THE NEOGENE CHAROPHYTE FLORA OF THE SIWALIK GROUP, INDIA AND ITS BIOSTRATIGRAPHICAL SIGNIFICANCE*

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ABSTRACT

Thirteen charophyte taxa are described from the well-known freshwater Neogene mollasse sediments —the Siwalik Group—of the sub Himalayas, India in the Circum-Pacific region. The assemblage includes two new species of *Sphaerochara*, one of *Tectochara*, one of *Hornichara*, and one new subspecies of *Chara rantzieni*. The biostratigraphic zonation of the group has been attempted for the first time. While the lowermost and the uppermost units of the group, namely the Kamlial and the Boulder Conglomerate formations, are completely devoid of any charophyte remains, the intervening succession comprising the Chinji, Nagri, Dhok Pathan, Tatrot and Pinjor formations contain a rich charophyte assemblage which is divisible into two range zones. The lower range zone comprising the Chinji-Dhok Pathan sequence is named as the *Tectochara meriani meriani* Zone (Tortonian-Pontian) while the upper range zone, named as the *Hornichara maslovi* Zone, comprises the Tatrot-Pinjor sequence (Astian-Villafranchian s. s.). Two subzones are proposed under the *Tectochara meriani meriani* Zone—a lower *T. meriani huangi* Sub Zone (restricted to Chinji) and an upper *Sphaerochara tewarii—S. pecki* Sub Zone (restricted to Dhok Pathan). The *Hornichara maslovi* Zone has a subzone in the lower part (Tatrot) in which *Chara surajpurica* is restricted. The Tatrot and Pinjor formations are considered as one biostratigraphic unit characterized by the exclusive occurrence of certain mammalian taxa and by *H. maslovi* sp. nov. Contrary to the prevalent views, the Pinjor Formation is assigned to the Pliocene (Villafranchian s.s.).

INTRODUCTION

The paper presents for the first time a comprehensive account of the charophytic flora of the well-known freshwater mollasse sediments—the Siwalik Group (Tortonian-Villafranchian s. s.)—of the sub Himalayas. Although this 6800 m thick sequence contains a wealth of fossil vertebrate, molluscan and ostracode fauna and flora, not much use has been made thereof in delineating biostratigraphic zones. This may perhaps be attributed to the fact that the vertebrate and other megafossils tend to occur in small pockets at certain specific levels/horizons. They are thus, not always easy to retrieve. We thus find that despite the occurrence of an overall rich vertebrate fauna, its utility in biostratigraphic zonation appears to be limited. Nevertheless, the first attempt at biostratigraphic zonation on the basis of mammalian fauna was made by PRASAD AND RAY (1964). This was followed by those of PANDEY (1973), who proposed three biozones on the basis of the proboscidean fauna, and NANDA (1973). In so far as the fossil flora is concerned, the first attempt at palynostratigraphic zonation has recently been made by NANDI (1975). A comprehensive reference to the hitherto known fossil flora of the Siwalik Group may also be found in NANDI's paper (1975). A perusal of these references shows that the charophytic flora is comparatively little known, the only papers being those by BHATIA AND MATHUR (1970), TEWARI AND SHARMA (1972) and LAKHANPAL *et al.* (1976). The present paper, which is a sequel to our earlier short communication of 1970, describes the entire Neogene

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charophytic flora of the Siwaliks in detail. Besides bringing the taxonomy of the known charophytic flora up-to-date, the paper also attempts a biostratigraphic subdivision of the Siwaliks on the basis of fossil Charophyta.

STRATIGRAPHIC SETTING

A simplified geological map of the area between the rivers Ghaggar and the Ravi, from where the present suite of charophyte taxa is being recorded, is shown in Fig. 1. As

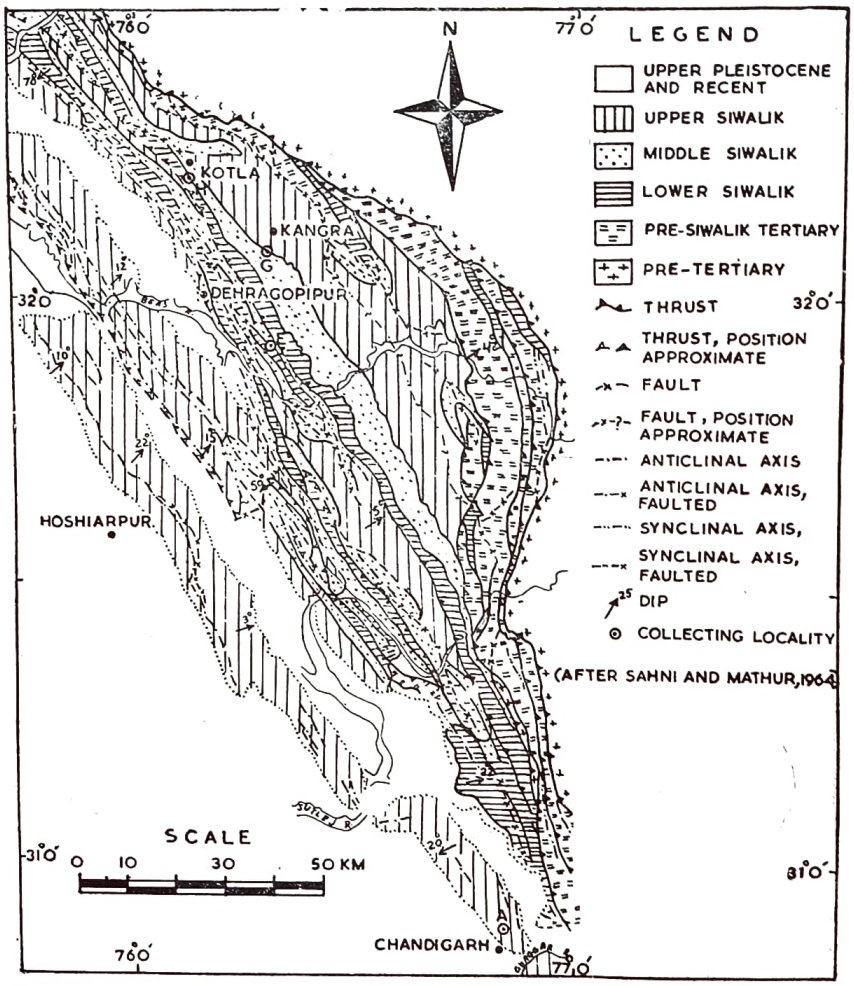

Fig. 1. Geological map of the sub Himalayas north and northwest of Chandigarh showing collecting localities.

a working expediency, we have retained the traditional subdivisions of the Siwaliks originally proposed by PILGRIM (1913) and subsequently followed by numerous authors. However, we have favoured the use of lithostratigraphic nomenclature for the various subdivisions, as suggested by SAHNI AND MATHUR (1964) and HUSSAIN (1971). A synoptic historical account of the more important views on the classification, including our own, is given in Fig. 2. Following the works of GRICHUK *et al.* (1965, p. 327), HAYS AND BERGGREN (1971) and BERGGREN (1973) we have assigned the Pinjor Formation (Villafranchian s. s.) to the Pliocene, equivalent at least in part to the Astian Stage. The type Villafranchian is now considered older than the base of the Calabrian and is dated at 3.4 M. yrs. Although as pointed out by SAVAGE AND CURTIS (1967), the presence of *Equus*, *Bos* (*Leptobos*) and *Elephas* fauna is not yet definitely established from the type Villafranchian, their presence in other areas, e.g. in the U S.S.R. (GROMOV *et al.*, 1964) in the Villafranchian s. s. is well known. Our views are in harmony with those of DUTTA AND GREGORESCU (1975) who arrived at similar conclusions (particularly *vis-a-vis* the Pinjor Formation) on the basis of their correlation of the Siwalik mammalian fauna with equivalent faunas in south-eastern Europe,

including Crimea and Caucasus. Although the Tatrot fauna contains a number of hold overs from the Dhok Pathan, we are inclined to consider Tatrot and the Pinjor together as one biostratigraphic unit, being characterized by the exclusive occurrence of *Archidiskodon*, *Potamochoerus*, *Hemibos* and *Hexaprotodon* among the mammals (PRASAD, 1968 ; 1972) and by *Hornichara maslovi* sp. nov. among the charophyta.

BIOSTRATIGRAPHIC IMPLICATION OF THE CHAROPHYTE FLORA

A rich Neogene charophyte flora comprising thirteen taxa has been found in the Siwalik Group (Fig. 3). No charophytes were found in the Kamlial and Nagri formations. A rich Chinji flora comprising *Tectochara meriani meriani*, *T. meriani huangi*, *T. sahnii*, *T.* sp. indet. and *Sphaerochara* sp. indet. has been found at locality H. Of these, *T. meriani meriani* extends up to the Dhok Pathan (*T. meriani meriani* Zone), while *T. meriani huangi* and *T. sahnii* are apparently restricted to the Chinji Formation (*T. meriani huangi—T. sahnii* Sub Zone). The Dhok Pathan Formation is characterised by the exclusive occurrence and abundance of two new species of *Sphaerochara—S. tewarii* and *S. pecki*—and one new subspecies *Chara rantzieni sivalensis* (*S. tewarii—S. pecki* Sub Zone). As already remarked in the previous section, the Tatrot and Pinjor formations are characterized by the occurrence of a new species—*Hornichara maslovi*—which is apparently restricted to these two formations (*H. maslovi* Zone). The rest of the charophytic flora in this zone comprises four taxa of *Chara—C. contraria*, *C. rantzieni*, *C. surajpurica* and *C.* sp. indet. Of these, *C. surajpurica* is apparently restricted to the Tatrot Formation (*C. surajpurica* Sub Zone), while the other three taxa extend into the Quaternary (Late Pleistocene terrace deposits).

TAXONOMIC COMMENTS ON THE GENUS *GRAMBASTICHARA*

The organ-genus *Grambastichara* was erected by HORN AF RANTZIEN (1959a, p. 68) to include charophyte gyrogonites which are distinguishable from *Chara* Linnaeus (1753) by the presence of an apical rosette, thicker (convex) lime spirals, and thicker basal plug, and from *Tectochara* Grambast & Grambast (1954) by the absence of distinct regular depression outside the basal pore, thicker basal plug and less considerable narrowing of the spiral cells in the apical periphery. However, GRAMBAST (*in* HORN AF RANTZIEN & GRAMBAST, 1962, pp. 140, 141) pointed out that "*Charites* and *Grambastichara* should be treated as synonymous even in such an artificial system as used by HORN, because both are within the range of variation of modern *Chara* lime-shells." They further concluded that "the authors were uncertain whether the *Grambastichara*- type of gyrogonite is really produced in the normal way by recent species of *Chara*. Special investigation should also be useful to know more about the comparative stratigraphic distribution of *Chara* or *Charites* and *Grambastichara;* adequate information on Pliocene and Pleistocene charophytes is lacking."

In view of the above mentioned discussion on the validity or otherwise of the organ-genus *Grambastichara* Horn af Rantzien, its taxonomic position became uncertain and GRAMBAST (1962) doubtfully included this genus in the tribe Charaeae. In order to find a satisfactory answer to this controversy, the authors carried out certain experiments on the recent specimens of *Chara fragilis* Desvaux which is growing abundantly in a pond in the Botanical Garden of the Panjab University, Chandigarh. Some mature lime shells of *Chara fragilis* were collected during the dry period (August, 1971) while living plants of it were collected in February, 1973, so as to duplicate "the mode of occurrence of the fossil material" as suggested by GRAMBAST (in HORN AF RANTZIEN & GRAMBAST, 1962, p. 140). It was observed that the younger lime shells in these plants bore concave lime spirals and

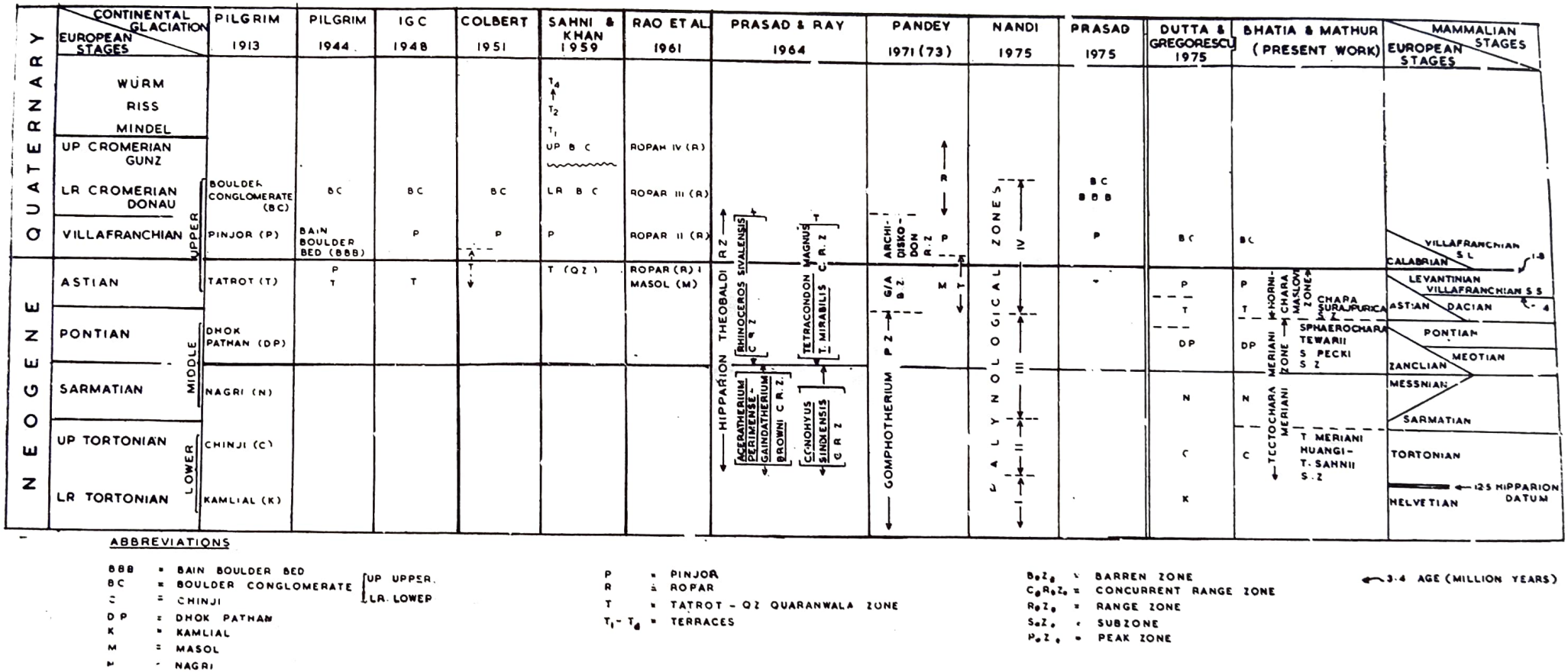

Fig. 3. Historical resume of the more important views on the classification of Siwaliks.

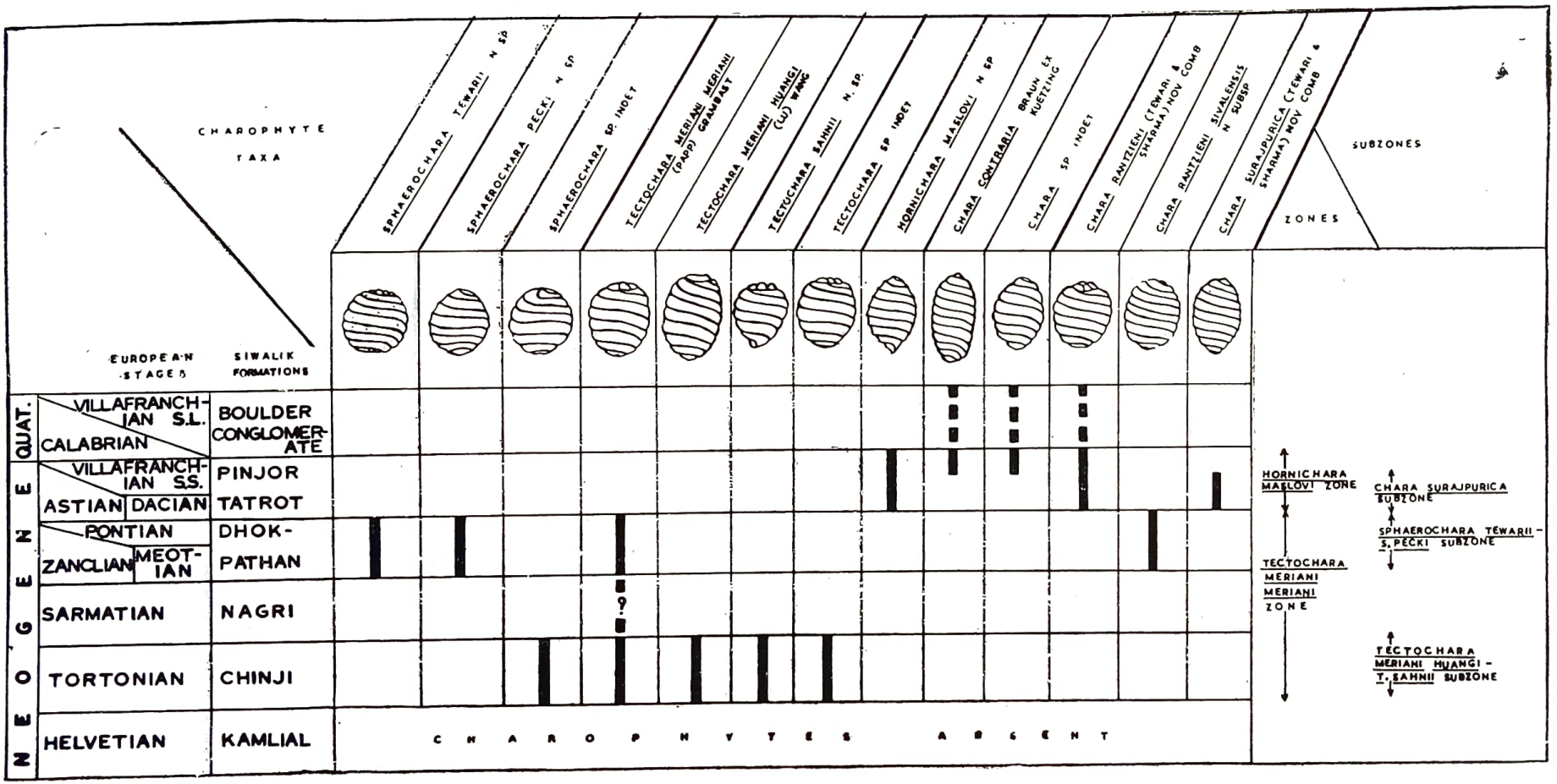

Fig. 2. Stratigraphical ranges of the charophyte taxa and the proposed biozones.

charoid-type of apical structure while the mature shells bore convex lime spirals, an apical dehiscence and not-so-well developed apical rosette. Both types of fructifications were present in the sample collected from dry pond. Thus, the characters of mature lime shells favoured their placement in *Grambastichara* Horn af Rantzien. It is, thus, obvious that certain species of the genus *Chara* Linnaeus are capable of producing *Grambastichara*-type of gyrogonites, proving thereby that both these genera are synonyms and that *Chara* Linnaeus (1753) includes *Grambastichara* Horn af Rantzien (1959a).

Results of these experiments were conveyed to late Prof. L. Grambast who in reply commented as follows (personal communication): "The ability of *Chara fragilis* to produce gyrogonites which, when completely calcified really show the characters of *Grambastichara* are quite interesting. Mme Soulie, here, has observed the same thing. This seems to confirm my previously expressed opinion, that you quote, about the fact that *Grambastichara* falls into the limits of *Chara*." He further observes that much higher proportions of *Grambastichara* type gyrogonites occur in "sediments of Upper Eocene and Lower Oligocene age than later on."

It is, thus, evident from the foregoing that the description of *Chara* Linnaeus (1753) needs to be modified so as also to include characters hitherto referred to the organ-genus *Grambastichara* Horn af Rantzien (1959a). In view of the above, the five taxa which were tentatively assigned to the genus *Grambastichara* Horn af Rantzien by Bhatia and Mathur (1970) are now placed in *Chara rantzieni* (Tewari & Sharma) *nov. comb.* and *Chara* sp. indet. A. Tewari and Sharma (1972) assigned to the organ-genus *Grambastichara* Horn af Rantzien, two taxa viz., *Grambastichara rantzieni* and *G. bhatiai*. Both these taxa have now been found to be conspecific and have been placed in the genus *Chara* Linnaeus on account of the above mentioned reasons. Of these two taxa, *Chara rantzieni* (Tewari & Sharma) *nov. comb.* has been retained on the basis of priority in pagination.

TAXONOMIC COMMENTS ON THE SIWALIK *TECTOCHARA*

In the present material from the Siwalik Group, four taxa have been assigned to the genus *Tectochara* Grambast & Grambast viz., *Tectochara meriani meriani*, *T. meriani huangi*, *T. sahnii* and *Tectochara* sp. indet. These have been found to occur in the Lower and Middle Siwaliks only and do not extend to the Upper Siwaliks. In view of this and also the generic diagnosis of *Tectochara* by Grambast and Grambast (1954) and emended diagnosis by Grambast (1956), it has become necessary to revise those taxa from Upper Siwaliks which were inadvertently placed in this genus by Bhatia and Mathur (1970) and Tewari and Sharma (1972). Accordingly, six taxa of charophytes assigned to the genus *Tectochara* by Bhatia and Mathur (1970) have been placed in *Chara rantzieni* (Tewari & Sharma) *comb. nov.* since they have been found to be conspecific with this species on the basis of morphologic characters and statistical analysis of their populations. Similarly, two other taxa viz., *Tectochara pinjorica* Tewari & Sharma and *Tectochara* sp. cf. *T. diluviana* Tewari & Sharma (*non* Maedler) described from the Upper Siwaliks are also considered as synonyms of *Chara rantzieni* (Tewari & Sharma) *comb. nov.*

LOCATION OF SECTIONS

Although twenty-one sections (eight localities) spread over an area of some 403 sq km were examined, the charophytes were found only in four localities A, E, G & H (vide Fig. 1). A brief description of the location of these sections follows :

Locality A—Here, Upper Siwaliks exposed north and northeast of Chandigarh between rivers Ghaggar and Jainti Devi ki Rao were studied and seven sections were examined in

detail. Sections AI to AIII were measured along Patiali Rao and its tributaries, sections AIV to AVI along Sukhna Choa and its tributaries and section AVII near village Dhamla, about 6 km westnorthwest of Pinjor.

Locality E—Here, Middle Siwaliks (Dhok Pathan Formation), 7.5 km northeast of Dehra Gopipur, near Neker Bridge were studied.

Locality G—At this locality, the Middle Siwaliks (Dhok Pathan Formation) exposed along the stream east of Daulatpur were studied.

Locality H—Here, Lower Siwaliks (Chinji Formation) exposed about 20 km southeast of Nurpur were studied. Section HII was examined along Brahl stream, near village Triloknath, section HIII along the old Triloknath-Kotla road passing through the village Bharil, and section HIV along Bed Khad, about 600 m north of Kotla Bridge.

The detailed biostratigraphy of these sections, as well as of the others, will be dealt with by one of us (AKM) in a separate communication.

REPOSITORY

All the holotypes and a paratype each of the new species and one hypotype each of the remaining taxa have been deposited in the Museum of the Centre of Advanced Study in Geology, Panjab University, Chandigarh, under catalogue numbers CASGMF 513-531.

SYSTEMATIC DESCRIPTIONS

Order — CHARALES
Family — CHARACEAE
Subfamily — CHAROIDEAE
Tribe — GYROGONAE
Genus — **Sphaerochara** Maedler, 1952
emend. Horn af Rantzien & Grambast, 1962

Sphaerochara tewarii sp. nov. (Pl. 1, Figs. 1a-1c).

Name—The species is named to honour Prof. B. S. Tewari, Department of Geology, Panjab University, Chandigarh.

Material—165 gyrogonites from Dhok Pathan Formation near Daulatpur (samples BA/19-25, Locality GII).

Type level—Dhok Pathan Formation (Middle Siwaliks).

Type locality—In a stream near village Bagh, about 1 kilometre NNE of Daulatpur (Locality GII).

Diagnosis—Gyrogonites small, narrowly oblate spheroidal to broadly prolate spheroidal, ellipsoidal to subobovoidal ; apically somewhat rounded to subtruncate, basally rounded or slightly protruding conically ; somewhat truncated in the apical peripheral zone in lateral view; eight to ten (rarely eleven), flat to convex (rarely slightly concave), moderately thick convolutions ; spiral cells in the apical periphery about one-half as thick as in the equatorial region ; apical cells low to moderately thick, nodules joined at a point ; basal pore outer opening pentagonal to subcircular, at the same level or slightly below the surface of the surrounding spiral cells ; basal plug nearly as thick as wide ; spiral cells with low irregularly distributed nodes.

Table 1—Measurements (in μ) of *Sphaerochara tewarii* sp. nov.

	Holotype	Paratypes		
	(CASGMF 513)	1 (CASGMF 514)	2	3
LPA	400	380	400	405
LED	425	400	400	425
AND	250	225	250	235
ISI	94	95	100	94
ANI	62	59	62	58
Number of convolutions	10	10	10	9
Width of convolution at equatorial axis	65	48	55	50
Basal pore outer opening	50	50	50	45

Remarks—The species somewhat resembles *Sphaerochara granulifera* (Heer) in shape but differs from it in being smaller in size and in the shape of the basal pore and apical nodules. This species is so far known only from the Dhok Pathan Formation (Middle Siwalik).

Sphaerochara pecki sp. nov. (Pl. 1, Figs. 2a-2c).

Name—This species is named in honour of Professor R. E. Peck, University of Missouri, Columbia, U.S.A.

Material—160 gyrogonites from Dhok Pathan Formation near Daulatpur (samples BA/19-25, Locality GII).

Type level—Dhok Pathan Formation (Middle Siwaliks).

Type locality—In a stream, near village Bagh, about 1 kilometre NNE of Daulatpur (Locality GII).

Diagnosis—Gyrogonites small ; predominantly prolate spheroidal (also oblate spheroidal and rarely subprolate) ; apically rounded or slightly protruding conically and basally rounded to subtruncate ; somewhat truncated along apical periphery in lateral view ; eight to eleven concave to flat convolutions ; width of the spiral cells not reduced in the apical periphery, cells widened in the apical centre, joining at a point ; apical nodules not developed ; intercellular ridges sharp; basal pore somewhat cylindrical, outer opening nearly at the same level as the surrounding spiral cells; basal plug slightly thicker than wide.

Table 2—Measurements (in μ) of *Sphaerochara pecki* sp. nov.

	Holotype	Paratypes		
	(CASGMF 515)	1 (CASGMF 516)	2	3
LPA	405	400	375	400
LED	350	355	350	375
AND	200	185	185	190
ISI	116	113	107	107
ANI	49	46	49	46
Number of convolutions	11	11	10	11
Width of convulutions at equatorial axis	45	45	50	45
Basal pore outer opening	50	55	50	55

Remarks—This new species differs from its nearest ally *Sphaerochara tewarii* in having a more protruding apex, concave lime spirals and a distinct pentagonal basal pore and in the absence of apical nodules. This species is also restricted to the Dhok Pathan Formation (Middle Siwalik).

Sphaerochara sp. indet. (Pl. 1, Figs. 3a-3c).

Material—7 gyrogonites from Chinji Formation (Lower Siwalik) near Triloknath (samples TR/16, Locality HII) and Bharil (sample BR/5, Locality HIII).

Description—Gyrogonites large sized ; as a rule prolate sphaeroidal and ellipsoidal ; apically rounded, basally rounded to subtruncate ; somewhat truncated in the apical periphery in lateral view ; eight to eleven broad, thick, flat to convex convolutions ; spiral cells slightly thinned in the apical periphery; apical cells slightly widened in the apical centre joined at a point, apical nodules not developed ; basal pore comparatively narrow, pentagonal.

Table 3—Measurements (in μ) of *Sphaerochara* sp. indet.

	Hypotypes			
	1 (CASGMF 517)	2	3	4
LPA	715	800	775	750
LED	700	715	750	725
AND	357	400	387	375
ISI	111	111	103	103
ANI	45	47	48	50
Number of convolutions	11	10	9	8
Width of convolutions at equatorial axis	115	115	110	125
Basal pore outer opening	125	125	115	130

Remarks—This indeterminate species of the genus *Sphaerochara* differs from *S. tewarii* in being much larger in size and in having wide and flat convolutions. The paucity of material precludes precise specific identification.

So far this indeterminate species is known only from the Chinji Formation (Lower Siwalik).

Genus—**Tectochara** Grambast & Grambast, 1954

Tectochara meriani meriani (Papp) Grambast (Pl. 1, Figs. 4a-4c).

Chara meriani Heer 1855, p. 24, pl. 4, fig. 3 (*non vidi*) *? non* Unger 1850, p. 34.
Chara meriani meriani Papp, 1951, p. 283, pl. 1, figs. 3, 4.
Chara meriani Straub, 1952, p. 467, pl. A, figs. 9, 10.
Aclistochara sinkiangensis (Lu) Horn af Rantzien, 1954, p. 10, fig. 3a-c.
Tectochara meriani Grambast & Grambast, 1954, p. 68.
Tectochara meriani meriani (Papp) Maedler, 1955, pp. 278-280, pl. 23, figs. 1-5.
Tectochara meriani (Grambast & Grambast) Horn af Rantzien, 1959a, pp. 81-90, pl. 5, figs. 4-9; pl. 6, figs. 1-9; pl. 7, figs. 1-9.
Tectochara meriani meriani (Papp) Wang, 1961, p. 211, pl. 1, figs. 1-6; Wang, 1965, p. 494, pl. 3, fig. 35; pl. 5, figs. 5-8.
Tectochara meriani (Grambast & Grambast) Grambast & Paul, 1965, p. 241, pl. 1, figs. 5-7.
Tectochara meriani (Grambast & Grambast) Maslov, 1966, pp. 45-48, text-figs. 8, 9, pl. 8, figs. 1-3.
Tectochara meriani (Grambast & Grambast) Castel, 1967, p. 514, pl. 19, figs. 1-4.

Material—21 gyrogonites from Dhok Pathan Formation (Middle Siwaliks) near Daulatpur (samples BA/19, 20, Locality GII) and Chinji Formation (Lower Siwaliks) near Triloknath (samples TR/16, 17, Locality HII), Bharil (samples BR/5, 6, 20, Locality HIII) and Kotla (sample KL/9, Locality HIV).

Table 4—Measurements (in μ) of *Tectochara meriani meriani*

	Hypotypes			
	1 (CASGMF 518)	2	3	4
LPA	1025	1000	950	1000
LED	975	985	910	975
AND	575	585	480	525
ISI	105	101	104	102
ANI	56	58	50	52
Number of convolutions	11	9	10	9
Width of convulution at equatorial axis	150	145	150	140
Basal pore outer opening	100	125	125	150

Remarks—This species, originally described from Oligocene/Miocene of Switzerland by HEER (HORN AF RANTZIEN, 1959a) is here recorded for the first time from the Indian subcontinent. The species is distinguished by its prolate spheroidal to subprolate and ellipsoidal shape, large size, convex convolutions and thin basal plug. The identifications have been confirmed by late Prof. L. Grambast (personal communication).

T. meriani meriani is widely distributed in the Tertiary formations (Oligocene to Pliocene) of Europe (Southern Germany, Austria, Switzerland and France) and Asia (China and U.S.S.R.).

In the Siwalik Group, *T. meriani meriani* is known to occur in the Lower and the Middle Siwaliks and apparently does not extend upwards into the Upper Siwaliks.

Tectochara meriani huangi (Lu) Wang (Pl. 2, Figs. 2a-2c).

Chara huangi Lu, 1945, p. 34, pl. 1, figs. 2a-c (*non vidi*).

Chara meriani minoritesta Papp, 1951, p. 284, pl. 2, figs. 5-6.

Tectochara meriani stipitata Maedler, 1955, p. 283, pl. 24, figs. 3-8.

Tectochara huangi (Lu) Horn af Rantzien, 1959a, p. 79.

Tectochara meriani huangi (Lu) Wang 1961, p. 189, pl. 2, figs. 1-7; Wang, 1965, pp. 494, 495, pl. 5, figs. 9-14; Castel, 1967, pp. 515, 516, pl. 19, figs. 5-10, 13, 14.

Material—8 gyrogonites from Chinji Formation (Lower Siwaliks) near Triloknath (samples TR/16, 17, Locality HII) and Kotla (sample KL/9, Locality HIV).

Remarks—The characteristic protruding basal pore and wide, pentagonal to subcircular basal pore help in distinguishing this subspecies from the other subspecies of *T. meriani* (Heer). LU (1945), *non vidi*, *fide* HORN AF RANTZIEN, 1959a originally described this subspecies from the Kuchar Group of Sinkiang Province, China. It is here recorded for the first time from the Siwalik Group as also from India. *T. meriani huangi* (Lu) is widely distributed in Europe (*fide* CASTEL, 1967) and Asia (WANG, 1961, 1965).

T. meriani huangi has been found to be restricted to the Lower Siwalik.

Table 5—Measurements (in μ) of *Tectochara meriani huangi*

	Hypotypes			
	1 (CASGMF 519)	2	3	4
LPA	1050	1050	1075	1080
LED	825	825	875	830
AND	500	575	575	525
ISI	115	115	123	130
ANI	47	56	53	48
Number of convolutions	10	11	11	11
Width of convolution at equatorial axis	125	100	125	125
Basal pore outer opening	100	85	100	100

Tectochara sahnii sp. nov. (Pl. 1, Figs. 5a-5c).

Name—This species is named in honour of late Prof. Birbal Sahni, the renowned Indian palaeobotanist.

Material—110 gyrogonites from Chinji Formation (Lower Siwalik) near Triloknath (samples TR/16-18, Locality HII), Bharil (samples BR/5, 6, Locality HIII) and Kotla (sample KL/9, Locality HIV).

Type level—Chinji Formation (Lower Siwalik).

Type locality—In a stream near Kotla, about 1 kilometre N of Kotla bridge (Locality HIV).

Diagnosis—Gyrogonites as a rule small, elongate ; oblate spheroidal to prolate spheroidal and ellipsoidal to subobovoidal ; apically rounded to subtruncate, basally produced conically ; basal pole truncated ; apical periphery distinctly truncated in lateral view ; eight to ten flat to convex, thick convolutions, narrow to moderately wide in equatorial region ; width of spiral cells reduced in the apical periphery to about 2/3 than at equator ; apical peripheral dehiscence distinct ; apical cells form a well developed apical rosette, meeting at a point ; basal pore moderate to very wide, pentagonal, at the same level as the surrounding basal cells ; well defined depression outside the basal pore ; basal plug thinner than wide.

Table 6—Measurements (in μ) of *Tectochara sahnii* sp. nov.

	Holotype	Paratypes		
	(CASGMF 520)	1 (CASGMF 521)	2	3
LPA	400	400	415	410
LED	410	420	375	375
AND	250	250	250	245
ISI	97	95	110	109
ANI	62	62	60	59
Number of convolutions	9	8	8	9
Width of convolution at equatorial axis	55	55	60	55
Basal pore outer opening	75	80	90	100

Remarks—This new species differs from most of the other known species of the genus *Tectochara* Grambast & Grambast in being small in size, narrowly oblate spheroidal to prolate in shape and in having a prolonged basal pore. It resembles superficially *Tectochara conica* Maedler which is not a *Tectochara*, *fide* Grambast (personal communication), in shape and small size but differs in possessing well developed apical rosette, wider and protruding basal pore and thicker basal plug.

This new species is so far known only from the Chinji Formation (Lower Siwalik).

Tectochara sp. indet. (Pl. 2, Figs. 1a-1c).

Material—10 gyrogonites from Chinji Formation (Lower Siwaliks) near Triloknath (samples TK/16, 17, Locality HII) and Bharil (samples BR/5, 6, Locality HIII).

Description—Gyrogonites large, predominantly prolate, spheroidal to subprolate and ellipsoidal to subobovoidal ; apically rounded, basally subtruncate to rounded ; apical periphery truncated in lateral view, ten to eleven flat to convex very wide convolutions ; width of the spiral cells decreased in the apical periphery to about 2/3 of the equatorial width, regained in the apical centre forming distinct apical rosette ; apical cells not very high, joined at a point or along a short zigzag line; basal pore wide, funnel shaped, pentagonal to subcircular ; basal plug almost as thick as wide.

Table 7—Measurements (in μ) of *Tectochara* sp. indet.

	Hypotypes			
	1 (CASGMF 522)	2	3	4
LPA	1075	1075	1050	1050
LED	1000	975	975	1050
AND	600	550	525	535
ISI	107	110	107	100
ANI	55	51	50	51
Number of convolutions	9	10	10	9
Width of convolution at equatorial axis	150	155	125	150
Basal pore outer opening	130	140	150	175

Remarks—This indeterminate species resembles in overall shape *Tectochara etrusca* Tongiorgi (1956) originally described from Italy. However, the deeper pentagonal basal pore distinguishes it from the latter. Precise specific identification has not been possible due to insufficient material.

This indeterminate species of *Tectochara* is known only from the Chinji Formation (Lower Siwalik).

Genus—**Hornichara** Maslov, 1963

Hornichara maslovi sp. nov. (Pl. 3, Fig. 8)

Name—This species is named in honour of Late Dr. V. P. Maslov of U.S.S.R. Academy of Sciences.

Material—23 gyrogonites from Pinjor Formation (Upper Siwalik) near Chandigarh (samples MN/24, Locality AIV and samples SK/57, 58, Locality AV) and Tatrot Formation (Upper Siwalik) near Dhamala (sample B11, Locality AVII).

Type level—Pinjor Formation.

Type locality—In a tributary to Sukhna Choa, about 3 kilometres SW of Manakpur (Locality AIV).

Diagnosis—Gyrogonites small, predominantly subprolate, occasionally prolate spheroidal and rarely prolate, and ellipsoidal ; apically broadly rounded, basally conically produced ; nine to twelve moderately wide concave convolutions ; intercellular ridges sharp ; width of the spiral cells slightly narrowed in the apical periphery, regained in the apical centre ; apical cells joined at a point, basal cells prolonged into a nozzle, basal pore narrow to moderately wide, pentagonal, cylindrical ; basal plug thinner than wide.

Table 8—Measurements (in μ) of *Hornichara maslovi* sp. nov.

	Holotype		Paratypes	
	1 (CASGMF 523)	2 (CASGMF 525)	3	4
LPA	450	400	425	400
LED	375	300	400	370
AND	215	185	225	200
ISI	120	133	106	108
ANI	48	46	53	50
Number of convolutions	10	9	10	10
Width of convolution at equatorial axis	50	48	55	50
Basal pore outer opening	50	60	50	50

Remarks—Bhatia and Mathur (1970) in their preliminary note on the charophyta from the Tatrot Formation (Upper Siwalik) questionably assigned this species to the genus *Hornichara* Maslov. Subsequent to the publication of the above mentioned brief note, the authors were able to recover more specimens from Tatrot as well as Pinjor formations of the Upper Siwaliks. This new species resembles closely *Hornichara kasakstanica* Maslov (1963) originally described from the Oligocene of Kasakstan, in shape but has wider convolutions and relatively less elongate basal pore. The intercellular ridges are sharper in the new species.

This new species of *Hornichara* is apparently restricted to the Upper Siwaliks (Tatrot and Pinjor formations) only.

Tribe — Chareae

Genus — **Chara** Linnaeus. 1753.

Chara contraria Braun ex Kuetzing (Pl. 3, Figs. 4a-4c).

Chara contraria Braun ex Kuetzing, 1845, p. 258 (*non vidi*); Horn af Rantzien, 1959b, pp. 260-263, pl. 12, figs. 1-11; Daily, 1961, pp. 53, 54, pl. 1, figs. 11-13, 19-21; pl. 2, figs. 6-80; Pal *et al.* 1962, p. 103, figs. 243-247 *et syn.*; Daily, 1970, p. 372.

Material—53 gyrogonites from Pinjor Formation (Upper Siwaliks) near Chandigarh (sample BP/35, Locality AI and samples KH/40, 41, Locality AVI).

Table 9—Measurements (in μ) of *Chara contraria*

	Hypotypes			
	1 (CASGMF 525)	2	3	4
LPA	700	625	600	650
LED	405	300	350	375
AND	325	285	300	325
ISI	172	208	171	173
ANI	46	45	50	50
Number of convolutions	13	13	12	13
Width of convolution at equatorial axis	60	50	55	55
Basal pore outer opening	55	60	70	50

Remarks—The gyrogonites of *C. contraria* in the present collection come within the range of variation of the species. This widely distributed species in the Recent of Indian subcontinent (*fide* Pal *et al.*, 1962, p. 103) is being recorded here for the first time in fossil state from this region. It has also been recorded from the Quaternary of Europe and North America (*fide* Daily, 1961, p. 54).

The species is apparently restricted to the Pinjor Formation (Upper Siwalik).

Chara sp. indet. (Pl. 2, Figs. 3a-3c).

Material—78 gyrogonites from Tatrot Formation (Upper Siwaliks) near Chandigarh (sample ND/6, Locality AII and samples B11, B20, Locality AVII), Pinjor Formation (Upper Siwaliks) near Chandigarh (sample BP/9, Locality AI, sample ND/57, Locality AII and samples XH/40, 41, Locality AVI).

Type level—Tatrot Formation (Upper Siwaliks).

Type locality—In a stream near Dhamala, 6 kilometres WNW of Pinjaur (Locality AVII).

Description—Gyrogonites small to medium sized ; subprolate to prolate, rarely prolate spheroidal, and ellipsoidal, rarely subobovoidal ; apically slightly protruding to broadly rounded, basally broadly rounded ; nine to eleven (rarely seven or twelve) moderately thick concave convolutions ; width of the convolutions reduced in the apical periphery to about 3/4 or 2/3 of their equatorial width, without distinct groove in the apical periphery ; apical cells very wide, joined at a point or along short straight line ; basal pore pentagonal, wide-conical ; basal plug thinner than wide.

Table 10—Measurements (in μ) of *Chara* sp. indet.

	Hypotypes	
	(CASGMF 526)	(CASGMF 527)
LPA	635	625
LED	495	490
AND	320	315
ISI	127	127
ANI	48	50
Number of convolutions	10	9
Width of convolution at equatorial axis	80	85
Basal pore outer opening	55	55

Remarks—This indeterminate species from the Upper Siwaliks superficially resembles in shape *Charites angusta* described by MASLOV (1966) from the Soviet Union, but differs in being smaller in size, rarely approaching highly prolate shape and in having narrower convolutions.

Chara rantzieni (Tewari & Sharma) *comb. nov. emend.* (Pl. 3, Figs. 1a-1c ; 2a-2c).

Grambastichara rantzieni Tewari & Sharma, 1972, pp. 7-9; pl. 1, figs. 3a-c; text-fig. 2, figs. 3a-c.
Grambastichara bhatiai Tewari & Sharma, 1972, pp. 9, 12; pl. 1, figs. 4a-c, text-fig. 2, figs. 4b-c; text-fig.3, fig. 4a.
Tectochara pinjorica Tewari & Sharma, 1972, pp. 12-14; pl. 1, figs. 5a-c; text-fig. 3, figs. 5a-c.
Tectochara cf. *diluviana* Tewari & Sharma (*non* Maedler, 1955), 1972, pp. 14, 15; pl. 1, figs. 6a-c; text-fig. 3, figs. 6a-c.

Material—128 gyrogonites from Tatrot Formation (Upper Siwaliks) near Chandigarh (samples BP/5, 6, Locality AI; sample MN/6, Locality AIV; samples B11, B20, Locality AI; sample ND/34, Locality AVI; samples SK/57, 58, Locality AV and samples KH/40, 41, Locality AVI).

Description—Gyrogonites small to medium sized; predominantly prolate spheroidal to subprolate, ellipsoidal to subobovoidal ; apically rounded to subtruncate, basally predominantly rounded ; apical periphery somewhat truncated in the lateral view; eight to twelve, flat to convex, moderately thick and wide convolutions, thinned and narrowed in the apical periphery to about 2/3 their equatorial width and often with low peripheral groove, width regained in the apical centre ; apical cells form a not-so-well developed rosette, joined along a short zigzag line ; intercellular ridges somewhat prominent in thinly calcified gyrogonites ; basal pore cone shaped, pentagonal to subcircular, without outer basal depression ; basal plug nearly as thick as wide.

Table 11—Measurements (in μ) of *Chara rantzieni* (Tewari & Sharma)

	Hypotypes			
	1 (CASGMF 528)	2	3	4
LPA	525	485	530	525
LED	475	475	500	455
AND	325	260	300	335
ISI	110	102	106	115
ANI	61	53	56	63
Number of convolutions	9	9	11	10
Width of convolution at equatorial axis	70	70	65	60
Basal pore outer opening	50	55	55	65

Remarks—TEWARI AND SHARMA (1972) originally described *Grambastichara rantzieni* from the Tatrot Formation near village Naipli which falls in the Locality AV (present work). This species is highly variable in shape which has necessitated the inclusion of *Grambastichara bhatiai* Tewari & Sharma, *Tectochara pinjorica* Tewari & Sharma and *Tectochara* sp. cf. *T. diluviana* Tewari & Sharma (*non.* Maedler, 1955) as its synonyms. The specific description has also been emended to include these taxa. The present species

also includes gyrogonites in which the apical cells are abnormally sunken below the apical periphery.

The gyrogonites of the present species superficially resemble those of *Tectochara meriani globula* Maedler and *T. meriani diluviana* Maedler in shape but are smaller, and lack the generic characters of *Tectochara* Grambast & Grambast.

Chara rantzieni sivalensis subsp. nov. (Pl. 3, Figs. 3a-3c, 6)

Name—This subspecies is named after the Siwalik Hills.

Material—134 gyrogonites from the Dhok Pathan Formation (Middle Siwaliks) near Daulatpur (samples BA/19-25, Locality GII) and Neker (samples NK/2, 3, Locality EII).

Type level—Dhok Pathan Formation (Middle Siwalik).

Type locality—In a stream about 1 kilometre NNE of Daulatpur near village Bagh (Locality GII).

Diagnosis—Gyrogonites medium sized, prolate spheroidal to subprolate, and ellipsoidal to subobovoidal ; apically broadly rounded to subtruncate, basally broadly rounded, rarely subtruncate or conically protruding ; apical periphery truncated in the lateral view ; nine to thirteen, thick, convex, wide convolutions ; spiral cells thinned, reduced in width in the apical periphery to about 2/3 of their equatorial width and forming a peripheral groove, width regained in the apical centre ; apical cells moderately high, form an apical rosette, apical cells meet along a short zigzag line, basal pore moderately wide, cone shaped without an outer basal depression ; basal plug almost as thick as wide.

Table 12—Measurements (in μ) of *Chara rantzieni sivalensis* subsp. nov.

	Holotype	Paratypes		
	(CASGMF 529)	1 (CASGMF 530)	2	3
LPA	655	600	650	625
LED	550	530	550	575
AND	375	315	380	360
ISI	119	113	118	109
ANI	57	52	58	57
Number of convolutions	12	11	12	10
Width of convolution at equatorial axis	75	65	65	70
Basal pore outer opening	75	70	75	65

Remarks—This new subspecies differs from its close ally *Chara rantzieni* (Tewari & Sharma) in having higher mean LPA, LED, ISI and number of convolutions and a lower mean ANI. It also differs from *C. tornata* Reid & Groves (1921) described from the Lower Headon beds of London in having lower LPA, LED and ISI.

C. rantzieni sivalensis is so far known only from the Middle Siwalik (Dhok Pathan Formation).

Chara surajpurica (Tewari & Sharma) comb. nov. (Pl. 3, Figs. 5a-5c).

Charites surajpurica Tewari & Sharma, 1972, pp. 5, 6, pl. 1, figs. 1a-c, text-fig. 2, figs. 1a-c.

Material—10 gyrogonites from the Tatrot Formation (Upper Siwalik) near Chandigarh (sample MN/6, Locality (AIV) and Dhamala (samples B11, B20, Locality AVII).

Table 13—Measurements (in μ) of *Chara surajpurica* (Tewari & Sharma)

	Hypotypes			
	1 (CASGMF 531)	2	3	4
LPA	575	655	655	650
LED	450	520	445	440
AND	275	300	290	275
ISI	128	126	147	147
ANI	48	46	44	42
Number of convolutions	12	11	11	10
Width of convolution at equatorial axis	50	70	55	60
Basal pore outer opening	50	70	50	55

Remarks—Tewari and Sharma (1972) originally described and illustrated this species from the Tatrot Formation (Upper Siwalik) near village Naipli, about 2 km SW of Surajpur. The present collection of *C. surajpurica* is also from the Tatrot Formation exposed near Mankapur (Locality AIV) which is close to the type locality, and from near village Dhamala (Locality AVII). *C. columinaria* Wang (1961) described from Tertiary deposits of Chaidamu basin resembles the present species in overall shape, but differs in having a more conical apical pole.

This species is apparently restricted to the Upper Siwalik (Tatrot Formation).

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REFERENCES

Berggren, W. A. (1973). The Pliocene Time Scale; calibration of planktonic foraminiferal and calcareous nannoplankton zones. *Nature, Lond.* **243** : 391-397.

Bhatia, S. B. & Mathur, A. K. (1970). First record of Charophyta from the Upper Siwaliks, near Pinjore. *Bull. Indian geol. Assoc.*, **3** (1-2) : 27, 28.

Castel, M. (1967). Charophytes de l'Oligocene superieur de Marseille. *Soc. Geol. Fr.* **7**(9) : 514-519.

COLBERT, E. H. (1951). A note on the Plio-Pleistocene boundary in the Siwalik Series of India. *Am. J. Sci.*, **249** : 533-538.

DAILY, F. K. (1961). Glacial and Post-Glacial Charophytes from New York and Indiana. *Butler Univ. bot. Stud.*, **14**(1) : 39-72.

DAILY, F. K. (1970). Fossil Charophytes from South Dakota and Iowa with a review of a modern species. *Am. Midland Naturalist* **84**(2) : 365-375.

DUTTA, A. K. & GREGORESCU, D. A. (1975). Towards a correlation of the Mammalian fauna of the Siwaliks with their equivalents in southeastern Europe, including Crimea & Caucasus. *In* Verma, V. K., Ed. *Recent Researches in Geology*, **2** : 265-274.

GRAMBAST, L. (1956). Sur le genre *Tectochara*. *C. r. Somm. Soc. Geol. Fr.* **8** : 113, 114.

GRAMBAST, L. (1962). Classification de l'Embranchement des Charophytes. *Naturalia Monspeliana, Ser. Bot.* **4** : 63-86,

GRAMBAST, L. & GRAMBAST, N. (1954). Sur la position systematique de quelques Charophytes tertiaires. *Rev. Gen. Bot.*, **61** : 665-671.

GRAMBAST, L. & PAUL, P. (1965). Observations nouvelles sur la flore de Charophytes du Stampien du basin de Paris. *Bull. Soc. geol. Fr.*, **7**(7) : 239-247.

GRICHUK, V. P., HEY, R. W. & VENZO, S. (1965). Report of the Subcommission on the Plio-Pleistocene boundary. *Rept. VI Int. Congr. on the Quaternary*, Warsaw, Poland : 311-329.

GROMOV, V. I., VANKENGEIM, E. A. & NIKIFOROVA, K. V. (1964). Biostratigraphic basis of the Lower Boundary and a Subdivision of the Anthropogene System. *Int. geol. Congr., 22nd Sess., New Delhi,* **8** : 257-273.

HAYS, J. D. & BERGGREN, W. A. (1971). Quaternary boundaries and correlations. *In* Funnell and Riedel, Eds. *Micropalaentology of Oceans*. Cambridge.

HORN AF RANTZIEN, H. (1954). Revision of some Pliocene Charophyte gyrogonites. *Bot. Not.*, **1** : 1-33.

HORN AF RANTZIEN, H. (1956). Morphological terminology relating to female charophyte gametangia and fructifications. *Bot. Not.* **109** : (2) : 212-259.

HORN AF RANTZIEN, H. (1959a). Morphological types and organ-genera of Tertiary charophyte fructifications. *Stockholm Contributions in Geology*, **4**(2) : 45-197.

HORN AF RANTZIEN, H. (1959b). Recent charophyte fructifications and their relations to fossil charophyte gyrogonites. *K. Svenska Vet. Akad. Arkiv. Bot.*, **2**(4) : 165-332.

HORN AF RANTZIEN, H. & GRAMBAST, L. (1962). Some questions concerning recent and fossil charophyte, morphology and nomenclature. *Stockholm Contributions in Geology*, **9**(3) : 135-144.

HUSSAIN, S. T. (1971). Revision of Hipparion (Equidae, Mammalia) from the Siwalik Hills of Pakistan and India. *Abh. Baver. Akad. Wissens. Neue Foege.* **147** : 1-68.

LAKHANPAL, R. N., KAPOOR, S. & JAIN, K. P. (1976). Some Charophytic remains from the Lower Siwalik of Tanakpur, District Nainital. *Palaeobotanist* **23**(1) : 40-43.

LINNAEUS, C. (1753). *Species plantarum*. Stockholm.

MAEDLER, K. (1952). Charophyten aus dem Nordwestdeutschen Kimmeridge. *Geol. Jahrb.*, **67** : 1-46.

MASLOV, V. P. (1966). Fossil Charophytes of the U.S.S.R. (508). *Trans. Acad. Sci. geol. Inst.*, **143** : 5-92

NANDA, A. C. (1973). A note on the biostratigraphy of the Upper Siwaliks of Naraingarh Tehsil, Ambala. *Curr. Sci.* **42** : (9) : 319.

NANDI, B. (1975). Palynostratigraphy of the Siwalik Group of Panjab. *Himalayan Geol.*, **5** : 411-424.

PAL, B. P., KUNDU, B. C., SUNDRALINGAM, V. S. & VENKATARAMAN, G. S. (1962). *Charophyta*. New Delhi.

PANDEY, J. (1973). Classification and biostratigraphy of the Siwalik Formation between Sutlej and Yamuna. *J. palaeont. Soc. India* **16** : 67-77.

PAPP, A. (1951). Charophytenreste aus dem Jungtertiar Österreichs. *Osterr. Akad. Wiss., Math.-Naturw Klasse Sitzb.*, **160**(3-4) : 279-293.

PILGRIM, G. E. (1913). Correlation of the Siwaliks with mammal horizons of Europe. *Rec. geol. Surv. India*, **43**(4) : 264-326.

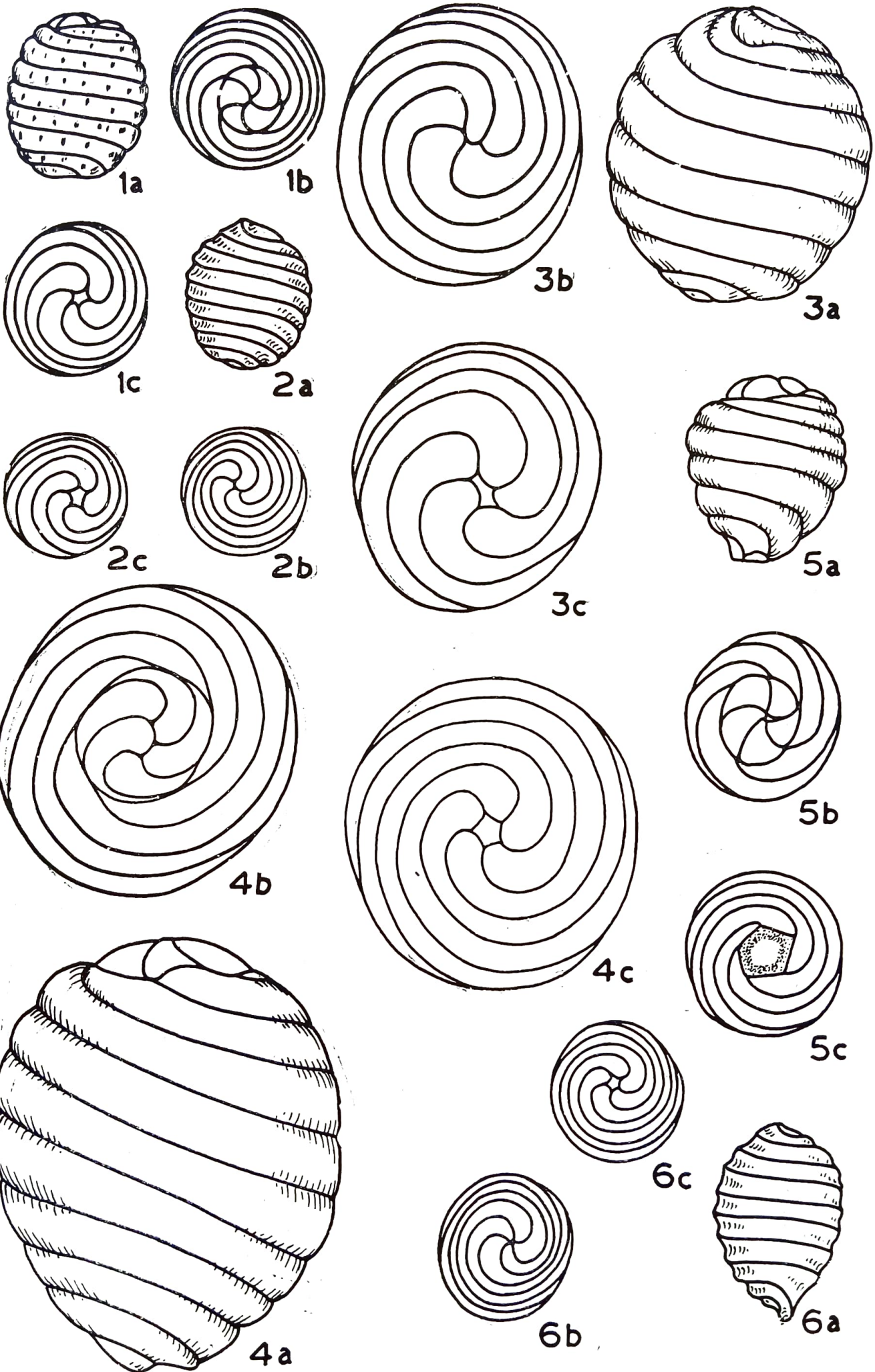
PILGRIM, G. E. (1944). The lower limit of Pleistocene in Europe and Asia. *Geol. Mag.*, **81** : 22-38.

PRASAD, K. N. (1968). Observations on the Stratigraphy and Fauna of the Siwalik System. *J. Indian geol. Assoc.*, **8** : 57-65.

PRASAD, K. N. (1972). Observations on the Siwalik System of India. *Rec. geol. Surv. India*, **99**(2) : 17-26.

PRASAD, K. N. (1975). Observations on the Neogene-Quaternary formations in India, China and Java. *Koninkl. Nederl. Akad. Wetens.* **78**(5) : 392-397.

PRASAD, K. N. & RAY, D. K. (1964). A classification of the Siwalik System and Nomenclature. *Int. geol. Congr., 22nd session,* **8** : 390-406.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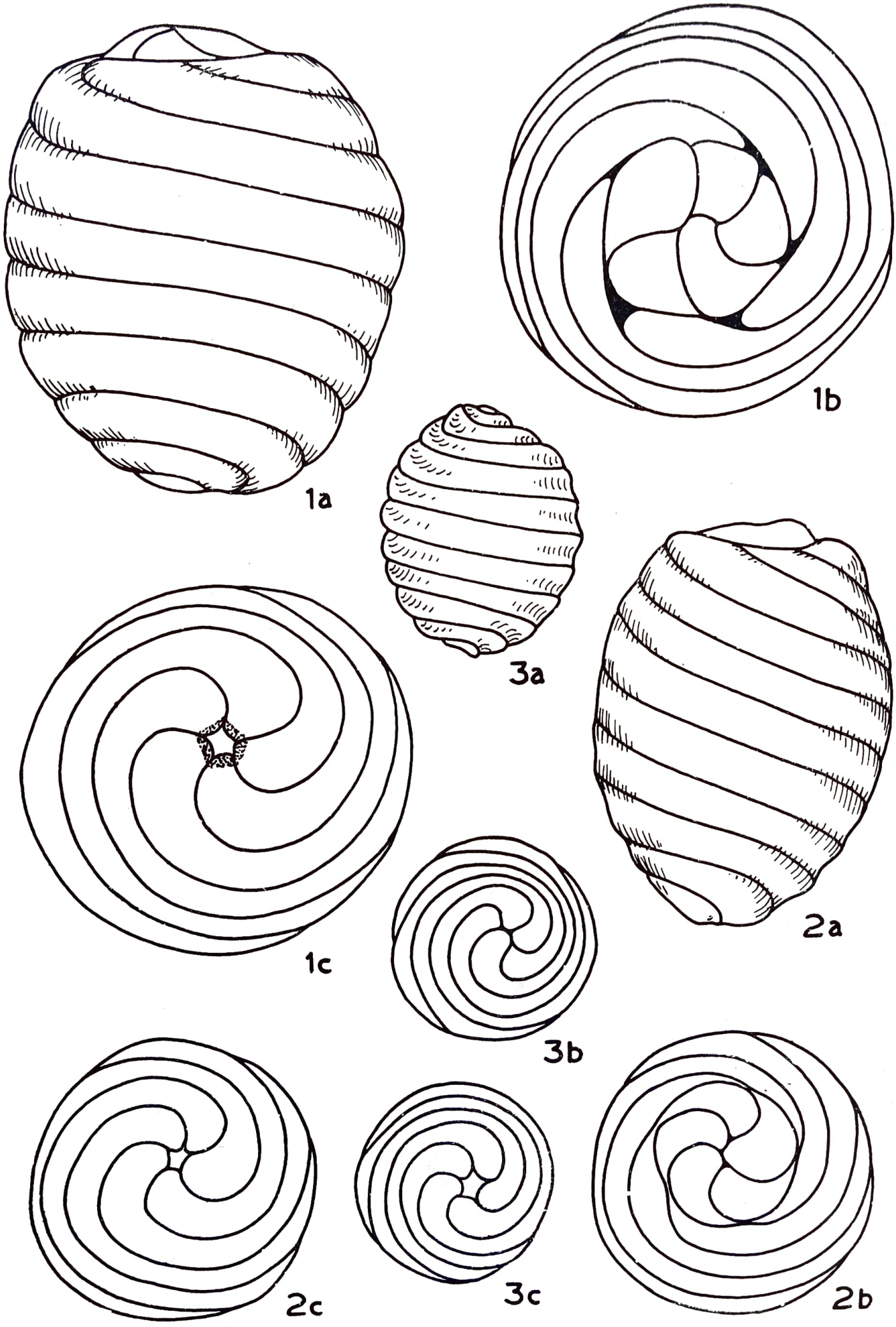
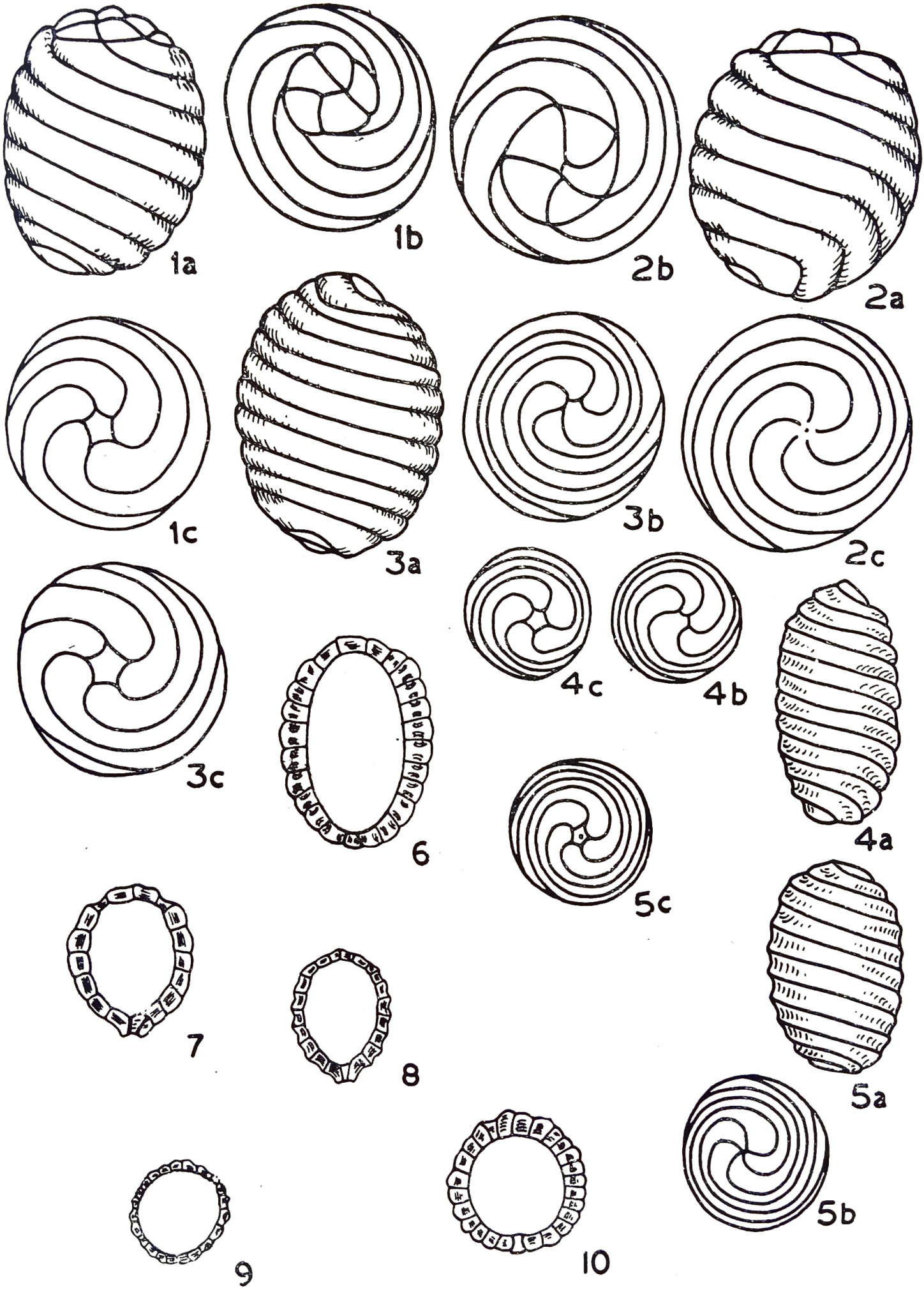


Bhatia & Mathur—Plate 2



Bhatia & Mathur—Plate 3

Reid, C. & Groves, J. (1921). The Charophyta of the Lower Headon Beds of Hordle Cliffs (South Hampshire). *Geol. Soc. London, Quart. Jour.*, **77**(3) : 175-192.

Sahni, M. R. (1959). Stratigraphy, structure and correlation of the Upper Shivaliks east of Chandigarh. *J. palaeont. Soc. India*, **4** : 61-74.

Sahni, M. R. & Mathur, L. P. (1964). Stratigraphy of the Siwalik Group. *Spl. Publ. 22nd Int. geol. Congr., India* : 1-24.

Savage, D. E. & Curtis, G. H. (1967). The Villafranchian age and its radiometric dating. *Bull. Am. Assoc. Petr. Geol.*, **51** : 479-80. (Abstract)

Straub, E. W. (1952). Mikropaläontologische Untersuchungen im Tertiär Wisehen Ehingen und Ulm an der Donau. *Geol. Jahrb.*, **66** : 433-524.

Tewari, B. S. & Sharma, S. P. (1972). Some fossil Charophyta from Upper Siwalik near Chandigarh, India. *Bull. Indian geol. Assoc.*, **5**(1,2) : 1-21.

Wang, S. (1951). Tertiary Charophyta from Chaidamu (Tsaidam) basin, Qinghai (Chinghai) Province. *Acta Paleont. Sinica*, **9** (3) : 209-219.

Wang, S. (1955). Mesozoic and Tertiary charophyta from Jiuquan basin of Kansu Province. *Acta Paleont. Sinica*, **13**(3) : 485-499.

EXPLANATION OF PLATES

Plate 1

(All figures ×62, a, lateral view; b, apical view; c, basal view)

1a-1c. *Sphaerochara tewarii* sp. nov.
Holotype

2a-2c. *Sphaerochara pecki* sp. nov.
Holotype

3a-3c. *Sphaerochara* sp. indet.
Hypotype 1

4a-4c. *Tectochara meriani meriani* (Papp) Grambast
Hypotype 1

5a-5c. *Tectochara sahnii* sp. nov.
Holotype

6a-6c. *Hornichara maslovi* sp. nov.
Holotype

Plate 2

(All figures ×62, a, lateral view; b, apical view; c, basal view)

1a-1c. *Tectochara* sp. indet.
Hypotype 2

2a-2c. *Tectochara meriani huangi* (Lu) Wang
Hypotype 3

3a-3c. *Chara* sp. indet.

Plate 3

(Figures 1-5 × 62, a, lateral view; b, apical view; c, basal view; figures 6-10 × 45)

1a-1c, 2a-2c. *Chara rantzieni* (Tewari & Sharma) comb. nov. emend.
1a-c, hypotype 1; 2a-c hypotype 3.

3a-3c. 6. *Chara rantzieni sivalensis* subsp. nov.
Holotype; 6 thin section

4a-4c. *Chara contraria* Braun ex Kuetzing
Hypotype 1

5a-5c. *Chara surajpurica* (Tewari & Sharma) comb. nov.
Hypotype 4

7. *Tectochara sahnii* sp. nov.
Thin section

8. *Hornichara maslovi* sp. nov.
Thin section

9. *Sphaerochara pecki* sp. nov.
Thin section

10. *Sphaerochara tewarii* sp. nov.
Thin section