# First Find of Coprolites (Fossilized Excreta) from Denwa Formation in Siarkhera area, Hoshangabad District, Madhya Pradesh of Satpura Basin

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Satpura basin is located in the heart of Indian peninsula along southern flank of Narmada valley. The spindle shaped basin is about 200 km long, 60 km wide; covering an area of 12000 km² with estimated thickness of sediments is about 5000m (Peters and Singh, 2001). It is unique among all the Indian Gondwana basins by having the longest range of stratigraphic records spanning from Permian to Cretaceous (Crookshank, 1936). In connection with FSP Id. M4CRP/NC/CR/2018/19927, palaeontological studies were carried out in the Siarkhera area, Sohagpur Tehsil, Hoshangabad district, Madhya Pradesh within Satpura basin during the FS 2018-19. Denwa and Bagra Formation of Upper Gondwana are present in the study area, among which sedimentaries of Denwa Formation have yield vertebrate and petrified wood fossils. Denwa Formation is 300-450m thick and represented mostly by red mustone, purple mudstone, greenish gray fine sandstone and gray coarse gained sandstone forming bad land topography. Maulik et al. (2000) have differentiated Denwa Formation into upper and lower units. The lower unit is dominated by mudstone and lacks thick sand bodies whereas the upper unit has alternating medium to fine grained sandstone bodies and red mudstone. The age of the Denwa Formation is considered broadly as Mid Triassic (Anisian) (Sengupta et al., 2017).

Vertebrate faunal assemblage like reptiles, amphibians and fishes except coprolite have been reported from the Denwa Formation by various workers (Welles, 1993; Mukherjee and Sengupta, 1998; Bandyopadhyay and Sengupta, 1999; Damiani, 2001;Bandyopadhyay, 2011; Sengupta et al., 2017). During the course of present study, 30 coprolite samples have been collected from the greenish gray sandstones of Denwa Formation for the **first time** of different shapes and sizes. Coprolites are significant tool to unravel the palaeobiology and palaeoecology of the depositional basin (Hunt, 1992; Chin, 1994; Hunt et al., 1994). Coprolites provide clues on digestive progress, diet, behaviour, predator–prey interactions and broad physiology of the extinct animals (McAllister, 1988; Chin, 1994; Hattin, 1996; Chin and Kirkland, 1998; Northwood, 2005; Hollocher et al., 2005, Chin, 2007; Nakajima and Izumi, 2014).

Microscopic studies of the collected coprolites have also been carried out to identify the diagnostic features of the extinct animals. Several workers have classified coprolites on the basis of their shape, size and composition (Hantzschel et al., 1968; Hunt & Lucas, 2012; Niedzwiedzki et al.,2016; Dentzien-Dias et al., 2018). Hunt and Lucas (2012), classified coprolites and recent feces into 11 main categories. In the present study seven morphotypes of coprolite recovered from Denwa Formation have been identified on the basis of their morphological characters. A brief description of these various morphotypes of Denwa coprolites are tabulated below:

| Morphotype | Descriptions of coprolites | Size (maximum) | | Inclusions within coprolites | Probable producers | Figure no. |
|---|---|---|---|---|---|---|
| | | l(mm) | w(mm) | | | |
| Morphotype-I | Bullet coprolites | 46.78-54.32 | 33.44-34.72 | Small bone fragments | Carnivores | Fig.1 |
| Morphotype-II | Reniform coprolites | 24.70-35 | 12.30-15.30 | No inclusions | Amphibians and reptiliomorphs | Fig.2 |
| Morphotype-III | Cylindrical coprolites | 7-73.40 | 11.68-59 | No or rare bone inclusions | Archosauromoriforms | Fig.3 |
| Morphotype-IV | Tear drop coprolites | 17.66-20.58 | 8.30-12.78 | Bone inclusions | Unknown | Fig.4 |
| Morphotype-V | Spiral/scroll coprolites | 40.30-62.76 | 18-22.52 | Small bone fragments | Dipnoan fishes | Fig.5 |
| Morphotype-VI | Ovoid coprolites | 31 | 18.24 | No inclusions | Unknown herbivores | Fig.6 |
| Morphotype-VII | Irregular coprolites | 24.60-38.20 | 25.50-34.50 | Bone fragments of teeth and fish scales. | Carnivores | Fig.7 |

Morphotype-I is yellowish white, medium size, segmented, bullet shape with conical top and sub rounded bottom (Fig.1). Morphotype- II is dull white in colour, bean or cashew shape, small sized with smooth external surface having longitudinal striations(Fig.2). Morphotype-III is dull white to light yellow, cylindrical, narrow to elongated, mostly non-striated, few striated with rare or no bone inclusions. The length of the cylindrical coprolites varies from 7mm to 73.4mm (Fig.3). Morphotype-III is most dominant coprolite in the study area. Morphotype-IV is dull white, shape resembles with tear drop, mostly non-striated with few bone inclusions (Fig.4). Morphotype-V is dull white, spiral, smooth to uneven surface, non-striated with bone inclusions (Fig.5). Spiral coprolites is further categorised into spiral and scroll type. Morphotype-VI is dull white, ovoid to sub-spherical, rough external surface and non-striated (Fig.6). Morphotype- VII is dull white, irregular shape, non-striated, rough external surface with lots of undigested bone fragments (Fig.7).

For elemental composition, coprolites were analysed under SEM-EDX between 49X and 700X. SEM-EDX analysis of coprolites has shown presence of Ca and P (Fig.10), confirming phosphatic composition which is an indicative of biogenic origin. XRD analysis of one coprolite specimen has shown presence of flourapatite{$Ca_5(PO_4)_3F$} as main mineral constituents. Apatites are important minerals in vertebrate bone, teeth and scales, and are often preserved in fossilized bones and in coprolites of carnivorous origin (Hansen et al., 2015).

Morphological features and food inclusions in coprolites is used as an indirect method to identify the producing animals. Microscopic study of the present coprolites shows numerous undigested food inclusions in the form of bone fragments (Fig.11), scales (Fig.8) and teeth suggesting that the probable producers were carnivores. Spiral coprolites (Fig.5) may be produced by dipnoan fishes. Smooth external surface of the spiral coprolites suggests that they were deposited and buried in an aquatic environment.

On the other hand, cylindrical coprolites (Fig.3) have been attributed to Archosauromorpiforms and Therapsids. Reni form or bean shaped coprolites (Fig.2) with longitudinally striations suggests amphibians and reptiles as a probable producers. The difference in morphology, suggests presence of different types of animals thriving in the study area with diverse palaeohabitat. Overall, the first finding of coprolites in the Satpura Gondwana basin is one the significant contribution by GSI in the field of vertebrate palaeontology on which further studies are being continued.

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**Fig.1:** Morphotype-I(Bullet coprolite with inclusions)

**Fig.2:** Morphotype-II( Reniform coprolite)

**Fig.3:** Morphotype-III (Cylindrical coprolite)

**Fig.4.**Morphotype-IV (Tear drop coprolite)

**Fig.5 .**Morphotype-V (Scroll coprolite)

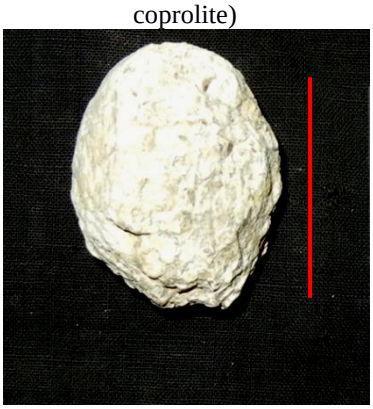

**Fig.6**. Morphotype-VI( Ovoid coprolite)

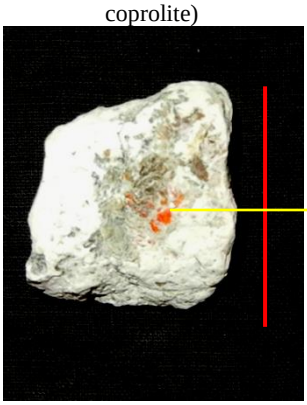

**Fig.7.** Morphotype-VII ( Irregular Coprolite)

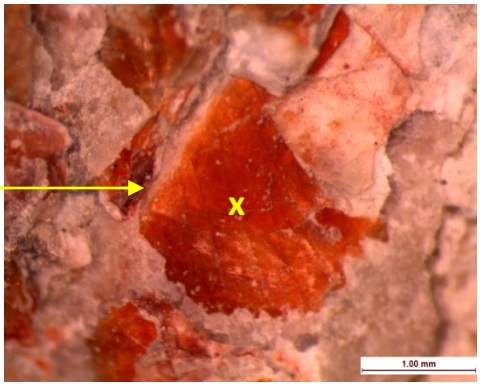


**Fig.8.** Microphotographs showing bone inclusions(x) in matrix of irregular coprolite

**Fig.9.** Small size coprolite with bone inclusions.

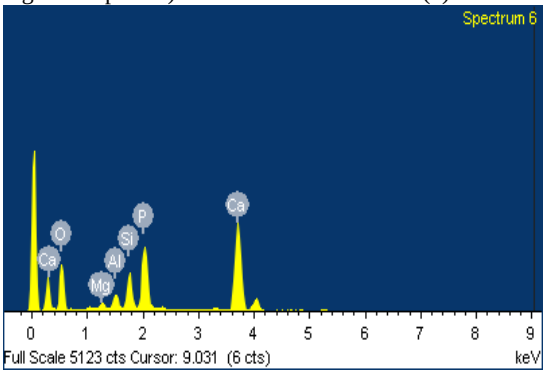


**Fig.10.** EDS analysis of coprolite showing peaks of Ca and P.

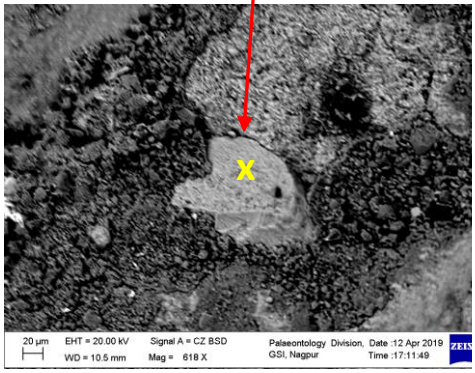


**Fig.11.** SEM image of coprolite external surface with bone inclusion(x)

***( Scale bar equal to 3cm( for Fig.1-7), 2cm for Fig.9 )***