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DISCOVERY OF TRACE FOSSILS FROM THE TONS VALLEY SECTION OF DHARAGAD GROUP (?MESOPROTEROZOIC), INNER SEDIMENTARY BELT, LESSER HIMALAYA, INDIA

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ABSTRACT

Tracefossil discovery is being made from a siliciclastic sequence, which is interbedded with the Dharagad Group of Inner Sedimentary Belt of the Lesser Himalaya. The report carries significance as major modifications need to be made to the stratigraphy to accommodate these discoveries. The ichno-assemblage includes *Skolithos*, *? Fucusopsis*, a tri-radially symmetrical impression and three indeterminate forms. A ?brachiopod / bivalve impression was also found. The assemblage indicates a late Vendian to early Cambrian age for the horizon yielding trace fossils. A possible geological evolution of the area is also presented.

INTRODUCTION

Biostratigraphy is a tool used in establishing a geological sequence. The significance of this tool is enhanced if we are dealing with the Proterozoic, that too in a structurally complex terrain, such as the Himalayas. Therefore, any record which drastically influences the age of a Proterozoic sedimentary sequence and, in the process, shatters a monolithic stratigraphic framework, needs critical examination. In effect, it influences the overall evolutionary history of the Himalayas.

The study was carried out in the Chakrata area at the Uttar Pradesh - Himachal Pradesh border where the Tons river meanders through its deep gorge between Tiuni and Kalsi. The road that connects the Chakrata township with Tiuni at an altitude of over 2000 m wraps around the steep slopes of the Deoban Group and after crossing two streamlets viz. Benal Gad and Kailana Gad, reaches Dharagad village. The Dharagad Group has been named after this scenic village. The sequence of rocks exposed in the vicinity of the type area include bedded siliciclastics such as shales, siltstones, micaceous sandstones and orthoquartzites with few interlayered basic rocks. These basic rocks occur either in a sill like manner (contemporaneous with siliciclastics) or constitute massive bed forms.

On a regional scale, the geology of the Lesser Himalaya has been configured into two belts, the outer sedimentary belt which occurs in the south and the inner sedimentary belt which occurs in the north (Bhargava, 1972). The Lesser Himalaya is bounded by two tectonic planes, the Main Boundary Fault (MBF) in the south and the Main Central Thrust (MCT) in the north. The outer sedimentary belt includes the Krol Belt and the inner sedimentary belt includes the Shali, the Larji, the Deoban and the Garhwal Belts in the Himachal - Garhwal - Kumaon areas. The inner belt is being considered to be older in comparison to the outer belt and both the belts constitute thick sequences of unmetamorphosed sedimentaries. The established lithostratigraphic framework for these belts (Chittora and Kacker, 1991) is given in table 1.

In the Deoban-Chakrata area, a thick carbonate suite of rocks of the Deoban Group are considered to belong to Lower to Middle Riphean on the basis of stromatolites (Valdiya,1969) and microbiotic assemblages (Kumar and Singh, 1979; Shukla *et al.*, 1987 and Kumar and Srivastava, 1992) from the bedded cherts. These biotic assemblages were quite comparable with other well established Proterozoic sequences of China, Australia, Russia and Canada. A tentative age assignment of about 1000 Ma for the sequence is considered appropriate as the coeval Jammu limestone has given an isotopic model age of 976 Ma for the syngenetic galena (Raha *et al.*, 1978).

In the established stratigraphic set-up, the Deoban Group is considered to overlie the Dharagad Group and underlie the Chakrata-Morar Group (Srikantia and Bhargava, 1974). On a regional correlation, the Dharagad Group was correlated with the Sundernagar Group, the Naraul Group and the Rameshwar Formation of Shali, Larji and Garhwal Belts respectively (Chittora and Kacker, 1991). This correlation was mainly based on lithological similarities, as no biostratigraphically crucial entities such as stromatolites, fossils or trace-fossils were recorded from these sequences. Since, in all of these belts, the contact of various groups was tectonic and / or unconformable with the underlying or overlying sequences, the true nature of order of superposition was never understood completely and correlation based only on lithological grounds was considered to be final.

The Dharagad Group, which has been considered to be 900 Ma to 1600 Ma in age (Srivastava and Mathur, 1996) has presently yielded well preserved trace fossils from its several layers which are exposed near its type area at Dharagad (Rai *et al.*, 1996). The present record of trace fossils from the horizons of the Dharagad Group

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Table 1. Lithostratigraphic correlation chart of the (Inner Sedimentary Belt) Shali, Larji, Deoban and Garhwal Belts (after Chittora and Kacker, 1991).

Shali Belt	Larji Belt	Deoban Belt	Garhwal Belt
Basantpur Formation		Mandhali Formation	
——— unnconformity ——		--------unnconformity-------	
	Manikaran Quartzite		Berinag Formation (257m)
	Ram- pur Group: Green Bed		Kanalichina Formation (1248m)
	Bhalan Formation		
	——————— fault ———————		
Bandla Formation (250m)	Aut Formation (455m)	Khadamba Formation (662m)	
Shali Group: Parnali Formation (608m)	Larji Group: Hurla Formation (155m)	Deoban Group: Bajamara Formation (3223m)	Garhwal Group: Pithoragarh Formation (2960 m)
Makri Formation (140 m)		Bajrikhan Formation (300 m)	
Tattapani Formation (630 m)			
Sorgharwari Formation (390m)			
Khatpul Formation (250m)			
KhairaFormation (390m)			
Ropri Formation (77m)			
——— unnconformity ———	—— unnconformity ———	——— unnconformity ——	
Sundarnagar Group (1830m) with volcanics	Naraul Group (2670m) with volcanics	Dharagad Group (3599m) with volcanics	Rameshwar Formation (3913m)
—— Base not exposed ———	—— Base not exposed ——	— Base not exposed ———	—— Base not exposed ——

pushes up the age of the trace-fossil yielding horizons near the terminal Vendian to early Cambrian.

In recent years, emphasis has been laid on the various evolutionary events amongst the organic community during the later phases of Proterozoic. The Riphean period is considered to be dominated by stromatolite community, the Vendian Period showed the acme of Ediacaran life and the end of the Proterozoic which coincides with the beginning of Cambrian, is marked by the first diversified small shelly fossils, archaeocyathids and well developed trace-fossil assemblages (Crimes, 1994; Fedonkin, 1990). The Vendian trace fossils are mainly grazing surface trails with characteristic absence of vertical burrows such as *Skolithos*. In fact, the Precambrian-Cambrian boundary stratotype in Newfoundland is based on the occurrence of *Phycodes pedum*, where its first occurrence marks the beginning of the Cambrian.

The Proterozoic sequences around the world have been searched for trace-fossils since a long time. The pre-Vendian time-span is believed to be devoid of trace fossils, possibly due to the absence of trace producing animal phyla which might not have yet evolved (Fedonkin and Runnegar, 1992). The only convincing traces which come from about a billion year old horizons of USA (Horodyski, 1982) and Australia (Grey and Williams, 1990) are beaded structures on sandstone surfaces. Even these were considered to be made by some mega-algal group (Grey and Williams, 1990).

Although the trace-fossils are not good biostratigraphic markers in the Phanerozoic, they certainly have an edge in the Proterozoic as they indicate the level of development in the organic macro-community. Considering the evolution of trace-fossil producing communities through time specially in the Proterozoic, it is understandable that any occurrence of *Skolithos* and other vertical burrow systems from the so

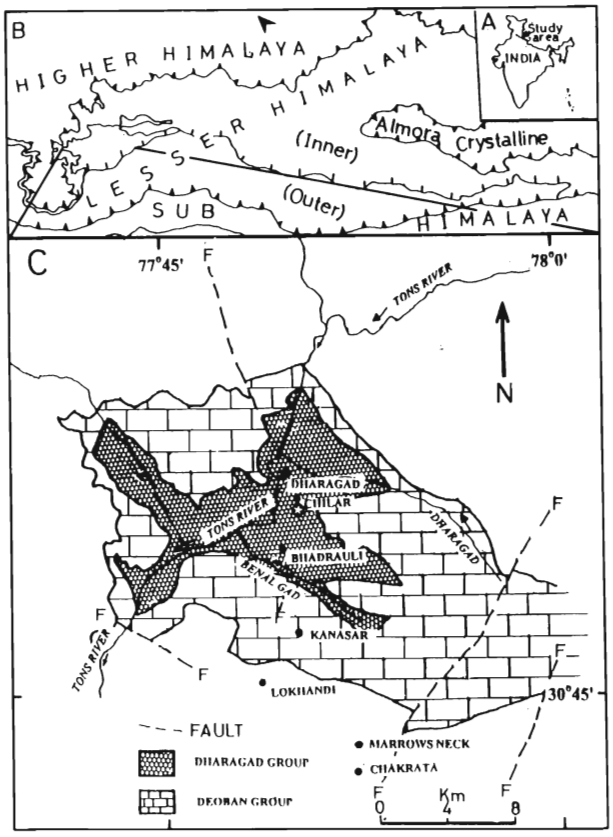

Fig. 1. Locality map of studied area, A. Study area in Himalaya, B. Position of 'Inner' and 'Outer' sedimentary belts of Lesser Himalaya with the geographical extension of the Deoban Belt, C. Generalised geological map of Chakrata area (based on Chittora and Kacker, 1991; Ganesan and Thussu,1978; Ganesan and Verma, 1974; and our own field observation) showing location of the trace fossil yielding horizon (marked by star) near Chilar village.

called Mesoproterozoic succession needs greater attention and scrutiny. Considering this fact, about 100 samples were collected from the field. They were studied rigorously and are described here.

GEOLOGICAL SETTING

The inner sedimentary Belt of the Lesser Himalaya is well exposed in the Himachal, Garhwal and Kumaon regions, striking regionally in a west to east direction. The entire belt is about 280 km long and 30-80 km wide including the crystalline thrust sheet within the sequence. The understanding of the geological setting of the belt is rather complex as several stratigraphical names have been used by different workers for the same succession and also for coeval successions in different areas. The structural complexities have also contributed to the confusion in understanding the geological setting of the region. In fact there are at least three different geological maps for the area (Rupke, 1974; Ganesan and Thussu, 1978; Prashra, 1982). The generalized lithostratigraphic classification of the Tons river area is as follows (Srikantia and Bhargava, 1982) :

Jaunsar Group/ Morar-Chakrata Group

————Unconformable/Tectonic————

Deoban Group

————Unconformable/ Tectonic————

Dharagad Group

The Dharagad Group (fig.1) is considered to be the oldest sedimentary sequence in the area with its lower contact not being exposed (Srikantia, 1977). The rocks of the Dharagad Group constitute mainly coarse siliciclastics with minor shales and siltstones. Occasional presence of basic rocks such as dolerites and basalts in the form of intrusives (sills and dykes) and extrusives (flows) characterize the succession. The depositional environment of the Dharagad Group is mainly in the high energy domain where large scale cross bedding associated with hummocky bedding is prominent. A few micaceous siltstones with ripple laminated horizons and mud-cracked surfaces indicate inter-tidal conditions. The basic flows, sills and dykes may possibly indicate submarine volcanism and later phases of intrusive activity.

The Dharagad succession was considered to be overlain by the carbonate dominated Deoban Group (about 3000 to 4000 m thick). The carbonate beds are 10 to 20 m thick with interbedded shale partings. The carbonates show subtidal to supratidal environments based on carbonate fabrics and stromatolite communities. A well developed stromatolite assemblage indicates a Lower Riphean to Upper Riphean age (Valdiya, 1969; Prashra, 1977; Tewari, 1993) for the sequence which is well corroborated by the organic walled microfossils from the bedded black cherts (Kumar and Srivastava, 1992; Shukla *et al.*, 1987).

AREA OF STUDY

The study area for the present paper deals with the succession exposed on Chakrata - Tiuni motor road, near the Chilar village (Lat. 30° 51' 30'' N and Long. 77° 50' 0'' E) between the milestones 2 and 1 km towards Chilar. The beds dip 35° towards N 40° E direction. The lithocolumn of the measured succession is given in the litholog (Fig. 2).

DESCRIPTION OF TRACE FOSSILS

Skolithos Haldeman 1840

(Pl.I, figs. 2,5,6; Pl.II, figs. 2,3,4,5,6; Pl.III, figs. 1,3,6)

Description: Vertical to inclined, cylindrical burrows which are unbranched and 1-15 mm wide. These burrows are usually straight with circular to elliptical cross-

section. The burrows occur either isolated or in defined clusters and are rarely crowded. The burrow walls are distinct to indistinct.

Remarks: The Dharagad sequence which is usually made up of thick, coarse to very coarse siliciclastic succession, is dominated by micaceous silty sandstone horizons which show flaser-lenticular bedding, ripple laminated cross bedding with occasional mud cracked surfaces. Abundant *Skolithos* occur in a wide variety of forms, shapes and sizes along with a few other ichnofossils such as ? *Fucusopsis* and other distinct but possibly new forms of traces.

The *Skolithos* tubes are 5-7 cm in length but most of them are at an angle to the bedding plane. Many of these tubes show absolute parallelism (Plate II, fig. 4) along their lengths besides their cross-sections being elliptical, with the larger axis of the ellipse also being parallel. This phenomenon indicates the impact of stresses (shear) which has resulted in the inclined nature of the *Skolithos* (Pl. I, figs. 2,5). However, a few beds show undeformed vertical *Skolithos* tubes as well, which usually occur in more compact unlaminated sandstones.

We have noticed that there is significant variation in size, shape and density of *Skolithos* burrows which can be explained by the occurrence of varied epifaunal community which made these traces. Large, inclined, smooth wall tubes (Pl. I, fig.5), irregular dense clusters (Pl. I, fig. 6), tubes clustered in a linear manner (Pl. II, fig. 2), cluster of four *Skolithos* (Pl. II, fig. 3), cluster of six *Skolithos* surrounding one *Skolithos* tube as nucleus

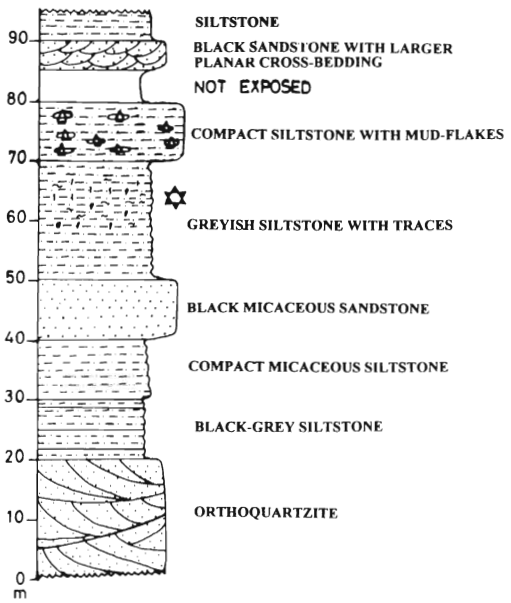

Fig. 2. Lithocolumn of the part of Dharagad Group, exposed near Chilar Village showing the trace-fossil yielding horizons (marked by star).

(Pl. II, fig. 5), overlapping clusters of *Skolithos* (Pl. II, fig. 6) and densely populated *Skolithos* with a central light coloured portion (mica flakes) shows the variation in morphology of the traces.

This *Skolithos* population is closely comparable with "Pipe-rock facies" which is characteristic of the Lower Cambrian deposits (Droser, 1991). In fact the Arenaceous Member of the Tal Formation of the Krol Belt has very close similarity with these *Skolithos* bearing beds.

? *Fucusopsis*
(Pl. III, figs. 1,5)

Description: These are tubular burrows which are occasionally spindle shaped with width varying between 2-7 mm and length 50-60 mm. These are long, straight, sometimes branching with typical thread like sculpture. These are possibly made by infaunal organisms due to their burrowing and/or grazing activity.

Remarks: These can be clearly distinguished from mud cracks or tension faulting due to their typical thread like morphology. The preservation of the specimens is not perfect and therefore the nature of the form is questionable.

Dharagad Ichnogenus 'A'
(Pl.I, fig.4; Pl.II, fig.1)

Description: These are unusual surface markings occurring as epichnial ridges which are circular to oblong to elongated. There is a large variation in size from a few mm to a few cms and occasionally these occur in clusters. These clusters are 1-2 mm in height and are well seen on the freshly split samples.

These are possibly grazing or crawling traces made by some epifaunal animal, possibly occurring in large numbers.

Dharagad Ichnogenus 'B'
(Pl. III, fig.2)

Description: This is a tri-radially symmetrical burrow system where three petal like raised ridges surround a central cavity. Each of the petal is conical at the centre. Strong depressions surround each petal which gives it a unique characteristic. No definitive behavioural aspect of the animal could be ascertained. Each petal is about 6-8 mm long and about 1 mm raised from the surface.

Dharagad Ichnogenus 'C'
(Pl.I, fig.3; Pl. III, fig.1)

Description: Large sized cylindrical tube with circular feeding character and a central raised feature. Subconical shape with a diameter of 10-12 mm, central part

2-4 mm. The burrow is preserved in full relief. The population density of *'Dharagad Ichnogenus C'* is very limited in comparison to *Skolithos*. This burrow is considered to be a dwelling structure of some primitive animal.

Remarks: They can be distinguished clearly from *Skolithos* due to their circularly filled characteristic as well as the shape of the burrow. A closely resembling form with *'Dharagad Ichnogenus C'* is *Cylindrichnus*.

? Brachiopod/ bivalve Impression
(Pl. III, fig. 4)

Description: This is a bedding surface impression with outer elliptical margin but shows concave growth lines within it. It is about 4 mm wide and 26 mm long with unclear margin at the top. The specimen is about 2 mm deep. A single specimen has been so far recorded which closely resembles a brachiopod (similar to *Lingula* in morphology). It can be a bivalve impression also.

Tool mark / ? Monomorphichnus
(Pl. II, fig. 7)

Description: These are paired or unpaired linear markings which occur in epichnial ridge form. Occasional occurrence of bulbous structures at regular intervals is also seen. These structures closely resemble with tool marks. At best they can superficially be compared with ichnogenus *Monomorphichnus*.

DISCUSSION

The occurrence of *Skolithos*, *? Fucusopsis* and three other indeterminate ichnofossils shows that the ichnocoenosis was represented by a well developed community. This diversity in the nature and occurrence of trace fossils is closely related to other Precambrian-Cambrian occurrences of the world, e.g., Spain, China, Russia etc. *Skolithos* is one of the important ichnofossils which ranges in age from Vendian to Recent and occurs in almost all kinds of environments. Densely occurring *Skolithos* tubes generate a "pipe-rock" ichnofabric and are mainly recorded from the Lower Cambrian strata, indicating the development of marine metazoans to such a stage where they were capable of burrowing across the sedimentary layers (Droser, 1991). This, infact represents an evolutionary event in the benthic community.

Once this biologic character was attained by the organisms, they further diversified into generating more complex structures in the sediment. Although there is no information available regarding the occurrence of any biologic entity from the Dharagad Group, the only sketchy record of surface tracks (Rupke, 1974, p.122) from Middle Deoban sequence, interestingly corroborates to the present findings. Considering the fact that only a very small portion of the sequence has been worked out so far, a rigorous mapping of the area is needed. This would ascertain the true nature of the sequence instead of mere lithological correlation on regional scale.

It is worth mentioning that a similar ichno-assemblage has been located in the Krol Belt (the Tal Formation) of the outer sedimentary belt where *Skolithos* and allied trace fossils dominate the siliciclastic sequences (Singh and Rai, 1983). These are mainly from the Mussoorie Synform and the Nigalidhar Synform. The Nigalidhar Synform lies quite close (about 40 km, the map distance) to the present trace-fossil yielding area and a possibility can not be ruled out that the earliest Cambrian global transgression (which deposited the Tal Formation) also transgressed the present area where primitive animals left their traces, about 540 Ma ago. In the subsequent Tertiary orogeny and later folding and faulting phases during the formation of the Himalayan mountain chain, the sequence of these earliest Cambrian horizons got sandwiched within the older sedimentaries. This possibility needs confirmation by additional field data.

Considering the present discovery as the indicator of latest Vendian to earliest Cambrian age and the trace-fossil yielding horizon to be the part of conformable Dharagad succession, the stratigraphical setup of the area would need major modification. And if such be the case, the trace fossil yielding sequence would go up in the stratigraphical hierarchy and in this case would overlie the Deoban - Jaunsar Group.

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REFERENCES

Bhargava, O.N. 1972. A reinterpretation of the Krol belt. *Him. Geol.* **2**: 47-81.

Chittora, V.K. and Kacker, A.K. 1991. Stratigraphic Correlation of Shali-Larji-Deoban and Garhwal Groups. *Rec. Geol. Surv. India,* **124(8)** : 212-215.

Crimes, T.P. 1994. The period of early evolutionary failure and the dawn of evolutionary success: The record of biotic changes across the Precambrian-Cambrian boundary, p.105-133. In : *The Palaeobiology of Trace Fossils* (Ed. Donovan, S.K.), J.Wiley & Sons, England.

Droser, M.L. 1991. Ichnofabric of the Paleozoic *Skolithos* Ichnofacies and the Nature and Distribution of *Skolithos* Piperock. *Palaios,* **6**: 316-325.

Fedonkin, M.A. 1990. Paleoichnology of Vendian metazoa, p. 132-137. In : *The Vendian system* Pt. 1 (Eds. Sokolov, B.S. and Iwanowski, A.B.), Springer Verlag, Berlin.

Fedonkin, M.A. and Runnegar, B.R. 1992. Proterozoic metazoan trace-fossils, p. 389-395. In : *The Proterozoic Biosphere: A multidisciplinary Study* (Eds. Schopf, J.W. and Klein, C.), Cambridge University Press, U.S.A.

Ganesan, T.M. and Verma, R. N. 1974. Geology of the part of Simla district (H.P.) and Dehradun district (U.P.) with special reference to copper mineralisation. *Indian Minerals,* **28(3)** : 47-60.

Ganesan, T.M. and Thussu, J.L. 1978. Geology of a part of Tons valley, Garhwal Himalaya with reference to old folds trends. *Jour. Geol. Soc. India,* **19(7)** : 285-291.

Grey, K. and Williams, I.R. 1990. Problematic bedding-plane markings from the middle Proterozoic Manganese Subgroup, Bangemall Basin, Western Australia. *Precamb. Res.* **46** : 307-327.

Haldeman, S.S. 1840. Supplement to No.1 of "A monograph of the Limniades, and other freshwater univalves shells of North America" containing descriptions of apparently new animals in different classes, and the names and characters of the subgenera in Paludina and Anculosa. Philadelphia, PA, 3 p.

Horodyski, R.J. 1982. Problematic bedding-plane markings from the Middle Proterozoic Appekunny Argillite, Belt Supergroup, Northwestern Montana. *Jour. Paleont.* **56** : 882-889.

Kumar, S. and Singh, S.N. 1979. Significance of *Jacutophyton* in the Deoban Limestone, Chakrata Area, Dehradun district, Uttar Pradesh. *Curr. Sci.* **48(9)** : 401.

Kumar, S. and Srivastava, P. 1992. Middle to Late Proterozoic microbiota from the Deoban Limestone, Garhwal Himalaya, India. *Precamb. Res.* **56** : 291-318.

Prashra, K.C. 1977. Algal stromatolites of the Deoban, Atal quartzite & Mandhali Formations in the Tons valley, H.P. *Rec. Geol. Surv. India,* **109(2)** : 112-122.

Prashra, K.C. 1982. Recent observations on Mandhali Formation and Simla slate- Tertiary sequence in the Tons region of Garhwal Himalaya. *G.S.I. Misc. Pub.* **41**: 70-80.

Raha, P.K., Chandy, M.C. and Balasubrahmanyam, M.N. 1978. Geochronology of the Jammu Limestone, Udhampur District, Jammu & Kashmir State, India. *Jour. Geol. Soc. India,* **19(5)** : 221-223.

Rai, Vibhuti, Singh, A.K. and Kumar, M. 1996. Discovery of trace fossil assemblage from Dharagad Group, Inner sedimentary Belt, Lesser Himalaya. *Golden Jubilee Conference on physical and biological changes across the major geological boundaries November 15-17, 1996, Birbal Sahni Institute of Palaeobotany, Lucknow* : p. 80 (Abstract).

Rupke, J. 1974. Stratigraphic and structural evolution of the Kumaon Lesser Himalaya. *Sedimentary Geol.* **11** : 81-265.

Shukla, M., Tewari, V.C. and Yadav, V.K. 1987. Late Precambrian microfossils from Deoban Limestone Formation, Lesser Himalaya, India. *The Palaeobotanist,* **35 (3)** : 347-356.

Singh, I. B. and Rai, Vibhuti 1983. Fauna and Biogenic structures in Kro-Tal Succession (Vendian-Early Cambrian), Lesser Himalaya: Their biostratigraphic and palaeoecological significance. *Jour. Pal. Soc. India,* **28:** 67-90.

Srikantia, S.V. 1977. The Sundarnagar Group: its geology, correlation and significance as stratigraphically the deepest sediment in the Peninsular or Lesser Himalaya. *Jour. Geol. Soc. India,* **18(1)** : 7-22.

Srikantia, S.V. and Bhargava, O.N. 1974a. Jaunsar problem in the Himalaya- a critical analysis and elucidation. *Jour. Geol. Soc. India,* **15(2)** :115-136.

Srikantia, S.V. and Bhargava, O.N. 1982. Precambrian carbonate belts of the Lesser Himalaya : Their Geology, correlation, sedimentation and palaeogeography. *Recent Researches in Geology,* **8** : 521-581.

Srivastava, R.N. and Mathur, S.K. 1996. Origin of carbonate hosted base metal mineralisation of northwestern Himalaya. *Spl. Pub. Geol. Surv. India,* **21(1)** : 507-513.

Tewari, V.C. 1993. Precambrian and Lower Cambrian stromatolites of the Lesser Himalaya, India. *Geophytology,* **23(1)** : 19-39.

Valdiya, K.S. 1969. Stromatolites of the Lesser Himalaya carbonate formations and the Vindhyans. *Jour. Geol. Soc. India,* **10** : 1-25.

EXPLANATION OF PLATES

Plate I

1. Field photograph showing Trace-fossil bearing outcrop along the road section.

2. A cluster of large *Skolithos* tubes showing elliptical outline in cross-section preserved as hypichnial ridge. The larger axis of tube diameter varies between 5-9 mm. Diameter of the coin = 24 mm.

3. Bedding surface markings of *Dharagad Ichnogenus* 'C' with slightly oblong cross-section. There is a prominent bulge inside the tube (marked by an arrow). The larger diameter of the tube cross-section is 12 mm. Diameter of the coin = 24 mm.

4. Bedding surface showing elliptical to elongated burrow system (*Dharagad Ichnogenus 'A'*) with 10-20mm length and 5-8mm width. Preservation as epichnial ridges with prominent marginal depression. Diameter of the coin = 24 mm.

5. Large inclined *Skolithos* tubes with cylindrical shape and uniform diameter all along the length. Tube diameter varies between 5-9mm. Diameter of the coin = 24 mm.

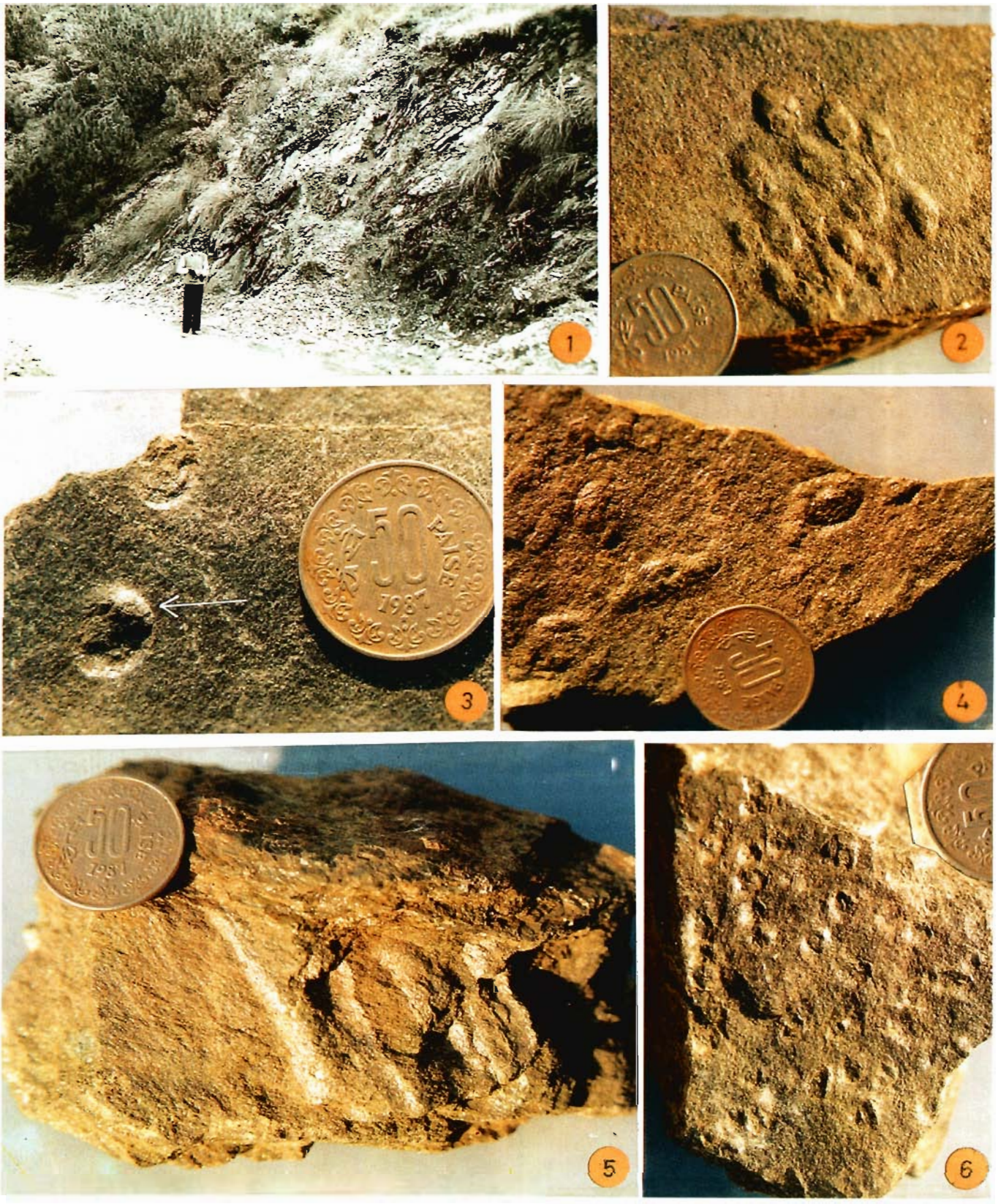
6. Cluster of *Skolithos* on the bedding surface with circular to subelliptical cross section. The periphery of the tube shows inward depression. Larger axis of the tube diameter varies between 4-5mm. Diameter of the coin = 24 mm.

Plate II

1. Cluster of *Skolithos* on the bedding surface with circular to sub-elliptical cross section. The periphery of the tube shows inward depression. Larger axis of the tube diameter varies between 2-7mm. Diameter of the coin = 24 mm.
2. A series of *Skolithos* tubes occurring in a linear pattern. The tube wall is prominent and wall structure is well seen in the left portion of the photograph where the *Skolithos* is seen in vertical section (marked by arrows). Diameter of the coin = 24 mm.
3. Cluster of four *Skolithos* on the bedding surface with circular cross-section. The infilling material is darker than the matrix. Diameter of the coin = 24 mm.
4. Densely populated *Skolithos* tubes with their diameter varying between 4-5 mm showing their parallel character. The sheen on the tubes is due to shearing of micaceous beds. Diameter of the coin = 24 mm.
5. An unusual occurrence of a cluster of *Skolithos* with a central tube surrounded by six tubes. The tube cross-sections are circular to elliptical with larger axis being 4-5 mm. Another such cluster is seen in the lower part of the photograph. Diameter of the coin = 24 mm.
6. Cluster of *Skolithos* with cross-section showing overlapping character. Diameter of the coin = 24 mm.
7. Surfacial markings faintly resembling traces but are actually tool marks. Diameter of the coin = 24 mm.

Plate III

1. Field photograph of the bedding surface showing *Skolithos, Dharagad Ichnogenus 'C'* and ? *Fucusopsis* burrows. Random occurrence of these traces can clearly be seen. Lens cap on the left side of the photograph is for scale.
2. A tri-radially symmetrical burrow system (*Dharagad Ichnogenus 'B'*) showing a central cavity (marked by arrow) with three raised radial ridges (leaf like) surrounding it. The prominent depression on the margins of 'petal' is clearly seen. Length of the bar = 10 mm.
3. Densely populated *Skolithos* burrows on a slab of bedding surface. The coin diameter is 18 mm.
4. A possible ? brachiopod / bivalve impression on the bedding plane with faint growth lines (concavity upward). Length of the bar = 20 mm.
5. Ichnogenus ? *Fucusopsis* on the bedding plane with elongated spindle shape morphology. Well developed thread like structures are seen on the structure (marked by arrows). Diameter of the coin = 24 mm.
6. Polished section of Ichnogenus *Skolithos* in vertical section showing disruption in bedding lamination and irregular margin of the tube. Scale = 10 mm.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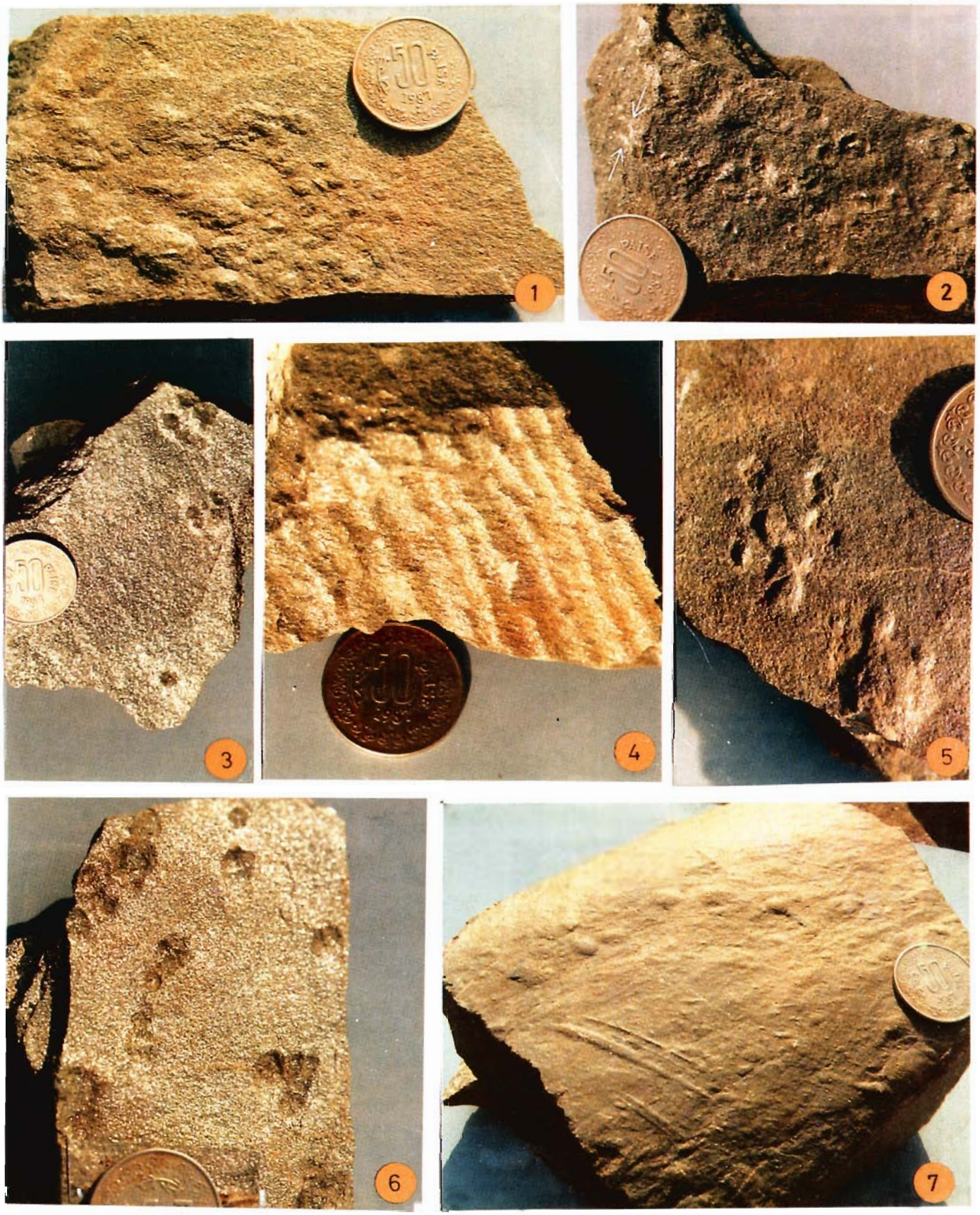
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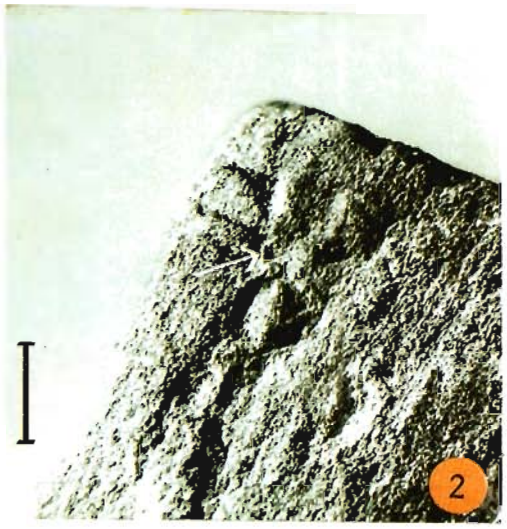
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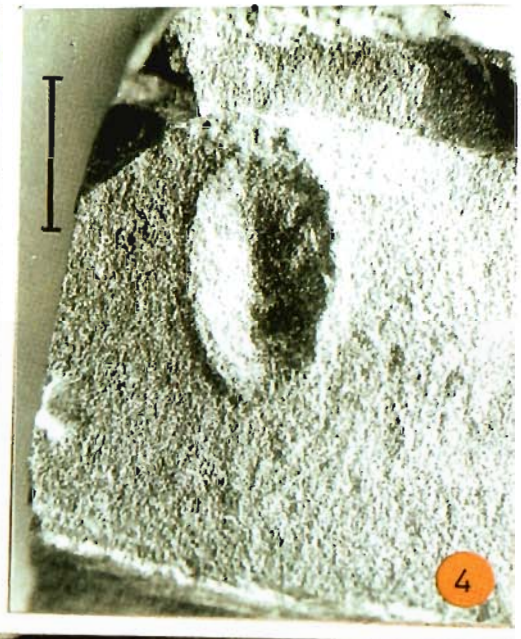
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