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Amended diagnosis of *Colveraia variabilis* Klinghardt, 1921 (Bivalvia) from Friuli (NE Italy) and redescription of *Colveraia darendeensis* Karacabey, 1974 from Turkey: Taxonomy, comparisons and biogeography

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ABSTRACT

An examination of the historical material of *Colveraia variabilis* Klinghardt, 1921 housed in the collections of the Steinmann Institute of Palaeontology (Bonn, Germany) and of some newly collected specimens from the type area of Mt. Jouf (Friuli, NE Italy) has revealed many previously unknown characters of this radiolitid. Klinghardt had only large fragments of *Colveraia variabilis* at his disposal and he erred in some respects, mainly by mistaking the upper valve for the lower one. Representatives of the genus *Colveraia* have been collected at different localities of the Central-Eastern Mediterranean Tethys and the Arabian Plate, but the majority of these have never been described in detail or have been identified solely on the basis of transverse sections, except in Turkey, where many well-preserved specimens have been recovered. Historical and new examples of *Colveraia variabilis* from Mt. Jouf and the material recovered from Turkish localities show different external characters as far as radial zone, general shell shape and ornamentation are concerned. These lead us to assign all Turkish specimens to *Colveraia darendeensis* Karacabey, 1974, which is here described in detail. Comparisons with congeneric forms from the Central-Eastern Mediterranean Tethys and the Arabian Plate are also made.

1. Introduction

The radiolitid genus *Colveraia* was erected by the German palaeontologist Klinghardt almost a century ago (Klinghardt, 1921). The historical type locality of the genus discussed here is a small quarry near the Colvera torrent (Mt. Jouf area, Friuli, NE Italy), long since disused. In addition to Friuli, *Colveraia variabilis* has been recorded in Apulia, southern Italy (Sladić-Trifunović and Campobasso, 1980), Slovenia (Pleničar, 1963, 2005), Croatia (Sladić-Trifunović, 1981b, 1987; Moro et al., 2005), Bosnia-Herzegovina (Slišković, 1984), Romania (Lupu, 1970), Turkey (Karacabey, 1974, Karacabey-Öztemür, 1980; Özer, 1988b, 2002; Özer et al., 2008, 2009), Iran (Khazaei et al., 2010) and the United Arab Emirates (Morris and Skelton, 1995).

A number of specimens of *C. variabilis* recovered at different localities were identified solely on the basis of transverse sections (mostly left valve), except in Turkey, where entire, well-preserved examples were collected. There are a few significant morphological differences between the material of this species from Friuli and that from Turkey (Tarlao et al., 2014). Klinghardt (1921) was correct in assigning the genus *Colveraia* to the Radiolitidae. It is currently (Skelton, 2013a) placed in a group that includes also *Klinghardtites* Lupu, 1971, *Balabania* Karacabey-Öztemür, 1980, *Hatayia* Karacabey-Öztemür and Selçuk, 1981 and *Branislavia* Sladić-Trifunović, 1981a.

When screening figures and tables in Klinghardt's paper (1921), it can be noted that he had no intact, well-preserved specimens of *Colveraia variabilis* at his disposal, but only more or less large shell fragments. This explains why Klinghardt failed to describe all morphological features of this species adequately, and despite his punctilious diagnosis he erred in some respects, particularly when mistaking the upper valve for the lower one (Tarlao et al., 2014). It should also be noted that Klinghardt (1921) did not designate a holotype for *Colveraia variabilis*.

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The aim of the present study is threefold: i) provide an amended diagnosis and taxonomic revision of *Colveraia variabilis* from the Mt. Jouf area on the basis of a single historical specimen housed in the Goldfuss Museum (Steinmann Institute of Palaeontology, Bonn) and a few newly collected examples from near Forcella di Pala Barzana (Mt. Jouf area), ii) compare material of *Colveraia variabilis* from Mt. Jouf with Turkish specimens that have previously been referred to as *Colveraia variabilis* and *Colveraia darendeensis* Karacabey, 1974, and iii) provide a brief discussion of other specimens and species of *Colveraia* from a number of countries.

2. Geological setting and stratigraphy

Geological data on the Mt. Jouf area and the Turkish regions are as follows:

2.1. Mt. Jouf, NE Italy

Specimens of *Colveraia variabilis* collected by Klinghardt (1921) and recently by ourselves stem from the Colvera torrent and near Forcella di Pala Barzana, respectively (Fig. 1). The most recent paper on the stratigraphic succession and rudist assemblages of the Mt. Jouf area is that by Swinburne and Noacco (1993). Most of the Mt. Jouf area consists of Cretaceous limestones assigned to the Calcari del Monte Cavallo Formation (?Albian–Campanian/Maastrichtian). This formation was subdivided by Swinburne and Noacco (1993) into four lithostratigraphic units. According to those authors, and on the basis of our own work, unit 4 (*c.* 45-m-thick) contains a rich and diverse fauna of radiolitids (among which, besides *Colveraia variabilis*, are *Joufia reticulata* Böhm, 1897, *Pseudopolyconites* sp., *Sauvagesia* sp.), less abundant hippuritids (*Pironaea polystyla* Pirona, 1868, *Hippuritella lapeirousei* Goldfuss, 1840), *Plagioptychus* sp. and rare requieniids. Unit 4 limestones are mostly coarse grained (rudstone, grainstone and packstone) and well washed, and consist of rudist fragments, echinoderm ossicles, micritised orbitoids and poorly preserved foraminifera, including *Siderolites* cf. *vidali* (see Swinburne and Noacco, 1993). Graded bioclastic, storm-related beds were also recognised. The texture of the coarse rudist-rich calcirudites and calcarenites of unit 4 indicates a high-energy subtidal depositional setting. An open-marine environment is suggested by the presence of rare planktonic foraminifera.

Unit 4 was dated by strontium isotope stratigraphy (SIS) of samples of rudist shells (Swinburne and Noacco, 1993). The numerical ages derived from geochemical analyses calibrated with the chronostratigraphy of the time suggested an age close to the Campanian/Maastrichtian boundary or earliest Maastrichtian ($^{87}Sr/^{86}Sr$ mean = 0.707682 and an age mean = 72.61 Ma). The contribution by Swinburne and Noacco (1993) represents one of the first pioneering studies that carried out SIS analysis, despite the fact that Steuber and Schlüter (2012) expressed some doubts over the overall quality of their data. Despite this, the rudist assemblage of unit 4 in the Mt. Jouf area may be reasonably placed in the *Hippuritella lapeirousei* interval zone (upper Campanian–lowermost Maastrichtian) as proposed by Steuber and Schlüter (2012) for rudist biozones of the Central-Eastern Mediterranean.

2.2. Turkey

Well-preserved specimens of *Colveraia* were collected mostly in eastern Anatolia around Hekimhan-Darende-Balaban-Yazıhan-Yeşilyurt in the Malatya Basin (Fig. 2). There are also some specimens from Gürün in the Sivas Basin (eastern Anatolia) and Çerkeş (Çankırı Basin, northeast-central Anatolia).

The Malatya Basin is located in the eastern part of the Anatolide-Tauride platform (or block) where the rudist-bearing Campanian–Maastrichtian transgressive mixed siliciclastic-carbonate sequences unconformably overlie ophiolitic, metamorphic and Mesozoic sedimentary rocks. From the bottom to the top, the diachronous sequence consists of reddish clastics, neritic limestones, sandy limestones with rudists and pelagic mudstones with planktonic foraminifera (Akkuş, 1971; Özer, 1983, 1988a, 2002; İzdar and Ünlü, 1985; Görmüş, 1990, 1992; Bozkaya and Yalçın, 1992; İnan et al., 1996; Meriç and İnan, 1997; Yıldız and Özdemir, 1999; Akyazı and Özgen-Erdem, 2003, 2009; Sarı et al., 2016). The clastic rocks are characterised by poorly to moderately sorted reddish, thick-bedded, matrix supported conglomerates, thin to thick-bedded, poorly sorted sandstones and thin to thick-bedded well-consolidated mudstones. Conglomerates predominate in this unit and interfinger with sandstones and mudstones. The thickness

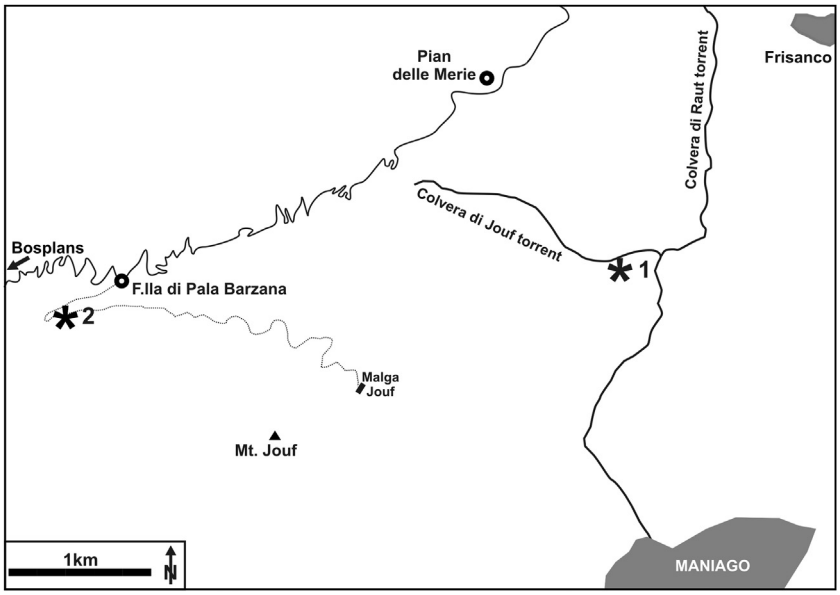

Fig. 1. Locality map of the Mt. Jouf area; 1. Old quarry near the Colvera torrent; 2. Poor outcrop of strata with specimens of *Colveraia variabilis* near Forcella di Pala Barzana.