

Rusophycus (Early Ordovician ichnofossil) from the Mithaka Formation, Georgina Basin

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Large trilobite resting traces (*Rusophycus*) from the Mithaka Formation are up to 30 cm or more in length, and are found in association with asaphid trilobites of similar length. The portion of the Mithaka Formation in which the *Rusophycus* occur contains a rich fauna and ichnofauna, and is considered to have been deposited in very shallow-water marginal to wide intertidal barrier flats behind a sand barrier.

Introduction

The Mithaka Formation (Casey in Smith, 1963), of Ordovician (Arenig to Llanvirn) age, forms part of the Toko Group of the Georgina Basin (Fig. 1). In discussing the depositional environment of the Carlo Sandstone, Draper (1977) described the lowermost portion of the Mithaka Formation, and proposed a lagoonal origin for the unit. Among the various biogenic sedimentary structures in the Mithaka Formation are large trilobite resting traces (*Rusophycus*).

The size of the traces (over 30 cm), and their association with trilobites of similar size, are of particular importance.

The Mithaka Formation

A composite section of the Mithaka Formation is given in Figure 3. Medium-bedded, bioturbated, fine-grained quartzose sandstones with shale and siltstone interbeds comprise the lower 5 metres. Mudstone, with numerous thin lensoid beds of fine-grained sandstone, constitutes the remainder of the unit, which has a maximum thickness of 127 m in Ethabuka No. 1 (Alliance, 1975). Finely disseminated pyrite is present throughout as replacements after shell fragments, or rarely, as framboids about 1 cm in diameter. Ironstone ooids are present in the lower 5 m. Lamination is common throughout in both mudstone and sandstone, but is often disrupted by bioturbation.

The Mithaka Formation conformably and transitionally overlies Subunit C of the Carlo Sandstone (Draper, 1977), and is overlain in a similar manner by

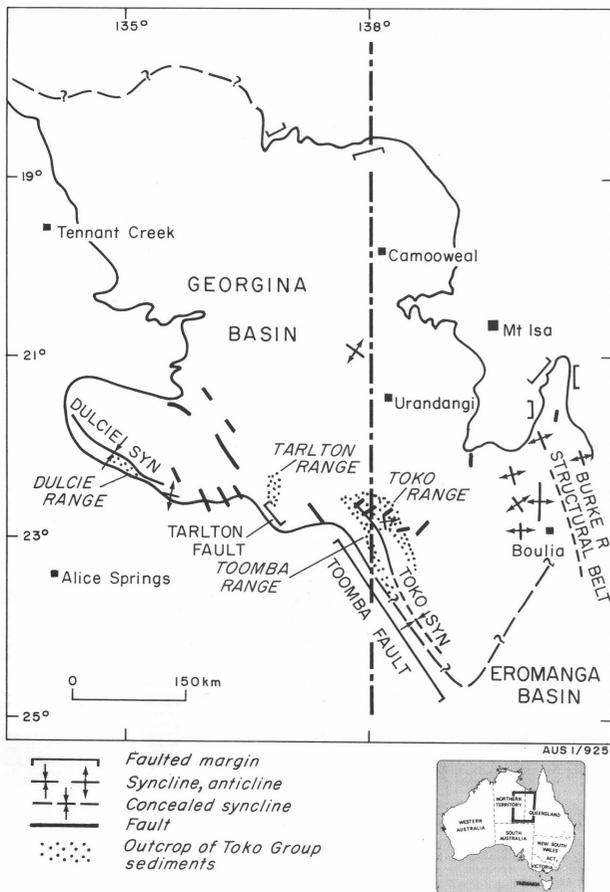


Figure 1. Locality, general geography and general structure of the Georgina Basin; and distribution of the Toko Group.

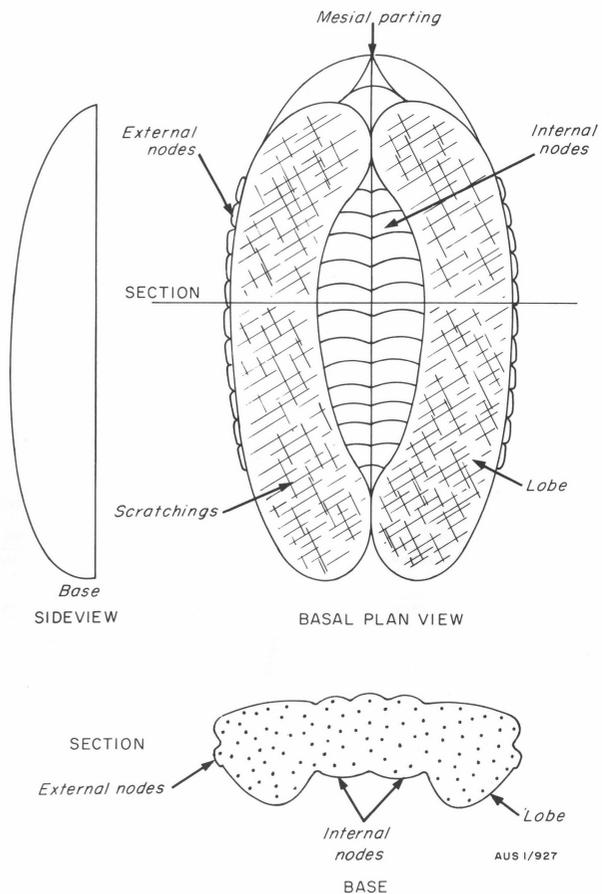


Figure 2. Major features of *Rusophycus* in the Mithaka Formation. Nomenclature modified from Osgood (1970).

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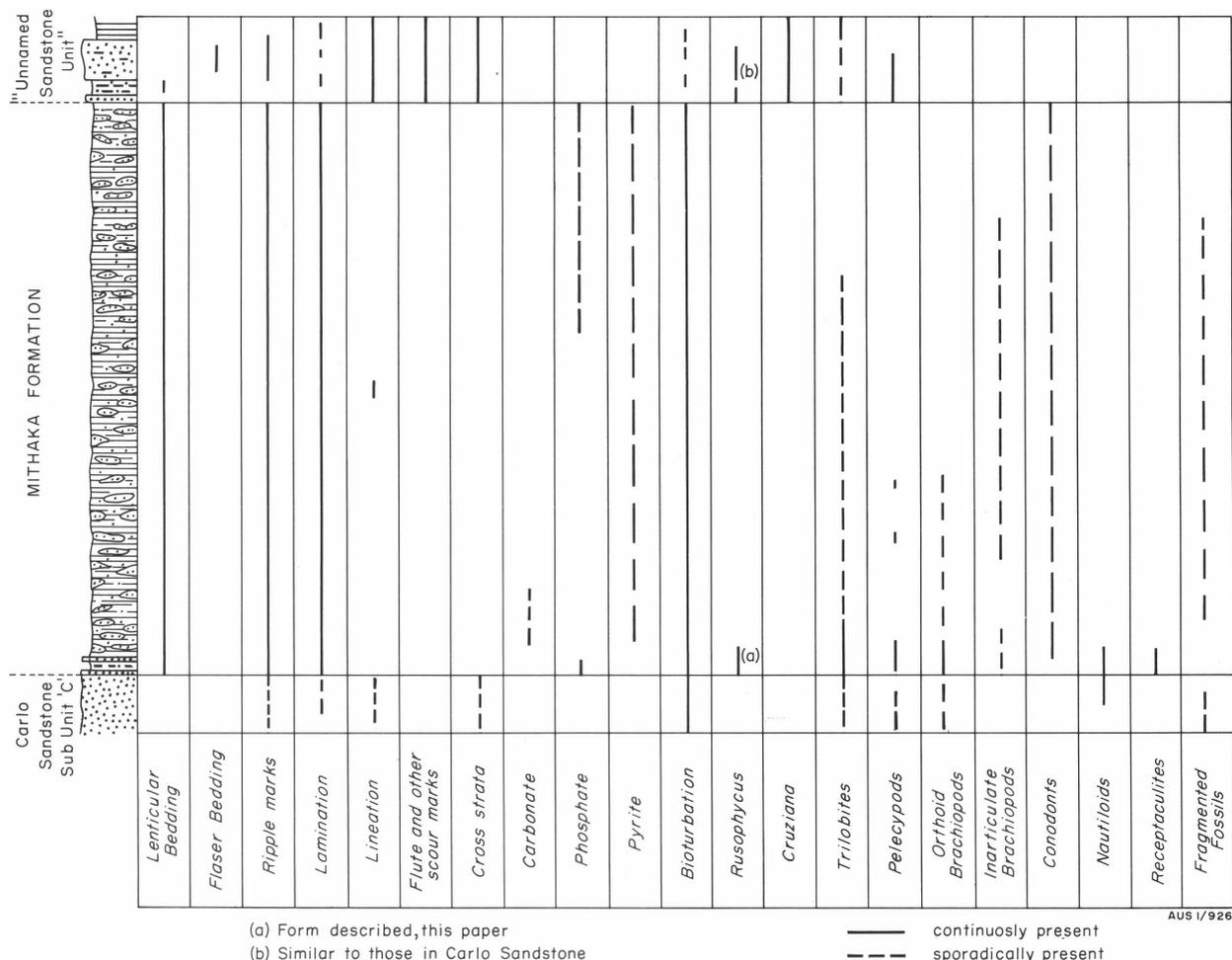


Figure 3. Vertical distribution of various components of the Mithaka Formation.

an 'unnamed sandstone unit' (Shergold & others, 1976). Draper (1977) proposed a barrier-lagoonal model for the Carlo Sandstone and Mithaka Formation, with the Carlo Sandstone representing the barrier and the Mithaka Formation the lagoon. More specifically, the Mithaka Formation was considered to represent shallow bay deposits associated with a wide barrier flat and central bay deposits; the sandy lower portion of the Mithaka Formation representing the shallow bay facies. The formation contains littoral and sublittoral deposits, becoming progressively deeper upwards.

A prolific and diverse fauna is present, particularly in the lower part of the Mithaka Formation, but, to date, none of it has been described, although the trilobites, conodonts, and pelecypods are currently being studied. Large asaphid trilobites (over 30 cm in length), large nautiloid cephalopods, pelecypods, gastropods, articulate and inarticulate brachiopods, bryozoans, sponge spicules, ostracods, *Receptaculites*, and fish remains are present. A chitinozoan, *Desmochitina complanata*, has been identified from this formation in Bedourie Scout Hole (French Petroleum Company,

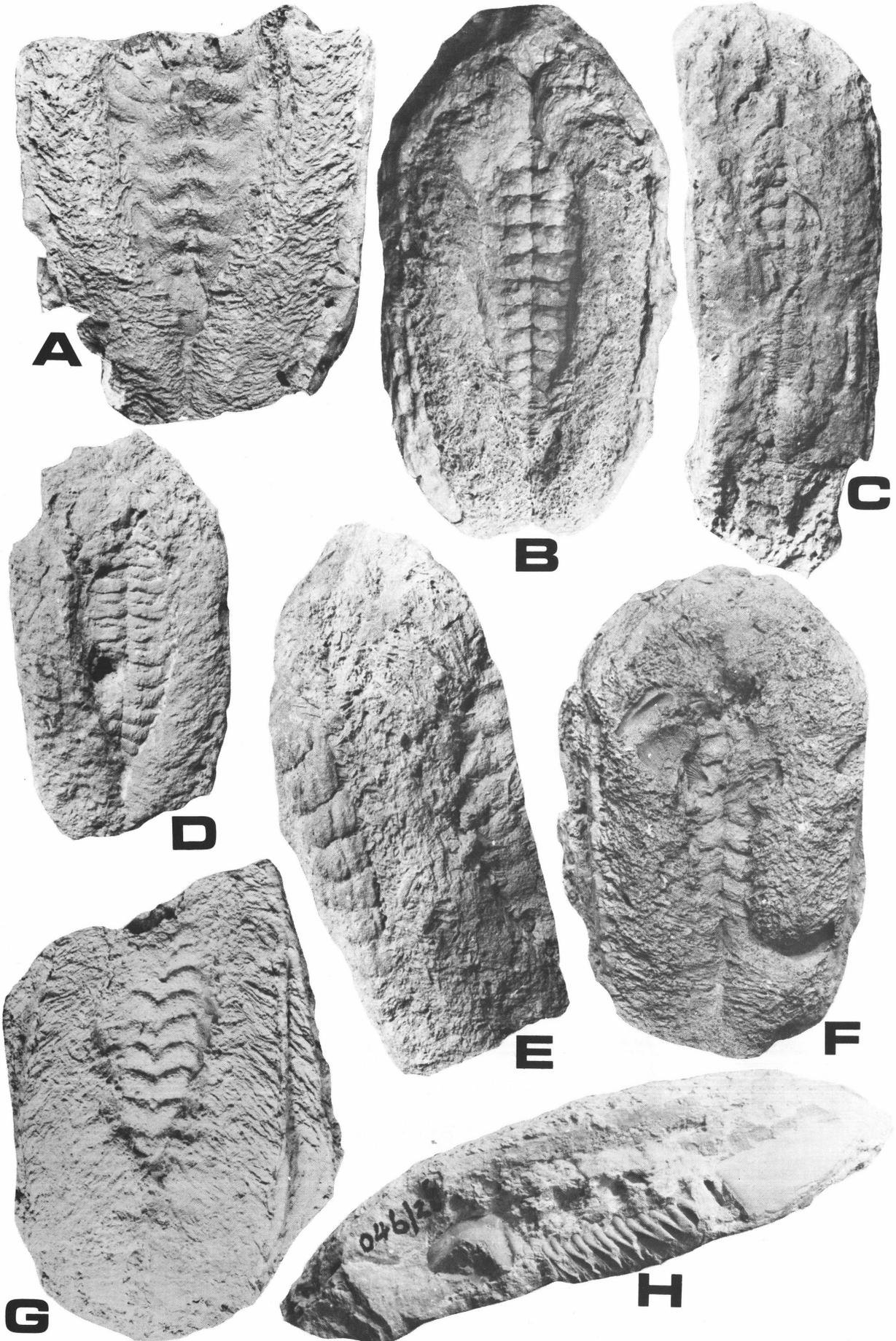
1964). The distribution of some of the fossil groups within the vertical sequence is shown in Figure 3.

Biogenic sedimentary structures are abundant in the lower part of the unit: particularly *Diplocraterion*, *Monocraterion*, *Arenicolites* and numerous irregular burrows (Fig. 5, A-C). Scratch marks are preserved as sole markings. Thin sandstone beds contain numerous surface markings and trails, as well as burrows, including *Chondrites*-like burrows, and the large *Rusophycus*. The upper, lenticular bedded, mudstone-sandstone sequence is bioturbated throughout. Vertical, horizontal and random burrows are present, although the sediment often has a churned appearance.

The *Rusophycus* are generally associated with thinner bedded sandstones, whereas the numerous burrows occur in slightly thicker sandstone beds; but both sandstones are closely related. The types of burrows in the thicker sandstone (Fig. 5) are very similar to those described from the intertidal zone of the Wash in England (Evans, 1965). The biogenic sedimentary structures of this interval in the Mithaka Formation fit within the *Glossifungites* and *Skolithos* facies of

Figure 4.

A. *Rusophycus* with internal nodes and possibly proximal portion of articulated walking leg. Scratches well developed on lobes, x0.5, CPC 19794; **B.** Complete *Rusophycus* showing internal and external nodes, scratches on lobes and striae on external nodes, x0.3, CPC 19795; **C.** Cruziform trace which passes into more definite *Rusophycus*, x0.2, CPC 19796; **D.** Complete *Rusophycus*, weathered surface, x0.3, CPC 19797; **E.** Partial *Rusophycus*, showing internal and external nodes, and scratches on lobe, x0.4, CPC 19798; **F.** Complete *Rusophycus*, internal nodes and lobe well developed, x0.4, CPC 19799; **G.** Partial *Rusophycus* showing well developed internal nodes and scratches on lobes. Portion of earlier *Rusophycus* visible on edge, x0.3, CPC 19800; **H.** Side view of asaphid trilobite and of *Rusophycus*. The trilobite is lying on its back with respect to correct orientation of trace, x0.4, CPC 19801.



Seilacher (1964), and as such are considered to represent littoral environments. The *Rusophycus* would normally be considered to belong to the *Cruziana* Facies (Seilacher, 1964) and hence to represent shallow subtidal deposition. The presence of thinner sandstone beds, pelletal phosphates and the fact that the traces were formed in mud would seem to support this. The *Rusophycus* probably formed in very shallow water marginal to wide intertidal barrier flats, inside a sand barrier.

Description of *Rusophycus*

The *Rusophycus* is a large, bilobate resting trace, which separates mesially to reveal two longitudinal series of nodes (Figs. 2, 4, 5). *Rusophycus* is normally attributed to trilobites (Bergström, 1973), but rarely is the trace-forming trilobite found associated with the trace. In the Mithaka Formation, however, a trilobite of suitable size and shape is found associated with the traces. The large asaphid trilobite (Fig. 4H) is currently being studied by Dr J. H. Shergold (BMR) and Dr R. A. Fortey (British Museum of Natural History), as part of a study of Ordovician trilobites of the Georgina Basin. Osgood (1970) considered *Isotellus* sp., a form similar to those in the Mithaka Formation, to be the trilobite responsible for *Rusophycus carleyi*.

Seilacher (1970, p. 474 & fig. 2) included a rusiform *Cruziana* (*Cruziana dilatata*) from the Toko Group

with the *Carleyi* Group of his *Cruziana* ichnogenus. Although some forms from the Mithaka Formation are similar to *C. dilatata*, most resemble *C. carleyi* more closely; however, intermediate forms are present. All traces appear to have been made by similar trilobites, and differences therefore appear to reflect sedimentological factors.

The traces are preserved as sandstone casts, and are, in effect, sole markings. Considerable variations exist between traces, but the essential features are as shown in Figure 2. The plan shape is nearly elliptical, but tends to be thinner towards the posterior end. Overall the *Rusophycus* are approximately twice as long as wide and may be up to 10 cm in depth. The largest complete samples are 31 cm in length, but several incomplete specimens have extrapolated lengths which exceed that by 5 cm or more.

The lobes may or may not be separated at each end, and are covered in a series of fine ridges—which may be random and chaotic, or show a preferred angle of orientation. On the outer lateral portions of the lobes are a series of striated nodes (external nodes) which may number up to 11; but these are present in only a few specimens. In most examples the internal nodes are clearly visible, numbering 9 to 11 in complete samples.

The internal nodes are the impressions of coxae or coxal gnathoblastic extensions of the walking leg (Osgood, 1970). The external nodes preserved on the

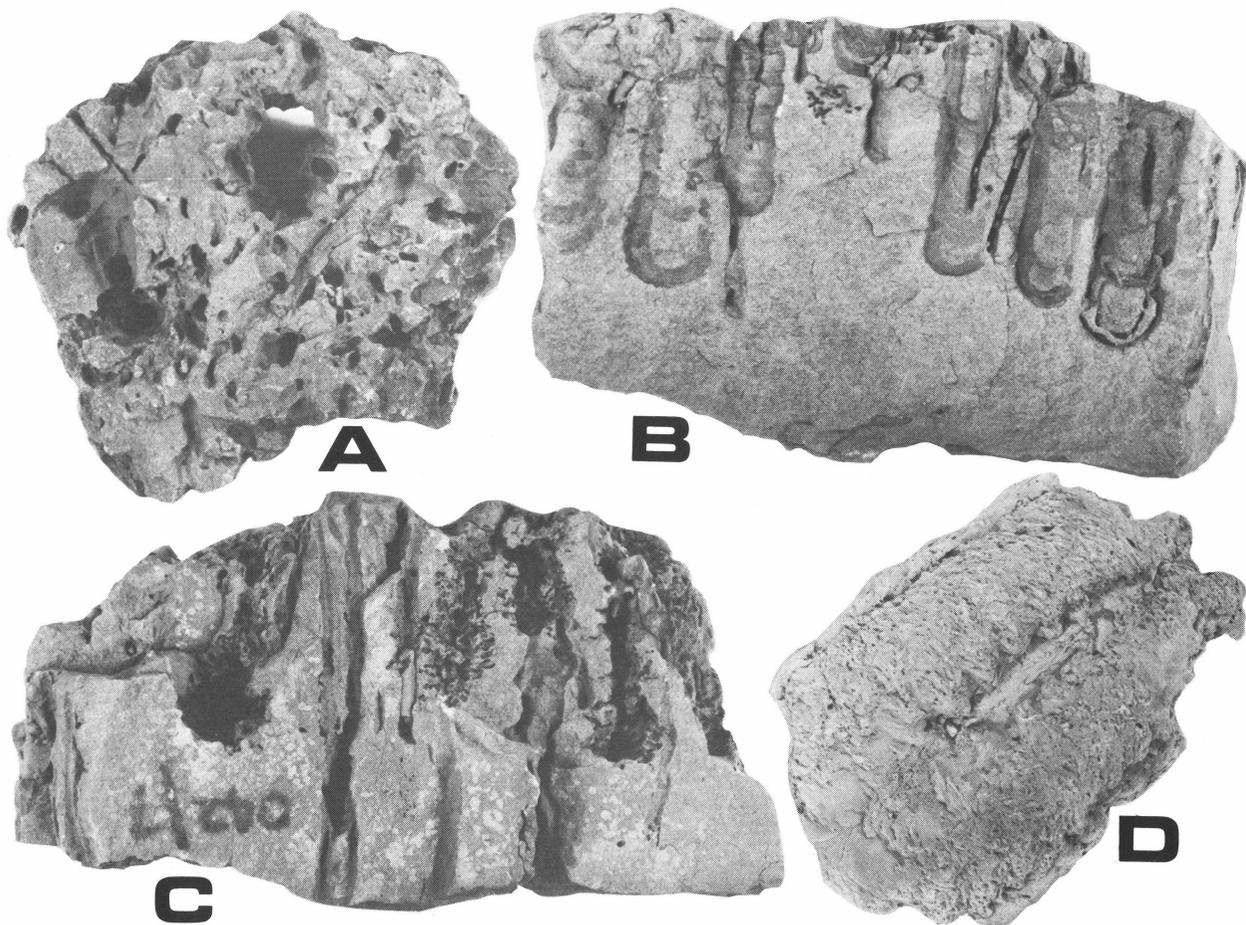


Figure 5.

A. View of upper surface of rock showing numerous burrows, lower Mithaka Formation, x0.5, CPC 19802; B. U-shaped burrows, lower Mithaka Formation, x0.5, CPC 19803; C. Irregular burrows, lower Mithaka Formation, x0.4, CPC 19804; D. Poorly developed *Rusophycus*, x0.4, CPC 19805.

perimeter of the trace probably result from movement of the distal portion of the walking legs, the striae being formed by small claws at the extremity of the walking legs. Osgood (1970) suggested that the trace may have been excavated by a broad sweeping motion of the appendages in manner similar to a swimmer doing the breaststroke. The length of the external nodes indicate limited movement of the walking legs; this, and the presence of the numerous scratches, indicate that the major excavating tool was the pre-epipodite, which is the outer and upper branch of the biramous post-antennal appendages, the walking legs (or endopodites) forming the lower inner branch. The scratches on the lobe would be formed by gill filaments on the pre-epipodite.

A backward and forward motion of the pre-epipodite could form the lobes by turbulent water flow, by direct digging, or, most likely, a combination of these processes. The gill filaments were probably comb-like and stiff.

Variations in the traces are related to a number of factors. Crimes (1975) suggested that there are three stages in the preservation of trilobite traces: production of the trace; preservation between the time of formation and deposition of casting sand; and preservation during the casting process. A fourth factor should be added to these three, namely, that the trace must survive diagenetic, deformational and weathering processes. Trace formation is dependent on the nature of the underlying sediments and the behaviour of the trace-forming animal. The animal may excavate to varying depths and may also excavate at various speeds; these factors influence the shape and morphology of the trace. The preservation of the trace prior to casting depends not only on the nature of the sediment, but also on the manner in which the trilobite leaves the trace—the mode of departure from the trace gives it its final form. The preservation during casting depends on the nature of sediment in which the trace formed, the velocity of the depositing current, and the grain size of the casting medium. The sediment in which the traces formed is not preserved in outcrop, but the casting medium varies from very fine or fine sand to sandy pelletal phosphorite, or fine sands containing ironstone ooids. The traces from the Mithaka Formation have not undergone excessive diagenetic and deformational process, but do show varying degrees of weathering.

The purpose of the traces is not altogether clear, but Bergström (1973) postulated that the smooth exterior and wide rhachis of asaphids is an adaptation to a burrowing habit. Burrows may be for hunting or feeding purposes, passive resting, or a means of escaping predators.

Acknowledgements

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