

## ADDITIONAL TRACE FOSSILS FROM THE TAL FORMATION (EARLY CAMBRIAN) MUSSOORIE HILLS, UTTAR PRADESH, INDIA.

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**ABSTRACT**

The Tal Formation (Early Cambrian) has yielded well developed and diversified ichnofossil assemblage from the Mussoorie Syncline. The present paper records six additional traces from the Arenaceous Member (*Rusophycus*, *Teichichnus*, *Tal Ichnogenus* 'N', 'O', 'P' and 'Q') and three traces from the Quartzite Member (*Rusophycus*, *Ichnospica* and *Planolites*). A detailed morphological and palaeoecological analysis shows that the community was dominated by worms and arthropods besides a few molluscs.

**INTRODUCTION**

In recent years the Tal Formation has gained significance as its age has been proved to be Lower Cambrian instead of Mesozoic, as suggested earlier (Auden, 1934, Kumar and Dhaundiyal, 1979). In the light of Mesozoic age, Gansser (1964) and Banerjee and Narain (1976) recorded a number of trace fossils from the upper part of the Tal Formation. However, Singh (1979) while proposing a Precambrian-Cambrian model for the Tal Formation, recorded a few burrow structures. Later, Singh and Rai (1983) made a systematic study of its trace fossils and described 37 ichnogenera including some distinct trilobite traces. Kumar et al. (1983) recorded *Taphrhelminthopsis circularis* from the Garhwal Syncline. *Skolithos*, a very common burrow structure of the Tal Formation of Mussoorie Syncline, has been studied in detail by Singh *et al.* (1984).

Bhargava (1984) for the first time described three traces from the Tal Formation of Nigali Dhar Syncline, Himachal Pradesh.

A search for more trace fossils was conducted in the Mussoorie Syncline, where the Tal sediments are best developed (Fig. 1). A number of additional trace fossils were found which are described in this paper. These include 6 trace fossils from the Arenaceous Member and 3 from the Quartzite Member.

**GEOLOGICAL SETTING**

The Krol Belt extends from near Solan upto Nainital and constitutes the southern part of the Lesser Himalaya. Tal sediments are laterally developed in its middle part i.e. Nigali Dhar, Mussoorie and Garhwal Synclines. The Tal Formation, the youngest lithounit of the Krol Belt, has been subdivided into five units on the basis of lithology. The lithostratigraphic classification, followed in this paper is based on Shanker (1975) with modifications proposed by Singh (1979a Table-1).

Table 1. Lithostratigraphy of Tal Formation

Shanker (1975)	Singh (1979a)
Limestone Member	Nilkanth Formation
	----- Unconformity -----
Quartzite Member	Quartzite Member
----- Unconformity -----	
Calcareous Member	Calcareous Member
Arenaceous member	Arenaceous member
Argillaceous Member	Argillaceous Member
Chert Member	Chert Member
Krol Formation	Krol Formation

**TRACE FOSSIL IN ARENACEOUS MEMBER**

The top 30 m of the Arenaceous Member (Fig.2) reflects deposition in extensive mixed flats and sand flats of a shallow tidal sea under moderate energy conditions with occasional phases of subaerial exposure (Singh, 1979; Rai, 1985). Such conditions are well

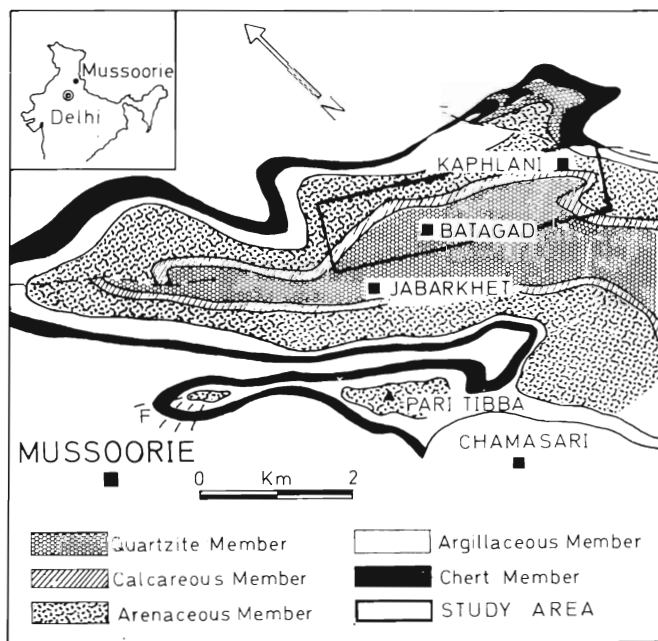


Fig. 1. Generalized geological map of Mussoorie area showing the trace fossil localities on Mussoorie-Dhanaulti road. Map modified after, Shanker (1975).

suitied for the inhabitation of macrobenthos. The traces, thus produced are well preserved due to presence of contrasting lithologies of shale/siltstone. Detailed descriptions of these trace fossils are given below, out of which four has been given informal names. These

informal names are in continuation with Singh and Rai's (1983) nomenclature of the Tal trace fossils.

All the specimens illustrated and described in the paper are deposited with the Geology Department, Lucknow University, Lucknow.

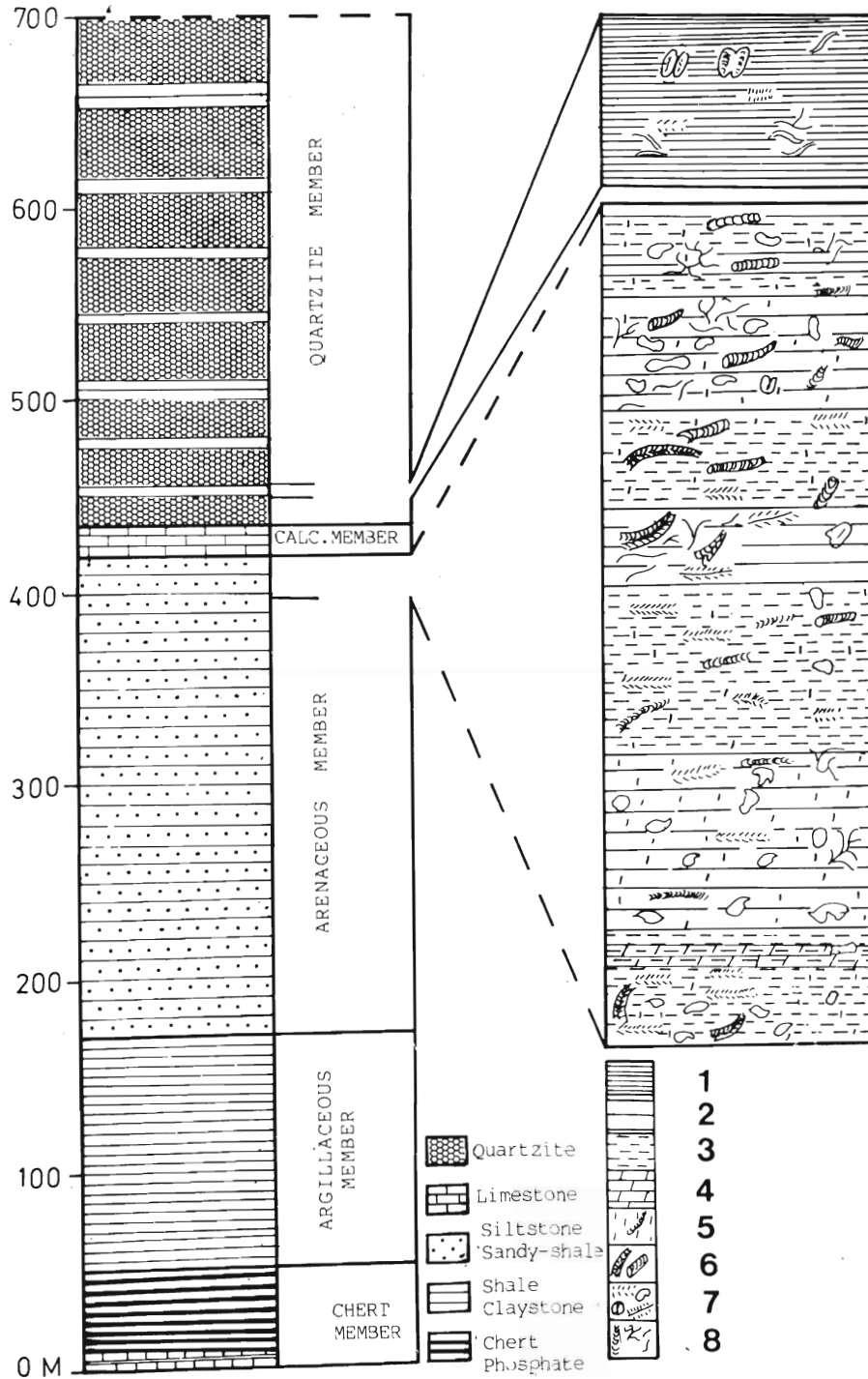


Fig. 2. Litholog between Masrana and Batagad on the Mussoorie-Dhanaulti road. The trace fossil bearing horizons are enlarged. 1-Red/Green shales, 2-Red siltstone, 3-Green siltstone, 4-Calcareous sandstone, 5-Skolithos and vertical burrows, 6-Aulichnites, tunnels and other horizontal traces, 7-Tracks, trails and resting traces, 8-Spreite structures, Halopoa and other surfacial traces.

SYSTEMATIC DESCRIPTION

*Rusophycus* HALL 1852  
(Plate I—3)

These are short bilobate, buckle like forms, resembling to the shapes of coffee beans, are elliptical in outline, with a number of faint striations on the two lobes. The width of the trace is 1.0 cm and depth 0.5 cm. These were possibly made by trilobites/ or other arthropods for resting purposes. The present trace is preserved both in the form of epichnial groove and hypichnial ridge.

Remarks: A number of *Skolithos* burrows are associated with it

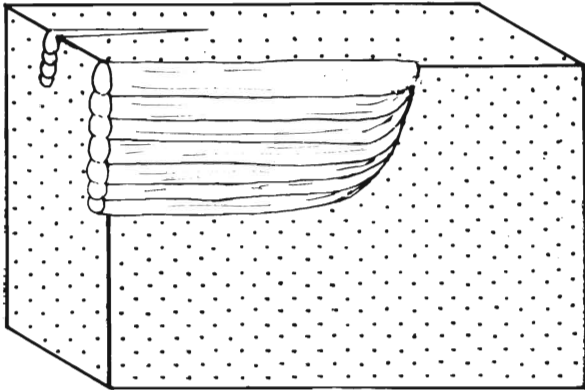


Fig. 3. Diagrammatic representation of *Teichichnus* burrow.

*Teichichnus* SEILACHER 1955  
(Plate I — 5)

This is a tube shaped laminar body which is straight or curved and non-branching. It consists of a series of gutter-shaped horizontal backfill laminae, which are stacked vertical to the bedding. The Tal specimen is 6.0 cm in length and 1.0 cm in height and has the typical internal structure. It is considered to be the feeding structure of some annelid (Fig.3).

Remarks: *Teichichnus* of the Arenaceous Member is associated with *Skolithos*.

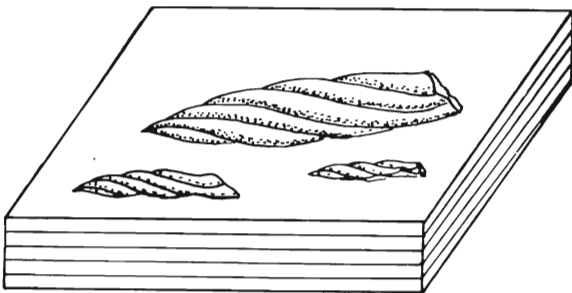


Fig. 4. Schematic diagram of *Tal-Ichnogenus* 'N'.

*Tal-Ichnogenus* N (Twisted grooves)  
(Plate I — 1)

These are horizontal burrows, the outer wall of which shows very distinct twisted grooves. The internal

structure can be seen from a few broken parts of the burrow, which shows active back filling. The length of the burrow is 0.5 – 2.5 cm and are 0.2 – 0.3 cm in diameter. In one such sample, three burrows are clearly seen. These structures are preserved as epichnial ridges. The trace seems to be a feeding structure of a worm (Fig.4)

Remarks: *Tal-Ichnogenus* N is associated with *Skolithos*.

*Tal-Ichnogenus* O (Elongated sack structures)  
(Plate I — 2)

These are elongated to gently curved, sack like structures showing a rounded broad end and the other narrow tapering end. They are haphazardly oriented. The faint transverse ornamentation on the surface is visible. The maximum length of the trace is 2.0 – 3.5 cm, whereas the width and height is 0.5 cm. The trace occur in the form of epichnial ridge. It seems to be a feeding structure of a worm-like organism.

Remarks: The sample of the Arenaceous Member is similar to *Volkichnium* where 5 or 6 such sack like bodies are arranged in radiating pattern.

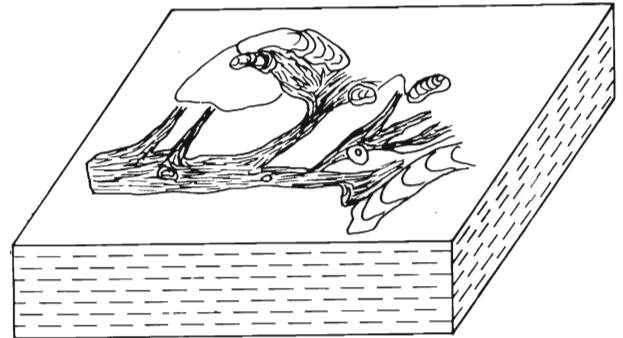


Fig. 5. Schematic diagram of *Tal-Ichnogenus* 'P'. The spreite structure is clearly visible.

*Tal-Ichnogenus* P (Branching planar burrow)  
(Plate I — 8)

This burrow system has a main burrow with a number of branches (planar small burrows) emerging from it. The meniscoid internal structure indicates active back filling. The whole burrow system is 8.0 cm long and 5.0 cm wide. It occurs as epichnial ridges or in full relief. The trace appears to be a feeding/dwelling structure of some animal of complex habit, probably worms (Fig.5)

Remarks: The structure is associated with *Monocraterion*, *Skolithos*, *Planolites* and *Chondrites*. It is similar to *Halopoa* and *Chondrites* in filling character.

*Tal Ichnogenus* Q (Slipper like burrow)  
(Plate I — 4)

*Tal Ichnogenus* is a gently curved slipper-like endichnial burrow, whose outer wall is made up of fine grained material while the infilled material is coarser. The smaller end is 0.35 cm and the broader end 1.0

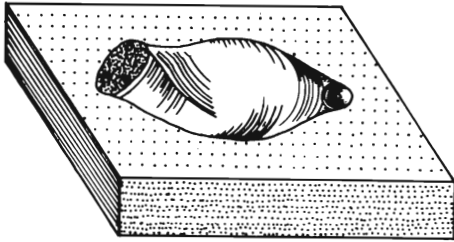


Fig. 6. Schematic diagram of *Tal-Ichnogenus* 'Q'

cm in diameter. There is a bulge in the middle part of the burrow. The trace can be a feeding or dwelling structure of some mollusc (Fig. 6). The dwelling habit is reconstructed in Fig. 7.

*Remarks:* The trace is associated with *Skolithos* and *Halopoa*.

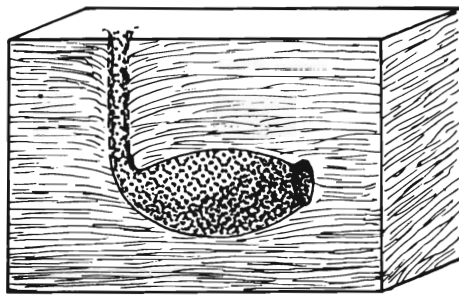


Fig. 7. Diagrammatic representation of *Tal-Ichnogenus* 'Q', showing the possible dwelling character.

Table 2. List of additional ichnofossils with their ethological and biological interpretation (In continuation to Singh and Rai, 1983)

S. INCHNOGENUS No	HABIT	PROBABLE TRACE MAKER
1. <i>Rusophycus</i>	Resting	Arthropod
2. <i>Teichichnus</i>	Feeding	Worm
3. <i>Tal-Ichnogenus-N</i>	Feeding	Worm
4. <i>Tal-Ichnogenus-O</i>	Feeding	Worm
5. <i>Tal-Ichnogenus-P</i>	Dwelling	Worm
6. <i>Tal-Ichnogenus-Q</i>	Feeding	Mollusc

#### ICHNOCOENOSIS OF ARENACEOUS MEMBER

The presence of such a diversified assemblage of trace fossils (along with the ones described by Singh and Rai, 1983), indicate a varied macrobenthonic community inhabiting on these tidal flats. The total 43 trace fossils so far recorded from the upper part of the Arenaceous Member show four groups of animals which were responsible for making these traces viz. worms, arthropods, molluscs and coelenterates.

With the help of the available data of Singh and Rai (1983), a concise picture of ichnocoenosis of the Arenaceous Member is formulated in Table 3.

The table shows that worms and arthropods dominated the animal community, along with ample number of molluscs and a few coelenterates. The relative abundance of communities is comparable to the Lower

Table 3.

Probable Animal	Feeding	Crawling	Dwelling	Resting	Grazing	Total
Worms	11	1	4	—	1	17
Arthropods	1	8	—	6	2	17
Molluscs	3	4	—	—	1	8
Coelenterates	—	—	1	—	—	1
Total	15	13	5	6	4	43

Cambrian ichnocoenosis of Spain (Crimes *et al.* 1977).

#### TRACE FOSSILS IN QUARTZITE MEMBER

The lower part of the Quartzite Member is well exposed on the Mussoorie — Dhanaulti road section (Fig. 1). Lithologically, it consists of medium to coarse grained, white to grey quartzites with minor amounts of olive green/purple shales. Green, flattened mud pebbles are occasionally seen along the bedding planes of quartzites. At places a few gritty horizons are also present.

These thickly bedded quartzite horizons show parallel bedding, planar cross bedding and thin bands of small ripple bedding indicating moderate to strong current action (Singh and Rai, 1983; Rai, 1985).

The trace fossils of the Quartzite Member are preserved at the interface of sand/shale layers while none are found in pure sand and in pure shale. These traces are recorded for the first time from the Quartzite Member of the Mussoorie Syncline. However, Bhargava (1984) described three traces (viz. *Palaeophycus*, *Skolithos* and trilobite trace '?Cruziana') from the Quartzite Member of the Nigali Dhar Syncline.

#### SYSTEMATIC DESCRIPTION

##### *Ichnospica* LINCK 1949 (Plate I — 7)

This is a double track, each composed of numerous 'teeth', which are straight and ends are very sharp. Both the rows are parallel and are 1.0 cm wide. Each mark is 0.4 cm wide. The height of these marks is 0.1 cm. The track is preserved as hypichnial ridge. The track could be made by the locomotion of some arthropod (? trilobite) which indicates the crawling habit of the animal.

*Remarks:* *Ichnospica* is associated with *Planolites*.

##### *Planolites* NICHOLSON 1873 (Plate I — 6)

These are straight, unbranched, horizontal, cylindrical burrows. The thickness of these traces is constant throughout. Burrows do not cross each other, but pass over or under previously formed burrows. The *Planolites* of the Quartzite Member are 0.3 - 0.5 cm in diameter and 2.0 - 4.0 cm in length and occur as hypichnial

relief form. It is a burrow made by feeding worms. A few burrows show faint spreite like structure.

*Remarks:* Often these are associated with *Rusophycus* or *Ichnospica*. The *Planolites* of the Quartzite Member is larger in size than that of the Arenaceous Member.

*Rusophycus* HALL 1852  
(Plate I — 9)

It is a pair of ridges with a depression in between. The sample of the Quartzite Member is 6.0 cm long and 5.0 cm wide. A number of transverse ridges occur on the lobes. The maximum height of the lobe is 1.0 cm and the width of the small transverse ridge varies between 0.2 - 0.4 cm. They occur as hypichnial ridges. The probable trace maker is some arthropod (possibly trilobite) with strong appendages. The animal used to dig the sediments for resting purposes.

*Remarks:* The *Rusophycus* of the Quartzite Member is associated with *Planolites* and is larger in size than that of the Arenaceous Member.

Table 4. List of ichnofossils with their biological and ethological interpretations.

S.No.	Ichnogenus	Habit	Probable Trace Maker
1.	<i>Ichnospica</i>	Crawling	Arthropod
2.	<i>Planolites</i>	Feeding	Worm
3.	<i>Rusophycus</i>	Resting	Arthropod

So far only these three types of trace fossils are recorded from the Quartzite Member of the Tal Formation in the Mussoorie Syncline (Table 4). Thick sand/quartzite units within this Member shows unsuitable lithology for the preservation of the living activity of the animal community. The scarcity of trace fossils probably demonstrates the preservational control of lithology. It is noted that the trace fossils of the Quartzite Member are larger in size than those of the Arenaceous Member. On the basis of scarce occurrence of only three trace fossils, nothing concretely could be said about the ichnoecoenosis of the Quartzite Member

#### DISCUSSION AND CONCLUSIONS

1. The trace fossils of the Tal Formation are so far recorded from the Arenaceous Member and the Quartzite Member only.
2. The nine trace fossils which are discussed in this paper are in addition to already recorded traces from the Tal Formation (Singh and Rai, 1983).
3. The upper part of the Arenaceous Member has so far yielded 43 ichnogenera whereas the Quartzite Member has yielded 3 ichnogenera.
4. The above distribution pattern may probably be related to better substrate conditions for living and better preservational lithology. The traces occur

profusely in fine sand — silty sediments, showing sand/shale alternations, representing deposits of medium energy. They are rare to absent in pure shales (low energy deposits) or pure quartzites (very high energy deposits).

5. The above trace fossil assemblage demonstrates that the macrobenthonic community was dominated by worms, arthropods, molluscs and a few coelenterates.
6. The general size of the trace fossils of the Quartzite Member is larger than that of the Arenaceous Member. The reason may be related to grain size or larger size of the inhabiting organisms.
7. Despite the fact that the trace fossils are poor index fossils because of their long ranging time span, a few like *Rusophycus*, *Cruziana*, *Skolithos*, *Plagiogmus*, *Diplichnites* etc. are indicative of Early Cambrian times (Glaessner, 1984). The said assemblage is also recorded from the Tal Formation.

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## EXPLANATION OF PLATE

## PLATE I

1. Photograph showing *Tal-Ichnogenus* 'N' (indicated by arrows). Length of the scale = 1 cm.
2. Bedding surface showing *Tal-Ichnogenus* 'O' Five to six elongated sack like structure showing active filling. Horizontal dark smooth lines are scratches on the negative of the Photograph. 1 div. of the scale = 1 cm.
3. Photograph showing *Rusophycus*, preserved as hypichnial ridge. Length of the scale = 1 cm.
4. *Tal-Ichnogenus* 'Q' showing curved slipper like burrow, occurring in endichnial form. Both the smaller end (on the left) and the broader end (on the right) with a bulge in between are seen in the sample. Length of the scale = 1 cm.
5. Vertical section of *Teichichnus* showing spreite structure (concave upwards). Length of the scale = 0.5 cm. Photograph retouched.
6. *Planolites* occurring as hypichnial ridge on the underside of the quartzite. Overlapping and active filling (indicated by arrow) of the burrow is clearly seen in the sample. Length of the scale = 1 cm.
7. Comb like grooves (indicated by an arrow) of *Ichnospica* occurring in a hypichnial ridge form, on the under side of the quartzite bedding. Length of the scale = 1 cm.
8. Photograph showing *Tal-Ichnogenus* 'P', Main burrow system (indicated by arrow) with a number of branches emerging from it. The trace is also burrowed by *Skolithos*. Length of the scale = 1 cm.
9. *Rusophycus* occurring on the underside of the quartzite, showing two broad ridges with an inbetween groove. 1 div. of the scale = 1 cm.

