

the space between the highest stable graded slope angle and the top of healed slope accommodation. In case of the graded slope, no ponded accommodation occurs and hence there is predominance of the healed slope or slope accommodation. So in this case there is greater bypass of sediments on the upper part and more deposition towards the basinal side¹¹. Total space available for deposition is measured by fitting a 3D convex hull from the shelf slope break to the toe of the slope. Ponded accommodation is interpreted where there are three-way closing lows. Healed slope accommodation is the difference between the total slope and the ponded slope accommodation.

This study reveals that moderate resolution bathymetric data are suitable for automated feature extraction. Further, data processing is faster and results are fairly accurate in GIS system. Based on present-day channel system and sediment transport pattern along ECMI interpreted on a regional scale, the road map ahead calls for efforts to undertake further research to scale down high-resolution data like seismic imaging, gravity magnetic profiles and multibeam side scan image. This may help provide deeper understanding on depositional elements and

establish petroleum systems in the respective sedimentary basins. Such studies can be combined with subsurface geological information and regional anomalies (gravity, magnetic, etc.) to derive more geomorphic parameters of deeper regime horizontal and vertical profiles of depositional systems. Remote sensing data are a viable alternative, as they are less expensive as compared to any other geological data and the results provided are promising. They can be a valuable tool for oil and gas exploration research in the days to come.

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Occurrence of Neoproterozoic animal embryos in the Chambaghat Formation of Himachal Lesser Himalaya, India

We report here the occurrence of definite Neoproterozoic animal embryos showing internal morphology through micro-CT from the phosphatic chert lenticles associated with quartz arenite of Chambaghat Formation, Krol Group, Lesser Himalaya, Himachal Pradesh (HP). The phosphatic chert samples yielding animal embryo were collected from Sauti area of Kamlidhar Syncline of Sirmaur district, HP (Figure 1). Earlier, animal eggs and embryos have also been interpreted from a similar horizon^{1,2} without high-resolution internal structure.

The black phosphatic chert samples were subjected to maceration by soaking in 10–15% acetic acid for a fortnight and then washed, dried and sieved. Different fractions of sieved material were screened under a microscope which yielded

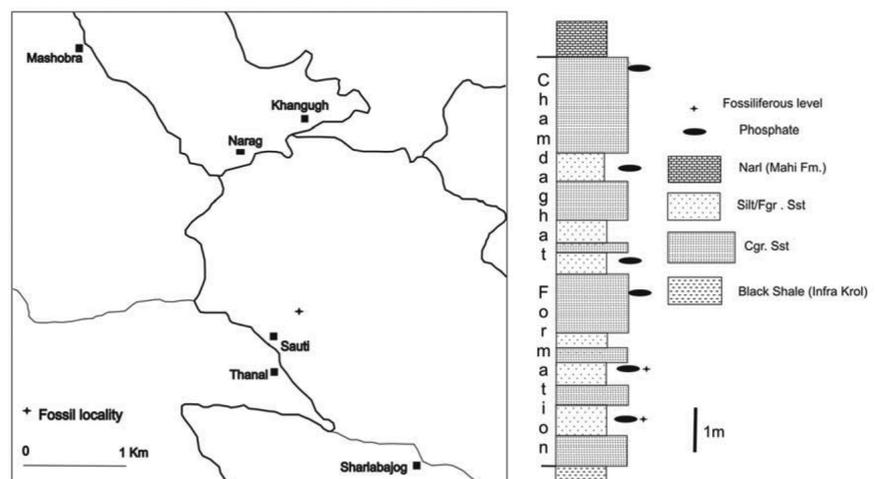


Figure 1. Fossil locality map and litho-section of Chambaghat Formation as measured in near Sauti village.

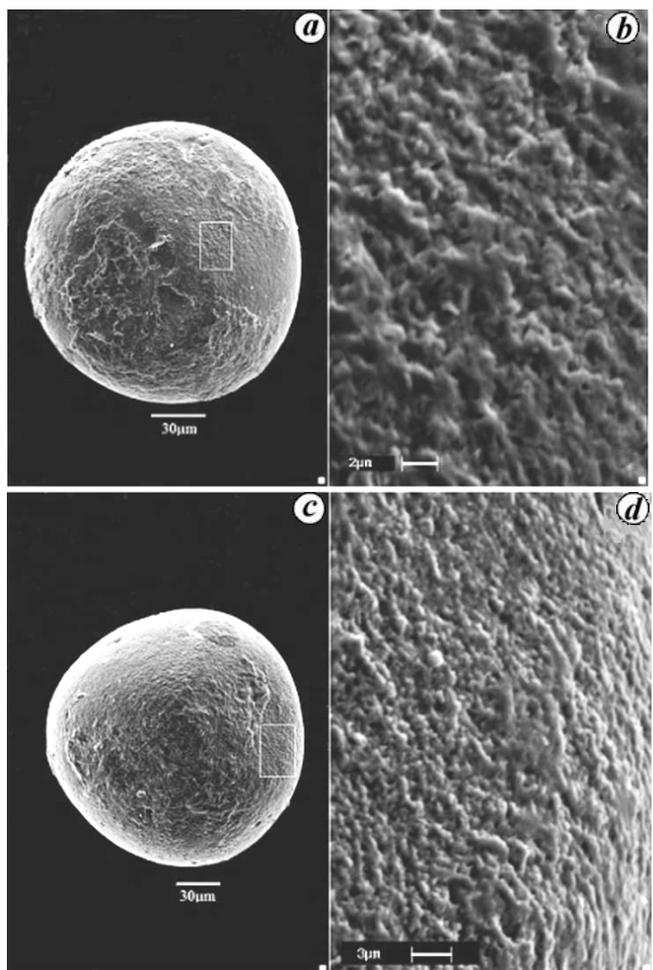


Figure 2. *a*, SEM image of *Megasphaera* sp. (Reg. No. NRF-2/459). *b*, Enlarged view of part of (*a*). *c*, SEM image of *Parapandorina* sp. (Reg. No. NRF-2/460). *d*, Enlarged view of part of (*c*).

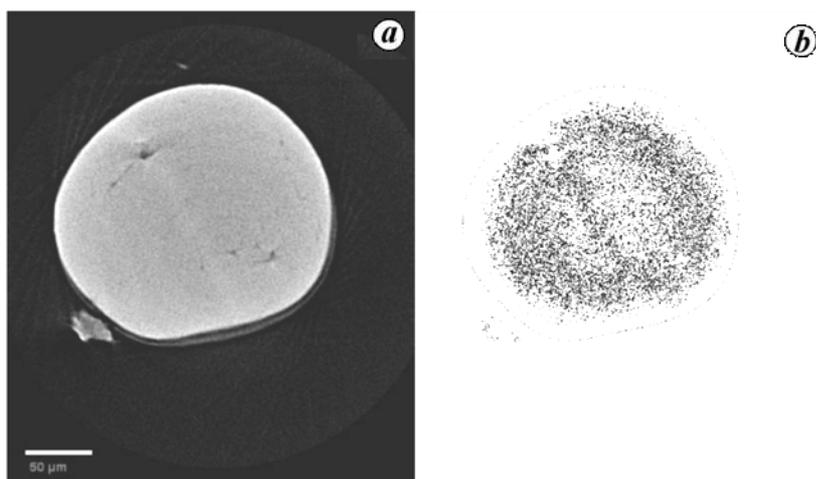


Figure 3. *a*, Image of CT scan slice of the specimen in Figure 2 *c* depicting two hemispheres. *b*, Threshold image of (*a*).

several spherical putative microfossils. Under SEM these spherical structures are identified as early developmental stages of animal embryos. Identification is

mainly based on the nature of the surface and internal structures. Preservational artefacts in most of the cases obscured structural and functional interpretation of

spheres which lack distinct features. In the present study globular body with one internal body enclosed by an envelope is comparable with *Megasphaera*³ and the other with two internal bodies is assigned to *Parapandorina*⁴.

Megasphaera sp. (Figure 2 *a* and *b*) is microscopic body which is globular in shape with one internal body enclosed by an envelope. The diameter of the body is ~400 μm. Envelope (where preserved) is thin and either smooth or possesses surface ornamentation characterized by small scalids, anastomosing ridges and minor tubercles, which are indistinguishable from resting egg of modern metazoans³. *Megasphaera* is also interpreted as embryonic animal⁵, specially a developmental sequence from resting eggs to blastulas. Envelope with smooth surface is also not uncommon. The specimens are closely similar to *M. ornata*⁶ and *M. inornata*³.

Parapandorina sp. (Figure 2 *c* and *d*) is a globular microfossil with thin and

smooth envelope that encases more than one internal body. The X-ray tomographic slices of this microfossil show two internal bodies (Figure 3). The internal bodies are hemispherical in nature and interpreted as blastomeres. This is comparable to the blastula stage embryos of Neoproterozoic animals⁴. Due to its large size it cannot be interpreted as a single-celled organism; rather it might have got fossilized during mitosis. The Doushantuo forms described as *P. raphospissa*³ have 2, 4, 8 and 16 internal bodies at different stages of development. Our specimen with only two internal structures represents very early stage of development. Associated Acritarchs are spherical to sub-spherical in shape and much smaller in size range from 80 to 175 µm across² and the size of the algal cyst is also comparatively small⁷. Besides, thin sections of phosphatic chert-bearing arenite of the Chambaghat Formation, show various stages of animal embryos (see figure 4 a–h in Babu *et al.*²).

Near absence of recognizable adult body fossils renders understanding of the phylogenetic relationship of these microfossils difficult. However, relationship to extinct stem group, sponges, cnidarians and bilaterians is possible. The recent record of sponge and sponge spicules from this stratigraphic level and the same location² indicates that these embryos might be related to these adult morphologies. The Palaeontology Division, Geological Survey of India, Northern Region, Lucknow is the repository of the specimens described here.

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