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SMALL SHELLY FOSSILS OF EARLY CAMBRIAN (TOMMOTIAN) AGE FROM CHERT-PHOSPHORITE MEMBER, TAL FORMATION, MUSSOORIE SYNCLINE, LESSER HIMALAYA, INDIA AND THEIR CHRONOSTRATIGRAPHIC EVALUATION

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ABSTRACT

The paper describes and illustrates small shelly fossils of Tommotian (Early Cambrian) age from Chert-Phosphorite Member of Tal Formation, exposed in the PPCL Mine at Maldeota in Dehra Dun district, where it forms part of the southern limb of Mussoorie Syncline in Lesser Himalaya. The recovered assemblage of small shelly fauna is more or less precisely correlatable to fossil zones known from other well-established Early Cambrian sequences in the world.

The assemblage of small shelly fossils from Chert-Phosphorite Member of Tal Formation, consisting of hyolithids, paraconodonts and other forms of uncertain affinity, is chronostratigraphically assigned to the oldest part of Tommotian Stage (trilobite-lacking basal Cambrian) of Russian (and Siberian) Platform, Mangolia or to the oldest fossil zone of Meishucunian Stage of Chinese sections.

INTRODUCTION

The Tal Formation in western Lesser Himalaya constitutes a well-understood lithostratigraphical unit of the younger part of Krol Belt succession, which was traditionally considered to be of Mesozoic age as a result of the tentative suggestion put forth by Auden (1934). Lately, however, the chronostratigraphic status of Krol Belt sediments was disputed by Singh (1976, 1979), who, in contrast to the traditional view, suggested these to be of Precambrian age based on sedimentational interpretations. Singh's view also got support from the lack of undisputed record of body fossils from the strata of Krol Belt (Singh, 1981).

The above controversy on the age of Krol Belt succession gradually began to be resolved with the record of abundant and easily reproducible small shelly fauna of Tommotian age from Chert-Phosphorite Member of Tal Formation (Bhatt *et al.*, 1983) and later records of other fossil groups (including stromatolites and ichno-fossils) from the material of Chert-Phosphorite Member and several other younger horizons of Tal Formation (Tewari, 1984) stromatolite of Tommotian age from Chert-Phosphorite Member; Singh and Rai, 1983, ichnofossils of upper Tommotian from Arenaceous Member ; Rai and Singh, 1983, trilobite impressions of Upper Tommotian or Atdabanian from Arenaceous Member ; Kumar *et al.*, 1983, gastropod and brachiopod of Atdabanian Stage from Calcareous Member in Garhwal Synform ; Tripathi *et al.*, 1984, assemblage of brachiopod of Botomian Stage from Quartzite Member; see Table I for the different lithostratigraphic units of Tal Formation). Thus about 700-800 m of basal sequence of Tal Formation has now revealed several levels of fossiliferous beds which characterise all the three stages of Early Cambrian, viz. Tommotian Stage, Atdabanian Stage and Botomian Stage, as established in type sections in Siberian Platform.

The object of the present paper is to re-examine in relative detail the various elements of small shelly fauna recovered from the material of Chert-Phosphorite Member of Tal Formation and record the systematic palaeontologial description of these elements. This study has resulted in modification of identification in the case of several elements since their first record earlier (Bhatt *et al.*, 1983).

PREPARATION OF SAMPLES

The samples yielding the shelly microfauna consist of granular or finely layered phosphate rock or phosphate mixed with shale. The samples come out from the outcrop in a brittle, powdery form.

About 750 gm to 1000 gm of phosphate sample was immersed in 10%-12% acetic acid (glacial) for about 20 days. The acid was changed after a period of every

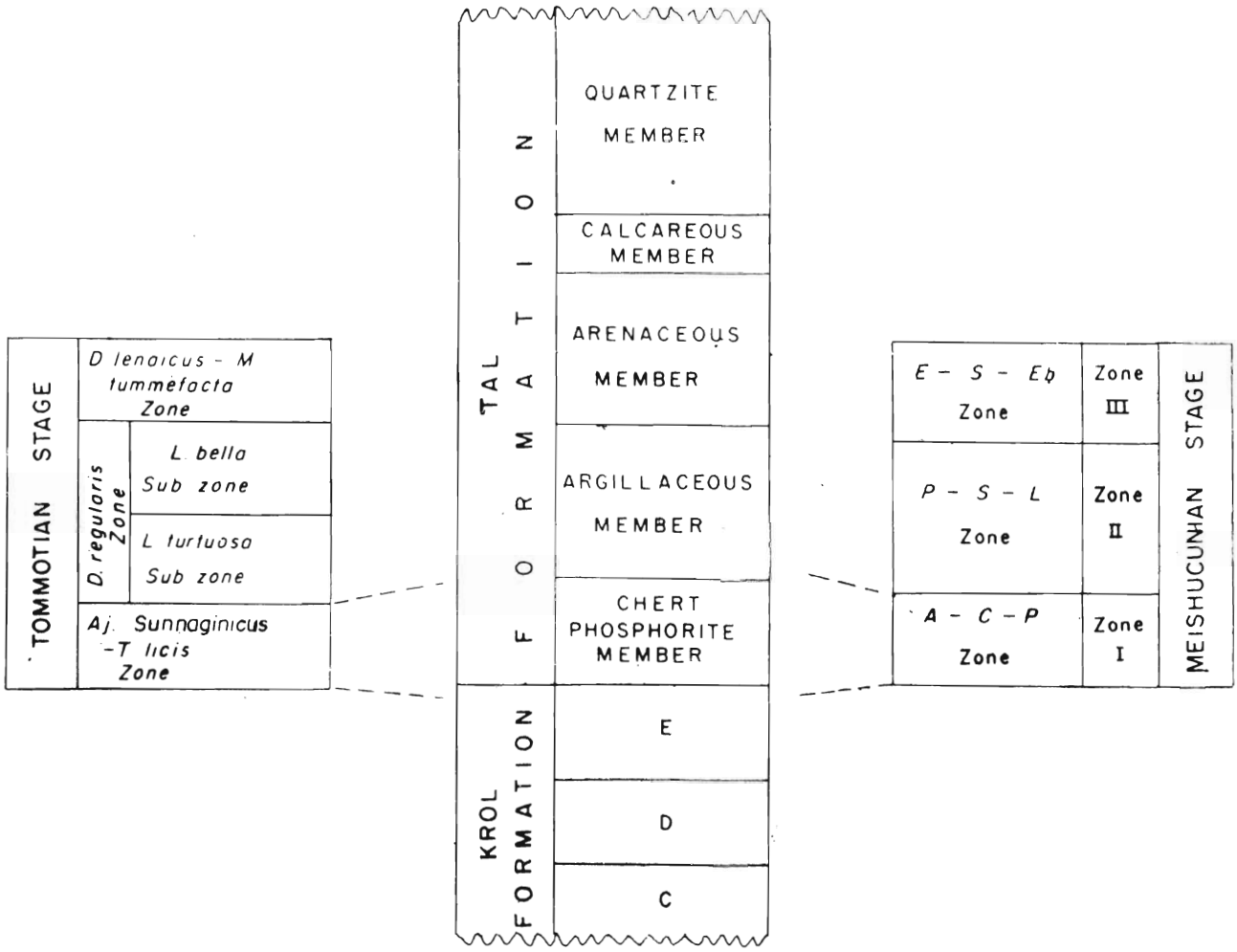

Table 1. The inferred correlation of Chert-Phosphorite Member, Tal Formation, Lesser Himalaya, India in the Early Cambrian chronostratigraphy; *A-C-P* Zone : *Anabarites-Circotheca-Protohertzina* Zone, *P-S-L* Zone : *Paragloborilus-Siphogonuchites-Lapworthella* Zone, *E-S-Eb* Zone : *Eonovittatus-Sinosachites-Ebianotheca* Zone.

5 days. Fine, macerated rock powder produced as a consequence, was washed and dried for examination under a binocular microscope.

It is likely that some alteration/modification in the maceration process, viz. strength of acid, duration of acid bath, shaking/stirring technique, may improve the apparent quality of preservation of the microfauna, although the factor of powdery nature of the parent sample would remain constant.

SYSTEMATIC PALAEONTOLOGY

The microfauna of Chert-Phosphorite Member of Tal Formation, consisting of small shelly fossils, is illustrated and described. Some of the typical and charac-

teristic froms of paraconodonts, hyolithids and some other shelly microfossils present in the recovered assemblage are considered sufficient to fix the age of the stratigraphic horizon yielding the microfauna. Consideration of more specialised aspects of taxonomy of the recovered forms will need future specialist treatment.

The sudden spurt and radiation of animals with shelly cover at the begining of Cambrian, i.e. in Tommotian Stage, gave rise to parent stocks of several animal phyla and orders. Many of these animal phyla and orders appear to be short lived and rapidly evolved into newer types, for Tommotian Stage skeletal faunas "lack many important Cambro-Ordovician groups and contain certain problematical forms not found in younger strata" (Stanley, 1976). These palaeontological observations on the evoutionary aspects of the earliest shelled organisms have so far thwarted efforts for unanimity towards one agreed scheme of zoological classification for many of the Tommotian problematical shelled forms. In the present work the original systematic classification proposed by Missarzhevsky (1969) for hyolithids is followed, except for the genus *Tiksitheca*, which has been placed in Family ANABARITIDAE Miss., 1974, Similarly for conodontids the classification proposed in the *Treatise on Invertebrate Paleontology* (Clark, 1981) is followed. The revision of the hyolithid genus '*Circotheca*' lately proposed by Meshkhova *et al.* (1983) and Qian Yi (1984) is not considered here and the original revised definition of the genus (Missarzhevsky, 1969) is followed. The conodontid genus *Protohertzina* has been placed in *Protoconodonta* (?Phylum Chaetognatha) by Bengtson (1983).

Fig. 1 illustrates the location and stratigraphic setting of the Tal sequence in Mussoorrie Syncline and the litho-column of Chert-Phosphorite Member in PPCL Mine. 42 channel samples, covering the entire stratigraphic thickness of Chert-Phosphorite Member at PPCL Mine, were examined for their microfauna. Intense laboratory preparations would be necessary in a future work before vertical differentiation of microfaunal zones, if at all definable in the sequence of Chert-Phosphorite Member(total thickness in PPCL Mine is 12 m), can be attempted. For chronostratigraphic considerations the record of small shelly fossils described here should be taken as coming from the entire thickness of Chert-Phosphorite Member, exposed at Maldeota in Mussoorie Syncline.

The illustrated specimens are housed on SEM stubs in the Repository Unit, Palaeontology and Stratigraphy Division, Geological Survey of India, Calcutta, bearing G. S. I. Type Numbers 20076 to 20122.

Phylum Mollusca ?
Class Hyolitha MAREK, 1963

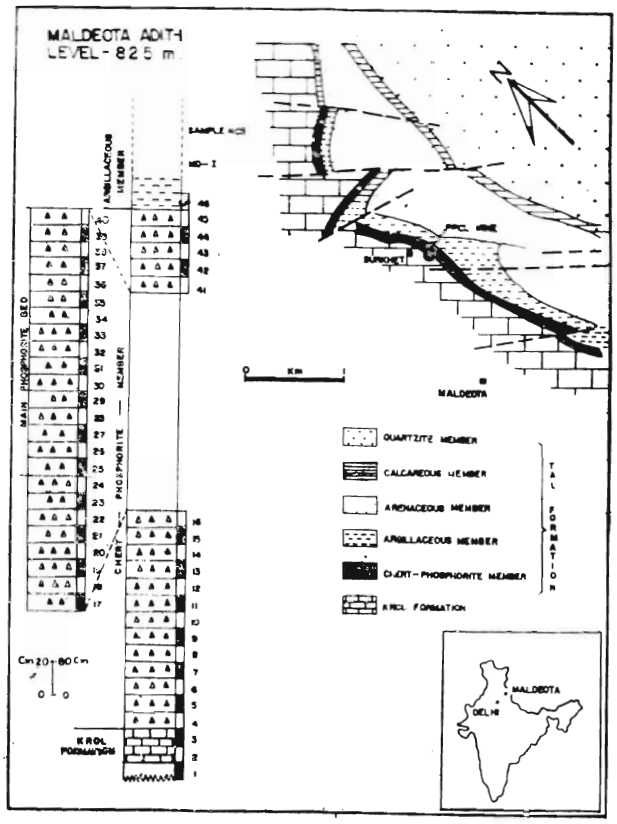

Fig. 1. Location and stratigraphic setting of Tal Formation at Maldeota, Mussoorie Syncline, Lesser Himalaya, India and the lithocolumn of Chert-Phosphorite Member of Tal Formation at level-825 in Adit-1, PPCL Mine (geological map after Shanker, 1975).

Order Orthothecid MAREK, 1966
Family Allathecidae MISSARZHEVSKY, 1969
Genus Allatheca MISSARZHEVSKY, 1969

Allatheca concinna MISSARZHEVSKY
(Pl. I—17 & 17a)

1969 *Allatheca concinna* Missarzhevsky n. sp. Missarzhevsky (in Raaben, Ed., 1981), p. 140, Pl. I, Fig. 3, Pl. XII, Figs. 14 & 15.

The shell is straight with assymetrically oval cross-section. It is sculptured with transverse folds throughout the length. The transverse folds are, however, not very prominent and are with rounded crests (Plate I—17a).

Material : One specimen
Repository : G. S. I. Type No. 20076

Family Circothecidae MISSARZHEVSKY, 1969
Genus *Circotheca* SYSOIEV, 1958, emend. MISSARZHEVSKY, 1969

Circotheca longiconica QIAN
(Pl. I—3, 3a, 4, 4a, 7 & 7a)

1978 *Circotheca longiconica* n. sp. Qian, Pl. 1, Figs. 3 & 9.
1983 *Circotheca* sp. 1; Bhatt *et al.*, Pl. 1, Fig. 2.

The long, slender, nearly straight, smooth, hollow cones with circular cross-section are almost identical to forms recorded from central and Southwest China by Qian (1978). The degree of flare toward the apical end is restricted to 5°-6° and this small angle of divergence imparts a slender appearance to the conical shells of this species. The shell wall is delicate and thin. Specimens with both larger and smaller dimensions are available in the collection.

Material : Abundant specimens
Repository : G. S. I. Type Nos. 20077, 20078 & 20079

Circotheca obesa QIAN
(Pl. I—5 & 5a)

1978 *Circotheca obesa* n. sp. Qian, Pl. I, Figs. 1 & 2.
1983 *Circotheca* sp. 2; Bhatt *et al.*, Pl. 1, Fig. 3.

The degree of divergence from the apical end toward the apertural end is appreciably more in the present form than in *C. longiconica* Qian. This characteristic imparts a massive appearance to this species. The shell is nearly straight in case of the present form. In the cross-section, the outline is a circle, characteristic of the genus. The angle at the apical end measures 12°, which is the same as for the Chinese form originally described by Qian (1978).

Material : Fair number of specimens
Repository : G. S. I. Type No. 20080

Circotheca sp.
(Pl. I—6, 6a & 11)

Some of the tubular, conical shells in the collection have a circular cross-section and possess a thick shell wall. These forms were found to be usually broken and, therefore, no determination could be made. These specimens are placed under the genus *Circotheca* only doubtfully for their unusually thick shell wall.

Through an examination of photomicrographs, Dr. Jiang Zhiwen, Yunan Institute of Geological Sciences, Kunming, P. R. C. (pers. comm. to Gopendra Kumar, Geological Survey of India, Lucknow) opined that the specimen at Plate I—6 was *Turcutheca* sp. But the unusually thick shell wall for an orthothecid genus prohibits us to make a final comment on the identification; although the circular cross-section of the shells makes us inclined, for the present, to place them in the genus *Circotheca*.

Material : Fair number of specimens
Repository : G. S. I. Type Nos. 20081 & 20082

Genus *Turcutheca* MISSARZHEVSKY, 1969
Turcutheca sp. indet. aff. *T. annae* (SYSOIEV
(Pl. I—9 & 9a)

1939 *Turcutheca annae* (Sysoiev); Missarzhevsky (in Raaben Ed., 1981), Pl. I, Figs. 2, 5 & 7, Pl. XVI, Figs. 1 & 2a.
1983 *Trapezotheca* sp. 1; Bhatt *et al.*, Pl. 1, Fig. 4.

The specimens are long and slender ; the apical tip of the specimens is usually broken. The shell is nearly straight and in the cross-section, it is ovate with one of the lateral sides narrower. The shells are usually not so well preserved (or damaged by acid during maceration) as to show surface ornamentation.

The ovate cross-section with one of the lateral sides narrower than the other is considered typical and characteristic of *T. annae* (Sys.).

Material : Fair number of specimens
Repository : G. S. I. Type No. 20084

Turcutheca lubrica QIAN
(Pl. I—2 & 2a)

1978 *Turcutheca lubrica* n. sp.; Qian, Pl. 1, Figs. 4 & 6 .
1983 *Turcutheca lubrica* Qian; Xing Yusheng *et al.*, Pl. 20, Fig. 19.

The shell is relatively stout and is feebly curved toward one of the lateral sides. The cross-section is broadly oval, with one of the lateral sides away from which the shell curves, appearing little narrower.

The stout nature of the shell and curved profile distinguishes this species from *T. annae* (Sys.).

Material : Fair number of specimens
Repository : G. S. I. Type No. 20085

Turcutheca maldeotaensis n. sp.
(Pl. I—8, 8a, 10 & 10a)

1983 *Trapezotheca* sp. 2; Bhatt *et al.*, Pl. 1, Fig. 5.
1983 *Trapezotheca* sp. 3; Bhatt *et al.*, Pl. 1, Fig. 6.
1983 *Turcutheca* aff. *T. praenguis* Jiang; Azmi and Pancholi, Pl. 1, Fig. 11.

The shells of the species are relatively short, but straight and rather rapidly flaring toward the apertural end. The shells are compressed along broader sides, this makes the corss-section thinly oval or egg-shaped. The surface of the shell is smooth and shell wall delicate.

The new species differs from *T. annae* (Sys.) in more compressed nature of broader sides and in possessing a much greater angle of divergence of lateral sides, viz. 15°-20°. This angle in case of *T. annae* (Sys.) is only 3°-5°. It differs from *T. praenguis* Jiang in having one of the sides narrower, as observed in cross-section.

Material : Abundant specimens
Repository : G. S. I. Type Nos. 20086 & 20087 (Holotype, Pl. I, Figs. 10 & 10a)
Etymology : Its first record from Maldeota phosphorite deposits.

Phylum Conodonta EICHENBERG, 1930
Class Conodonta EICHENBERG, 1930
Order Paraconodontida MULLER, 1962
Superfamily Furnishinacea MULLER, 1981
Family Furnishinidae MULLER & NOGAMI, 1971
Genus *Protohertzina* MISSARZHEVSKY, 1973

Protohertzina anabarica MISSARZHEVSKY
(Pl. I—12, 12a & 13)

1973 *Protohertzina anabarica* Missarzhevsky; Missarzhevsky, p. 54, Text-figs. 1-3, Pl. 9, Figs. 1-4 & 6.
1983 *Protohertzina* sp.; Bhatt *et al.*, Pl. 1, Fig. 1.
1983 *Hertzina* sp. 2; Bhatt *et al.*, Pl. 1, Fig. 9.

The elements of this species are long, coniform, slender, proclined and nongeniculate. There is a well-marked keel on the posterior side; the posterior median keel becomes more prominent toward the basal cavity. The sub-parallel posterio-lateral sides join to form a rounded anterior side (Fig. 2). The basal cavity is deep, reaching the tip of the cusp.

Fig. 2. Cross-section of *Protohertzina anabarica* Miss.; A, anterior side, P, Posterior side.

Material : Abundant specimens
Repository : G. S. I. Type Nos. 20088 & 20089

Protohertzina sp. *indet.* aff. *P. robusta* QIAN
(Pl. I—15)

1977 *Protohertzina robusta* n. sp.; Qian, p. 263.
1984 *Protohertzina robusta* Qian; Chen Ping, Pl. 1, Fig. 13.

Some of the forms in the collection are relatively short and stout and possess a pear-shaped outline of the basal cavity, with a posterior median keel. These forms show close affinity to *P. robusta* Qian.
Material : Few specimens
Repository : G. S. I. Type No. 20090

Protohertzina siciformis MISSARZHEVSKY
(Pl. I—14)

1973 *Protohertzina siciformis* n. sp.; Missarzhevsky, p. 58. Pl. 9, Fig. 5.
1983 *Hertzina* sp. 1; Bhatt *et al.*, Pl. 1, Fig. 8.

The elements of the species are long and slender and are characterised by a prominent posterior median keel and rounded anterior side. The outline of the basal cavity is typically pear-shaped (Fig. 3).

Fig. 3. Cross-section of *Protohertzina siciformis* Miss; A, anterior side, P, posterior side.

Material : Fair number of specimens
Repository : G. S. I. Type No. 20091

Order and Superfamily indet.
Family Distacodidae
Genus *Ganloudina* HE, 1980

Ganloudina ?sp.
(Pl. I—16)

1984 *Ganloudina* He; Yang Xianhe nad He Tinggui, p. 39.

The element is simple, coniform, proclined and nongeniculate. The base of the element is distinct from cusp.

Detailed identification has not been attempted due to rarity of material. The recovered specimen has close morphologic identity with the conodontiform *Ganloudina* He (This identification has been suggested by Dr. Jiang Zhiwen, Yunan Institute of Geological Sciences, Kunming, P. R. C.). Two new species of *Ganloudina* He, have been illustrated more recently by Yang Xianhe and He Tinggui (1984).
Material : One specimen
Repository : G. S. I. Type No. 20092

Order Foraminiferida EICHWALD, 1830

Genus indet.
(Pl. II—14)

Test is agglutinated. The initial part is planispiral; the later part of the test becoming uncoiled. Aperture is terminal.
Material : One specimen
Repository : G. S. I. Type No. 20093

Incertae sedis
Family : Anabaritidae MISSARZHEVSKY, 1974
Genus : *Tiksitheca* MISSARZHEVSKY, 1969

Tiksitheca sp.
(Pl. I—1 & 1a)

The specimen illustrated here is cast in which only a small portion shows preservation of original shell material. The cross-section of specimen is characteristically triangular, assuming the shape of an equilateral triangle with straight sides and rounded apexes. The apical tip of the specimen is broken.

The well-known Siberian species *T. licis* Miss. has a greatly rounded triangular cross-section (Rozanov, 1982 Pl. V Fig 13 . Another Siberian species *T. korobovi* Miss., though apparently more triangular in cross-section, has appreciably more rounded sides than the species from Maldeota phosphorite. The Chinese species *T. minuta* Yue (Xing Yusheng *et al.*, 1983, pl. 25, Figs. 36 & 37 is also similar to *T. korobovi* (Miss.) in cross-section, though with greater angle of divergence at the apical end. The present lone specimen is broken at the apical end and, therefore, no further specific determination can be made, pending additional collection. The character, however, emerges that the specimen from Maldeota has a triangular cross-section to a degree not known in any of the presently established species of the genus.

Material : On single specimen
Repository : G. S. I. Type No. 20083
Incertae Sedis

Genus Maikhanella H. ZHEGALLO, 1982

Type Species: *Maikhanella multa* H. Zhegallo; from the Lower Cambrian of Western Mongolia; original designation.

Maikhanella sp.
(Pl. II—16 & 16a)

1982 *Maikhanella* H. Zhegallo in Rozanov, 1982), gen. nov.; Rozanov Editor-in-Chief , p. 49.

The shell is low, hood shaped. The apex (top) of the shell is shifted from the axis of symmetry toward the shell periphery. The surface of the shell is ornamented with small nodular protuberances, which are arranged parallel to the shell outline (Plate II—16a). This is an important generic character. Only one (slightly broken) specimen is available in the collection. Further examination of the forms in the Maldeota material is, therefore, not possible for the present. However, the visible characters of the shell, mentioned above, make us believe that the specimen from Maldeota is identical to the Mongolian form.

The present record of the genus *Maikhanella* H. Zhegallo is, to the best of our knowledge, the first record of the taxon outside Mongolia. Its first and the only other record so far comes from the genotype locality in Tommotian strata of Maikhan Mountain, Western Mongolia.

Measurements (in mm) :

Length of shell	Width of shell	Height of shell
1.00	0.50	0.30

Material : One specimen
Repository : G. S. I. Type No. 20094

Genus Olivooides QIAN, 1977

Type Species : *Olivooides multisulcatus* Qian, 1977; from the Lower Cambrian (Meishucunian Stage) of Central and Southwest China; original designation.

Olivooides sp.
(Pl. III—1-14)

They are globular hollow shells, with more or less spherical shape. The outer surface of the shell wall may be smooth (Pl. III—1-3) or irregularly shaped (Pl. III—4-14). The former types (with smooth surface) were earlier identified as *Olivooides* cf. *alveus* Qian (Bhatt *et al.*, 1983, Pl. 1, Figs. 17 & 18). The latter types could possibly be accommodated in the taxon *Olivooides blandes* Jiang (Luo *et al.*, 1982, Pl. 19, Figs. 2-4;6; Dr. Jiang Zhiwen, Yunan Institute of Geological Sciences, Kunming, China, also suggests this identification).

Several of the broken specimens present in the collection afford insight into the hollow globular shell (Pl. III—8-12, 14), which reveals irregularly developed shell wall with lot of encrusted material on the inner surface, giving a vuggy appearance. Sometimes the shells are not exactly spherical and appear distorted by compression (Pl. III—10, 11, 13 & 14). Smooth forms show porous shell wall in high resolution.

Further studies of these glublar shells are required to understand the morphologic attributes with greater precision, when their taxonomic position can also be better understood.

Material : Abundant specimens
Repository : G. S. I. Type Nos. 20109 to 20122

Family Coleolidae FISHER, 1962
Genus *Coleoloides* WALCOTT, 1889

Type Species : *Coleoloides typicalis* Walcott, 1889; from the Lower Cambrian of Newfoundland; original designation.

Coleoloides ? sp.
(Pl. II—1-6, 11, 17 & 7, 12, 13)

These are mostly cylindrical casts of various radii, apparently formed by tubular shells. Two types of forms are distinguishable, Type A and Type B. Type A (Plate II—1-6, 11, 17) Specimens with larger radii (within the total range of morphotype) are more com-

mon. In the profile view the forms are nearly straight (Plate II—3) to less or more arcuate types (Plate II—1, 4, 6). Sometimes a symmetrical looking bend at both the ends is observed (Plate II—2, 5). The most distinguishing feature of Type A is the surface ornamentation, which consists of parallel furrows along the length. Some of the furrows appear more deeply etched than the others. In Fig. 2 one of the deeper furrows has come out sharply due to the particular angle toward light source during photomicrography. Rarely forms with extremely small radius are also present (Pl. II—11).

A typical feature of Type A is its light copper-coloured tinge of the surface, which is present invariably in all the specimens. This colouration is possibly linked to some chemical factor in the composition of shell wall which never occurs preserved, presumably having altered or dissolved during fossilization. This character forbids us to place these forms within the genus *Coleoloides* Walcott straightaway. Type B (Plate II—7, 12, 13)- These possess rounded tubular or cylindrical shapes, irregularly deflected along length and do not have longitudinal furrows as in Type A. Sometimes the deflection appears symmetrical (Plate II—12), but such forms are rare. Only one such form was recorded (Plate II—12). The surface is usually smooth (Plate II— 7, 12), but some specimens have irregular, coarse-appearing surface of the cast (Plate II—13). Usually casts are present (Plate II—12, 13), rarely shell wall also occurs preserved (Plate II—7), where the shape of a hollow tube is discernible. Inside the tube, there is the infilling of irregularly encrusted shell material. Some of these forms could be mistaken for *Cambrotubulus* Missarzhevsky, an early Tommotian form, although these are not even faintly conoidal, a character which is essential according to the genotypic designation of the genus *Cambrotubulus* Missarzhevsky (Missarzhevsky, in Raaben, Ed., 1981).

In general the preservation of these forms is poor and nothing further can be said about the identification at this stage.

Material : Fair Number of specimens
Repository : G. S. I. Type Nos. 20096 to 20105

Incertae sedis

Genus *Spirellus* JIANG, 1982

Type Species : *Spirellus columnaris* Jiang, in Luo *et al.*, 1982; from the Lower Cambrin of China; original designation.

Spirellus ? sp.
(Pl. II—15)

Only one specimen, spirally coiled along an axis and broadly resembling the Chinese form *Spirellus* Jiang, is available in the collection. The spirally coiled tube is non-flaring. The specimen is little distorted, therefore, the present identification is only provisional.

Material : One specimen
Repository : G. S. I. Type No. 20095

Family Lapworthellidae MISSARZHEVSKY, 1966
Genus *Lapworthella* COBBOLD, 1921

Lapworthella ? sp.
(Pl. II—8-10)

1983 *Lapworthella* spp.; Azmi, Pl. 9, Figs. 13-15 (not Fig. 12).

These forms are oval to elliptical in cross-section and about straight to arcuate in the profile view. The surface is smooth, without any regular ornamentation. But small protuberances or nodes, through the length of the casts, impart them an irregular look.

Some of the forms described as *Lapworthella* spp. by Azmi (1983) are also grouped here as they also do not show deep transverse folds characteristic of *Lapworthella* Cobbold.

Material : Fair number of specimens
Repository : G. S. I. Type Nos. 20106 to 20108

REMARKS ON THE MICROFAUNAL ASSEMBLAGE

The elements most abundant in the microfaunal assemblage are the hyolithids *Circotheca* and *Turcutheca*, the conodontid *Protohertzina* and the problematical microfossil *Olivooides*. The individual abuandance of these elements through the column of Chert-Phosphorite Member is varying at the different levels. Whereas hyolithids and conodontid are frequency-wise generally well-matched in the levels of their occurrence, some of the levels in the sequence of Chert-Phosphorite Member show exclusive dominance of *Olivooides*. *Coleoloides* ? and *Lapworthella* ? are present in fair numbers, though never as abundant as the above referred elements. Rest of the forms are represented in the assemblage by rare occurrences.

Some phosphatic pseudofossils ?, which are generally globular in shape and include a variety of form outlines, also occur in the material of Chert-Phosphorite Member, sometimes in profusion in some of the levels. One of these pseudofossils ? was illustrated earlier by Bhatt *et al.* (1983, Pl. 2, Figs. 5, 10, 11).

CHRONOSTRATIGRAPHIC STATUS OF THE SMALL SHELLY FAUNA FROM CHERT-PHOSPHORITE MEMBER, TAL FORMATION, LESSER HIMALAYA

The marked presence of paraconodont *Protohertzina* in the microfaunal assemblage of Chert-Phosphorite Member of Tal Formation is significant inasmuch as the age connotation of the recovered microfaunal assem-

blage and, thereby, of the host strata is concerned. The genotype of *Protohertzina*, viz. *P. anabarica* Miss., which is abundantly present in some of the levels of Chert-Phosphorite Member, was first described from strata of Kotujkan river valley in the Anabar Shield of Siberian Platform, U. S. S. R. (Missarzhevsky, 1973); and according to the current Soviet literature the range of occurrence of *P. anabarica* is restricted within Nemakit-Daldynian Horizon (uppermost Proterozoic or Vendian) to the basal part of Tommotian Stage (early Early Cambrian; Sokolov and Fedonkin, 1984). The other species of the genus *P. siciformis* Miss., characterises the basal Tommotian strata of Karatau Ridge, Kazakhstan, U. S. S. R. In the Chinese sections the range of occurrence of the above two species of *Protohertzina* is restricted to the lower part of Meishucunian Stage (early Early Cambrian) and the association of *P. anabarica* and *P. siciformis* in the Maidiping Section, Emei, Sichuan, characterises the lowermost chronozone of Zone I of Meishucunian Stage, viz. *Circotheca-Anabarites-Protohertzina* Zone (Xing Yusheng *et al.*, 1984). The Chinese species *P. robusta* Qian is restricted in occurrence to the basal part of Meishucunian Stage in Shinzhonggou Section, Ningqiang, Shaanxi, P. R. C. (Xing Yusheng *et al.*, 1984) and to the basal fossiliferous sequence in the Meishucunian at Jijiapo, Yicheng West Hubei, P. R. C. (Chen Ping, 1984).

Amongst the hyolithids present in the material of Chert-Phosphorite Member, the Chinese forms *Circotheca longiconica* Qian and *C. obesa* Qian, which occur associated and in profusion in the material under investigation, characterise the basal chronozone or Zone I of Meishucunian Stage (Xing Yusheng *et al.*, 1984). The genus *Circotheca* as such is also known to have maximum radiation in the basal strata of Tommotian sequences in the U. S. S. R. (Raaben, Ed., 1981). *Turcutheca lubrica* Qian is known from Unit 5 of Zhongycun Member, Yushucun Formation, in the Chinese type section at Meishucun and chracterises Zone I of Meishucunian Stage (Luo *et al.*, 1984). *Turcutheca annae* (Sys.) and *Allatheca concinna* Miss. are known to range from the upper part of *Ajacicyathus sunnaginicus-Tiksitheca licis* Zone to lower part of *Dokidocyathus regularis* Zone, which together form the lower part of Tommotian Stage of Siberian Platform and other east European Early Cambrian sequences (Raaben, Ed., 1981). *Tiksitheca* characterises *Aj. sunnaginicus-T. licis* Zone and is more or less restricted to this fossil zone which forms the basal sequence in the Tommotian Stage (Raaben, Ed., 1981).

The record of *Incertae sedis* genus *Maikhanella* H. Zhegallo in the material of Chert-Phosphorite Member at Maldeota should be highlighted. This is probably the first record of the genus outside Mongolia, which contains the genotype locality. Significantly, the type species and the only species known so far of the genus *Maikhanella*, viz. *M. multa* H. Zhegallo, forms the guide fossil for *Tiksitheca licis-Maikhanella multa* Zone in the Bayangol Formation of the reference section at Salany-Gol, M. P. R., which is correlated with *Aj. sunnaginicus-T. licis* Zone, the oldest fossil zone in Tommotian Stage in the Siberian Platform (Rozanov, 1982).

The conodontiform *Ganloudina* He is known from Mofangyan Member of Dengying Formation, Nanjiang area, Northern Sichuan, and the associated small shelly fauna is correlated with lower part of Meishucunian Stage and Nemakit-Daldynian Horizon of Siberia (Yang Kianhe and He Tinggui, 1984).

DISCUSSION

The different elements of small shelly fauna of Chert-Phosphorite Member were referred earlier variously as re-worked gondolellid conodonts (Srivastava, 1974), forminifera of Moravamminidae family (Patwardhan, 1978), foraminifera or ? porifera (Ahluwalia 1978), primitive coniform conodonts (Azmi *et al.*, 1981), various external and internal hard parts of annelids (Singh and Shukla, 1981) and endothyrid foraminifera (Kalia, 1982). Bhatt *et al.* (1983) critically examined most of these reports and showed that these emerged through insufficient and wrong identification of the various elements of small shelly fauna of Tommotian age present in the material of Chert Phosphorite Member.

Subsequent to this, a report of Lias (Lower Jurassic) foraminiferal assemblage being present in the material of Chert-Phosphorite Member at PPCL Mine, Maldeota, appeared (Srivastava *et al.*, 1983), in which again the presumed similarity of only the external morphology of certain problematical microfossils of tubular and globular shapes of Tommotian age was tried to be emphasized with some Lias foraminifera and thereby wrongly inferring Lias age for the Chert-Phosphorite Member of Tal Formation, without examination of internal Parts which are so well-understood in case of foraminifera. In another detailed report Azmi (1983) gave a systematic description of the microfauna of Chert-Phosphorite Member exposed at seven locations in the Mussoorie Syncline, including the one at PPCL Mine, and mentioned occurrence this time, in addition to conodonts (Azmi *et al.*, 1981), "hyolithid, hyolithelminthid, lapworthellid, chancelloriid, a few miscellaneous forms of unknown affinity" in the microfauna recovered. He, however, again strongly advocated a Cambro-Ordovician boundary beds status (within Early Ordovician) for the chronostratigraphic level of Chert-Phosphorite Member and argued that the elements of Late Precambrian/Early Cambrian small shelly fauna

present in the assemblage came by re-working from older strata. However, the said mixing of microfauna of two different ages cannot be accepted on following grounds : i) The elements of small shelly fauna of Tommotian age present in the material of Chert-Phosphorite Member are extremely fragile and still do not show signs of abrasion or transport. ii) From available evidences, it turns out that Krol-Tal sequence represents deposits of continuous sedimentation without any hiatus (Singh and Rai, 1983) and in this context the re-working of older microfauna and its deposition in younger bed becomes an untenable proposition. Further, many of the elements of small shelly fauna of Tommotian age recorded by Azmi (1983) from Chert-Phosphorite Member of Tal Formation are not known in the material of the supposedly older Tommotian sequence of chert and phosphorite in Krol D at Durmala (Azmi and Pancholi, 1983).

The coniform conodonts of Cambro-Ordovician age (Azmi, 1983; Fig. 9) illustrated by Azmi (1983; Plates 1-4) have not been encountered by us in the material of Chert-Phosphorite Member of Tal Formation, exposed in PPCL Mine at Maldeota, Mussoorie and our studies have revealed that the stratigraphic level under discussion only yields small shelly fauna referable to lower of part Tommotian Stage or lower Part of Meishucunian Stage.

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EXPLANATION OF PLATES

(All figures X50, except where mentioned otherwise)

PLATE I

1 & 1a *Tiksitheca* sp.; 1a, cross-section; G. S. I. Type No. 20083.

2 & 2a *Turcutheca lubrica* Qian; 2a, cross-section; G. S. I. Type No. 20085.

3, 3a, 4, 4a, 7 & 7a *Circotheca longiconica* Qian; 3a, 4a & 7a, cross-sections; G. S. I. Type Nos. 20077, 20078, 4, and 20079, 7.

5 & 5a *Circotheca obesa* Qian; 5a, cross-section; G. S. I. Type No. 20080.

6, 6a & 11 *Circotheca* ? sp.; 6a, cross-section, X130; 11, X100; G. S. I. Type Nos. 20081, 6, and 20082, 11.

8, 8a, 10 & 10a *Turcutheca maldeotaensis* n. sp.; 8a & 10a. cross-sections; 10, holotype; G. S. I. Type Nos. 20086, 8, and 20087, 10.

9 & 9a *Turcutheca* aff. *T. annae* (Sys.); 9a, cross-section; G. S. I. Type No. 20084.

12, 12a & 13 *Protohertzina anabarica* Miss.; 12a, enlarged view of basal portion of 12, X130; posterior marginal keel : on the left-hand margin of the photomicrograph 12 and in the middle of photomicrograph 13; G. S. I. Type Nos. 20088, 12, and 20089, 13.

14 *Protohertzina siciformis* Miss; G. S. I. Type No. 20091.

15 *Protohertzina* aff. *P. robusta* Qian; posterior median keel on the left-hand margin of photomicrograph; G. S. I. Type No. 20090.

16 *Ganloudina* ? sp.; G. S. I. Type No. 20092.

17 & 17a *Allatheca concinna* Miss.; 17a, enlarged view of apertural end of 17, X160; G. S. I. Type No. 20076.

PLATE II

1-7, 11-13 & 17 — *Coleoloides* ? sp.; 1-6, 11 & 17, Type A and 7, 12 & 13, Type B; G. S. I. Type Nos. 20096, 1, 20097, 2, 20098, 3, 20099, 4, 20100, 5, 20101, 6, and 20102, 11 (Type A); 20103, 7, 20104, 12, and 20105, 13; 17, enlarged view of the surface of 3 (Type A).

8-10 — *Lapworthella* ? sp.; G. S. I. Type Nos. 20106, 8, 20107, 9, and 20108, 10.

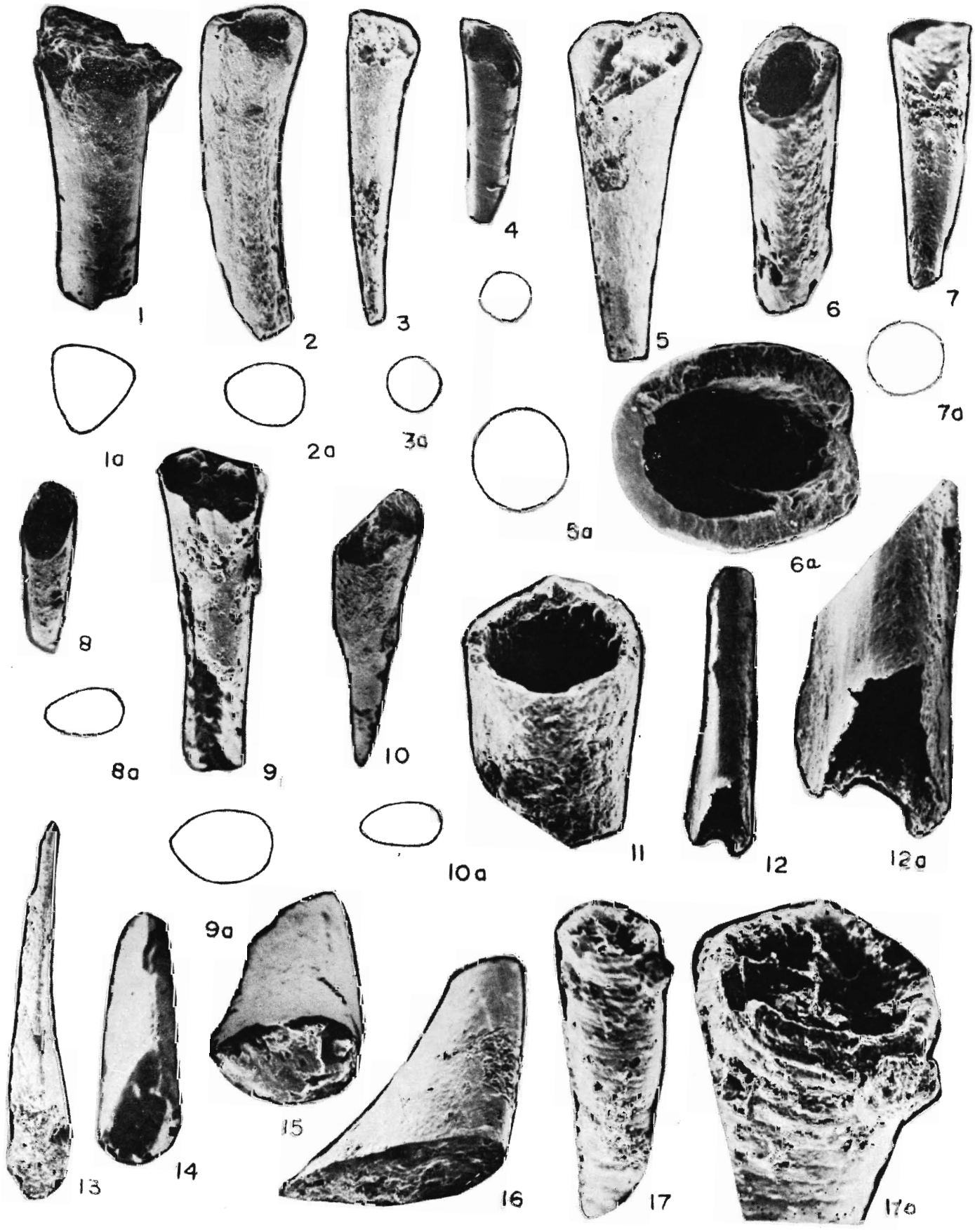
14 — Foraminiferida genus indet,; G. S. I. Type No. 20093.

15 — *Spirellus* ? sp.; G. S. I. Type No. 20095.

16 & 16a — *Maikhanella* sp.; 16, side view; 16a, top view showing arrangement of nodes parallel to the shell outline, X90; G. S. I. Type No. 20094.

PLATE III

1-14 — *Olivooides* sp.; 1,2,3, with smooth surface like in *Olivooides alveus* Qian; 4-14, with crumpled surface akin to *Olivooides blandes* Jiang; G. S. I. Type Nos. 20109 to 20122 for specimens from 1 to 14 serially.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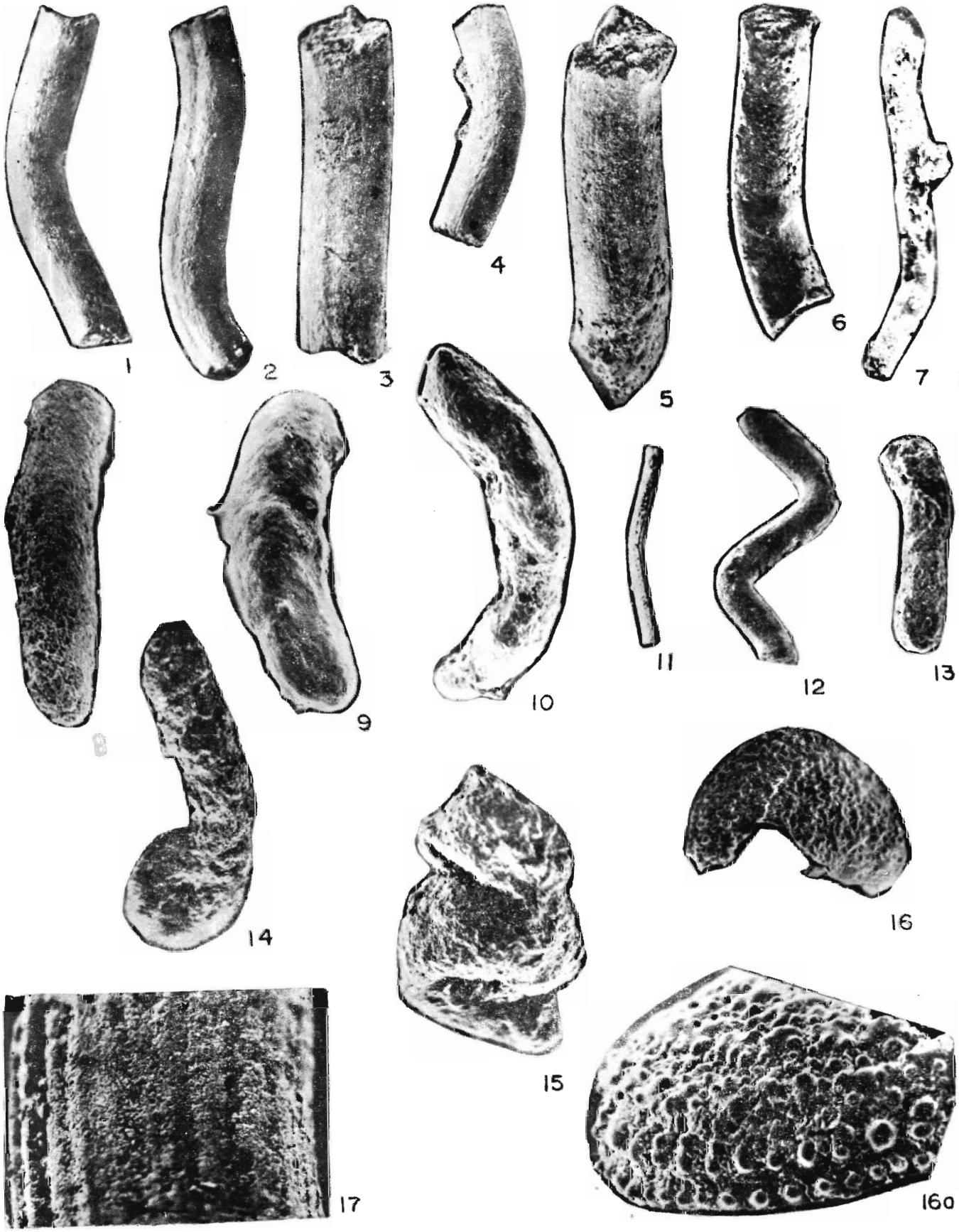
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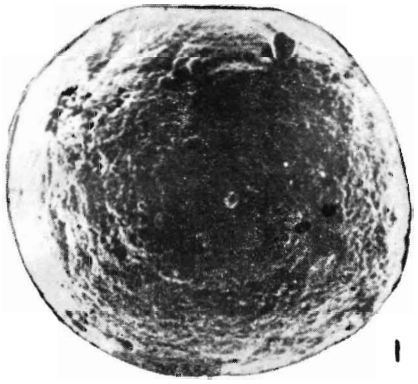
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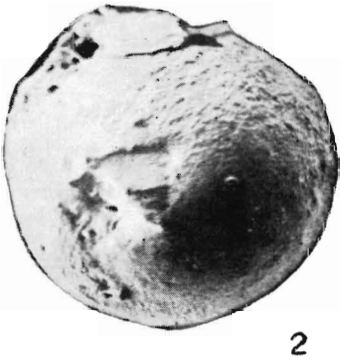
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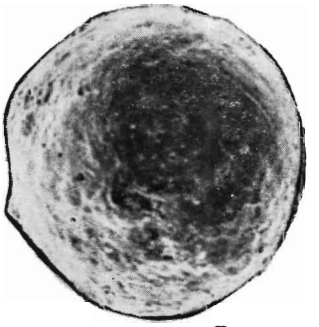
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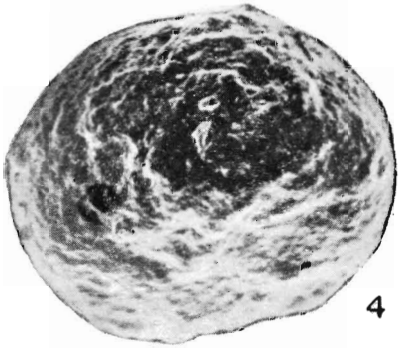
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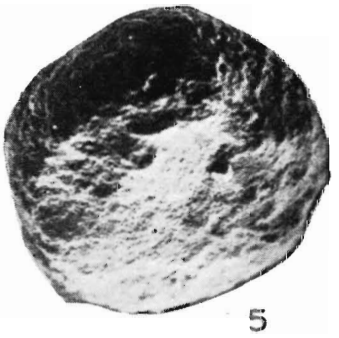
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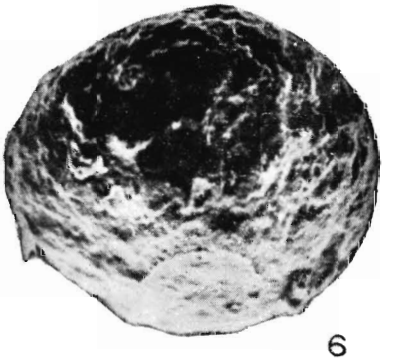
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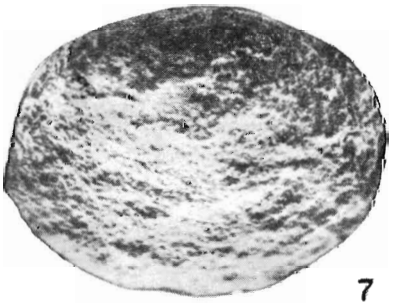
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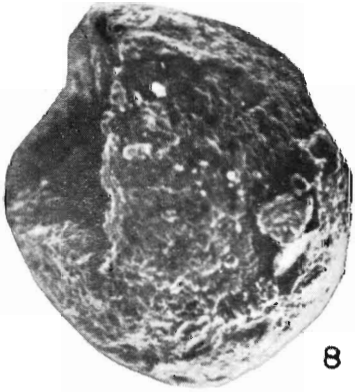
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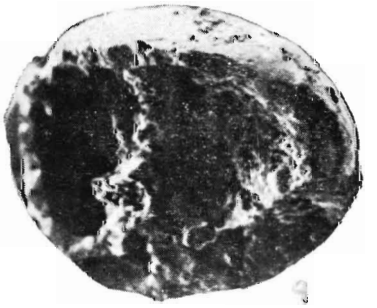

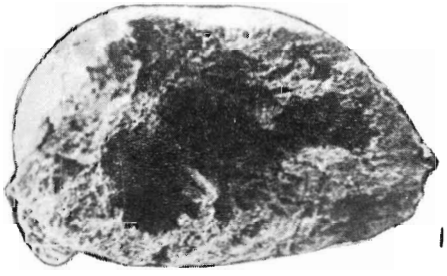
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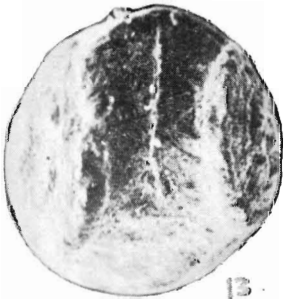

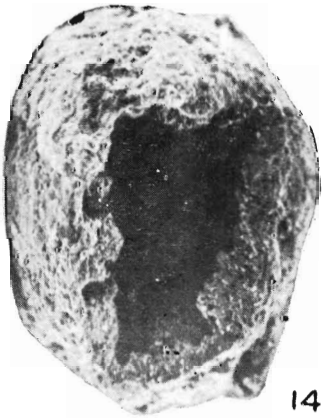
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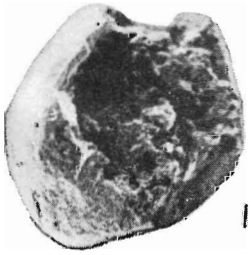
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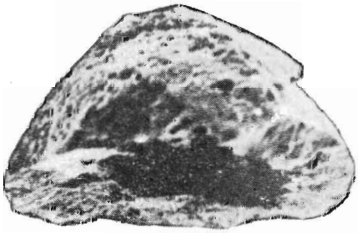
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