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Tetrapod tracks from the Middle Triassic of NW Sardinia (Nurra region, Italy)

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ABSTRACT

We report here on the first tetrapod tracks from the Triassic of the Nurra region (north-western Sardinia, Italy). The specimens were found on sandstone blocks used to build a fence limiting a seasonal camping, in the coastal area north of Capo Caccia promontory. Lithologic and petrographic features allowed an assignment of the track-bearing blocks to the middle-upper portion of the Anisian (Middle Triassic) Arenarie di Cala Viola ("Buntsandstein"). Footprints are attributed to the ichnotaxa *Rhynchosauroides* and *Rotodactylus*, two common ichnotaxa of late Early Triassic and Middle Triassic ichnofaunas of Europe and United States, commonly referred in the literature to neodiapsid and archosaur producers, respectively.

Key words: *Triassic, tetrapods,* Rhynchosauroides, Rotodactylus*, Arenarie di Cala Viola.*

INTRODUCTION

The Nurra area hosts a hundred-metres thick, Upper Palaeozoic-Lower Mesozoic continental succession known since the early twentieth century (Lotti, 1931; Oosterbaan, 1936). In the last decades, detailed stratigraphic and sedimentological studies of the succession have been carried out (Cassinis *et alii*, 1996, 2000, 2002, 2003; Fontana *et alii*, 2001; Ronchi, 2001; Sciunnach, 2001; Costamagna & Barca, 2002; Ghinassi *et alii*, 2009; Costamagna, 2011, 2012; Baucon *et alii*, 2014; Sinisi *et alii*, 2014).

For a long time, micro- and macroflora remains have constituted the only Permian and Triassic fossils from the Nurra succession. Specimens collected from the lowermost and uppermost lithostratigraphic units (Punta Lu Caparoni Formation and Arenarie di Cala Viola, respectively) in the area indicate respectively a middle "Autunian" (Pecorini, 1962; Gasperi & Gelmini, 1980; Ronchi *et alii*, 1998; Cassinis *et alii*, 2000) and an Early Triassic age (Pecorini, 1962). Two different microfloral associations, Olenekian?-early Anisian and late Anisian in age respectively, were recognized in the Triassic deposits from the subsurface (Cugiareddu well; Pomesano Cherchi, 1968; Pittau *et alii*, 1982) and, subsequently, added to the record (Pittau in Cassinis *et alii*, 2000; Pittau & Del Rio, 2002).

The overall scenario radically changed in 2008, after the discovery of bones in the uppermost Cisuralian-lower Guadalupian Cala del Vino Formation *sensu* Cassinis *et alii* (2002, 2003) at Torre del Porticciolo (Alghero, north-west Sardinia, Italy; Fig. 1A) (Ronchi *et alii*, 2008). These remains were referred to two non-therapsid synapsids: a huge caseid (Ronchi *et alii*, 2011), later named *Alierasaurus ronchii* Romano & Nicosia 2014 (Romano & Nicosia, 2014, 2015; Romano *et alii*, 2017) and a sphenacodontid synapsid (Romano *et alii*, 2019). In addition, footprints referred to *Merifontichnus* Gand *et alii* 2000, classically attributed to a therapsids-grade producer (e.g. Gand *et alii*, 2000), were reported from a third site (Citton *et alii*, 2019). All these specimens have been collected essentially from the same stratigraphic level within the Cala del Vino Formation, which turned out to represent a very informative window on the latest Cisuralian? to early Guadalupian fauna of western Europe (Citton *et alii*, 2019).

During recent field work on the Torre del Porticciolo area (see Fig. 1A), tetrapod tracks were found on two sandstone blocks, which were collected from rocks cropping out in the surroundings and that today constitute part of the fence of a seasonal camping. The aim of this work is to present and discuss the new ichnological material, also providing its stratigraphic significance. The stratigraphic attribution of the material is inferred from lithological and petrographic analysis of the track-bearing slabs and comparison with the outcropping succession, indicating that they belong to the Middle Triassic Arenarie di Cala Viola (Fig. 1B). The name of this still informal unit ("Arenarie di Cala Viola") was introduced by Pittau *et alii* (1982) and then used by various authors since Cassinis *et alii* (2002) onwards, as for the other informal Permian and Triassic units of the Nurra succession named by these authors. The material, here referred to *Rhynchosauroides* Maidwell 1911 and *Rotodactylus* Peabody 1948, represents the first vertebrate footprints from the Arenarie di Cala Viola deposits.

GEOLOGICAL SETTING

In north-west Sardinia, the post-Variscan continental succession of the Nurra area consists of Upper Palaeozoic-Lower Mesozoic siliciclastic and volcanic deposits,

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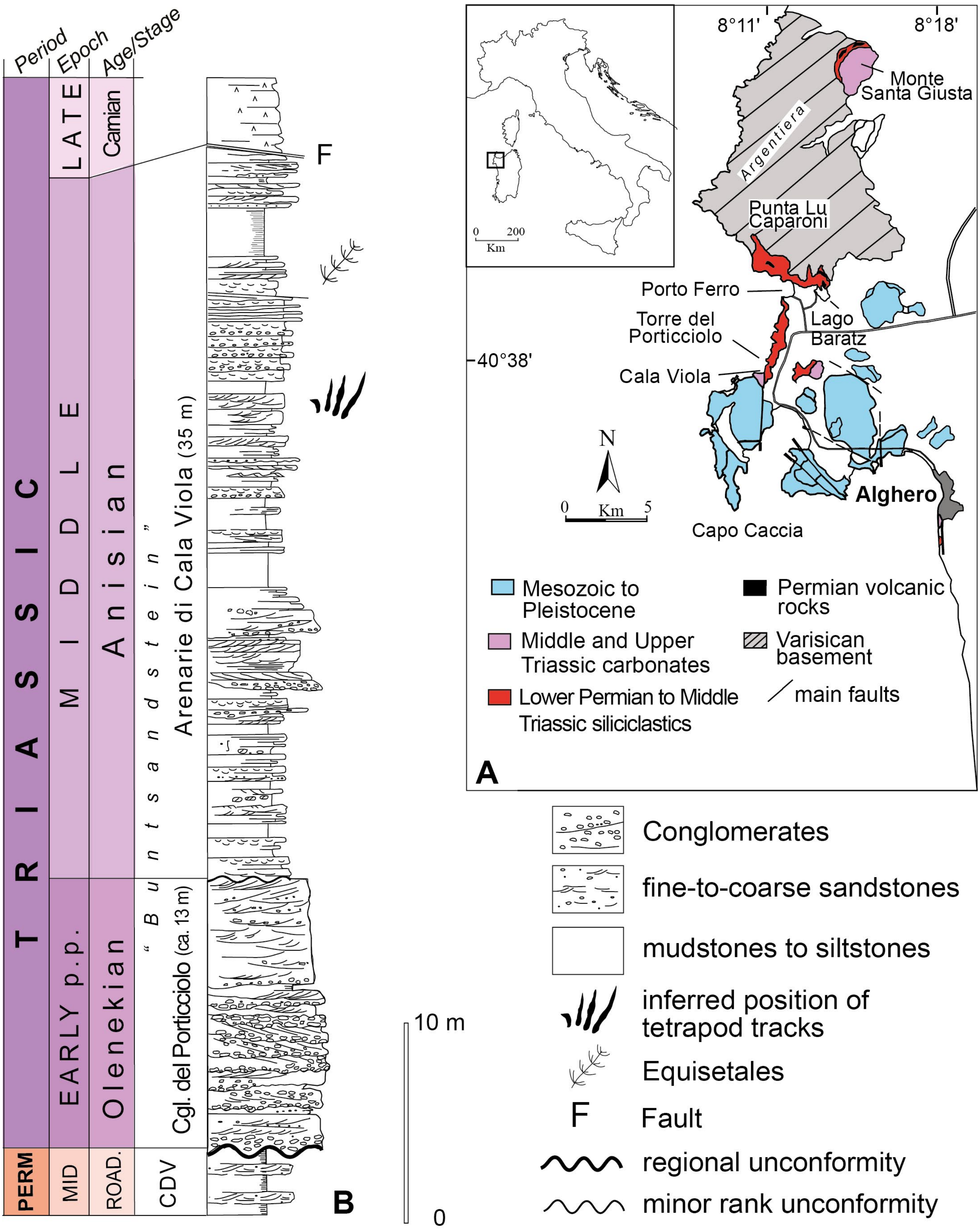

Fig. 1 - A) Location map of the Nurra Permian and Triassic continental and Middle-Upper Triassic marine to transitional deposits. B) Detailed stratigraphic section of the Triassic continental succession in the type area with the inferred stratigraphic position of tetrapod tracks. CVD = Cala del Vino Formation.

and has been subdivided into three distinct tectono-sedimentary cycles (Cassinis & Ronchi, 2002; Cassinis *et alii*, 2002, 2003).

The oldest (i.e. first) cycle, dated to the late "Autunian" on the basis of mega- and microfloras remains, consists of a thin (15-20 m) fluvio-lacustrine unit (Punta Lu Caparoni Formation *sensu* Gasperi & Gelmini, 1980), interfingered with, and locally covered by, Asselian volcanic products of calc-alkaline affinity (Gaggero *et alii*, 2017). These deposits are unconformably overlain by up to 700 m of coarse- to fine-grained alluvial, reddish, siliciclastic deposits (Verrucano Sardo *sensu* Gasperi & Gelmini, 1980) mainly related to braided and meandering river settings; associated are lacustrine, floodplain and volcanic deposits. The chronological extension of the associated gap is unknown. Both the second and third sedimentary cycle were identified in this younger succession. In particular, Cassinis *et alii* (2002, 2003) subdivided the second cycle into three lithostratigraphic units (Pedru Siligu, Porto Ferro and Cala del Vino formation-rank informal units, referred to the Cisuralian-Guadalupian *p.p.* and included in the also informal "Nurra Group" - Ronchi *et alii*, 2011), and the third cycle into two informal units (the Lower-Middle Triassic Conglomerato del Porticciolo and Arenarie di Cala Viola). The passage from the Upper Palaeozoic Cala del Vino Formation to the upper Lower Triassic (Bourquin *et alii*, 2007; Durand, 2008; Borruel-Abadia *et alii*, 2019) Conglomerato del Porticciolo is marked by a disconformity or a low-angle angular unconformity (Fig. 2A).

The Catalogue of the Italian geological formations (Cita *et alii*, 2007) refers the Triassic continental rocks of Sardinia to the Buntsandstein traditional unit (*sensu* Gandin *et alii*, 2007; see also Servizio Geologico d'Italia, 2002, 2011, 2015). In the present paper, we use the more detailed and practical subdivision of Cassinis *et alii* (2002, 2003). The whole Permian-Triassic continental succession has been correlated to coeval "Buntsandstein" deposits of southern France (Cassinis *et alii*, 2002, 2003; Durand, 2006, 2008) and is currently included in interregional correlations (Bourquin *et alii*, 2007, 2011; Linol *et alii*, 2009; Cassinis *et alii*, 2012, 2018; Borruel-Abadia *et alii*, 2015, 2019; Gretter *et alii*, 2015; Citton *et alii*, 2019; Schneider *et alii*, 2019).

Facies and environment of Arenarie di Cala Viola

The Arenarie di Cala Viola, more than 50 metres in thickness, are considered late Olenekian?-Anisian *p.p.* in age (Pittau *et alii*, 1982; Pittau in Cassinis *et alii*, 2000; Cassinis & Ronchi, 2002; Pittau & Del Rio, 2002) (Fig. 1B) and rest directly on the Conglomerato del Porticciolo via a disconformity surface (Cassinis *et alii*, 2002, 2003 – see Fig. 2A). The Arenarie di Cala Viola are mainly represented by:

- well- to thinly-bedded, medium to fine-grained, dark-red sandstones and siltstones, with subordinate mudstones, in the lower part of the unit. Sets of metre-thick climbing ripples (Fig. 2B) evolve into horizontal to low-angle laminated or trough-cross bedded sandstone layers (Fig. 2C);
- few metres of grey-green, pink and reddish, medium to coarse-grained sandstones, subordinately siltstones, in the lower-middle part of the unit. Lensoid geometries and trough cross-bedding occur;
- thinly- to well-bedded, medium- to fine-grained, dark orange/red to purple, sandstones and siltstones, in the medium-upper part of the unit. Whitish-green-grey siltstones and claystones occur in the upper part.

According to Cassinis *et alii* (2003), these deposits accumulated in a floodplain setting with ephemeral streams forming terminal fan lobes (see also Durand, 2006, 2008). Within the "white-greenish, arenaceous-clayey intercalation", located in the upper part of Arenarie di Cala Viola, Pecorini (1962) found abundant remains of Triassic equisetales (*Equisetum mougeotii*) and conchostracans (*Estheria* sp.). This led this author to a general Early Triassic age attribution. Some decades later, the finding of palynology assemblages from the subsurface (see above) allowed to refine the Arenarie di Cala Viola to the late Olenekian?-late Anisian stratigraphic interval (Pittau in Cassinis *et alii*, 2000; Pittau & Del Rio, 2002). Recently, super-regional comparisons with south-east France (Provence, Dôme de Barrot) and Spain (Balearic Islands, Catalan Ranges, Pyrenees, and Iberian Ranges) areas allowed a better age constrain of the Triassic succession of Nurra (Bourquin *et alii*, 2007; Linol *et alii*, 2009; Gretter *et alii*, 2015; Borruel-Abadia *et alii*, 2015, 2019, Fig. 3).

The marked facies change between the Conglomerato del Porticciolo and the overlying Arenarie di Cala Viola is an evidence of changing sedimentary and climatic conditions. The Conglomerato del Porticciolo, similarly to the Poudingue de Port-Issol in Provence, corresponds to the uppermost part of a late Early Triassic (Smithian-Spathian) sedimentary cycle, deposited under very arid conditions (Durand, 2006, 2008; Bourquin *et alii*, 2007, 2011; Borruel-Abadia *et alii*, 2019). By contrast, the finer grained facies of the Arenarie di Cala Viola were deposited in relatively sinuous channels in a terminal fan setting, developed under semi-arid conditions (Cassinis *et alii*, 2003; Durand, 2006, 2008). This is marked by typical floodplain-to-playa deposits, like pedogenetic carbonate concretions (both *in situ* or reworked; Fontana *et alii*, 2001; Cassinis *et alii*, 2002; Ghinassi *et alii*, 2009), mud cracks and tree-related bio-sedimentary structures. In the numerous sandy sequences (from few centimetres to 1 metre-thick) interfingered within the silty-clayey playa facies of the lower part of the unit, the most prominent structures are thin intra-formational breccias made up of pedogenic concretions, plane lamination and kappa cross-stratification (Allen, 1963). Each of these lithofacies (Fig. 2D) represents parts of inundate sequences (*sensu* Seilacher, 1982) and expresses the waning-flow stage ending a flood event (Durand *et alii*, 2011). Invertebrate trails (*Helminthoidichnites*, *Skolithos*, *Arenicolites*) and rhizoliths also occur in Arenarie di Cala Viola lithofacies (Baucon *et alii*, 2014; Fig. 2E). Some authors (i.e. Fontana *et alii*, 2001; Costamagna, 2012) postulated a tidal influence, based on sedimentology and the stratigraphic position of this unit, which shortly predates the widespread Middle Triassic marine transgression documented by the 'Muschelkalk'-type carbonates.

MATERIAL AND METHODS

Outline drawings of the most detailed footprints were executed on acetate film and later vectorialised; measurements of overall footprint length and overall

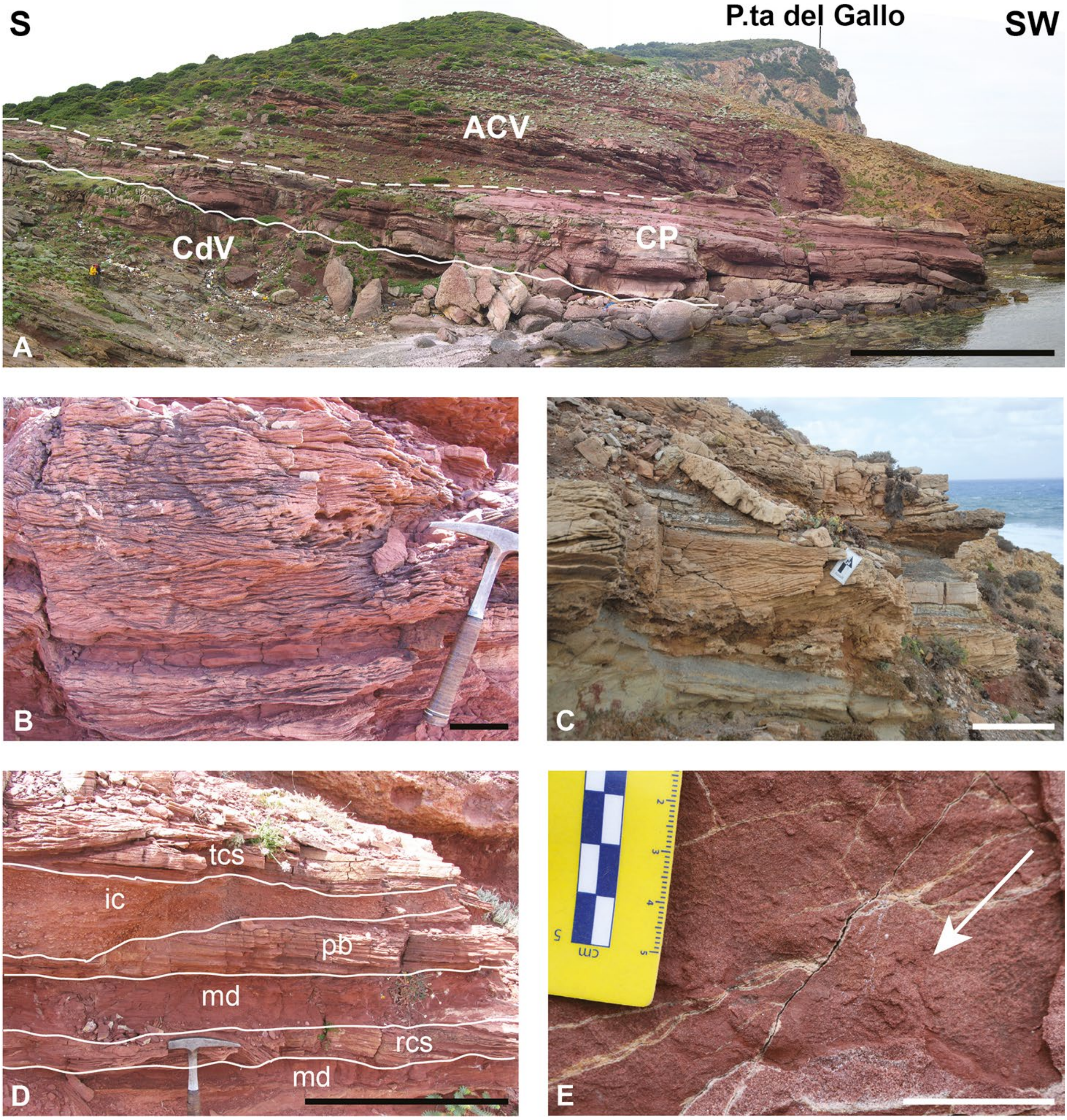

Fig. 2 - Stratigraphic relationships and sedimentological features of the Arenarie di Cala Viola in its type locality. A) The Cala Viola bay type-locality of the Arenarie di Cala Viola. Note the low-angle unconformity surfaces between CdV and CP (continuous white line), and between CP and ACV (dashed white line). Legend: ACV: Arenarie di Cala Viola; CP: Conglomerato del Porticciolo; CdV: Cala del Vino Formation. B) Reddish fine sandstones to siltstones in the lower part of the unit displaying crossing ripples. C) Yellowish through-cross stratified sandstone bodies and gray-greenish siltitic laminated layers in the upper portion of the unit in its type locality. D) Different portions of incomplete inundation sequences (*sensu* Durand, 2008) characterizing the basal part of the unit. Abbreviations legend: md) mud drapes; ic) intraformational soil-derived breccias; pb) planar beds; rcs) ripple-cross strata; tcs) through-cross strata. E) Invertebrate trace fossils (*Helminthoidichnites*, white arrow) preserved on a tetrapod track-bearing slab. Scale bars are 15 m (A), 10 cm (B), 50 cm (C, D) and 3 cm (E).

footprint width were taken on specimens following Leonardi (1987), and later checked on three-dimensional meshes. Close-range photogrammetry (Matthews *et alii*, 2016) was conducted to achieve digital models of the material and an objective representation of track morphologies (Falkingham *et alii*, 2018). The software Agisoft Metashape Pro (version 1.5.6, Educational License) was used to generate three-dimensional textured meshes

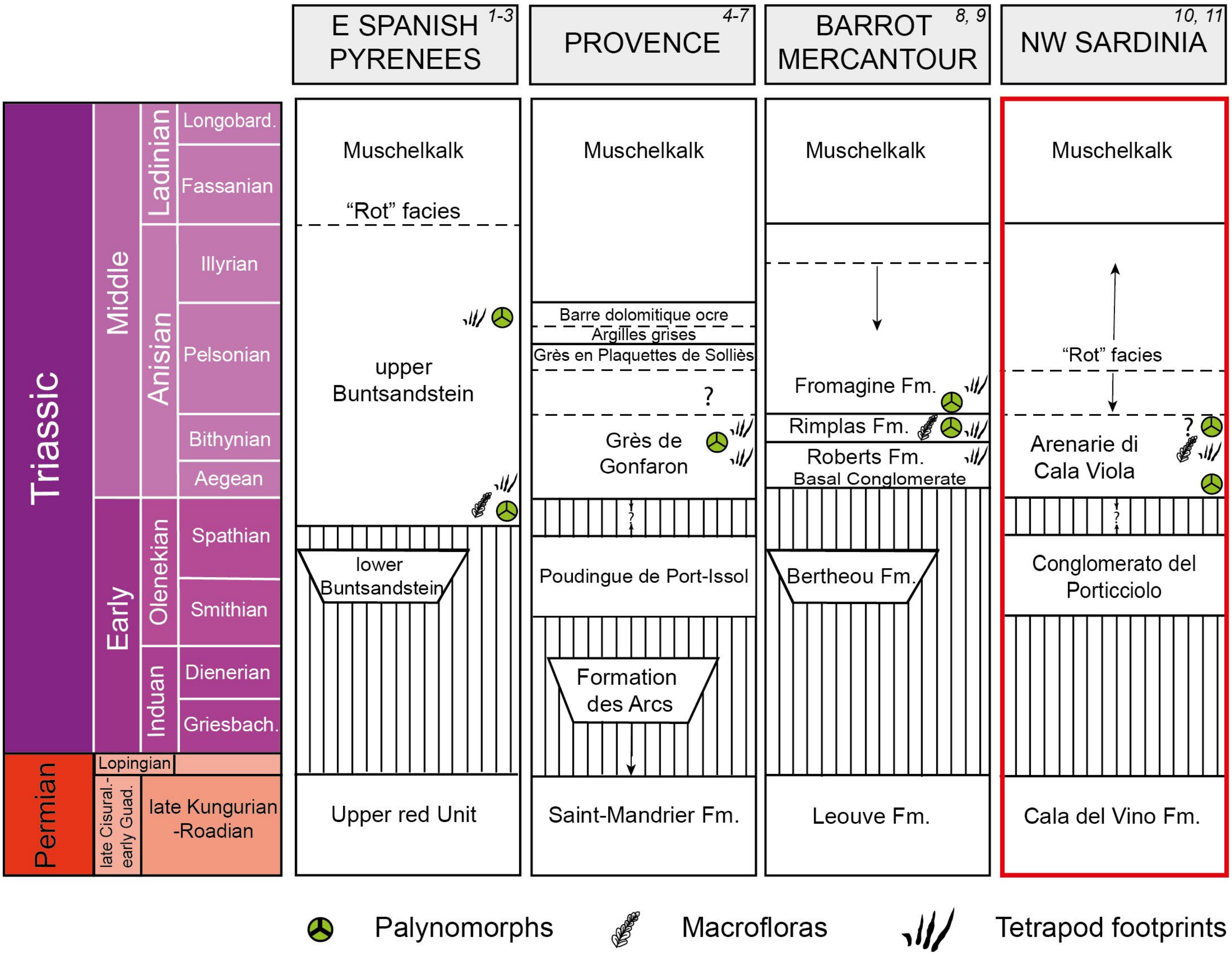

Fig. 3 - Proposed chronostratigraphic correlation of the Arenarie di Cala Viola with Iberian (E Spanish Pyrenees) and French (Provence, Dôme de Barrot) sectors. 1-3: Broutin *et alii*, 1988; Mujal *et alii*, 2016, 2017. 4-7: Durand, 2006, 2008; Durand *et alii*, 2011; Durand & Gand, 2007. 8, 9: Avril *et alii*, 1987; Durand *et alii*, 2011. 10, 11: Pittau *et alii*, 1982; Pittau & Del Rio, 2002.

of the trampled surfaces. A photogrammetric survey was planned and, in order to obtain a good image overlap, 66 and 59 images were respectively acquired for the two track-bearing blocks using a Canon EOS M50 mirrorless camera (24 megapixel resolution and 45 mm focal length). Three-dimensional models were converted to false-colour elevation map using the software Paraview (version 5.4.1). Tracks were progressively numbered from #1 to #9.

DESCRIPTION

Nine footprints preserved as convex hyporelief were recognized on two sandstone blocks, respectively measuring about 23x20 cm (Fig. 4A-C) and 29x15 cm (Fig. 4D-F) in overall dimensions. Six footprints (#1 to #6) are preserved on the first block (Fig. 4B-C, G), whereas the remaining three (#7 to #9) on the second (Fig. 4E-F, H). In general, footprints are incomplete and do not appear arranged in trackways or partial trackways, nor can the blocks be put together. Nevertheless, noteworthy is that in the first block the right footprints #2, #4 and #6 appear as roughly aligned, as well as footprints #1 (which is interrupted by a post-diagenetic fracture) and #3.

The two best detailed and more complete footprints (i.e. #3 and #8 in Fig. 4G-H and 5A-B) are 'lacertoid' in general appearance and are the casts of right autopodium impressions. Footprint #3 is tetradactyl and has an overall length of 1.2 cm and an overall width equals to 0.9 cm; footprint #8 is pentadactyl and measures 1.1 cm in overall length and 1.2 cm in overall width. Digit traces are slender, slightly curved, increasing in length from digit I trace to digit IV trace. Digit II, III and IV traces are inwardly bent in their distal portions. The remaining footprints (e.g. #1, #2, #4, #5, #6 and #7) are characterized by a similar morphology of digit traces with respect to footprints #3 and #8, albeit far less detailed. Footprints #1 and #6 are tetradactyl and share with the better detailed ones the curved distal portion of digit traces, similarly to footprint #5; the latter is also a right track but that is only represented by the terminal portion of digit traces, and here interpreted

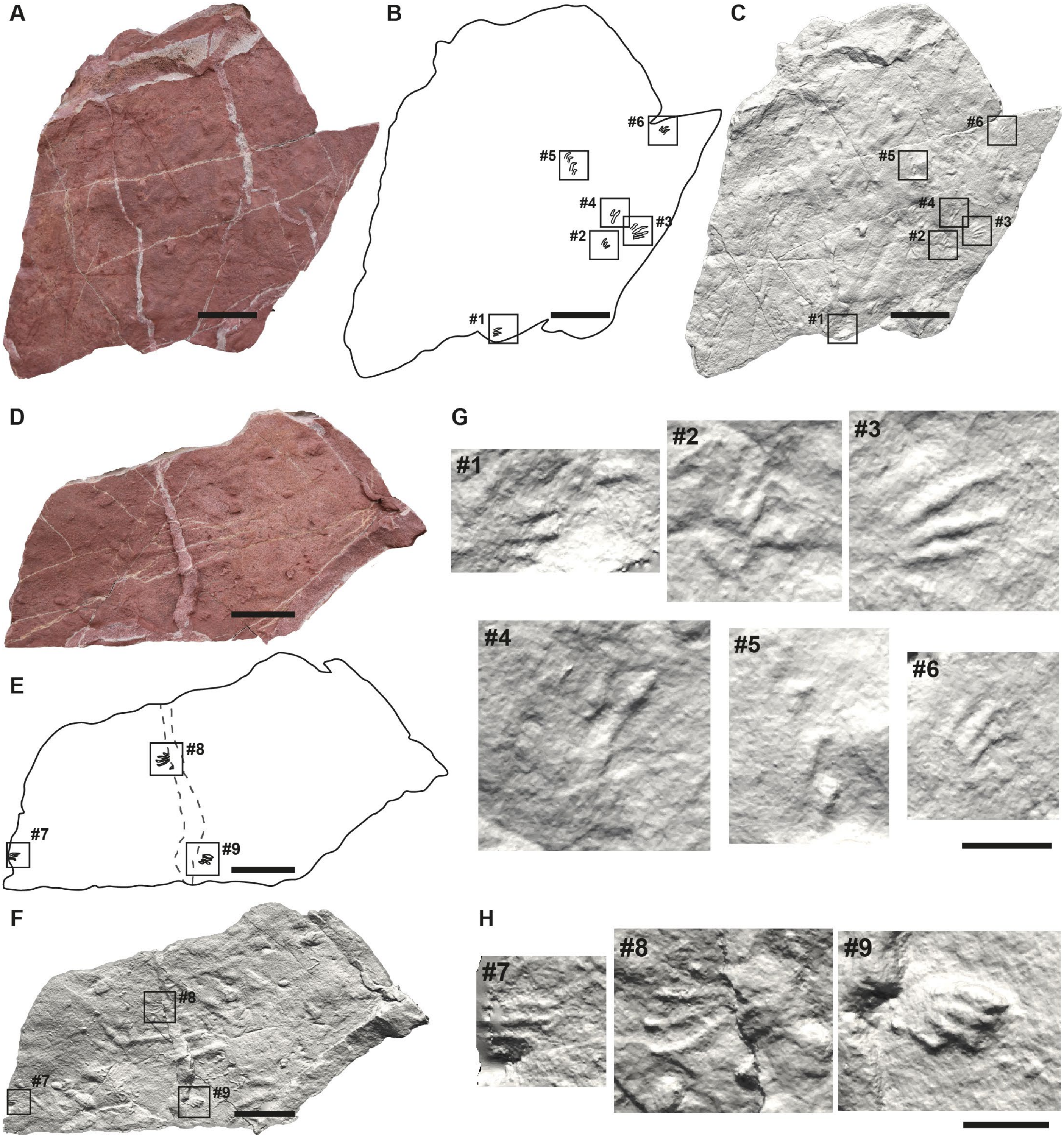

Fig. 4 - Footprints from Arenarie di Cala Viola. A) Track-bearing block preserving footprints #1 to #6, (B) outline drawing and (C) three-dimensional photogrammetric shaded grey model. D) Track-bearing block preserving footprints #7 to #9, (E) outline drawing and (F) three-dimensional photogrammetric shaded grey model. G) Close-ups of the shaded grey models of footprints #1 to #6. H) Close-ups of shaded grey models of footprints #7 to #9. Black squares and Arabic numbers indicate position of the identified footprints. Scale bars are 5 cm in A-F and 1 cm in G and H.

as isolated footprint. Footprints #2 and #4 are tridactyl and didactyl, respectively, and very faintly detailed; footprint #4 also share with footprints #5 and #8 enlarged and deeper digit tip traces, here considered as the product of a powerful stroke during the kick-off performed by the respective producers. Footprint #7 is the worst detailed trace; it appears tridactyl but the overall morphology is obliterated by the broken edge of the slab.

Footprint #9 (Figs. 4H, 5C) is morphologically different from the other ones. This footprint, a cast of a right autopodium, is tetradactyl, digitigrade and measure 0.9 cm in overall length and 0.7 cm in overall width. Digit

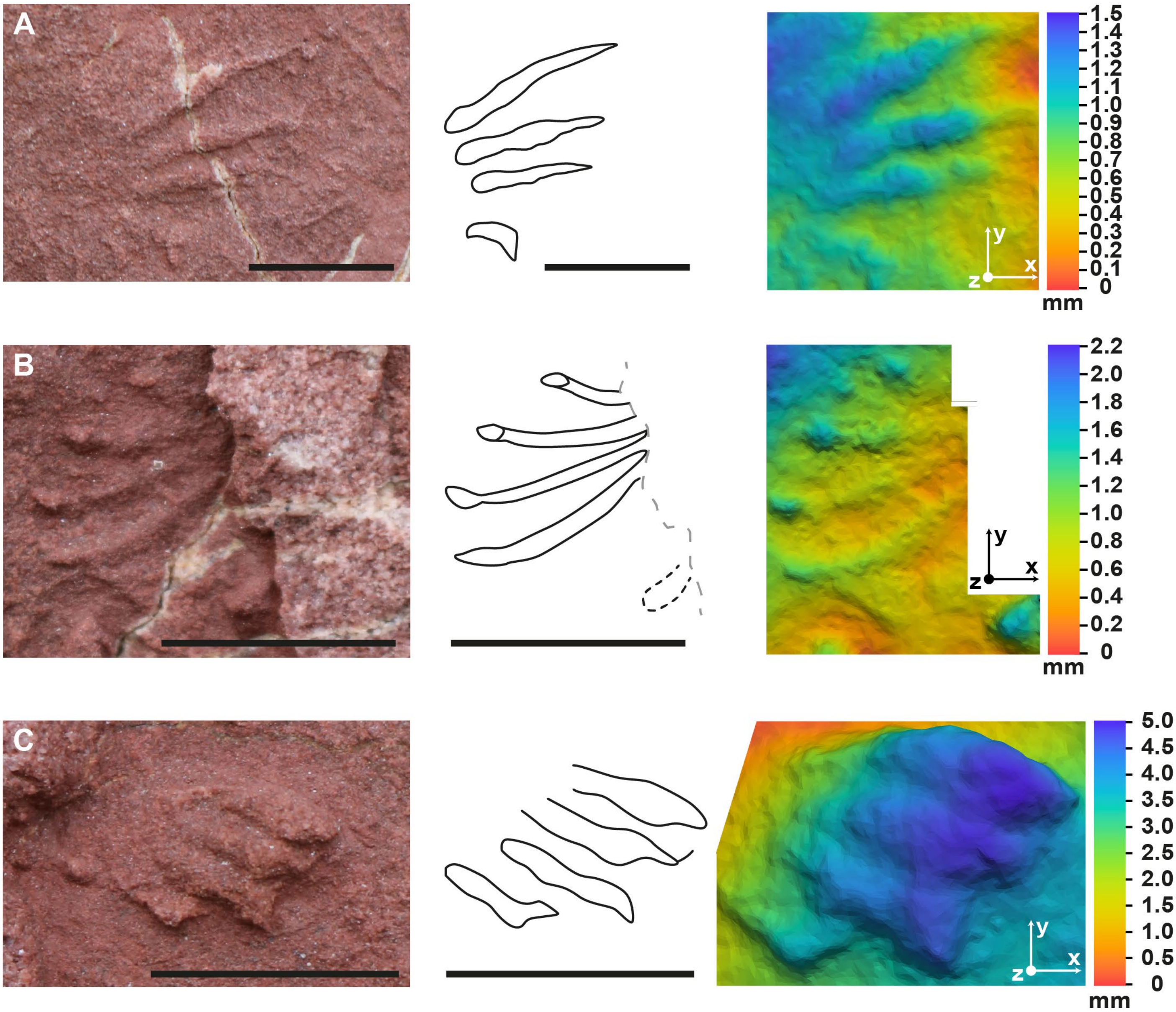

Fig. 5 - A) From left to right: close-up photograph of footprint #3, referred to *Rhynchosauroides*, footprint outline drawing; three-dimensional false-coloured elevation map. B) From left to right: close-up photograph of footprint #8, referred to *Rhynchosauroides*, footprint outline drawing; three-dimensional false-coloured elevation map. C) From left to right: close-up photograph of footprint #9, referred to *Rotodactylus*; footprint outline drawing; three-dimensional false-coloured elevation map. Scale bars are 1 cm.

I trace is the shortest, measuring about 2 mm in length and equals to almost half the length of digit II trace, which measure about 5 mm. Digit II, III and IV traces are parallel each other and closed together, slightly increasing in length from the medial to the lateral elements. Digit IV trace is the longest, measuring about 7 mm. Tips of digit III and IV traces retain an indication of probable claw marks.

DISCUSSION AND CONCLUSIONS

The here reported negative epichnia are impressed on slabs made up of medium- to fine-grained, dark orange-coloured, orthoquartzitic sandstones whose petrographic composition looks very similar to that of Arenarie di Cala Viola (petrofacies PU4 *sensu* Cassinis *et alii*, 1996). In the Arenarie di Cala Viola, primary porosity is reduced by authigenic carbonates nucleating initially from the fine matrix and also replacing the framework of the grains with a patchy appearance (Cassinis *et alii*, 1996). Moreover, the lithologic and petrographic features of the slabs are at all comparable with the facies characterizing the middle-upper part of Arenarie di Cala Viola. Vice versa, we exclude the similarity of the track-bearing slabs with the grey-green sandstones of the lower-middle part of the Permian Cala del Vino unit, due to the very different modal composition of the latter, made up of litharenites and sublitharenites (petrofacies PU3 *sensu* Cassinis *et alii*, 1996). Simple invertebrate trails (*Helminthoidichnites*, A. Baucon, pers. com., see also Baucon *et alii*, 2014) also occur on one of

Fig. 6 - Palaeoenvironmental reconstruction of the study area during the Anisian. The *Rhynchosauroides* (right) and *Rotodactylus* (left) producers, respectively based on the prolacertiform *Macrocnemus* and the dinosauromorph *Lagerpeton*, leave impressions in soft sediment while hunting dragonflies. Artwork by Fabio Manucci.

the studied slabs (Fig. 2E). They are referred to grazing traces of worm-like animals (nematods, anellids or insect nymphs – Buatois *et alii*, 1998), which can be found in different continental or marine environments. Concerning the former settings, they are typical of the *Batrachichnus* ichnofacies, a trace-fossil assemblage comprising vertebrate tracks, mud-cracks, typical of a poorly drained floodplain setting, crevasse-splay, ephemeral ponds, channel fill or fluvial bars (A. Baucon, pers. com.).

With regards to the studied footprints, the 'lacertoid-type' appearance of footprints #3 and #8, the slender and curved morphology of the digit traces and their length increase pattern, support the attribution of the material to *Rhynchosauroides*, an ichnogenus reported firstly from the Lower Triassic Helsby Sandstone of Great Britain (Maidwell, 1911); for comparison, the same attribution is proposed for footprints #1, #2 and #4 to #7. *Rhynchosauroides* has a wide geographic distribution, being recognized in Europe (e.g. Rühle von Lilienstern, 1939; Demathieu, 1966; Haubold, 1971; Mietto, 1986; Ptaszynski & Niedzwiedzki, 2004; Valentini *et alii*, 2007; Krainer *et alii*, 2012), United States (e.g. Lull, 1942; Baird, 1957; Martin & Hasiotis, 1998; Nesbitt, 1999), Canada (e.g. Olsen & Baird, 1986), South America (Leonardi *et alii*, 2000; Domnanovich *et alii*, 2008) and Africa (Klein *et alii*, 2010). The ichnogenus spans from the Lopingian of northern Italy (Conti *et alii*, 1977) to the Late Jurassic of Spain (Avanzini *et alii*, 2010). However, most of the reports are Triassic in age, with Middle Triassic occurrences mainly from European deposits (e.g. Demathieu, 1971, 1974, 1984; Demathieu & Gand, 1974; Demathieu & Oosterink, 1983; Demathieu & Durand, 1991; Avanzini & Mietto, 2008; Gand *et alii*, 2010; Todesco & Bernardi, 2011; Mujal *et alii*, 2016; Klein & Lucas, 2018).

A morphological comparison, without ichnotaxonomic purposes, has been conducted between specimens #3 and #8 and specimens already published from different localities. The footprints from the Arenarie di Cala Viola are considered morphologically similar to the material published by Demathieu & Oosterink (1983) from the Middle Triassic of the Netherlands (e.g. Plate 17, p. 35; specimen D70, Plate 29, p. 39; specimen D78, Plates 27-28, p. 39) and by Demathieu & Durand (1991) from the Triassic (early Anisian) of Provence (Plate 1, Fig. 4, p. 130; Plate 2, Fig. 5, p. 133). Other material considered morphologically similar was reported from the Middle Triassic of Southern Alps (Avanzini & Mietto, 2008, Fig. 3D, G, p. 6; Todesco & Bernardi, 2011, Plate 2b, d, p. 208) and France (Demathieu, 1974, Plate 1, Fig. 2; Demathieu, 1984, Plate 3, Fig. 3). Footprints referred to as *Rhynchosauroides* were attributed to neodiapsid (e.g. Haubold, 2000) and prolacertiforms producers (Avanzini & Renesto, 2002).

The grouped pattern of digit traces in footprint #9, their quite straight morphology and relative lengths, enable us to refer the material to *Rotodactylus*. The distinctly parallel orientation of pedal digits II-IV traces is a typical feature of *Rotodactylus*, allowing to exclude an attribution to *Rhynchosauroides* (see Fichter & Kunz, 2013). The ichnogenus was erected from the upper Lower to lower Middle Triassic Moenkopi Formation of south-western United States (Peabody, 1948). *Rotodactylus* has a temporal range from the late Olenekian to the early Ladinian and a widespread geographical distribution, being recognized from Arizona (Peabody, 1948; Klein & Haubold, 2007), Germany (e.g. Haubold, 1967, 1971, 1999; Demathieu & Fichter, 1989; Fichter & Kunz, 2013), France (e.g. Demathieu, 1971, 1984; Demathieu & Gand, 1973, 1974), Poland (Brusatte *et alii*, 2011), Spain (Fortuny *et alii*, 2011; Mujal *et alii*, 2016), Italy (e.g. Valdiserri & Avanzini, 2007; Todesco & Bernardi, 2011), Morocco (Klein *et alii*, 2011) and, less clearly, from Algeria (Kotanski *et alii*, 2004).

Additional features pointing to the attribution are the apparent reduction of digit I trace length in footprint #9 with respect to the central ones, which is a diagnostic character of *Rotodactylus* track, and closely apposed and parallel digits II-IV (Fichter & Kunz, 2013). A strong reduction of digit I and V traces is one of the elements relating this track morphology to archosaur producers in the context of an evolutionary trend toward tridactyly (Haubold, 1983). Regrettably, the lack of other footprints of this type or a trackway implies that no others track features diagnostic of an archosaur-grade producer can be identified from footprint #9, among those mentioned by Haubold (1983; e.g. reduction of the manus print and trackway pattern indicating a trend toward bipedalism and semi-erect to erect gait). With regard to the producer attribution, already Peabody (1948) indicated a cursorial animal as probable trackmaker, to be sought among pseudosuchians and with a 'dinosaur-like' habitus. Haubold (1971, 1983, 1984), and subsequently Haubold & Klein (2002), attributed *Rotodactylus* tracks to the clade Dinosauromorpha, finding a good match with the clade Lagosuchia on the basis of the skeletal record. Based on the synapomorphies already recognized to interpret the ichnogenus *Prorotodactylus*, Brusatte *et alii* (2011) interpreted the *Rotodactylus* putative trackmaker as a dinosauromorph, with a greater overall anatomical affinity to the small dinosauromorph *Lagerpeton* from Argentina. According to the interpretation proposed by Ptaszyński (2000), the producer of the *Rotodactylus* tracks could fall within an arboreal side branch of archosaurs, even if no skeletal evidence for such a lineage are available to date (Fichter & Kunz, 2013).

As for specimens #3 and #8, track #9 has been morphologically compared with already published specimens and without ichnotaxonomic purposes. Track #9 is morphologically similar to the material reported by Avanzini & Mietto (2008, Fig. 3I, p. 6), even if the footprint from the Arenarie di Cala Viola shows a longer digit I trace. Morphologically similar are also some tracks from the Middle Triassic of Lodève Basin reported by Demathieu (1984, Plate 1, Fig. 3), as well as the material reported from the Western High Atlas (Morocco) by Klein *et alii* (2011, Fig. 8f-h).

In both ichnotaxonomic attributions, even if a morphological similarity is observed, ichnospecific assignment is prevented due to the lack of diagnostic characters and poorness of our material. Tetrapod tracks of late Early Triassic and Middle Triassic ages are common, also in association with palynomorphs, in continental units of Provence (i.e. lower Anisian Grès de Gonfaron), Maritime Alps (i.e. Roberts, Rimplas and Fromagine Formations of the Dôme de Barrot area) (Avril *et alii*, 1987; Demathieu & Durand, 1991; Durand & Gand, 2007; Durand, 2008; Durand *et alii*, 2011), Catalan Pyrenees in Spain (e.g. Mujal *et alii*, 2017), and in other deposits mostly coeval with the Arenarie di Cala Viola. The occurrence of *Rhynchosauroides* and *Rotodactylus* from the Arenarie di Cala Viola enriches the local ichnological record from the Nurra area and represents further evidence of prolacertiforms and dinosauromorph in the Middle Triassic fauna of western Europe (Fig. 6)

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