



## MOLLUSCAN AND INSECT REMAINS FROM THE TYPE KASAULI FORMATION AND THEIR SIGNIFICANCE

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### ABSTRACT

Here we report the first gastropods and insect remains from the Kasauli Formation, (Kasauli, Himachal Pradesh) in addition to the record of the pelecypod *Parreysia (Radiatula) kohlii*. The gastropods are associated with broad-leaved plants and are abundant in pockets. They can be taxonomically assigned to *Melania kargilensis* and *Planorbis*, both taxa are known to occur from coeval beds at Kargil in Ladakh. Another taxa cf. *Brotia dobataensis* known from the Miocene Siwalik Surai Khola locality of Nepal is also present. The Kasauli molluscan fauna has common elements to the assemblages reported from Laren (Larea) locality near Udhampur and Kargil (Ladakh). The insect wing is referable to the order Blattaria which includes the cockroaches. Scanning electron microscopy has been used to provide greater details of the fine structure of the material. Reconstruction of basinal palaeoenvironments suggests large bodies of stagnant water forming under euxenic conditions in a facies similar to that found in Laren, Udhampur (Jammu and Kashmir). The Kasauli biotic assemblage, as now known, represents the first floras and faunas of an extensively developing lower Miocene foreland basin.

**Key words:** Molluscs, insects, palaeoenvironments, taphonomy, Kasauli Formation

### INTRODUCTION

In an earlier paper (Arya *et al.*, 2004), the occurrence of a rhinocerotoid mammal and additional fossil flower taxa were reported from two sections in Kasauli town. Here we record the presence of gastropods, pelecypods and an insect. After the initial report of the freshwater pelecypod by Medlicott (1864) and Pascoe (1973) from Kasauli, no subsequent record is available.

The Shiv Mandir section on the Parwanoo-Kasauli road (Arya, 1997, Arya and Awasthi, 1994, 1995; Arya *et al.*, 2001 and Arya *et al.*, 2004) is the most fossil-productive section (figs. 1a, 1b), and shows a contact with the underlying Daghsai Formation. Lithologically, grey-greenish siltstones and shales alternate with grey sandstones which may be coarse grained or gritty in small lenses. The fossil-bearing siltstones and shales exhibit a high degree of taxonomic diversity, with the occurrence of leaves, wood fragments, seeds, fruits and molluscan remains in a poorly laminated matrix representing an overbank facies (Mehra *et al.*, 1990)

The present assemblage reveals an extension of the same facies in widespread areas of the N.W. Himalayas, as for example in the Laren (Larea) Formation, Udhampur, Jammu and Kashmir (Khan *et al.*, 1973; Mehta and Jolly, 1989; Kad, 2000; Sahni and Kad, 1998 and Mathur, 1983), Dharamsala (Kumar, 1985) and the Kargil locality (Sahni and Bhatnagar, 1956 and Sahni *et al.*, 1984). Together with the previously reported assemblages (Arya *et al.*, 2004), the present biota contributes significantly towards the reconstruction of palaeoenvironments, palaeoecology and biostratigraphy.

### MATERIALS AND METHODS

The molluscan remains occur in the plant-bearing green carbonaceous siltstones and are found in great numbers in

the localised pockets. The gastropod and bivalve specimens were prepared in rock by fine chisels, as the high spired gastropods are very fragile. In some gastropods, the original shell material was preserved and therefore SEM studies in SEI mode at 20 Kv using JEOL instrument were undertaken at Regional Sophisticated Instrument Centre of Panjab University, Chandigarh, to provide details of the contact between whorls and the fine ornamentation on the specimens. Small molluscan specimens were micrographed for their detailed ultrastructure. The beautifully preserved insect wing was digitally photographed, whereas its fine structure was micrographed by the SEM. All the material is catalogued at Centre of Advanced Study in Geology, Panjab University, Chandigarh under VPL/RA/G numbers.

### SYSTEMATIC PALAEOONTOLOGY

*Class* **Gastropoda** Cuvier, 1797

*Family* **Melaniidae** (Lamarck) Gray

*Genus* **Melania** Lamarck

*Melania kargilensis* Sahni and Bhatnagar, 1956

(Pl. I, figs. 1-4)

*Referred Material:* Four almost complete and numerous incomplete, broken specimens; VPL/RA/G-90001, 90005, 90007, 900011-1A

*Description:* Shells assigned to *Melania kargilensis* (*sensu stricto*) moderate-sized, turreted, spire high, truncated at apex, composed of six to seven dextrally coiled whorls, regularly increasing in size and characterized by prominent spiral ribbing (Pl. I, figs. 1, 2, 3, 4). Good examples of the species are figured in Pl. I, fig. 1, which has a prominent body whorl with faint or absent vertical striations. Fig. 2 is very well preserved and shows about 8-10 spiral lines per spire in each whorl. Fig. 3

shows a prominent flange. Vertical striations are absent. The fine structure of the whorls and their contact with each other can be seen in fig.4.

*Remarks:* *Melania* has been previously reported from the Miocene freshwater sediments of northwest India by Anandale (1918), Lydekker (1883) and de Terra (1935). The specimens described by Sahni and Bhatnagar (1956) were obtained by Gautam Kohli during 1953-1954 field seasons of the Geological Survey of India. In the latter work, *Melania kargilensis* has been described as possessing a high, turreted spire with six to seven whorls increasing gradually in size with prominent spiral striations and ridges marking growth increments. However, the present Kasauli molluscan collection shows a wide variation in external ornamentation, ranging from strong spiral ribbing and poor vertical costae to a cancellate condition with prominent spiral and vertical ornamentation to a strongly vertical costae and subordinate spiral ribbing.

In the present work, we have, therefore, clearly differentiated between *M. kargilensis* as described above and another form cf. *Brotia dobataensis* which has recently been described from the Miocene Siwaliks of Nepal by Gurung (1998).

In fact, Sahni and Bhatnagar (1956) in their original paper had noted this conspicuous feature of the species, i.e. the vertical ribbing or costae which are present in some specimens (Pl. I, figs. 5, 6 and 7) and had used this to differentiate their species from *M. clementis* Mancini (1913-1914), which was also reported from the Ladakh Himalaya but remains poorly recorded.

Tewari and Dixit (1971) recorded *Subzebrinus gudei* also from the Kargil Formation (exposed near Kargil); while Mathur (1983) and Nanda and Sahni (1990) reported *Melania* from the

grey carbonaceous siltstone and the shale bands from the Wakka Chu River section of Kargil.

*Horizon:* Upper part of the basal Kasauli Formation.

*Locality:* Shiv Mandir.

cf. *Brotia dobataensis* Gurung, 1998

(Pl. I, figs. 5-7)

*Referred Material:* Three complete specimens; VPL/RA/G-90002, 90003, 90004

*Horizon:* Upper part of the basal Kasauli Formation.

*Locality:* Shiv Mandir.

*Description:* Shells small, turreted, spire high, composed of six to seven whorls, regularly decreasing in size towards the apex, small body whorl. Shell is highly ornamented; both

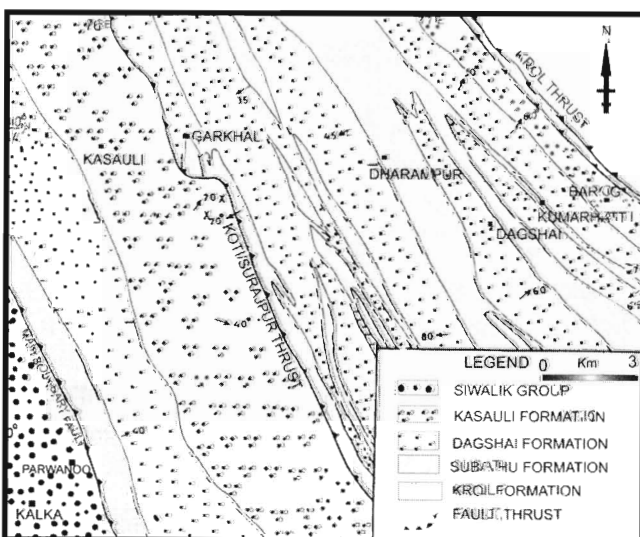


Fig. 1a. Geological map of the area around Kasauli, Himachal Pradesh (Modified after Raiverman *et al.* 1983).

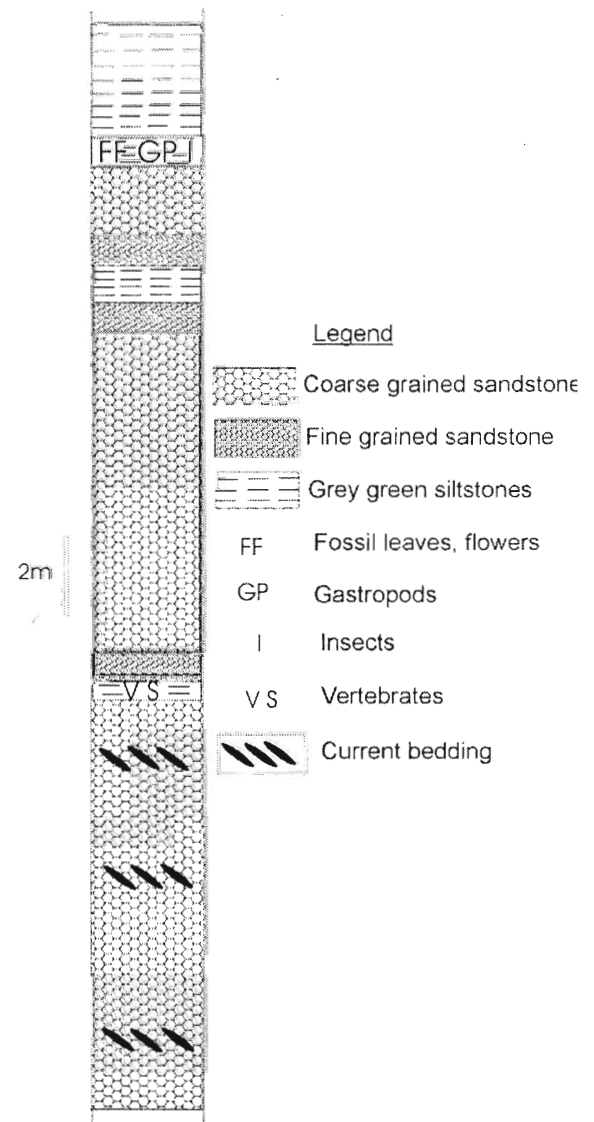


Fig. 1b. Stratigraphic column exposed at Shiv Mandir, Kasauli (After Arya *et al.*, 2004).

spiral lines and vertical striations are prominent, giving a cancellate appearance. In addition to the linear ornamentation, shells possess well defined ribs which vary from 8 to 10 in each whorl, sutures distinct, body whorl with well defined costae. Costae are distinct in the spiral region, each whorl is separated by a distinct suture. Pl. I, fig. 7 also shows similar characters.

Family **Planorbidae** Müller, 1774

Genus **Planorbis** (Guettard) Müller, 1774

*Planorbis* sp.

(Pl. I, fig.8)

Referred Material: VPL/RA/G-90201

Horizon: Upper part of basal Kasauli Formation.

Locality: Shiv Mandir.

Remarks: This single specimen is almost complete but is embedded in matrix. The shell is discoidal, distinctly compressed with an orthostrophic apex; 3-4 whorls are preserved which open gradually.

*Planorbis* is a small but important component of the fluvio-lacustrine community. Its poor representation in the assemblage may in part be the result of its more fragile shell. The present specimen was micrographed by SEM.

The taxon is comparable with the fossil specimens from the Kargil Formation near Kargil, reported by Sahni and Bhatnagar (1956) and those described by Sahni *et al.* (1984) from Kuksho Formation near Nyoma, Ladakh.

Class **Bivalvia** Linné, 1758 (Buonanni, 1681)

Family **Unionidae** Fleming 1828

Genus **Parreysia** Conard, 1853

Subgenus **Radiatula** Simpson, 1900

*Parreysia (Radiatula) kohlii* (Sahni & Bhatnagar), 1956

(Pl. I, figs.9-11)

*Indonaia (Unio) kohlii* Sahni and Bhatnagar, 1956, p. 470, pl. 7, figs. 1-2.

Referred Material: Two specimens from Shiv Mandir, Kasauli; another from Laren, Udhampur, Jammu and Kashmir; VPL/RA/G-900011, 900012, 90901

Description: *Indonaia* was established by Prashad (1918). It has been considered to be a junior synonym of *Parreysia (Radiatula)* by Cox *et al.* (1969). It includes unionids in which the shell is highly convex, quadrate or trapezoidal in shape; shell small to medium-sized, quadrate to trapezoidal; short anterior margin and a long gently rounded to straight dorsal margin; umbo small, prominent, situated anteriorly. Pronounced growth lines are present on both valves.

In their original description, Sahni and Bhatnagar (1956) placed the commonly occurring unionids in *Unio* (sensu lato), a nomenclature which was followed by (Sahni *et al.*, 1984 (Kuksho Formation, Ladakh). However, a recent work of Gurung (1998) from the late Miocene Siwaliks (Surai Khola Formation) of Nepal has shown that the specimens which have distinct trapezoidal and quadrate outlines including the previously referred forms such as *Unio kohlii*, can be transferred to the genus *Indonaia*. Since *Indonaia* was earlier considered to be invalid in the Treatise of Invertebrate Palaeontology, the Gurung's (1998) observations about the genus may be ignored.

*Parreysia (Radiatula) kohlii* (Sahni & Bhatnagar) is commonly found in the Ladakh Miocene sequences from Ladakh (Sahni and Bhatnagar, 1956; Sahni *et al.*, 1984) and from the Larea locality at Udhampur and Kasauli Formation (present study). The Nepalese specimens referred to *Indonaia tenella* from the Miocene Siwalik sequences are comparable in morphology.

In the current work, the specimen Pl. I, fig.9 shows posterodorsal view and a well developed hinge line and dentition.

Another specimen shown in Pl. I, fig.10 was obtained from the Laren (Larea) Formation along the Jammu-Srinagar National Highway at Udhampur. Pl. I, fig. 11 is from the Shiv Mandir locality and of diminutive size and was micrographed by SEM. All specimens show the highly inflated valves, prominent growth lines and a rather straight dorsal margin towards the posterior.

Horizon: Upper part of basal Kasauli Formation.

Locality: Shiv Mandir.

Superclass **Hexapoda** Latreille, 1825

Order **Blattaria** Latreille, 1810

Fam. et Gen. et sp. indet.

(Pl. I, figs.12,13)

Referred Material: Two specimens, one referred in work: VPL/RA/R-90101

Remarks: Well preserved, nearly complete hind wings were found along the bedding planes in the carbonaceous shales. The wing is elongated, bluntly rounded at the distal end and narrowly tapering at the point of attachment which is slightly damaged. The margins are smooth with a leathery and coriaceous texture. The venation is clear and can be defined into primary, secondary and tertiary divisions. The radius gives off three veins anteriorly and these bifurcate once. The veins are strong, well formed and raised and are found to bifurcate and trifurcate along the antero-distal margin. Ultrastructure as observed in the SEM shows the presence of raised parallel ridges having 5-6 minute parallel veinlets (Pl. I, fig. 13).

The shape and venation pattern of the present fossil wings

is comparable with the hind wing of the "ancient cockroach" group, Order Blattaria under Superclass Hexapoda. The broadly expanded fold brings it closest to some generalised forms. There are relatively few reports of insects from the Indian Neogene, the present one is the first report from the Kasauli Formation.

*Horizon:* Upper part of Lower Kasauli Formation.

*Locality:* Shiv Mandir.

## TAPHONOMY

By far the most interesting aspect of these finds is the data they provide on the palaeoecology and palaeoenvironments during deposition of the Kasauli Formation (Sahni and Mitra, 1980). The presence of a well-watered landscape was previously inferred (Arya *et al.*, 2004) on the basis of the abundant plant material including flowers and the rhinocerotoid mammal, which is a known forest-dweller. The presence of fossil logs of wood several meters in length in the sandstone levels in the Kasauli Formation (Arya, 1997) points to high precipitation and more energetic fluvial systems related to elevation pulses in the Himalayas.

In the current scenario, the medium to fine grained micaceous siltstones are the dominant lithofacies that are associated with abundant plant litter, molluscs and insects. The plant matter dominantly comprises entire leaves with well developed venation patterns, though ferruginous and carbonaceous plant films, woody matter, roots and stems are also not uncommon. Overgrowths of fine quartz and replacement textures frequently accentuate the preserved plant matter; microfolds, crumpling and displacements within the sediment not only result in haphazard clustering of the plant matter, but also affect the orientation of gastropod shells (Pl. I, figs. 14,15).

Moreover, the plant litter, especially the defoliated mass of entire leaves and molluscs are not aligned to the bedding planes. The association of the molluscan remains with plants

(Pl. I, fig.14) suggests occurrence of large stagnant, poorly oxygenated water bodies in which the plant and molluscan material collected *en masse* (Pl. I, fig.15). Both these materials were well preserved in a low energy overbank facies environment. However, more delicate biotas comprising insects and root structures could not have survived the more turbulent waters. During syndepositional activity, low energy activity alternated with short-spanned high energy events such as episodic flooding, quick meander shifting; these were further controlled by biologic and climatic factors that probably led to an overall assortment of plant and molluscan materials. The fine grained and compact character of the rock allowed some of the best preservations, particularly venation of insects and fine ornamentation of the smaller gastropods, such as *Planorbis*.

Sahni and Kad (1998) have related the contrasting environments between the Dagshai Formation and the Kasauli Formation to the onset of monsoonic conditions.

The abundance of organic material throughout the Kasauli Formation and the presence of broad leaved plants (Arya, 1997) also support this hypothesis. The presence of *Acrostichum* (Awasthi *et al.*, 1996) suggests presence of a mangrove type vegetation. In this context, it should be mentioned that a similar facies with fossil tree trunks and leaves and molluscan remains is found in the Zinda Pir dome in Pakistan (Downing, Lindsay, Downs and Speyer, 1993).

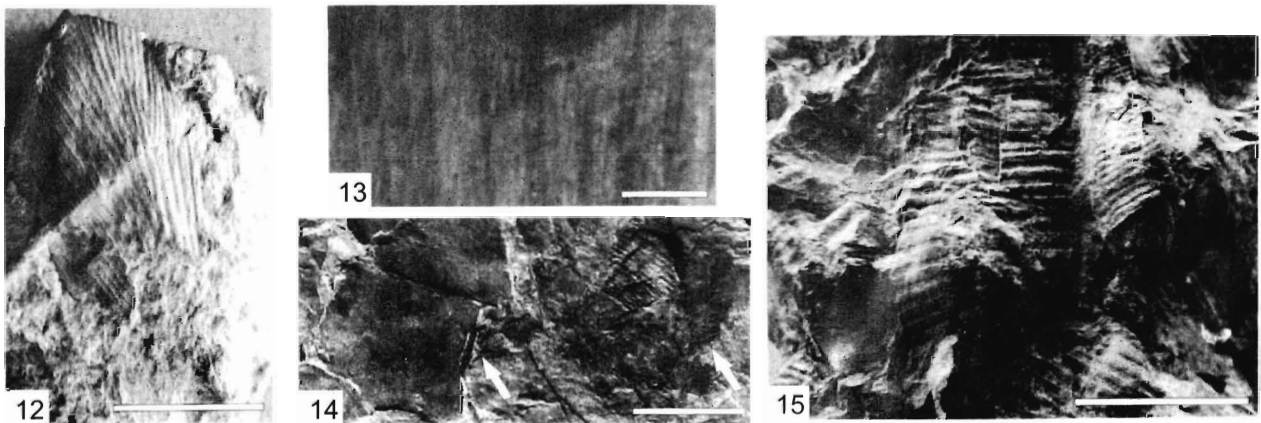
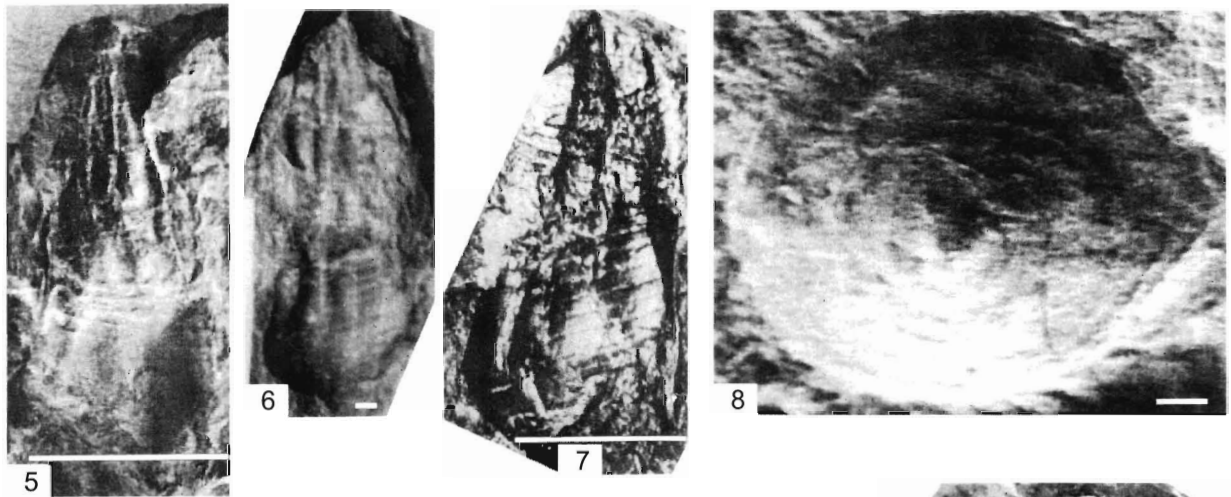
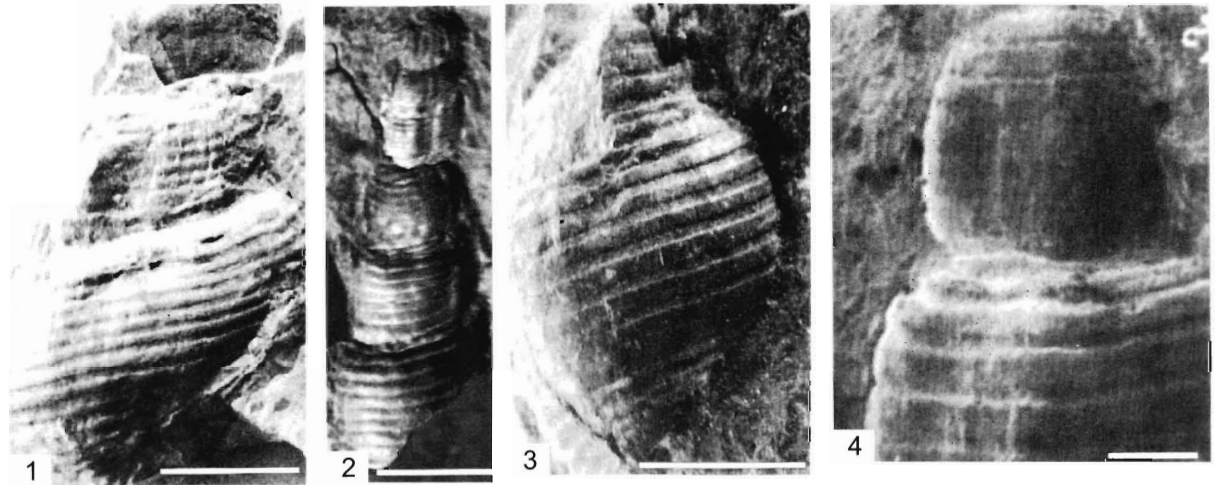
## CONCLUSIONS

Though not yet described in detail, the collections made by Arya (1997) have added greatly to our knowledge of the Kasauli biotas, and the charophytic assemblage recovered from the Kasauli Formation also provides important data. The present finds support correlations on a regional basis despite the fact that they are admittedly in their initial stages. However, as the Miocene freshwater fluvio-lacustrine invertebrates are better recorded from the Ladakh, Nepal, Jammu and Kash-

## EXPLANATION OF PLATE I

(Bar represents 1 cm in Figs. 1,2,3,5,7,9,10,12,14,15; Bar represents 1 mm in Figs. 4,6,8,11,13)

1. *Melania kargilensis*, abapertural view showing strong spiral ribbing and faint or absent vertical costae; VPL/RA/G-90007.
2. *Melania kargilensis*, well preserved specimen lacking aperture showing convex ribs, ornamented whorls gradually increasing in size towards aperture; VPL/RA/G-90001.
3. *Melania kargilensis*, abapertural view showing pronounced flange and spiral ribbing; VPL/RA/G-90005.
4. *Melania kargilensis*, SEM photograph showing fine spiral whorls; VPL/RA/G 900011-1A.
5. cf. *Brotia dobataensis*, abapertural view; well preserved specimen showing prominent vertical costae and rather faint spiral ribbing, VPL/RA/G-90004.
6. cf. *Brotia dobataensis*, abapertural view, VPL/RA/G-90003.
7. cf. *Brotia dobataensis*, abapertural view, VPL/RA/G-90002.
8. *Planorbis* sp., SEM photograph of external view showing well developed coiling; VPL/RA/G-90201.
9. *Parresia (Radiatula) kohlii*; postero-dorsal view, showing well-developed hinge line and dentition; VPL/RA/G-900011.
10. *Parresia (Radiatula) kohlii*; Laren Formation, Udhampur; exterior view of right valve; VPL/RA/G-900012.
11. *Parresia (Radiatula) kohlii*; SEM photograph of exterior of right valve, VPL/RA/G-90901.
12. *Blattaria* Fam. et Gen et Sp. indet., complete wing of insect, showing distinct venation pattern, VPL/RA/G-90101.
13. *Balattaria* Fam. et Gen et Sp. indet., SEM photograph showing fine parallel venation pattern, VPL/RA/G-90101.
14. A gastropod (top left hand) associated with large entire leaves (contacts shown by white arrows); VPL/RA/G-90009.
15. Haphazard clustering of an allochthonous gastropod community; VPL/RA/G-90008.



mir and the Himachal Pradesh Himalaya, better constraints will be forthcoming to delineate terrestrial biotas in a developing foreland basin. Further work can now be undertaken to refine the initial results. This may lead to a better understanding of the basinal palaeoenvironmental conditions of the Kasauli Formation and the palaeoclimatic reasons for supporting a tropical rainforest in a collisional geodynamic setting.

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