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# CORRESPONDENCE AND NOTES

## Skeletal microfauna of Meishucunian and Qiongzhusian (Precambrian–Cambrian boundary) age from the Ganga Valley, Lesser Himalaya, India

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**Abstract** – The earliest skeletal microfauna of Precambrian–Cambrian age recovered from the 'Lower Tal' sequence (Chert-Phosphorite to Calcareous members) of the Tal Formation, exposed in the Ganga Valley, Lesser Himalaya, Uttar Pradesh, India, has been grouped into three assemblages. In ascending order these are: assemblage I, containing *Anabarites trisulcatus* Missarzhevsky, *Tiksitheca korobovi* (Miss.). *Circotheca* sp., *Turcutheca* sp., *Spirellus columnorus* Jiang and *Olivooides alveus* Qian; assemblage II, yielding *Allonia erromenosa* Jiang, *A.* sp. cf. *A. erromenosa* Jiang, *Dimidia simpleca* Jiang, *D.* sp. cf. *D. simpleca* Jiang and *Hyolithellus* sp.; and assemblage III, comprising *Pelagiella lorenzi* Kobayashi, *Auriculatespira madianensis* Zhou & Xiao and *A. andunca* He & Pei. The assemblages I and II are correlatable to the Meishucunian Zone I and Zone III respectively, and the assemblage III to the Qiongzhusian Stage of China. Thus the 'Lower Tal' sequence is assigned to Precambrian–Cambrian age.

### 1. Introduction

The Tal Formation, in the Blaini-Krol-Tal succession of the Krol Belt in western Lesser Himalaya (Auden, 1934, 1937), is an important lithostratigraphic unit well known for phosphate deposits at its base. It conformably overlies the Krol Formation (E Member) and is transgressively overlapped either by the Early Permian Boulder Slate sequence (Waterhouse & Gupta, 1978; Bhatt & Singh, 1981) or the Cretaceous–Palaeocene Tal Shell Limestone (Manikot Shell Limestone/Nilkanth Formation). The sequence of the Tal Formation is exposed in the Garhwal, Mussoorie, Korgai and Nigalidhar synclines, and is divisible into Chert-Phosphorite, Argillaceous, Arenaceous, Calcareous and Phulchatti members in ascending order (Shanker, 1971; Kumar & Dhaundiyal, 1979). The first four members constitute the 'Lower Tal' and the Phulchatti Member corresponds to the 'Upper Tal' sequence (Auden, 1934, 1937). The Tal Formation was earlier assigned a probable Jurassic to Cretaceous age (Auden, 1934). More recently, Singh (1976, 1979*a*, *b*) argued for a Precambrian or Precambrian–Cambrian transition age for it. The renewed palaeontological studies resulted in several micropalaeontological records from the Chert-Phosphorite Member of the Tal Formation in the Mussoorie Syncline (Azmi, Joshi & Juyal, 1981; Singh & Shukla, 1981; Kalia, 1982; Srivastava *et al.* 1983; Bhatt *et al.* 1983; Azmi, 1983; Bhatt, Mamgain & Misra, 1985). However, the different workers interpreted the apparently same microfauna differently, both in terms of palaeobiology as well as chronostratigraphy, namely, Azmi, Joshi & Juyal and Azmi (1981, 1983, primitive conodonts of Upper Cambrian/Early Ordovician), Singh & Shukla (1981, internal and external hard parts of annelids of Upper Cretaceous), Kalia (1982, endothyrid foraminifera of Permian), Srivastava *et al.* (1983, foraminifera of Lower Jurassic'. Bhatt *et al.* (1983) and Bhatt, Mamgain & Misra (1985) showed that the microfauna of the Chert-Phosphorite Member consisted of earliest skeletal fossils of lower Tommotian age. This age assignment also received support from later records of other fossil groups from other stratigraphic levels of Tal Formation in the Mussoorie Syncline, namely Tewari (1984, stromatolite of Tommotian age from Chert-Phosphorite Member), Singh & Rai (1983, an assemblage of trace fossils of probable Tommotian to Atdabanian stages from Arenaceous Member), Rai & Singh (1983, trilobite impressions from Arenaceous Member) and Tripathi *et al.* (1984, 1986, brachipods of Botomian Stage from 'Upper Tal').

In the Garhwal Synform, lying southeast of the Mussoorie Syncline in the Lesser Himalaya, the only record of microfauna until now consisted of the microgastropod *Pelagiella* sp. in association with the brachiopod *Diadongia* sp. cf. *D. pista* Rong from the Calcareous Member (Kumar *et al.* 1983), which according to the authors indicated an Atdabanian level. The present record of the varied microfauna consisting of earliest skeletal fossils, many of them now having their first record from the Himalayan region, includes several zonal guide fossils from the earliest Meischucunian Stage to the Qiongzhusian Stage of the Precambrian–Early Cambrian sequences of China.

### 2. Lithostratigraphy

A good and easily accessible exposure of the entire Tal Formation is available for examination on Rishikesh–Deoprayag Highway, on the right bank of the Ganga River between Kauriyala and Singtali villages (Fig. 1). In this section, the basal Chert-Phosphorite Member of the Tal Formation, conformably overlying the calcareous sequence of the Krol Formation (Krol E), consists of chert (0.9 m)

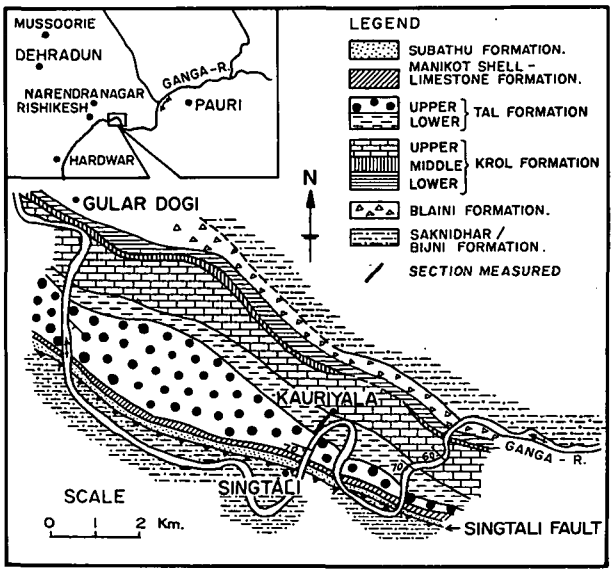


Figure 1. Location and sketch geological map of part of the Garhwal Synform (after Kumar *et al.* 1983) showing the section studied.

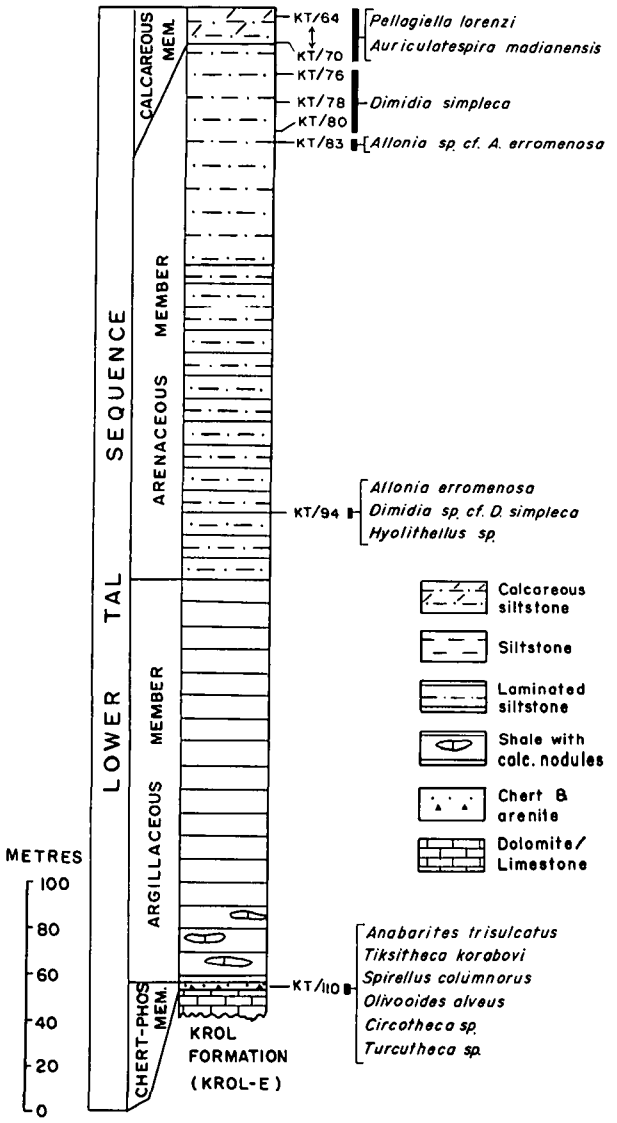


Figure 2. Lithocolumn of the 'Lower Tal' sequence, Tal Formation in Ganga Valley showing samples yielding diagnostic microfauna.

and friable sandstone (0.61 m) with streaks of phosphorite. The Argillaceous Member, 177 m thick, consists of black shale with bands, lenticles and nodules of calcareous concretions. The Arenaceous Member, 234 m thick, is characterized by dark grey to black laminated siltstone (149 m) and light grey thick-bedded siltstone (85 m). The Calcareous Member is only 16 m thick and is made up of grey calcareous siltstone weathering to brown. This succession, the Chert-Phosphorite to Calcareous members, constitutes the 'Lower Tal', and is conformably overlain by the Phulchatti Member ('Upper Tal'). Samples through the whole column of the 'Lower Tal' were collected; all the lithological members, except the Argillaceous Member, have yielded skeletal fossils (Fig. 2).

## 3. Microfauna

Given below are the three assemblages of the main microfauna recovered (Fig. 3), from base upwards.

*Assemblage I*

Friable sandstone (Chert-Phosphorite Member) contains *Anabarites trisulcatus* Miss., *Tiksitheca korobovi* (Miss.), *Circotheca* sp., *Turcutheca* sp., *Spirellus columnorus* Jiang and *Olivooides alveus* Qian.

*Assemblage II*

Laminated siltstone (lower part of Arenaceous Member) yields *Allonia erromenosa* Jiang, *Dimidia* sp. cf. *D. simpleca* Jiang and *Hyolithellus* sp.

Grey siltstone (upper part of Arenaceous Member) bears *Allonia* sp. cf. *A. erromenosa* Jiang, and *Dimidia simpleca* Jiang in association with the trace fossils *Skolithos* sp. and *Taphrhelminthopsis circularis* Crimes.

*Assemblage III*

Calcareous Member contains *Pelagiella lorenzi* Kobayashi, *Auriculatespira madianensis* Zhou & Xiao, *A. andunca* He & Pei and *A.* sp.; the latter genus can be distinguished from the former by a much narrower and elongated apertural opening than in *Pelagiella* (Fig. 31.).

The fair preservation of microfossils affords ready observation of morphological features and satisfactory identification. The fossil specimens are deposited in the Palaeontology and Stratigraphy Division, Geological Survey of India, Calcutta bearing GSI type nos. 19833, 19834, and 20192 to 20207.

## 4. Correlation and age

The present microfaunal assemblages containing several cosmopolitan taxa have considerable similarities with those known from the Meishucunian to Qiongzhusian stages of China, which may approximately correspond to the Tommotian and Atdabanian stages of the Russian Platform. The lithological succession of the present area also has close similarity with the Chinese sequence (Kumar, 1984).

Assemblage I consists of *Anabarites trisulcatus*, *Tiksitheca korobovi*, *Spirellus columnorus*, *Olivooides alveus*, *Turcutheca* sp. and *Circotheca* sp., which characterize the earliest fossil zones of the Meishucunian Stage in China – the *Anabarites–Circotheca–Protohertzina* Zone or Zone I (Xing Yusheng *et al.* 1984). The absence of *Protohertzina* in the present

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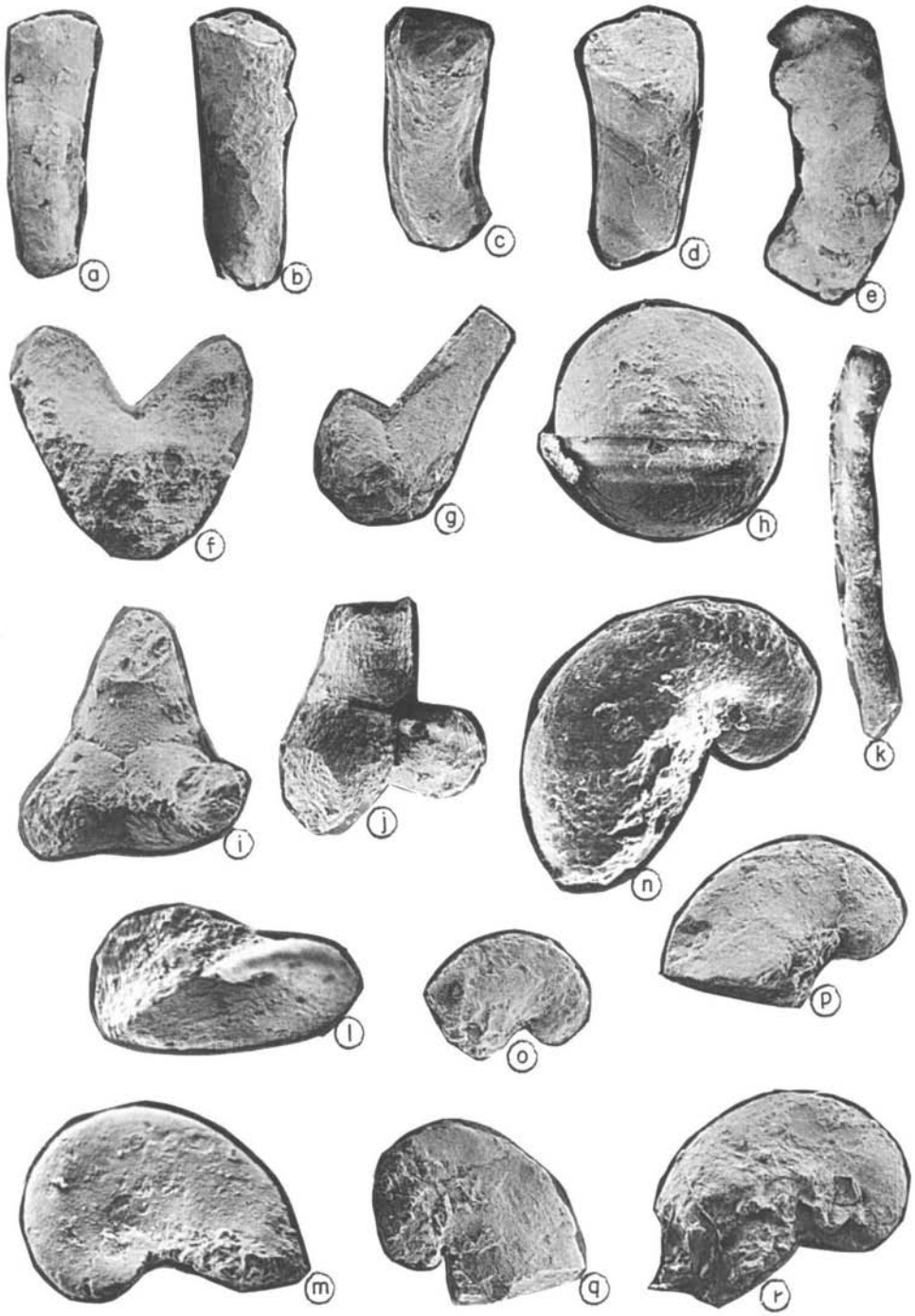


Figure 3. Diagnostic microfauna from the 'Lower Tal' sequence, Tal Formation, Garhwal Synform, Lesser Himalaya. a, b, c, d, e, h are from the Chert–Phosphorite Member; f, j, k, from the laminated siltstone and g, i from the grey siltstone of the Arenaceous Member; and l, m, n, o, p, q, r from the Calcareous Member. (a) *Turcutheca* sp., × 40. GSI type no. 20192. (b) *Circotheca* sp., × 40. GSI type no. 20193. (c) *Anabarites trisulcatus* Missarzhevsky, × 65. GSI type no. 20194. (d) *Tiksitheca korobovi* (Miss.) × 40. GSI type no. 20195. (e) *Spirellus columnorus* Jiang, × 40. GSI type no. 20196. (f) *Dimidia* sp. cf. *D. simpleca*, Jiang, × 110. GSI type no. 20197. (g) *Dimidia simpleca* Jiang, × 60. GSI type no. 20198. (h) *Olivooides alveus* Qian, × 60. GSI type no. 20199. (i) *Allonia* sp. cf. *A. erromenosa* Jiang, × 75. GSI type no. 20200. (j) *Allonia erromenosa* Jiang, × 150. GSI type no. 20201. (k) *Hyolithellus* sp., × 65. GSI type no. 20202. (l) *Pelagiella lorenzi* Kobayashi, apertural view, × 40. GSI type no. 19833. (m) *Pelagiella lorenzi* Kobayashi, lateral view, × 40. GSI type no. 19834. (n) *Auriculatespira andunca* He & Pei, × 30. GSI type no. 20203. (o) *Auriculatespira madianensis* Zhou & Xiao, × 95. GSI type no. 20204. (p) *Auriculatespira madianensis* Zhou & Xiao, × 65. GSI type no. 20205. (q) *Auriculatespira* sp., × 95. GSI type no. 20206. (r) *Auriculatespira* sp., × 30. GSI type no. 20207.

assemblage is notable as it is present in abundance in the adjoining section of the Mussoorie area (Bhatt, Mamgain & Misra, 1985), where *Anabarites trisulcatus* has, however, not been recorded. *Anabarites trisulcatus* and *Tiksitheca korobovi* also characterize the earliest fossil zone of the Tommotian sequence of the Russian Platform (Missarzhevsky & Rozanov, 1969, tables 7 and 8) – the *Aldanocyathus sunnaginicus* Zone (Cowie & Rozanov, 1983).

The association of chanceloriids, *Allonia* and *Dimidia*, in assemblage II, is quite significant as these are zonal guide

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fossils characterizing the topmost part of the Meishucunian Stage – the *Eionovitatus–Sinosachites–Ebianotheca* Zone or Zone III (Xing Yusheng *et al.* 1984), in the stratotype section at Meishucun, Jinning County, Yunnan, China (Luo Huilin *et al.* 1982, 1984). These chancelloriids are recorded here for the first time from the Himalayan region. The assemblage of these distinctive chancelloriids in the Himalayan region confirms that Zone III of the Meishucunian Stage of China extends westwards in the Tethyan belt at a similar stratigraphic level.

The presence of the gastropod *Pelagiella lorenzi*, in association with *Auriculatespira madianensis* and *A. andunca* in Assemblage III, is again quite significant. *Pelagiella lorenzi* is known from the Atdabanian Stage in the U.S.S.R. and England (Matthews & Missarzhevsky, 1975). However, some reviews of Siberian taxa (Sokolov & Zhuraleva, 1983; Rozanov & Sokolov, 1984) indicate a Botomian and possibly latest Atdabanian age for this taxon (attention to this information was kindly drawn by M. D. Brasier, University of Hull, England). *Pelagiella* sp. is also known from the Early Cambrian *Callavia* Zone of the northern Antigonish Highlands, Nova Scotia, Canada (Landing, Nowlan & Fletcher 1980). In the Chinese sections, *Pelagiella* sp. is recorded from the Qiongzhusian Stage (Xing Yusheng *et al.* 1983). Until its present discovery in India, the gastropod genus *Auriculatespira* has only been recorded in China. The genotype, *A. andunca* He & Pei, is described from the Tsanglangpuian Stage in the Xinji Formation of Henan (He Tinggui, Pei Fang & Fu Guang-Hong, 1984). *Auriculatespira madianensis* has been described from a middle Early Cambrian sequence (Qiongzhusian Stage) of the Yutaishan Formation in Huainan and Huoqin counties, Anhui Province, China (Zhou Benhe & Xiao Ligong, 1984). The available Chinese literature indicates that *Pelagiella* and *Auriculatespira* range from the Qiongzhusian Stage to the Tsanglangpuian Stage. However, in the Lesser Himalayan sequence, the strata yielding this association occur stratigraphically much below the beds bearing a Botomian (= ? Tsanglangpuian) brachiopod assemblage. In the Lesser Himalaya, therefore, the strata of the Calcareous Member, which contains the grastropod association in the present sequence (Fig. 2), are being considered Qiongzhusian in age.

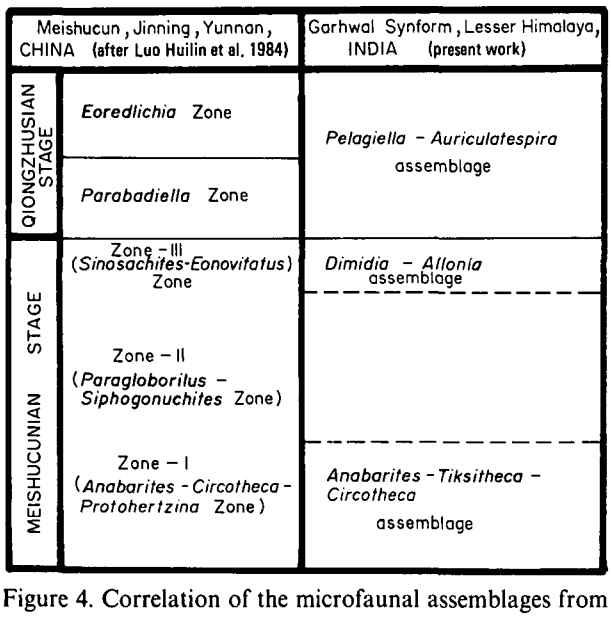


Figure 4. Correlation of the microfaunal assemblages from the 'Lower Tal' sequence of the Tal Formation, Ganga Valley, Lesser Himalaya, with that of China.

Based on the above chronostratigraphic inferences, the proposed correlation of the Ganga Valley sequence with that of the Chinese stratotype section is given in Figure 4. The microfauna representing Meishucunian Zone II of China, probably corresponding to the Argillaceous Member of the Tal Formation, has not been recorded from this area. According to the standing decision of IUGS, the Meishucunian Zone I is regarded as latest Precambrian.

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## References

AUDEN, J. B. 1934. Geology of the Krol belt. *Records Geological Survey of India* **67**, 357–454.

AUDEN, J. B. 1937. The structure of Himalaya in Garhwal. *Records Geological Survey of India* **71** (4), 407–433.

AZMI, R. J. 1983. Microfauna and age of the Lower Tal Phosphorite of Mussoorie Syncline, Garhwal Lesser Himalaya, India. *Himalayan Geology* **11**, 373–409.

AZMI, R. J., JOSHI, M. N. & JUYAL, K. P. 1981. Discovery of the Cambro-Ordovician conodonts from the Mussoorie Tal Phosphorite: its significance in correlation of Lesser Himalaya. In *Contemporary Geoscientific Researches in Himalaya* (ed. A. K. Sinha) **1**, 245–250. Bishan Singh Mahendra Pal Singh Publishers, Dehradun, India.

BHATT, D. K., MAMGAIN, V. D. & MISRA, R. S. 1985. Small shelly fossils of Early Cambrian (Tommotian) age from Chert-Phosphorite Member, Tal Formation, Mussoorie Syncline, Lesser Himalaya, India and their chronostratigraphic evaluation. *Journal of the Palaeontological Society of India* **30**, 92–102.

BHATT, D. K., MAMGAIN, V. D., MISRA, R. S. & SRIVASTAVA, J. P. 1983. Shelly microfossils of Tommotian age (Lower Cambrian) from Chert-Phosphorite Member of Lower Tal Formation, Maldeota, Dehradun district, Uttar Pradesh. *Geophytology* **13** (1), 116–123.

BHATT, D. K. & SINGH, M. P. 1981. A note on the fauna of Artinskian (Lower Permian) affinity from Garhwal Synform, Lesser Himalaya. *Journal Palaeontological Society of India* **26**, 1–5.

COWIE, J. W. & ROZANOV, A. YU. 1983. Precambrian–Cambrian Boundary candidate, Aldan River, Yakutia, USSR. *Geological Magazine* **120** (2), 129–130.

HE TINGGUI, PEI FANG & FU GUANG-HONG, 1984. Some small shelly fossils from the lower Cambrian Xinji Formation in Fengcheng county, Henan Province. *Acta Palaeontologica Sinica* **23**, 350–357; pls I, II.

KALIA, P. 1982. Discovery of endothyrid foraminifers from the bedded Maldeota Phosphorites, Garhwal Himalaya, *Current Science* **51** (10), 519–520.

KUMAR, G. 1984. The Precambrian–Cambrian boundary beds, Northwest Himalaya, India and boundary problem. *Proceedings V Indian Geophytological Conference, November, 1983*, pp. 98–111. Special issue, Palaeobotanical Society, Lucknow.

KUMAR, G. & DHAUNDIYAL, J. N. 1979. Stratigraphy and structure of Garhwal Synform, Garhwal and Tehri Garhwal districts, Uttar Pradesh: a reappraisal. *Himalayan Geology* **9**, 18–41.

KUMAR, G., RAINA, B. K., BHATT, D. K. & JANGPANGI, B. S. 1983. Lower Cambrian body- and trace-fossils from Tal Formation, Garhwal Synform, Uttar Pradesh, India. *Journal of the Palaeontological Society of India* **28**, 105–110.

LANDING, E., NOWLAN, G. S. & FLETCHER, T. P. 1980. A microfauna associated with Early Cambrian trilobites of the *Callavia* Zone, northern Antigonish Highlands, Nova Scotia. *Canadian Journal of Earth Sciences* **17** (3), 400–418.

LUO HUILIN, JIANG ZHIWEN, WU XICHE, SONG XUELING, QUYANG LIN *et al.* 1982. *The Sinian–Cambrian Boundary in Eastern Yunnan, China*, 265 pp., pl. 36.

LUO HUILIN, JIANG ZHIWEN, WU XICHE, SONG XUELING, QUYANG LIN, XING YUSHENG, LIU GUIZHI, ZHANG SHISHAN & TAO YONGHE, 1984. *Sinian–Cambrian Stratotype Section at Meischucun, Jinning, Yunnan, China*. People's Publishing House, Yunnan, China.

MATTHEWS, S. C. & MISSARZHEVSKY, V. V. 1975. Small shelly fossils of Late Precambrian – Early Cambrian age: a review of recent work. *Journal of the Geological Society of London* **131**, 289–304.

MISSARZHEVSKY, V. V. & ROZANOV, A. YU. 1969. Fossil assemblages and zonal stratigraphy of Cambrian–Precambrian boundary deposits of the Siberian Platform. In *The Tommotian Stage and the Cambrian Lower Boundary Problem* (ed. M. E. Raaben), pp. 62–70. New Delhi: Amerind Publishing Co. (English translation, 1981.)

RAI, V. & SINGH, I. B. 1983. Discovery of trilobite impressions in the Arenaceous Member of Tal Formation, Mussoorie area, India. *Journal of the Palaeontological Society of India* **28**, 114–117.

ROZANOV, A. YU. & SOKOLOV, B. 1984. Lower Cambrian stage subdivision. Stratigraphy. *Akad. Nauka, SSSR*, Moscow.

SHANKER RAVI, 1971. Stratigraphy and sedimentation of Tal Formation, Mussoorie Syncline, Uttar Pradesh. *Journal Palaeontological Society of India* **16**, 1–15.

SINGH, I. B. 1976. Evolution of Himalaya in light of marine transgressions in the Peninsular and Extra-peninsular India. *Proceedings 125th Anniversary Celebrations, Geological Survey of India, Symposium, Lucknow 1976* (preprint).

SINGH, I. B. 1979*a*. Some thoughts on the evolution of Himalaya and the northern limit of the Indian shield. *Geol. Rdsch.* **68**, 342–350.

SINGH, I. B. 1979*b*. Environment and age of the Tal Formation of Mussoorie and Nilkanth areas of Garhwal Himalaya. *Journal of the Geological Society of India* **20**, 214–225.

SINGH, I. B. & RAI, V. 1983. Fauna and biogenic structures in Krol-Tal Succession (Vendian– Early Cambrian), Lesser Himalaya: their biostratigraphic and palaeontological significance. *Journal of the Palaeontological Society of India* **28**, 67–90.

SINGH, P. & SHUKLA, S. D. 1981. Fossils from Lower Tal: their age and its bearing on the stratigraphy of Lesser Himalaya. *Geoscience Journal* **2**, 157–176.

SOKOLOV, B. & ZHURAVLEVA, I. T. 1983. Lower Cambrian Stage subdivisions of Siberia. Atlas of fossils. *Trans. Inst. Geol. Geophys.* **558**, *Nauka*, Moscow.

SRIVASTAVA, S. S., GOEL, R. K., JAIN, A. K., AWASTHY, A. K. & VERMA, R. M. 1983. Lower Jurassic foraminifera from the Chert-Phosphorite Member of Tal Formation, Garhwal Lesser Himalaya, and the age of the Krol belt sediments. *Current Science* **52** (23), 1136–1139.

TEWARI, V. C. 1984. Discovery of Lower Cambrian Stromatolite from the Mussoorie Tal Phosphorite, India. *Current Science* **53** (6), 319–321.

TRIPATHI, C., JANGPANGI, B. S., BHATT, D. K., KUMAR, G. & RAINA, B. K. 1984. Early Cambrian brachiopods from 'Upper Tal', Mussoorie Syncline, Dehradun district, Uttar Pradesh, India. *Geophytology* **14** (2), 221–227.

TRIPATHI, C., KUMAR, G., MEHRA, S., BHATT, D. K., MATHUR, V. K., JOSHI ASHUTOSH & JANGPANGI, B. S. 1986. Additional Early Cambrian (Botomian) brachiopod fossil localities in Tal Formation, Lesser Himalaya, India, and their significance. *Current Science* **55** (12), 585–588.

WATERHOUSE, J. B. & GUPTA, V. J. 1978. Early Permian fossils from Bijni Tectonic unit, Garhwal Himalaya. *Recent Researches in Geology*, **4**, 410–437. Delhi: Hindustan Publishing Corporation.

XING YUSHENG, DING QIXIU, LUO HUILIN, HE TINGGUI, WANG YANGENG *et al.* 1983. The Sinian–Cambrian boundary of China. *Bulletin Institute of Geology, Chinese Academy of Geological Sciences*, no. 10, special issue. Beijing: Geological Publishing House.

XING YUSHENG, DING QIXIU, LUO HUILIN, HE TINGGUI & WANG YANGENG, 1984. The Sinian–Cambrian boundary of China and its related problems. *Geological Magazine* **121**, 155–170.

ZHOU BENHE AND XIANG LIGONG, 1984. Early Cambrian monoplacophorans and gastropods from Huainan and Huoqiu counties, Anhai Province, *Professional Papers of Stratigraphy and Palaeontology* **13**, 125–140, (In Chinese with abstract in English.)