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Trace fossils and Ichnofabric analysis of the Aalenian (?)-Lower Bajocian strata of Volgograd region (south of Russian platform)

Desai B.G.[1], Ippolitov A.P.[2]

[1] School of Petroleum Technology, Pandit Deendayal Petroleum University, Gandhinagar, India; bhawanigd@gmail.com
[2] Geological Institute of Russian Academy of Science, Moscow, Russia; ippolitov.ap@gmail.com

Marine strata of the Aalenian(?)-Lower Bajocian age, recently discovered in Volgograd region and marking the earliest stage of Middle Jurassic marine transgression from Tethys to south of Russian platform (see Ippolitov, 2017, present volume), contain abundant ichnofossils. The latter are met throughout the whole clay-siltstone sequence of Unit II, but are best fixed within carbonate nodules in the middle part of the succession, where they are especially abundant and perfectly preserved. This material is of special interest for reconstructing the palaeoenvironments, as the nature of underlying sandy unit (marine/ continental) is not fully resolved (see review in Saltykov, 2008).

The present note contains brief discussion of trace fossils and general conclusions obtained from ichnofabric analysis on material collected by the second author (API) from the locality Dubovoi near Sirotinskaya, Volgograd region (see Ippolitov, 2017, present volume) in several closely spaced ravines.

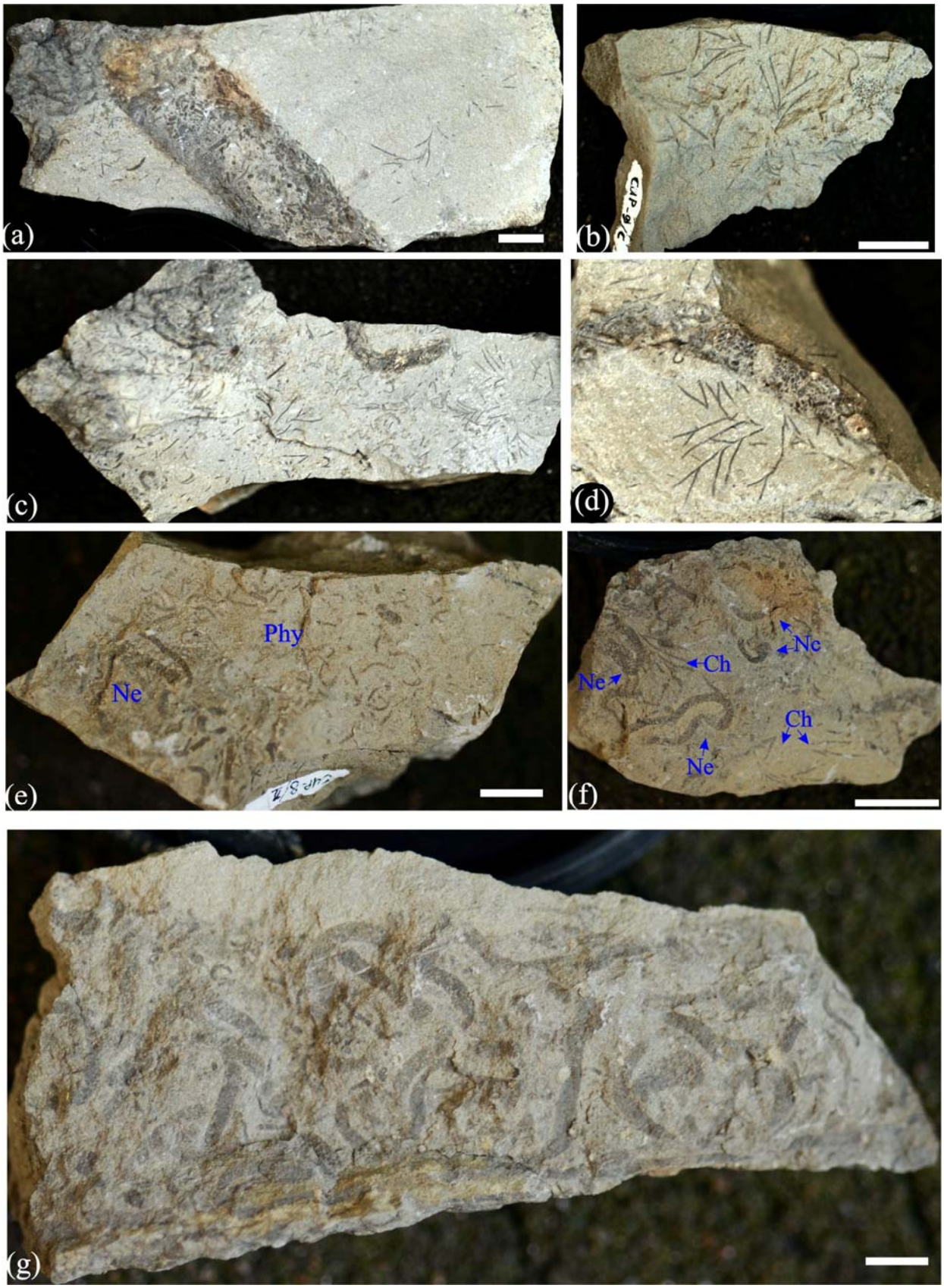
Within the carbonate nodules, the following ichnotaxa were met:

Alcyonidiopsis bavaricus Uchman, 1999 (**Fig. 1a,c,d**) occurs as simple, large horizontal tubular branched burrow, of 27 mm width, thinly lined with dark sediments. Burrow fill comprises of elongated pellets with longer axis length between 2 to 5 mm. The pellets are dark in color and of variable orientation. Pellets are densely packed and longitudinally aligned near the burrow wall and are dispersed in the central burrow fill region. The ichnotaxon is regarded as feeding burrow (Uchman, 1999). The trace maker is interpreted to have colonized soft ground substrate at Middle Tier level.

Chondrites intricatus (Brongnairt, 1823) (**Fig. 1a-f**) occurs as numerously radiating, tree-like branched burrows. Specimens show dominance of second order branching. The tunnels are elliptical or flattened in cross section. Burrow fill comprises of dark sediment that the host rock. The ichnotaxa is regarded as feeding burrow or chemosymbiotic burrow (Fu, 1991). Patel and Desai (2009) based on its observation in recent intertidal zone also considered it to be combined feeding and dwelling burrow. This ichnotaxon is deep tier colonizing the substrate during later stage.

Nereites cf. *irregularis* (Schafhautl, 1851) (**Fig. 1e-g**) occurs as closely packed, meandering full relief burrow with elliptical cross-section. The meanders are tight and irregular, occurring at different levels within the few millimeter of the sediment. Central tunnel is well preserved, while the outer envelope zone is not preserved. Burrow fill of central tunnel comprises of poorly preserved meniscate fill dark sediment than the host sediment. It co-occurs with *Phycosiphon* and is cross cut by *Chondrites intricatus*. *Nereites* occurs as shallow tier trace colonizing soft ground substrate. It is interpreted as feeding trace of deposit feeder.

Phycosiphon incertum (Fischer-Ooster, 1858) (**Fig. 1e**) occurs as small, complex burrow comprising of narrow U shaped tubes enclosing spreite. Spreite are not visible because of poor preservation. The tunnels are regularly or irregularly looped, comprising of dark core with light mantle. In sectional or oblique view of the sample, the ichnotaxon occurs as higher abundance of mud dominate “strings” of various shapes including several small and tight U shaped loops and antler shaped system. *Phycosiphon* are considered to be deposit-feeding activity of small vermiform organisms (Wetzel, 2010). It is an opportunistic organism initially colonizing the substrate for exploiting organic rich sediment (Wetzel, 2010). The trace maker colonizes soft ground substrate as early colonizer at shallow tier level.


(a)
(b)
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Ichnofabric Analysis

Four recurring ichnotaxa Viz. *Alcyonidiopsis bavaricus; Chondrites intricatus*; *Nereites* cf. *irregularis* and *Phycosiphon incertum* are recognized within the studied succession. The ichnofabric analysis was carried out and Ichnoguild and tiering was identified. Overall the ichnotaxa shows complex tiering pattern.

Ichnoguild is defined as group of organism that occupy same tier to exploit the same resources in similar way (Bromley, 1990). Three following ichnoguilds are recognized in the studied sequence:

(a) *Nereites-Phycosiphon* Ichnoguild

(b) *Alcyonidiopsis* Ichnoguild

(c) *Chondrites* Ichnoguild.

The *Nereites-Phycosiphon* Ichnoguild is characterized by active vagile organisms that adopted deposit feeding strategy and occupied shallow tiers. *Phycosiphon* is cross cut by all other ichnotaxa, including *Nereites* (**Fig. 1e**). Shallow tier *Phycosiphon* were also attributed to opportunistic behaviour by Goldring et al. (1991). Based on the tiering pattern it can be envisaged that the *Phycosiphon* trace maker were among the first to exploit the sediment followed by *Nereites* trace maker. Wetzel and Uchman (2001) argued that the immediate colonization of *Phycosiphon* implies a fully oxygenated habitat at that time of deposition as the *Phycosiphon*-producing organisms did not maintain contact with the bottom water. Further they also interpreted that since the size of the *Nereites* is larger than the *Phycosiphon*, the benthic food concentration of the sediment exploited by the *Nereites* producer was lower than the *Phycosiphon* producer. In some cases, *Phycosiphon* occupies middle to deep tier level (Bromley, 1990, p. 238; Buatois, Mángano, 2011, p. 90). However in the present case, the *Phycosiphon* and *Nereites* shows shifting of its tier level to shallow tier. This shifting of its tier level can be attributed to opportunistic behaviour of the trace makers.

The *Alcyonidiopsis* Ichnoguild is characterized by active vagile to semi-permanent organism that adopted deposit feeding in middle tier level. The trace makers have colonized the soft ground substrate during the initial colonization phase, as seen by lined burrow supported by pellets. Both the Shallow and Middle tier ichnoguild suggest fully marine, well oxygenated conditions of the deposition. The sediment received abundant organic matter which was quickly consumed by the shallow tier deposit feeders (*Nereites – Phycosiphon* Ichnoguild) and middle tier deposit feeders *Alcyonidiopsis* Ichnoguild.

The *Chondrites* Ichnoguild is characterized by non-vagile, deep-tier deposit feeder or chemosymbiont structures. It is cross cutting all previously formed trace fossils and is considered to be late phase colonizer of deep tier nature. Several studies suggested that the *Chondrites* producers colonizes oxygen deficient pore-water substrate by maintaining open connection to sediment-water interface. Based on the ichnofabric studies of Eocene muddy turbidites from Carpathians of Poland Wetzel and Uchman (2001) suggested that the in case of slowly developing oxygen deficiency, *Chondrites* will occupy deeper levels. In present case also the *Chondrites* is occupying deeper levels suggesting establishment of restricted environment for brief periods of time. Such conditions are usually formed during the marine transgressions.

Conclusion. Four recurring ichnotaxa viz. *Alcyonidiopsis bavaricus; Chondrites intricatus; Nereites cf. irregularis and Phycosiphon incertum* are recognized in the Aalenian(?)–Lower Bajocian sediments of the Volgograd region. They indicate shallow marine environment with normal salinity. The Ichnofabric analysis suggests the presense of three ichnoguilds: *Nereites-Phycosiphon* Ichnoguild and *Alcyonidiopsis* Ichnoguild forms shallow and Middle

Fig. 1. Trace fossils from the Aalenian(?) - Early Bajocian sequence at Dubovoi near Sirotinskaya (Volgograd region). Scale bar indicates 10 mm.

(a) *Alcyonidiopsis bavaricus* cross cut by *Chondrites intricatus.* Note the pelleted structure (i) densely packed elongated pellets aligned along the burrow wall; (ii) loosely packed pellets randomly oriented inside the burrow fill; (iii) *Chondrites intricatus* showing sharp boundary burrows with dark sediment fill;
(b) *Chondrites intricatus* showing dense accumulation along the bedding plane;
(c) Middle tier, small diameter *Alcyonidiopsis bavaricus* (i) cross cut by abundant deep tier *Chondrites intricatus*;
(d) Close-up of the *Alcyonidiopsis bavaricus* cross cut by deep tier *Chondrites intricatus*;
(e) Close association of Shallow tier *Nereites-Phycosiphon* Ichnoguild showing cross cutting relation *Nereites* and *Phycosiphon* (Ne- *Nereites;* Phy- *Phycosiphon*);
(f) Shallow tier *Nereites* cf. *irregularis* cross cut by deep tier *Chondrites intricatus,* Note the tight looped, large diameter meanders of *Nereites* (Ne- *Nereites;* Ch- *Chondrites)*;
(g) Central tunnel of large *Nereites* cf. *irregularis* showing darker burrow fill with weak meniscus.

tiers, while *Chondrites* Ichnoguild forms deep tier. The trace fossil and ichnofabric analysis are both indicating the early stage of marine transgression.

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ФГБУН Геологический институт Российской Академии Наук
Российский Фонд Фундаментальных Исследований

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ЮРСКАЯ СИСТЕМА РОССИИ: ПРОБЛЕМЫ СТРАТИГРАФИИ И ПАЛЕОГЕОГРАФИИ

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