartz-epidote veinlets. At their outcrop, these sediments are also cut by a basic dyke 45 cm. wide with an associated 12 cm. stringer and a coarsely porphyritic dyke about 2 m. wide. While the tuffs are largely concordant with the bedding of the coarser agglomerates, fragments of this sediment can be seen adhering to the face of the agglomerate outcrop above the tuff bed proper. It would thus appear that some of the tuff bed had been intruded into the sediments above as a small clastic dyke.

In thin section the dark tuffs are highly altered and consist of a very fine-grained, dark green matrix composed mostly of chlorite and low birefringence minerals, together with a few small scattered grains of quartz and feldspar. The whitish bands are cloudy grey in thin section. Ragged grains of iron pyrites up to 0·5 mm. across are scattered through the darker parts of the rock. Most of the clastic grains are of clear quartz with sharp angular outlines which apparently bear no relationship to the crystallographic symmetry of the crystals. These features are probably indicative of the primary volcanic origin of the quartz fragments. Rounded grains of quartz, which may be of detrital origin, and grains of altered feldspar occur less frequently.

THE FOSSILS

Vermicular structures

Trace fossils, which are similar to those described as vermicular structures by Taylor (1967) from the marine Aptian sediments of south-east Alexander Island, occur in the whitish bands of the fine-grained tuff (T.360.21a; Fig. 2). They are easily recognized in the field because the dark cores, characteristic of these trace fossils, are here filled with a green (?) chloritic mud and show up in strong contrast to the whitish sediment. The cores are about 0·5 mm. across and appear as a confused series of elongate, sometimes branching, worm-like structures on the bedding surfaces. On joint surfaces, perpendicular to the bedding, they appear as short blebs which are elongate in the plane of the bedding and sometimes show the characteristic hooked form seen in some of the Alexander Island specimens. Due to the light colour of the surrounding sediment, the rim of clean sediment, which is normally present around the cores, is only discernible in a few cases (bottom right of Fig. 2). Structures, described as *traces vermiculées* by Avias (1953, pl. XV, fig. 7) from the Norian (Upper Trias) of New Caledonia, perhaps resemble the present specimens more closely than do the Alexander Island examples. Avias believed that his structures were analogous to the *wurmförmige Bildungen* described by Zittel from New Zealand.

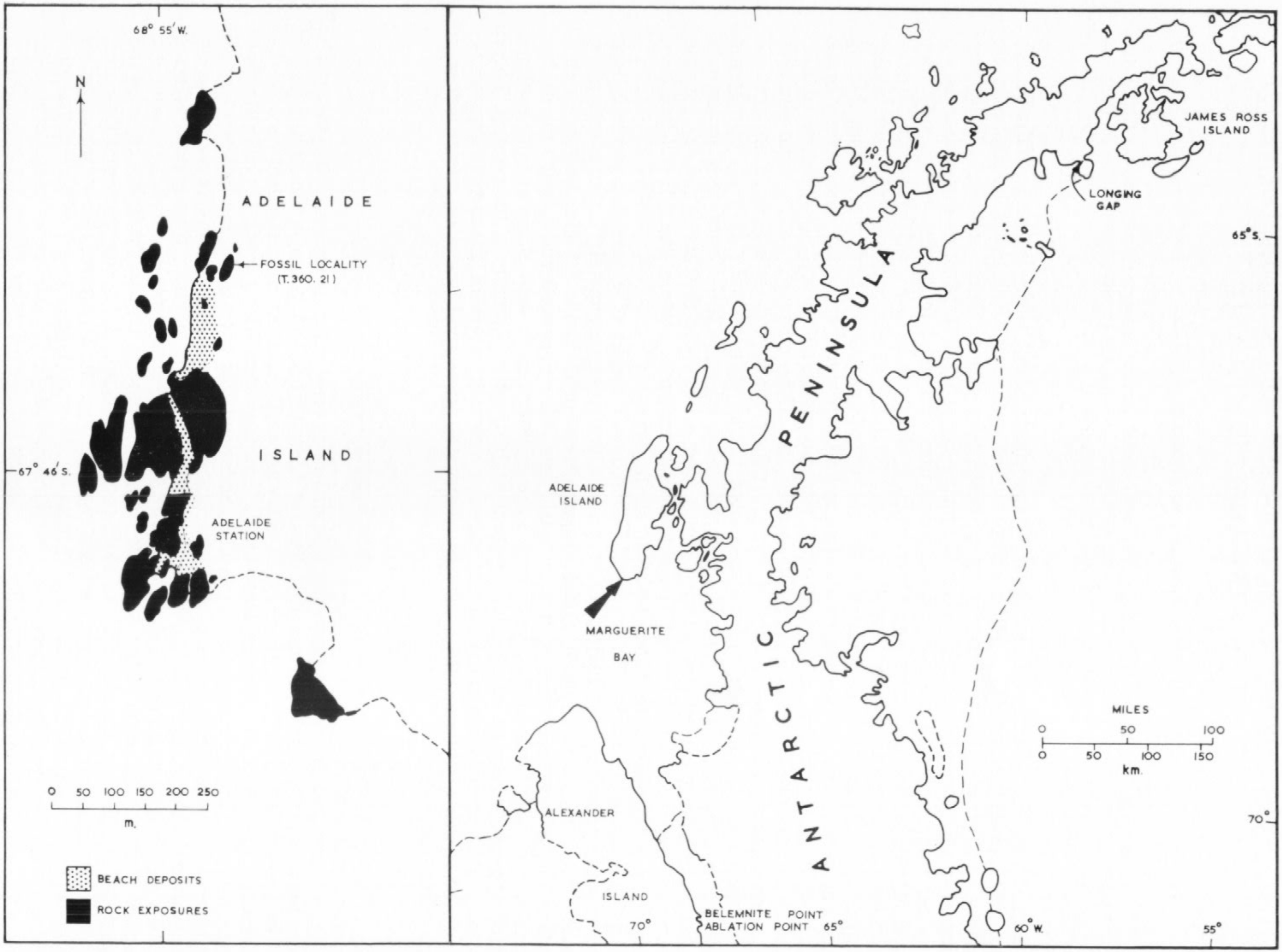


Fig.1. Sketch map of the Antarctic Peninsula, showing the location of the fossiliferous sediments in south-western Adelaide Island and the other localities mentioned in the text. The position of the inset, which shows the Adelaide Island scientific station and the exact location of the fossiliferous outcrop, is marked by the heavy black arrow.

Fig. 2. Vermicular structures on the bedding surface of a light green-coloured band in the tuffs (T.360.21a; ×7).

Sponge spicules

Megascleric sponge spicules are scattered through the tuff and they usually occur as short, smooth, perforated rod-like structures composed of recrystallized quartz. One of the better examples (Fig. 3) is 0·2 mm. long and 30 μm. across; at one end it bears a rounded boss about 50 μm. in diameter. The rod-like part is perforated along its length by a canal 10 μm. in diameter, and a similar canal passes through the rounded boss at right-angles to the plane of the section. These canals are filled with a green mineral which is probably chlorite.

The central canal in calcareous spicules is very slender and usually obscured by recrystallization in the fossil state (Shrock and Twenhofel, 1953, p. 77). The relatively large size and well-marked form of the canal in the present specimens indicates that these spicules are truly siliceous.

Protozoa

Two types of Protozoa have been found in the tuffs. The first (Fig. 4a) occurs as partially compressed ovoid bodies (perhaps once spherical) with a maximum diameter of 135 μm., a minimum diameter of about 90 μm. and a siliceous test about 5–7 μm. thick. In some specimens there are indications that this test was pierced by a series of fine radial pores. Similar but almost spherical bodies about 85 μm. in diameter are less well preserved. Indeed there seems to be a complete gradation between obviously testaceous bodies and ghost spherical structures in the matrix of the tuff, suggesting that once they were perhaps more common but have since been largely obscured by replacement or alteration. The interiors of these tests are filled with fine matrix and/or chlorite.

A second type of (?) Protozoa, represented by only one specimen (Fig. 4b), is oval in cross-section and is surrounded by a series of short projections which bifurcate at their outer extremities. It is preserved as an external mould filled with a very fine-grained granular aggregate of a low birefringence mineral and there is a well-defined inner layer, concentric with the outer contour of the structure, which may represent an inner test. The solid structure measures 77 by 65 μm. and the projections are about 12 μm. long.

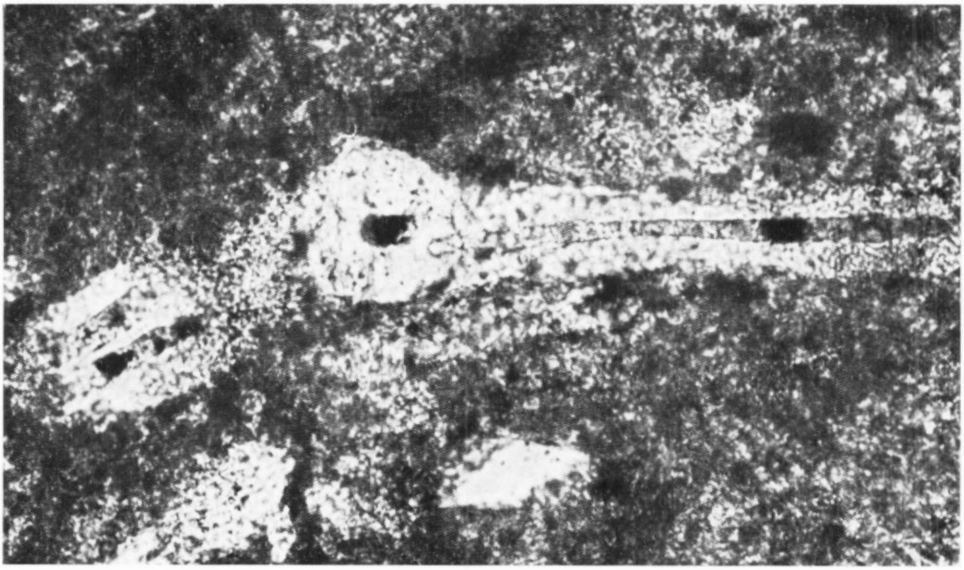
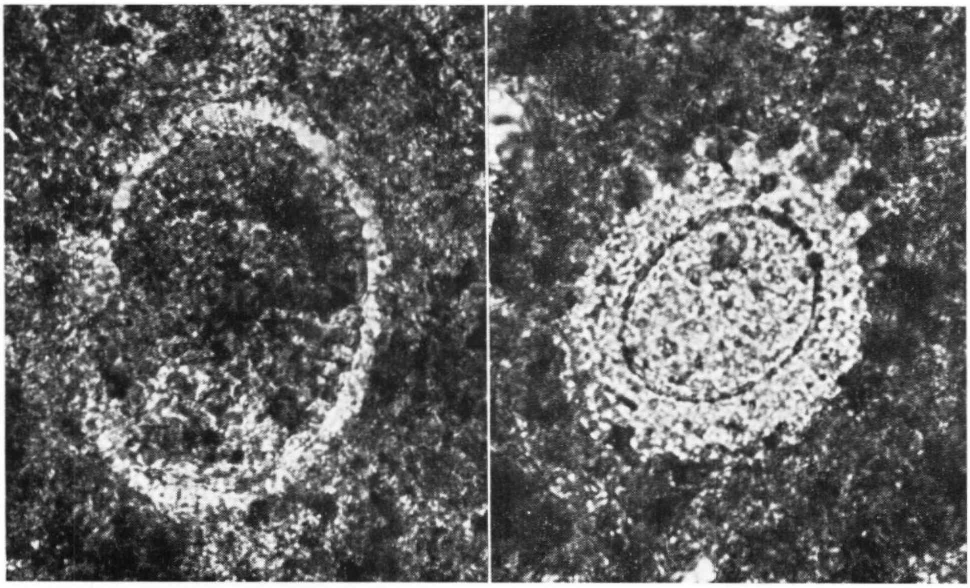


Fig. 3. A siliceous sponge spicule in a thin section of the dark-coloured tuff (T.360.21b; ordinary light; ×455).

Discussion

Although the fossils are poorly preserved, there is little doubt that they indicate a marine environment for the deposition of the tuffs. Vermicular structures have only previously been described from undisputed marine sediments in Graham Land (Thomson, 1967) and Alexander Island (Taylor, 1967) and New Caledonia (Avias, 1953); with the exception of members of the family Spongillidae, which have monaxonid spicules only (Shrock and Twenhofel, 1953, p. 85), all sponges are marine. The exact symmetry of the present spicules is uncertain but there are clear indications that they are more complex than monaxonid and are therefore from marine sponges. Because of the simple morphology of the first type of Protozoa, it is difficult to identify them very accurately. They may be assigned to the Radiolaria and compared to such genera as *Cenosphaera* or alternatively referred to the silicified remains of structures which have been described under a variety of names, but have been broadly referred to as "calcispheres". The probable presence of pores in the test suggests that they are most likely Radiolaria, but in either case a marine environment is indicated. The projections of the second type of (?) Protozoa resemble those found in some genera of the radiolarian family, Collosphaeridae. However, the different preservation of this specimen from that of the testaceous forms could suggest a quite different original composition of the test and different systematic affinities of the organism.

This new evidence that these Upper Jurassic tuffs of south-west Adelaide Island were deposited in a marine environment is interesting, because it augments the rather scanty data available at present concerning the extent of the Upper Jurassic sea surrounding the Antarctic Peninsula. Upper Jurassic belemnites have been found in volcanic sediments at Belemnite Point (Fig. 1) on the east coast of Alexander Island (Adie, 1964, p. 152), and the Upper Jurassic ammonite *Perisphinctes* sp. has been recorded from a sequence of siltstones near Longing Gap, north-east Graham Land (Bibby, 1966, p. 8). Bibby (1966) has stated that "The sequence may contain tuffaceous bands which could relate it to the Upper Jurassic Volcanic Group". Elsewhere in Graham Land the exact origin of water-lain volcanic rocks of Upper Jurassic age is not yet clear. In the Marguerite Bay area, for example, on Lagotellerie and Horseshoe Islands and at Cape Alexandra, Adelaide Island, such rocks contain fine-grained sediments with very poorly preserved plant remains. These may well have been deposited in fresh water, possibly near the coast and under conditions similar to those prevailing during the deposition of the Middle Jurassic plant beds of Hope Bay (Adie, 1964, p. 146). Normal



a **b**

Fig. 4. a. A thin section of an ovoid (?) Radiolaria with a thin, perforate siliceous test (T.360.21b; ordinary light; ×400).
b. A thin section of a second type of (?) Radiolaria with strong bifurcate projections on the outside of the test and perhaps also an inner test (T.360.21b; ordinary light; ×500).

marine sediments, which contain ammonites of Upper Oxfordian or Lower Kimmeridgian age (Howarth, 1958) occur in a thrust complex at Ablation Point, Alexander Island. However, until the belemnites from Belemnite Point are more accurately dated, it cannot be established whether the Ablation Point beds represent an extension of the same Upper Jurassic sea as existed at the time of volcanicity or not.

Belemnite Point and Longing Gap are at least 800 km. apart and on opposite sides of the Antarctic Peninsula; the present sediments provide the only definite evidence of Upper Jurassic marine sedimentation between these two localities of established age.

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