

also hasten the process of utilization of germplasm. It further gives a direction to the effect and practice studies for genetic improvement of this species.

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## Mesoproterozoic coiled megascopic fossil *Grypania spiralis* from the Rohtas Formation, Semri Group, Bihar, India

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**The present communication records rare megascopic coiled impressions present on a shale slab collected during the recent field work on the Early Mesoproterozoic Rohtas Formation of the Semri Group, Vindhyan Supergroup exposed in the Rohtas District, Bihar. The fossil *Grypania* is considered as an important evidence in understanding the evolution of oxygen in the early atmosphere and early experimentation in the biosphere. The present paper also traces the appearance of *Grypania* to the lower part of the Rohtas Formation and adds to our knowledge about the distribution of *Grypania* in the Rohtas Formation.**

**Keywords:** Early atmosphere, *Grypania spiralis*, Rohtas Formation, Semri Group, Vindhyan Supergroup.

THE coiled megascopic fossil, *Grypania spiralis*, is one of the most important members of the carbonaceous remains reported from Late Palaeoproterozoic to Mesoproterozoic successions of America, China and India. This report adds to a meagre record of *Grypania* in the world, in comparison to the other types of mega-remains, viz. *Chuarina*, *Tawuia*, Elipsophysid and Moranid remains mostly found worldwide in Mesoproterozoic to Neoproterozoic successions. Coiled fossils were first described by Walcott<sup>1</sup> more than a century ago and subsequently reported by different workers. They are interpreted vari-

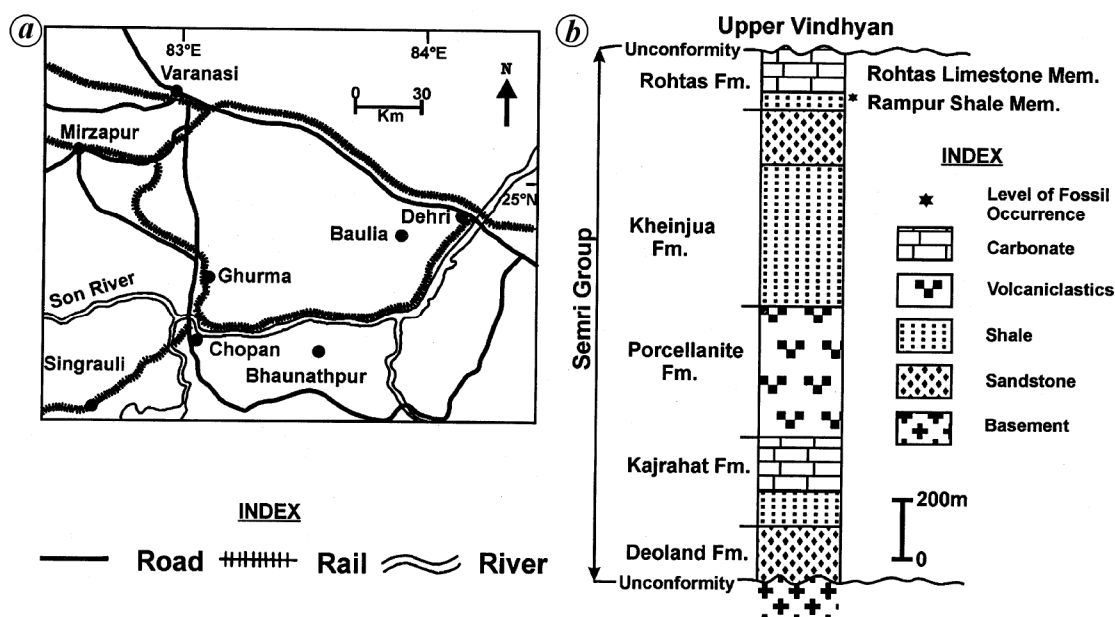
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ously as representing eukaryotes or large-size prokaryotes. Helically coiled megascopic fossils, *Grypania spiralis*, are known from a few Mesoproterozoic successions of the world. The large size of this fossil is a matter of special interest to Precambrian palaeobiologists. In spite of its rarity in the palaeontological records, this fossil has great significance in understanding the experimentation in the early biosphere. It has also been suggested that the advent of this fossil group represents a distinct level of oxygen evolution in the atmosphere and among the earliest evidence of the existence of eukaryotes on earth<sup>2</sup>. Therefore, each new discovery of the well-preserved fossil *Grypania* is important.

In India, *Grypania* is known only from the Vindhyan basin. In 1919, a solitary fossil spiral impression on a single slab from Saraidanr near Rohtas was reported by Beer<sup>3</sup> from the Rohtas Limestone exposed in Bihar. In spite of painstaking efforts, Beer could not locate another specimen from the area; repeated searches in the following years for helically coiled fossils were without any success. Although the sole occurrence intrigued many palaeontologists, this discovery<sup>3</sup> was well received in the scientific literature since after Walcott's<sup>1</sup> record, it was only the second report of coiled fossils from any other part of the world. However, both the reports were interpreted differently. Originally, the Vindhyan specimen<sup>3</sup> was considered as the impression left by a dead body of a small coiled worm or a track of some small burrowing animal. After restudy, Mathur<sup>4</sup> designated the specimen described by Beer<sup>3</sup> as *Spiroichnus beerii*. Later, from the central part of the Vindhyan basin in Madhya Pradesh (MP),

well-preserved, rich assemblages of helically coiled fossils were recorded<sup>5-8</sup>. Tandon and Kumar<sup>5</sup> originally designated these fossils as *Katnia singhii* and described them as the fossil remnants of an annelid. Subsequently, Kumar<sup>6</sup> considered these as *Grypania spiralis*. Glaessner<sup>9</sup>, after examining the Indian specimens from the Katni area supplied by Kumar, concluded that the specimens were large-sized oscillatorian filaments. Kumar<sup>6</sup> considered the large size of these helically coiled fossils to represent the phenomenon of gigantism – a natural experimentation in the biotic world. All these helically coiled fossil assemblages were invariably recorded from the Rohtas Formation of the Semri Group of the Vindhyan Supergroup. After nearly 90 years, during the recent field work, another shale slab containing specimens of the fossil *Grypania* was found in the same area where from Beer<sup>3</sup> reported a similar fossil. The present communication records the occurrence of megascopic coiled fossils of *G. spiralis* occurring as impressions in the Rohtas Formation of the Rohtas area. This is the second report of *G. spiralis* from Rohtas District, Bihar. In spite of ideal preservation conditions and stratigraphically correlative strata that yielded abundant *G. spiralis* in central India, their rare occurrence in the Rohtas area is puzzling and presently stands unexplained.

The Vindhyan Supergroup is well exposed in central India. It unconformably overlies the Bundelkhand massif and slightly metamorphosed Bijawar Group (~2500 Ma)<sup>10,11</sup>. The Vindhyan sediments comprise of a thick pile of sandstone, porcellanite, shales and limestone. The entire succession is divided into four groups, namely the Semri, the Kaimur, the Rewa and the Bhandar, in ascending order.



**Figure 1.** *a*, Location map of the Rohtas area, Rohtas District, Bihar. The Rohtas Formation succession was studied in Murali Pahar near Dehri, from where the present fossil has been collected. *b*, Generalized lithostratigraphic succession of the Semri Group as exposed at Rohtas (after Banerjee and Jeevankumar)<sup>12</sup>.



**Figure 2.** *a*, General view of the slab containing helically coiled *Grypania spiralis* recovered from the Rampur Shale Member of the Rohtas Formation exposed in the Murali Pahar, BSIP Specimen no. 39571. *b*, Enlarged view of the middle right-hand-side part of the slab showing well-preserved, loosely coiled specimens of *G. spiralis*. *c*, Further enlarged view of the *G. spiralis* specimens shown in (*b*). *d*, Enlarged view of the lower left-hand-side part of the slab shown in (*a*) displaying partially preserved specimens of *G. spiralis*. *e*, Enlarged view of the upper left-hand-side part of the slab shown in (*a*) displaying the largest incomplete specimen of *G. spiralis* on the slab. *f*, One of the tightly coiled specimens of *G. spiralis* present on the slab. Scale bar = 5 mm for all the photographs.

The stratigraphic succession of the Semri Group in the area comprises of the Deoland Formation, Kajrahat Formation, Porcellanite Formation, Kheinjua Formation and

Rohtas Formation, in ascending order<sup>12</sup>. The Rohtas Formation is exposed along the southern flank of the Vindhyan basin in the Son Valley area. From the Murali



Pahar locality near Dehri (Figure 1a), the Rampur Shale Member of the Rohtas Formation has yielded *G. spiralis* fossils (Figure 1b). The Rohtas Formation in the eastern sector of the Vindhyan basin has been considered a shallowing upward, increasingly calcareous shale–carbonate interbedded succession developed on an epeiric shelf, whereas the lower part of the Rohtas Formation represents an oxygen-depleted outershelf<sup>12</sup>. U/Pb SHRIMP age dating of the zircon crystals recovered from the ash beds at the top of the Rampur Shale, a lower Member of the Rohtas Formation, has yielded<sup>13</sup> an age of  $1599 \pm 8$  Ma– $1602 \pm 10$  Ma. The Rohtas Limestone resting gradationally above the Rampur Shale exposed in Bhadanpur area of Maihar, has been considered to be Early Mesoproterozoic, i.e.  $1601 \pm 130$  Ma by Pb–Pb technique<sup>14</sup> while the *Grypania*-bearing Rampur Shale of the Katni area provides  $1599 \pm 48$  Ma age by Pb–Pb technique<sup>15</sup>. On the basis of the correlation of strata of the Rohtas Formation exposed in different sectors of the Vindhyan basin, it is considered that the Rohtas Formation, including the fossil containing the Rampur Shale Member exposed in the Murali Pahar area, is also  $\sim 1.6$  Ga old.

The single fossil specimen described earlier by Beer<sup>3</sup> as having a spiral groove with relief, appeared to be a mould. Unlike the specimen recorded by Beer<sup>3</sup> that was preserved as cast and mould, the new set of specimens from Rohtas is preserved as impressions. These structures are present as loose coils and c-shaped forms. These forms have no partings or segmentations, and are of millimetre size. The new occurrence is being formally described here: Division – Incertae sedis; Genus – *Grypania*<sup>16</sup>; Type species – *G. spiralis*<sup>1,16</sup>; Locality – Murli Pahar, Rohtas District, Bihar; Stratigraphic position – The Rohtas Formation, Semri Group, Vindhyan Supergroup, Early Mesoproterozoic.

*Grypania spiralis* (Walcott) emend. Walter, Oehler and Oehler, 1976 (Figure 2)<sup>16</sup>.

Description: Flat, ribbon-like, unbranched impressions preserved on the bedding surface, generally loosely spirally coiled; coil diameter of the ribbon ranges between 0.95 and 1.6 cm, width of the ribbon is 0.9–1.75 mm, length of the ribbon ranges between 0.75 and 6.5 cm; terminations are rare and no segmentations are observed. Impressions are of the same colour as that of the adjacent matrix.

Discussion: Comparable specimens are reported from the Rohtas Formation exposed in Katni area, MP<sup>6</sup>, and the Gaoyuzhuang Formation, China<sup>17</sup>. Mathur<sup>4</sup> designated the previous specimen described from Rohtas, Bihar as *Spiroichnus beerii*. It was preserved as cast and mould. The specimens recorded from Katni area<sup>6</sup> are preserved on the bedding surface mostly as impressions and a few as possible mould of *Grypania*. In the Katni assemblage, the specimens are tightly to loosely coiled with distinct to indistinct septations. However, the recently found second shale slab has entire specimens preserved as impression

and no separation has been noted. On the basis of the preservation preference we have categorized the present specimen as *G. spiralis*. This slab was noted in the talus of the freshly excavated, unsuitable shale component of the limestone mine of the Kalyanpur Cements Ltd at Murali Pahar ( $24^{\circ}39'20.4''N$ ,  $83^{\circ}58'32.7''E$ ), which was brought to the periphery of the mine for dumping. An extensive search was made for two days in the areas from where the rocks were brought to locate more shale slabs containing similar fossil material. This exercise yielded no success. Though no second slab was found, the specimens on the present slab are described here to put on record the recovery of *G. spiralis* from the locality which yielded an only similar fossil in 1919.

Age – Early Mesoproterozoic.

On the basis of megascopic size of the fossil, *G. spiralis* from Chuar Group was considered by Walter *et al.*<sup>16</sup> to represent an eukaryotic fossil. On the basis of the size of the biotic remains, Runnegar<sup>2</sup> used *G. spiralis* to estimate the oxygen level of the atmosphere. Similar coiled fossils reported from the Late Palaeoproterozoic from Negaunee Iron Formation, Michigan, are considered to be the oldest eukaryotes<sup>18</sup>. Limited records of the coiled megascopic fossils and their relevance in determining the ancient oxygen level make each new report an important record in documenting the distribution of *G. spiralis*. *Grypania* is also considered to be the oldest biozone recognizable on the basis of megafossils<sup>19</sup>.

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