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2200 Ma-OLD "TRACE-FOSSILS" FROM THE TRANSVAAL SUPERGROUP IN THE TRANSVAAL

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by

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ABSTRACT

Trace-fossils are ubiquitous in late-Precambrian and younger sediments. These fossils are readily accepted to be the record of the behavioural activities of metazoans. Descriptions of traces in rocks older than the end-Precambrian are met with scepticism, largely because they pre-date the metazoan population-explosion that apparently took place around 700my ago. Yet, in the face of widespread opposition, descriptions of Precambrian ichnofossils continue to be published by recognized trace-fossil-authorities who are cognizant of the enigma of early- and middle-Proterozoic fossil traces.

This paper describes another example of early-Proterozoic "dubiofossils". Simple horizontal tubes resembling Planolites, horizontal and vertical, U-shaped tubes very similar to Rhizocorallium and Arenicolites, and complex, internally-laminated, walled tubes are sparsely developed in the 2200my-old Transvaal Supergroup of South Africa. Significantly, the traces are all contained within intertidal-to-shallow-subtidal sediments, consistent with the habitat of their younger counterparts.

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INTRODUCTION

Tracks, trails, burrows, and tubes preserved in sediments record the life-activities of animals. These sedimentary structures are known as trace-fossils, or ichnofossils (Frey, 1971), and result from metazoans moving, feeding, hiding, and resting on, or in, soft sediment. Trace-fossils are most commonly recognized in, and described from, end-Precambrian and younger sediments. Until recently, older sediments were regarded as being unfossiliferous. This, in part, led to the hypothesis that metazoan radiation took place rapidly about 700my ago (Cloud, 1968 and 1976; Schopf et al., 1973). The "explosion" in the metazoan population, according to prevailing current thought, followed an evolutionary trend beginning with prokaryotic-cell and stromatolite genesis at 3100-3500my, followed by bacteria-like structures at 3000-3100my and great diversification of stromatolites at 2200my, leading to the development of an oxygenated atmosphere and water-column at approximately 2000my, nucleated planktonic cells at 1500-1700my, multicellular benthic metaphytes at 700-900my, and, finally, the evolution of benthic metazoans from soft-bodied pelagic eumetazoans between 650 and 800my (Kauffman and Steidtmann, 1981).

However, in conflict with this evolutionary calendar are sparsely-developed "trace-fossils" that are significantly older than the postulated age of multi-cellularity. The ages of the traces generally fall within 900-1300my, but one group found in the Medicine Peak Quartzite of southeastern Wyoming is at least 2000my old (Kauffman and Steidtmann, 1981). The validity of these "dubiofossils" (Hofmann, 1972) has been strongly contested, most notably by Cloud (1968, 1973, and 1978). The controversy surrounding these mid- and early-Proterozoic "dubiofossils" has been reviewed recently (Kauffman and Steidtmann, 1981; Glaessner, 1984), and, although many have been demonstrated to be inorganic, others may be metazoan ichnofossils (Kauffman and Steidtmann, 1981). The purpose of this paper is to bring to the attention of the research community another example of early-Proterozoic "dubiofossils".

THE TRANSVAAL SUPERGROUP

The sparsely-developed traces were found in the Transvaal Supergroup in South Africa. Like the other early-Proterozoic sedimentary sequences deposited on the structurally-stable Kaapvaal Craton in northeastern South Africa, the Transvaal Supergroup (Fig. 1) is relatively undeformed. Regionally, it has been subjected to only lower-greenschist-grade metamorphism; locally, it has been contact-metamorphosed by the intrusive Bushveld Igneous Complex. Excellent outcrop exposures and numerous precious-metal-exploration boreholes have facilitated a detailed understanding of the sedimentary history of the basin.

The Transvaal Supergroup was one of the most-extensive, early-Proterozoic, intracratonic sequences deposited on the Kaapvaal Craton, covering at least 500 000sq.km. Twelve thousand metres of sediment were deposited in the basin, largely under conditions of shallow-marine sedimentation in an

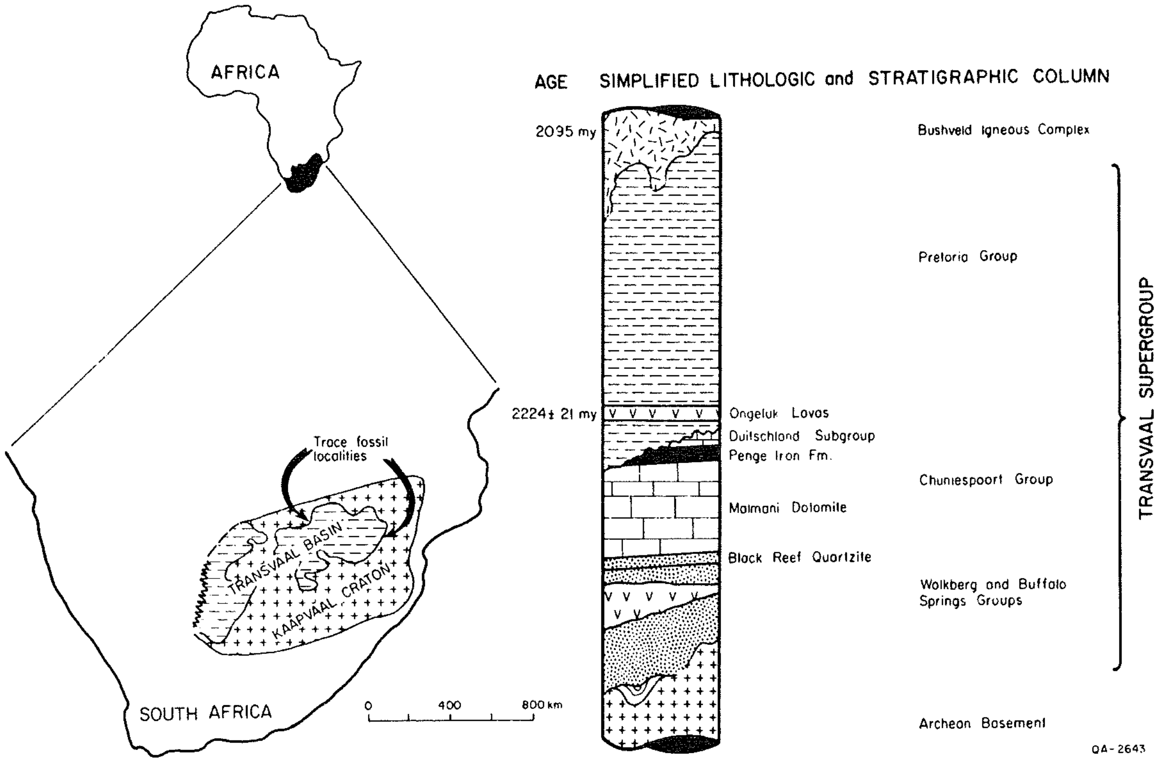

Figure 1 : Locality map and simplified stratigraphy of the early-Proterozoic Transvaal Basin.

epeiric sea. Initial basin-infilling took place in two local sub-basins, the Wolkberg and Buffalo Springs basins (Fig. 1) in the northeastern and west-central Transvaal, respectively (Button, 1973; Tyler, 1978). Fluvial and deltaic sedimentation predominated during this early phase of clastic sedimentation, which was periodically interrupted by volcanism. The crustal instability indicated by igneous activity subsequently manifested itself as a broad, crustal downwarp filled by high-energy shorezone clastics (Black Reef Quartzite), by supratidal-to-shelf-edge carbonates (the Chuniespoort Group), and by cyclic shorezone and shelf, clastic sediments (Pretoria Group). A sequence of pillowed basalts, the Ongeluk Lavas, intercalated in the Pretoria Group, has been dated at 2224 ± 21my (Button, 1976). In the central part of the basin, the Bushveld Igneous Complex intruded, metamorphosed, and assimilated Transvaal sediments, which also act as the roof of the layered, intrusive body. Rb-Sr and argon dates of the Bushveld have consistently yielded ages of 2095my (Hamilton, 1977; Coertze et al., 1978), so, there can be no doubt that the Transvaal Supergroup is early-Proterozoic in age.

"TRACE-FOSSILS" IN THE TRANSVAAL SUPERGROUP

"Dubiofossils" in the Transvaal Supergroup were found on bedding-surfaces in the Black Reef Quartzite, in the west-central Transvaal, and in the Malmani Dolomite of the Chuniespoort Group (Fig. 1), in the eastern Transvaal. The Black Reef Quartzite averages 20m thick and extends over most of the basin. In the western Transvaal, it is composed of medium-to-coarse-grained sandstones, representing braided-stream deposits at the base, that grade upward into finer-grained and texturally- and compositionally-mature shoreface and foreshore sandstones. These fine-to-medium-grained, nearshore deposits contain "dubio-fossils" similar to Planolites.

The convex epirelief structures occur as slightly-sinuous ridges on bedding-surfaces (Fig. 2). They are relatively large, having diameters of 10-13mm. The walls are smooth-to-slightly-irregular. The tubule shown in Figure 2 is 15cm long; one end displays a bulbous termination, slightly larger than the diameter of the cylindrical structure, which is constant throughout the remainder of the form. The tubes are filled with medium-grained sandstone, lithologically similar to the sandstones in which they occur. The morphology and habitat of these meandering, epichnial ridges is analogous to that of Precambrian-to-Holocene Planolites (Chamberlain, 1978), which are characteristic-ally contained in shoreface deposits and which are interpreted as the feeding-structures of vermiform animals (Howard and Frey, 1984).

The Black Reef Quartzite is overlain by the Malmani Dolomite. In the eastern Transvaal, the contact between the terrigenous-clastic-dominated Black Reef and the overlying 1000m-thick carbonate assemblage is gradational, consisting of decreasing coarse clastics, with concommitant increases in dolomite and black carbonaceous shale. The dolomites overlying the transition-zone contain only minor amounts of terrigenous, clastic sediments and display a variety of algal-stromatolite structures, including domes of small (centimetre-scale) to giant (40m wide by 25m high) proportions, columnar stromatolites, thrombolites, and cyptalgal laminites which exhibit both horizontal and crinkled morphologies. Salt-casts, desiccation-cracks, and teepee-structures are locally present. Deposition was cyclic; two transgressive sequences, from supratidal to shallow-subtidal and from intertidal to deep-subtidal (shelf) deposits, at the base, are overlain by a regressive cycle, from subtidal and intertidal dolomites to lagoonal sediments, at the top of the Malmani Dolomite.

Subvertical and horizontal tubes of possible biogenic, but non-algal, origin are found mostly in the transition-zone and in intertidal-to-subtidal dolomites that overlie the transition-zone. The best-preserved traces are found in borehole-cores. The structure illustrated in Figure 3 is a 10mm-wide, curvilinear tube, located in the upper half of a 4cm-thick, graded grain-stone, which is overlain by a thin, calcareous mudstone. The walls of the arcuate, subvertical form are smooth and mark a subtle colour-change from a lighter-gray groundmass to a slightly-darker interior. This simple, hemi-U-shaped structure is similar to Cambrian and younger Arenicolites, but may also be analogous to a meandering Planolites-like trace.

Large, horizontal elliptical tubules are also present (Fig. 4). This structure occurs in dolomite that has been partly replaced by chert; however, the "dubiofossil" is composed of tubes of dolomite in a dolomite host-rock. The two elliptical forms together compose a larger, horizontal, U-shaped structure,

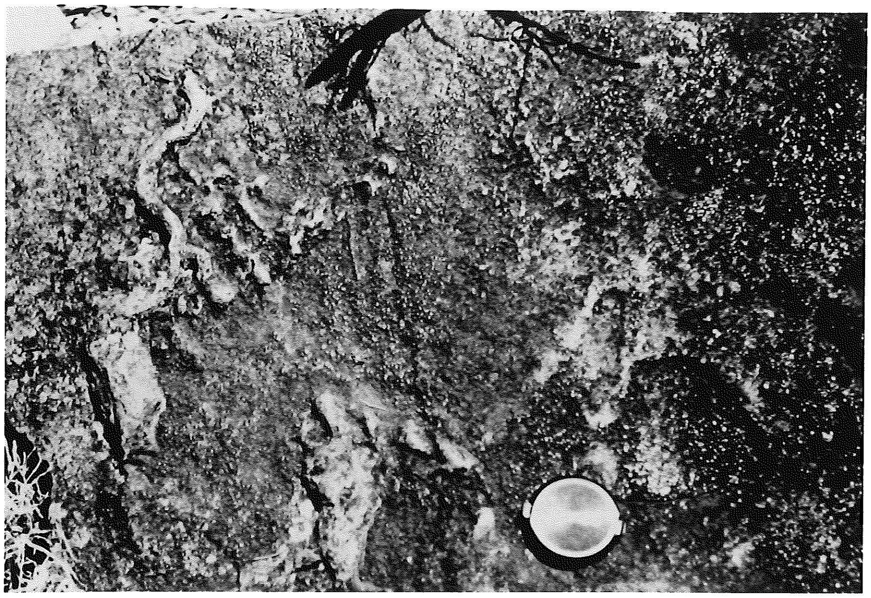

Figure 2 : *Bedding-surface view of a meandering, epichnal ridge, similar to Planolites, in the Black Reef Quartzite, west-central Transvaal.*

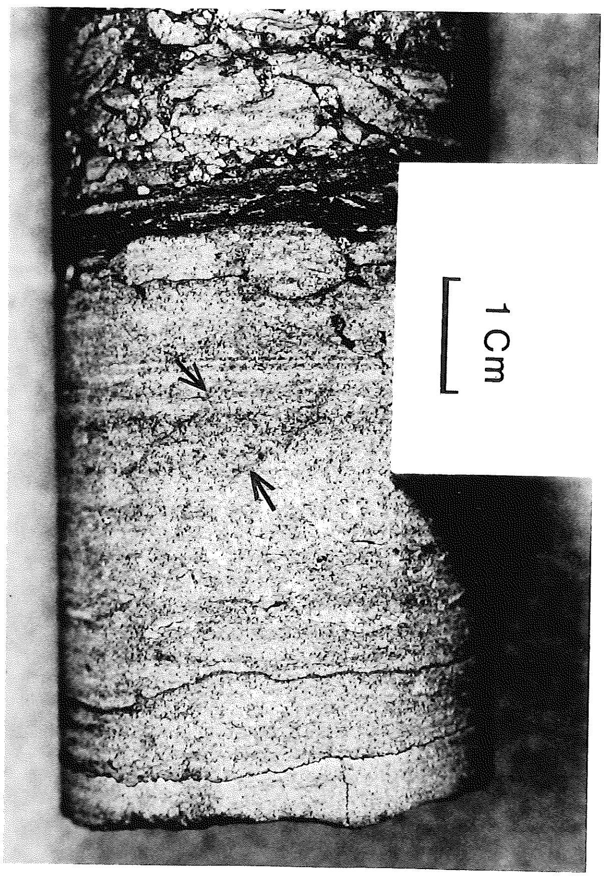

Figure 3 : *Curved, vertical tube thought to be one-half of a U-tube that curves out of the plane of the core in a Malmani Dolomite grainstone.*

with a width, on the face of the outcrop, of 18cm. The walls of the tubes are sharply defined, and the right-hand limb has a ribbed or striated exterior (Fig. 4). The rib runs parallel to the limbs of the U. Cambrian and younger Rhizocorallium display features similar to this horizontal, U-shaped tube (Chamberlain, 1978); however, the characteristic internal spreite of Rhizocorallium are not evident in this specimen.

In contrast to the smooth-walled and homogeneous-filled, morphologically-simple tubes illustrated in Figures 2, 3, and 4, the final "dubiofossil" observed in the Malmani Dolomite is complex. It is a subvertical, composite structure 3,5cm long and 2cm wide, at the base. The walls are irregular and are distinctly lined (Fig. 5). The lining consists of finely-crystalline, dark-gray dolomite, whereas the central core of the structure is composed of coarsely-crystalline, light dolomite. Most of the lining is tightly juxtaposed against the coarser core; however, it is separated, in places, from the core by a very thin (a fraction of a millimetre) sliver of black mudstone. Two centimetres above the base, the structure branches into two smaller, laterovertical offshoots; both display lined walls. A second, possibly-related structure is cradled in the apex between the offshoots (Fig. 5); the walls of the upper tube are also lined and irregular. The groundmass in which the tubes occur is composed of black, highly-carbonaceous mudstone.

The coarser core of the tubes contains intriguing, concave, subparallel, meniscate laminae, less than 1mm thick, that extend from wall to wall. At the base, younger laminae cut across and "truncate" older laminae (Fig. 5). Where the tube bifurcates, the laminae contained in the longer sub-tube become thinner, narrower, and more-steeply inclined; the shorter sub-tube is unlaminated. These concave, internal structures closely resemble the meniscate backfilling of the burrows of younger metazoans (e.g. Muensteria).

The horizontal and subvertical structures contained in lower-Transvaal sediments display a remarkable resemblance to ichnofossils of burrowing metazoans. Yet, like the 2000my "dubiofossils" present in the Medicine Peak Quartzite of southeastern Wyoming, there is no unequivocal evidence to support a biogenic origin for these structures. With the exception of one of the "dubiofossils", these structures are unlined, simple, meandering or curvilinear tubes, without spreite, body-fossils, carbon-residues, backfill-structures, or appendage-marks. One, however, does display the internal meniscae that signify active backfilling in younger ichnofossils. Furthermore, this "dubiofossil" exhibits texturally-distinct, lined walls that are in places displaced (pushed away ?) from the coarser material that composes the core of the tube. Could these be appendage-marks?

It is believed that the 2200my Transvaal "dubiofossils" present further evidence for the early-Proterozoic evolution of metazoans. It is anticipated that these structures and the conclusions drawn from their examination will be controversial.

ACKNOWLEDGEMENTS

Structures similar to Planolites were first observed by one of us (N.T.), during the 1976-1977 field-season, and the remaining structures were examined by both of us during an investigation of the Pilgrims Rest Goldfield

Figure 4 : *Horizontal, elliptical U-tube, oriented into the outcrop, composed of dolomite in a dolomite groundmass. This sharply-walled structure occurs in the partly-chertified (c), lower, dolomite-and-chert zone of the Malmani Dolomite. Note the ribbed exterior of the tube above the top of the pen.*

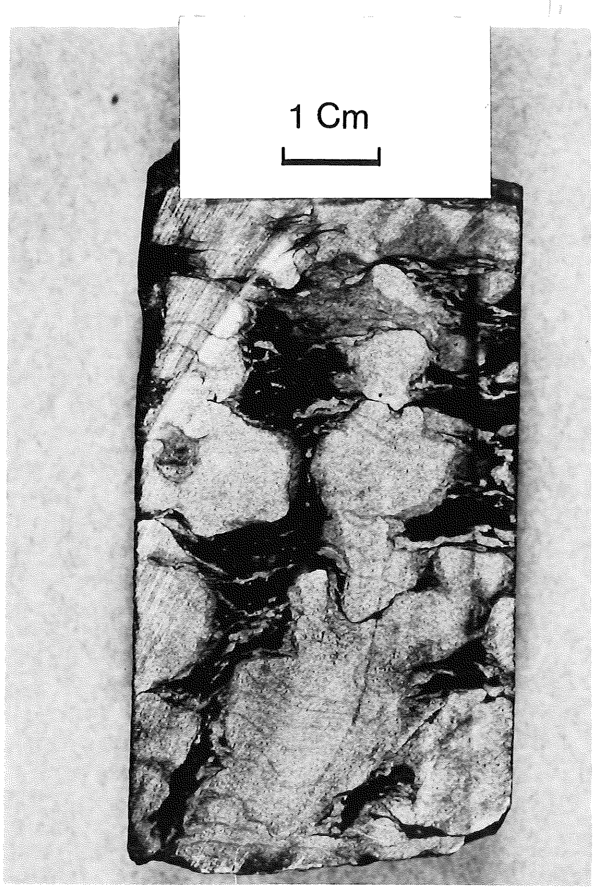

Figure 5 : *Complex, bifurcating tubes of coarsely-crystalline, light-coloured dolomite, with lined walls of finely-crystalline, darker dolomite in a carbonaceous-shale groundmass. The central core of the tubes contains concave, meniscate laminae, analogous to the backfill-structures of metazoan burrows in younger sediments. The lining of the walls, locally, is slightly displaced from the central core.*

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