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ORDOVICIAN ICHNOFOSSILS: A NEW SCIENTIFIC AND EDUCATIONAL RESOURCE FOR THE AROUCA GEOPARK

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In the area of Arouca Geopark 41 geosites were identified, mainly related with Pre-Variscan and Variscan geological occurrences (Sá et al., 2008). One of the most impressive geopark’ geosites is the “Valério’s Quarry”, where samples of the biggest trilobite fossils have been recovered during the latest years (Gutiérrez-Marco et al., 2009). Regarding Variscan occurrences, geosites are mostly associated with plutonic rocks and with gold and wolfram mineralisation (Sá et al., 2008). From a paleontological point of view, Middle Ordovician and Lower Silurian invertebrate remains (Gutiérrez-Marco & Sá, 2006, 2008), as well as some trace fossils from the “Armorican Quartzite” (Gutiérrez-Marco & Sá, 2006; Sá et al., 2006, 2007; Aceñolaza et al., 2008) constitutes the most important fossil record of the Arouca Geopark.

Inside the European Geoparks Network, Paleozoic trace fossils have also particular scientific, educational importance in the Naturtejo Geopark (Ordovician, Portugal) and in the English Riviera Geopark (Permian, UK). Regarding the Arouca Geopark, previous and recent research shows that the Ordovician trace fossils have high scientific and educational value because they supply important data about the behaviour of organisms that lived more than 465 million years ago. In the Arouca Geopark seven geosites with trace fossils have been identified so far, six of them in Lower Ordovician rocks (Meiriz, Mourinha, Cabanas Longas, Vilarinho, Grañheira d’Água and Vila Cova) and one in Middle Ordovician rocks (Valério’s Quarry).

The Floian (Lower Ordovician) ichnofossils occur in the Santa Justa Formation (a local equivalent of the Armorican Quartzite) developed within the Skolithos and Cruziana ichnofacies. This formation was deposited in coastal marine environments with shallow waters during a transgressive event. The ichnological record corresponds to diverse ichnogenera interpreted as locomotion, feeding, dwelling and resting traces, such as Arenicolites, Bergaueria, Cruziana, Daedalus, Didymaulichnus, Diplocraterion, Monocraterion, Monomorphichnus, Palaeophycus, Planolites, Rosselia, Rusophycus and Skolithos. Amongst these traces, the ones with particular interest are Cruziana imbricata, a rare age-diagnostic Floian form, and Rosselia socialis because it represents the second Portuguese record of the ichnospecies. Some of these occurrences were identified in vertical strata forming hypichnial surfaces of several square meters, which allow the visitors to understand the intense biological activity on the old marine bottom.

The rocks of the Valongo Formation (Darriwilian, Middle Ordovician) are represented by massive shales and slates formed in neritic, disaerobic environments, that gradually changed to more oxygen-rich conditions. The trace fossils recorded in
the slates are concentric pascichnia traces (Rotundusichnium), complex branched burrows (Chondrites, Cladichnus?, Phycodes), single burrows sometimes with meniscate infill (Taenidium) and aggregates of fecal pellets (Tomaculum). In more oxygenated sediments the trace fossils assemblage changed into single, burrows (Palaeophycus, Sericichnus?), irregular burrows coloured by iron oxides (Trichichnus), and intricate

**FIGURE 1:** Ordovician ichnofossils of the Arouca Geopark. 1 - Vertical hypnicial surface covered by Cruziana issp.; 2 - Bergaueria radiata Alpert, 1973 (x 0.6); 3 - Rusophycus carleyi (James, 1885) (x 0.4); 4 - Rosselia socialis Dahmer, 1937 (x 0.5); 5 - Cruziana rugosa d’Orbigny, 1842 (x 0.1); 6 - Skolithos linearis Haldeman, 1840 (x 0.2); 7 - Rotundusichnium issp. (x 0.3); 8 and 9 - Phycodes noha Mikulás, 1992 (8 x 25; 9 x 0.2); 10 - Taenidium cf. planicostatum (Książkiewicz, 1977) (x 0.8); 11 - Arachnostega gastrochaenae Bertling, 1992 (x 0.5); 12 - Praeichnion indet (x 0.8).
galleries (*Arachnostega*), the last ones excavated in the infilling of mollusc shells and trilobites. There are also some evidences of bioerosion, represented by triangular bite marks on trilobites and mollusc remains, probably made by large predators like the orthoconic nautiloids. Among the mid-Darriwilian ichnofossils two ichnotaxa deserve special interest. The first one represents the oldest record for *Rotundusichnium*, a trace fossil previously known in deep sediments from Upper Cretaceous to Eocene. Thus, the Arouca record precludes in about 400 million years the normal record of the ichnogenus. The second remarkable trace fossil is *Phycodes noha*, an ichnospecies being so far recorded in the Klabava Formation (Fioian – early Darriwilian) of Bohemia (Czech Republic). The Arouca specimens of *P. noha* are partially infilled by *Tomaculum problematicum*, which represents a novelty regarding the Bohemian specimens.

The richness and diversity of the Ordovician trace fossils (Fig.1) has a particular importance for science and for the new educational programs that will be implemented in the near future in the Arouca Geopark. The possibility for students and general public to act like “geodetectives” discovering not only the fossil organisms but also their behaviour throughout the study of its characteristic living traces, constitutes a major attraction that will be used to enhance the educational and touristic programs at the Arouca Geopark.

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