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A PUTATIVE JUVENILE SPECIMEN OF *EUSAUROSPHARGIS DALSASSOI* FROM THE ANISIAN (MIDDLE TRIASSIC) OF PIZ DA PERES (DOLOMITES, NORTHERN ITALY)

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Keywords: Reptilia; Diapsida; juvenile individual; *Eusaurosphargis*; Northern Dolomites; paleogeography; basinal distribution.

Abstract. The partial skeleton of a small tetrapod, collected from the lower Buchenstein Formation (uppermost Illyrian, Anisian Middle Triassic) of Piz da Peres (Northern Dolomites, Italy) is described. Incomplete ossification of some bones indicate that the specimen is a juvenile. Its absolute size and proportions, along with several skeletal structures show striking similarities with a juvenile specimen of *Eusaurosphargis dalsassoi* from the slightly younger Prosanto Formation (Switzerland), a taxon known also from the Anisian/Ladinian Besano Formation (Italy and Switzerland). The finding may suggest that during the middle-late Anisian the basins of the Northern Dolomites, of the Besano Formation and Prosanto Formation shared not only several taxa of fishes but also the emerged lands nearby had a similar reptilian fauna.

Introduction

The Prags/Braies Dolomites are a mountain range in the north-eastern part of the Dolomites, part of the Natural Park of Prags/Braies, which belongs to the Northern Dolomites system of the UNESCO world heritage site Dolomites (Fig. 1). The Braies Dolomites are famous since the XIX century for its extensive marine stratigraphic successions (e.g., Mojsisovics 1879; Ogilvie Gordon 1927, 1934; Pia 1937; Bechstädt & Brandner 1970; De Zanche et al. 1992; Senowbari-Daryan et al. 1993). These successions, in combination with their rich marine fauna, especially brachiopods and ammonoids (Loretz 1875; Mojsisovics 1879, 1882; Bittner 1890), and calcareous algae of the *alpiner Muschelkalk* (Pia 1937), made it a reference area for the Anisian successions of the Southern Alps (cf. Gianolla et al. 2018).

Lately, one of its peaks, the Kühwiesenkopf/Monte Prà della Vacca, has become famous because of a rich and diverse terrestrial plant assemblage (e.g., Broglio-Loriga et al. 2002; Van Konijnenburg-van Cittert et al. 2006; Kustatscher et al. 2007, 2009, 2010a, 2010b) and numerous marine fossils including bivalves (Posenato 2008a, 2008b), brachiopods (Gaetani & Mantovani 2015), ammonoids (e.g., Bechstädt & Brandner 1970; Broglio Loriga et al. 2002), foraminifera (Fugagnoli & Posenato 2004) and fishes (Tintori et al. 2016; Renesto & Kustatscher 2019). The terrestrial reptile *Megachirella*

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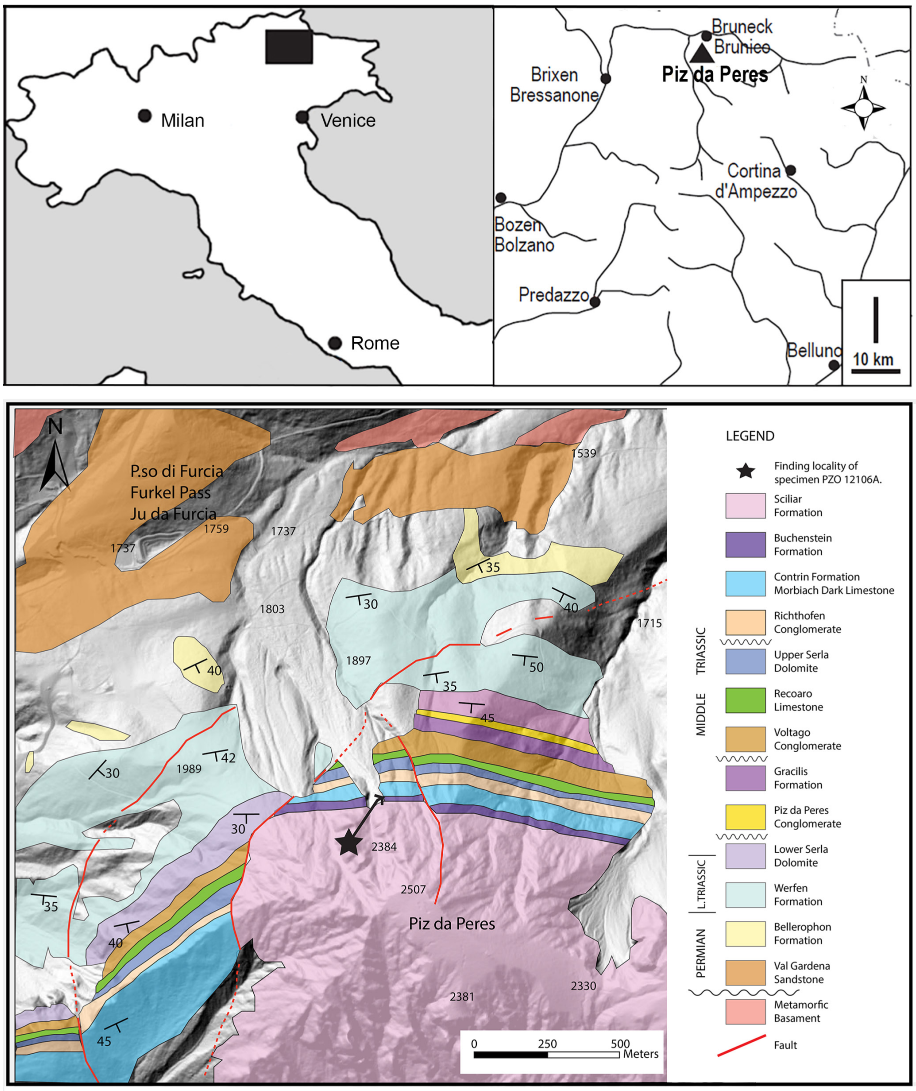

Fig. 1 - Geographic setting and simplified geological map of the locality Piz da Peres. Geological map from unpublished data of the geological Survey of the province of Bolzano and observations of the authors.

wachtleri is of particular importance since it is the oldest known stem squamate (Renesto & Posenato 2003; Renesto & Bernardi 2013; Simões et al. 2018). These remains were found within an extensive succession attributed to the Dont Formation and dated to the middle-late Pelsonian (Fugagnoli & Posenato 2004; Kustatscher & Roghi 2006; Kustatscher et al. 2006, 2010; Gianolla et al. 2018).

Another peak, the Piz da Peres, is historically well known for its stratigraphy (e.g., De Zanche et al. 1992), tetrapod footprints (e.g., Abel 1926; Pia 1937; Bechstädt & Brandner 1970; Brandner 1973), calcareous algae (Pia 1937) and foraminifera (Zaninetti et al. 1994). It recently became the focus of paleontological studies because of its numerous tetrapod tracks, marine biota (jellyfish, bivalves, etc.) and abundant plant fossils discovered in a near-shore succession (Avanzini & Wachtler 2012; Todesco et al. 2008). The latter corresponds to the Richthofen Conglomerate and Morbiac Dark Limestone, both Illyrian in age (De Zanche et. al. 1992; Gianolla et al. 2018).

In 2009 a local collector (M. Wachtler) found a partial skeleton of a tiny reptile on a small stone slab dispersed on the northern slope of Piz da Peres. The area (about 2300 m a.s.l.) is well known in literature (Mojsisovics 1879; Pia 1937; Bechstädt & Brandner 1970; De Zanche et al. 1992; Zühlke 2000). Although the specimen was not collected in situ, the position on the slope of its recovery as well as the lithology of the rock slab allows a confident attribution to the Plattenkalk member of the Buchenstein Formation, even when palynological analyses did not yield any results. Because of the high correlability inside the Buchenstein Fm. in the western Dolomites (Brack & Rieber 1993; Brack & Muttoni 2000; Maurer et al. 2003; Wotzlaw et al. 2018) the age of the specimen is latest Illyrian (uppermost Anisian). The here described specimen is the first terrestrial reptile collected in the Buchenstein

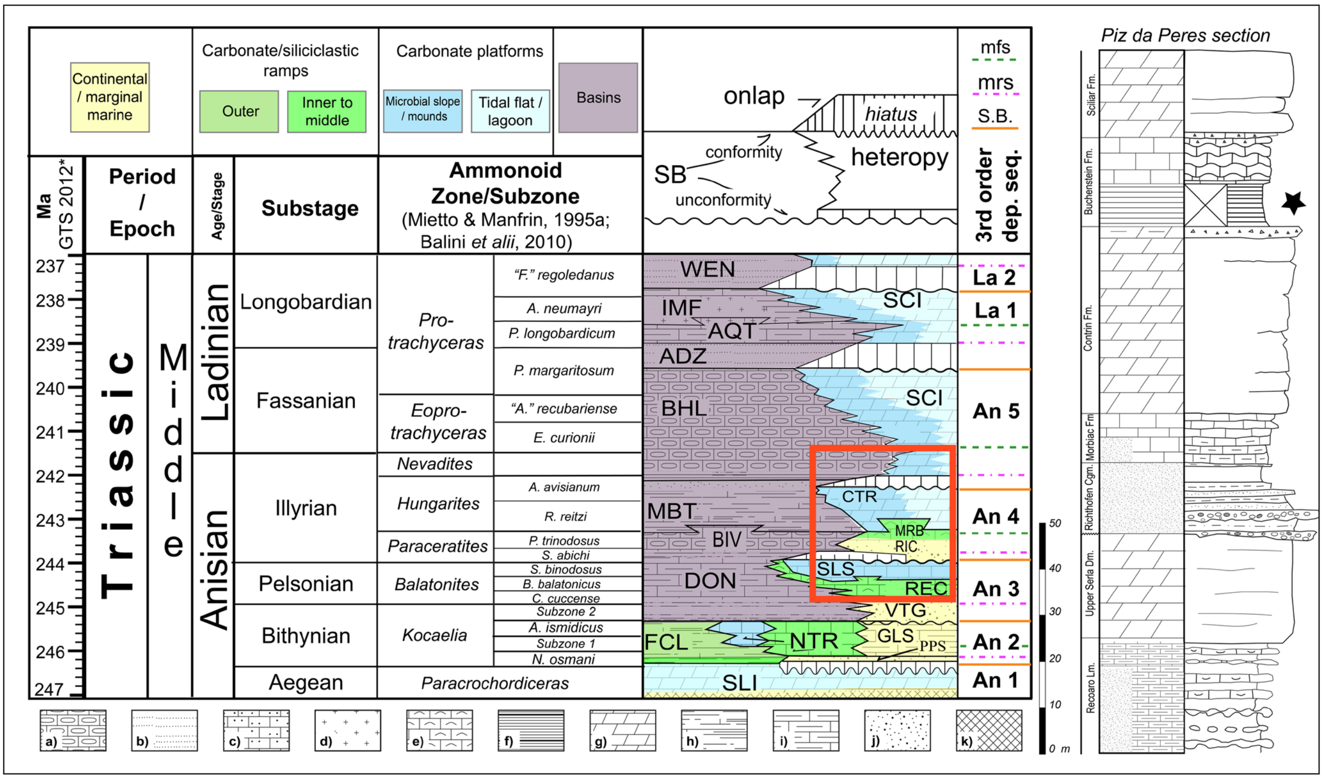

Fig. 2 - Stratigraphic framework of the Middle Triassic of the Peres/Prags Dolomites (modified after Gianolla et al. 2018) The red rectangle refers to the Piz da Peres section detailed on the right, the black star indicates the levels which yielded specimen PZO 12106A. Lithostratigraphic abbreviations: ADZ = Zoppé Sandstone; AQT = Acquatona Formation; BHL = Buchenstein Formation; BIV = Bivera Formation; CTR = Contrin Formation; DON = Dont Formation; FCL = Coll'Alto dark limestones; GLS = Gracilis Formation; IMF = Fernazza Formation and volcanites; MBT = Ambata Formation; MNA = Moena Formation; MRB/RIC = Richthofen Conglomerate and Morbiac dark limestone; NTR = Monte Rite Formation; PPS = Piz da Peres Conglomerate; REC = Recoaro Limestone; SCI = Sciliar Formation; SLI = Lower Serla Dolomite; SLS = Upper Serla Formation; VTG = Voltago Conglomerate; WEN = Wengen Formation. Sequence stratigraphy abbreviations: mfs = maximum flooding surface; mrs = maximum regression surface; S.B. = sequence boundary. Depositional sequences after Gianolla et al. 2018. Lithologies: a = cherty limestone; b = sandstone; c = sandy limestone; d = volcanics; e = oolitic–bioclastic limestone; f = black platy limestone or dolostone, black shale; g = dolostone; h = marlstone, claystone, and shale; i = marly limestone; j = conglomerate; k = evaporites. GTS 2012= geologic time scale modified after Wotzalw et al. 2018.

of Northern Dolomites and show affinities with specimens known from the middle-late Anisian of the Besano Formation of the Monte San Giorgio area and from the Prosanto Formation near Davos (Austroalpine Silvretta Nappe, Switzerland).

Geological and palaeogeographic setting

Stratigraphic reconstructions of the Middle Triassic of this sector of the Northern Dolomites show from early Anisian to late Anisian a progressive environmental differentiation that terminates the flat topography that characterized the latest Permian–Early Triassic (Werfen Fm. and Lower Serla Dolomite). Differential subsidence and relative sea level changes: originated in the Prags/Braies Dolomites (Fig. 2) almost three depositional sequences are distinguished (De Zanche et al. 1992, 1993; Ruffer & Zühlke 1995; Zühlke 2000; Gianolla et al. 1998, 2018); the sequences are punctuate at the base by emersion unconformities associated with continental conglomerates (Piz da Peres, Voltago and Richthofen conglomerates), followed by shallow-water mixed clastic-carbonate deposits, merging upward, in the more subsiding areas, into outer ramps and basins (Dont, Recoaro, Bivera and Ambata formations) or, in the less subsiding areas, into three generations of carbonate banks and platforms (Rite Fm., Upper Serla Dolomite and Contrin Fm.) (De Zanche et al. 1992, 1993; Senowbari-Daryan et al. 1993; Gianolla et al. 1998, 2018). The differential subsidence allows a definition of a shallow marine area in the western sector (Piz da Peres) and a more basinal setting towards the East (Bad Altprags/Braies Vecchia). During the latest Anisian another relative sea level fall is documented by the increase in siliciclastic in the uppermost part of the Ambata Formation and by subaerial exposure of the carbonate platforms (De Zanche et al. 1993; Gianolla et al. 1998). The region experienced almost coevally a new extensional tectonic pulse and a fast increase in tectonic subsidence. The combinate effect resulted in a general drowning of the carbonate banks with a strong reduction of shallow sedimentation (De Zanche et al. 1992, 1993; Stefani et al. 2010). This initiated the growth of several aggradational high-relief microbial carbonate platforms (Sciliar Fm.) starting from previous carbonate highs and the development of widespread deep-water sedimentation.

The basinal sediments are assigned to the Buchenstein Formation (Viel 1979; Bosellini & Stefani 1991; Brack & Rieber 1993). The unit can be subdivided in three members (not always present): the lower portion consists of anoxic laminated calcareous mudstones, fine-grained dolostones and radiolarian-rich laminae (*Plattenkalke*), the middle portion of well-bedded laminated to nodular calcareous mudstones, alternated with cherty limestones (*Knollenkalke*). The upper part is characterized by alternations of laminated micritic limestones, rare cherty layers, acidic volcaniclastic layers and thin calcarenites (*Bänderkalke*). The Buchenstein Fm. is characterized by the presence of distinct intercalations of acidic volcaniclastic layers as ash fall and crystal tuffs (*pietra verde*, Brack & Rieber 1993; Brack et al. 1996; Wotzlaw et al. 2018; Storck et al. 2019). The *Plattenkalke* member of the Piz da Peres area belongs to the Avisianum subzone of the Hungarites zone of Mietto & Manfrin (1995). This corresponds to the Reitzi/Kellnerites Zone of Brack & Rieber (1993).

Near the slopes of the active carbonate platforms, the Buchenstein Fm. contains platform-derived calciturbidites and breccias and even closer to the platforms the basinal succession is progressively replaced by slope deposits. The entire formation may disappear, thus, over short distances (Bosellini 1984; Maurer 1999, 2000). Stratification patterns are laterally persistent, and the unit shows an impressive lateral continuity over distances in order of hundreds of kilometres (e.g., Brack & Rieber 1993; Brack & Muttoni 2000; Maurer et al. 2003; Wotzlaw et al. 2018) that, together with bio-, magneto-, tephra-stratigraphy and U-Pb geochronology, allows a very high-resolution within the lithostratigraphic unit (Brack & Muttoni 2000; Wotzlaw et al. 2018).

Systematic Palaeontology

REPTILIA Laurenti, 1768
Diapsida Osborn, 1903

cf. ***Eusaurosphargis dalsassoi*** Nosotti et Rieppel, 2003

Fig. 3, 5

Material: Specimen PZO 12106 (Fig. 3) housed at the Museum of Nature South Tyrol (Bozen/Bolzano, Italy), partial skeleton consisting of fragments of dorsal and sacral vertebrae and ribs, portions of the caudal ribs of the first four caudal vertebrae; portions of the pelvic girdle and a nearly complete right hind limb and few fragments of very small osteoderms.

Horizon and locality: Northern slope of the Piz da Peres (46°42'52.94"N, 11°58'38.13"E); Plattenkalk member of the Buchenstein Formation (latest Illyrian) (Fig. 2).

Description

General remarks. The specimen (Fig. 3) is exposed on its ventral side. It lies on the margin of a small stone slab that was found among the debris on the outcrop surface, so that the slab is weathered, and the conservation of many bones is poor. In addition, the surface of the slab on which the fossil is exposed is not flat, but rather irregular, with concavities and convexities, thus some bones are either flexed or fractured. The specimen is mostly articulated, but very incomplete: the right half of the skeleton is completely missing due to the original fragmentation. Only partial ribs of the left posterior dorsal region of the trunk, part of the pelvic girdle and the complete left hindlimb, along with fragments of the first caudal ribs are preserved.

Axial skeleton. Few splints of bone is all what is left of the posterior dorsal vertebrae. The dorsal ribs show their maximum curvature toward their distal end suggesting that the body was dorsoventrally flattened. An isolated centrum of a sacral vertebra (Fig. 3) is preserved in ventral view, its ventral margin shows a faint hourglass shape and on its left side a prominent transverse process for the articulation of the sacral rib is clearly visible. Two isolated sacral ribs are also visible. They are elongate and stout, distally expanded elements. Fragments of other sacral and caudal centra are present, but their preservation does not allow any description. Five very long and narrow caudal ribs are preserved on the right side of the specimen at the base of the tail (Fig. 3), they are incom-

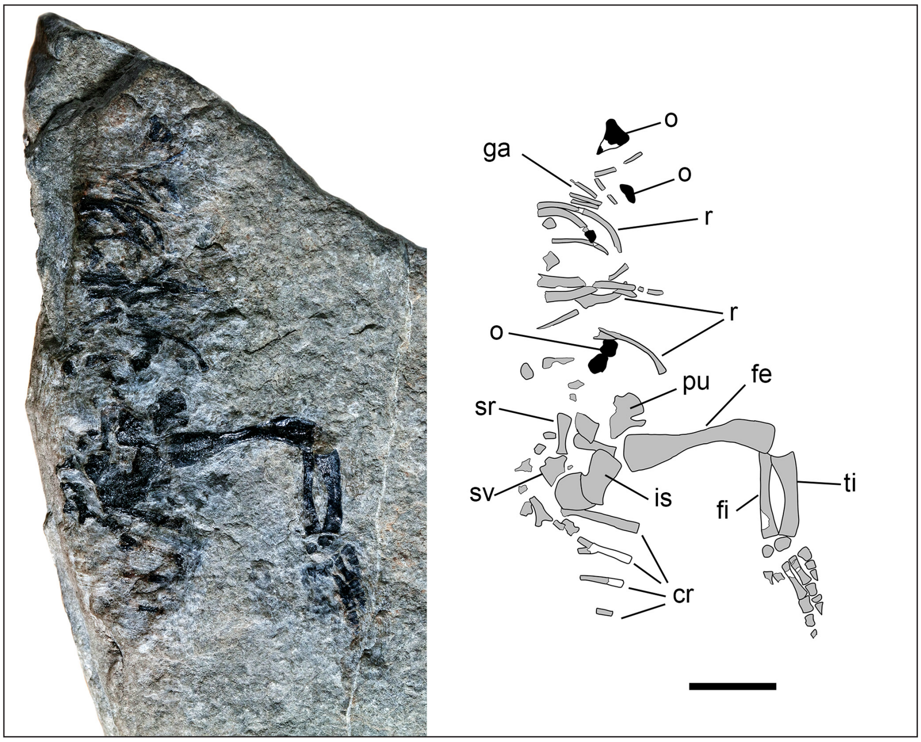

Fig. 3 - Specimen PZO 12106 with interpretative drawing of preserved elements. Abbreviations: cr) caudal ribs; fe) femur; fi) fibula; ga) gastralia; is) ischium; o) osteoderms; pu) pubis; r) thoracic ribs; sr) sacral ribs; sv) sacral vertebra; ti) tibia. Scale bar equals 10 mm.

plete, but the second one, which is more complete, reaches 8.5 mm in proximo-distal width.

Several narrow, straight isolated elements belonging to the gastralia are interspersed among dorsal ribs.

Pelvic girdle. The dorsal half of left pubis is detectable along with a fragment of the right pubis (Fig. 3), the bone had a slightly convex dorsal outline and concave anterior and posterior margins. Close to the posterodorsal end of the bone a deep notch is interpreted as the obturator foramen. The left ischium is subrectangular in shape with concave anterior and posterior margins so that it narrows in its middle portion then becoming more expanded distally, thus resembling a hatchet blade. Another flat bone overlaps part the left ischium, its identification is problematic, but it may possibly represent a fragment of the right ischium.

Hindlimb. The left hindlimb (Fig. 4) is the best preserved part of the skeleton, with most bones in anatomical connection. The femur is 17 mm long, its shaft shows a sygmoidal curvature, and the proximal and distal heads are both expanded, the proximal head being slightly larger than the distal one. The proximal and distal heads are nearly flat or slightly concave and seem to have a rough "unfinished" structure as if they were capped with cartilage in life, indicating that the bone epiphyses were not yet ossified.

The tibia and fibula are nearly of the same length (9.5 mm vs 10 mm, respectively). Both have expanded proximal and distal heads; the tibia is much stouter than the fibula and its proximal articular surface is concave while the distal one is flat. The fibula (Fig. 4A) shows a slightly convex proximal articular area and a faintly concave distal one. Both the tibia and the fibula have a concave medial margin, enclosing a distinct *spatium interosseum*. Only two tarsals are present (Fig. 4B): the astragalus and the calcaneum. The astragalus has a

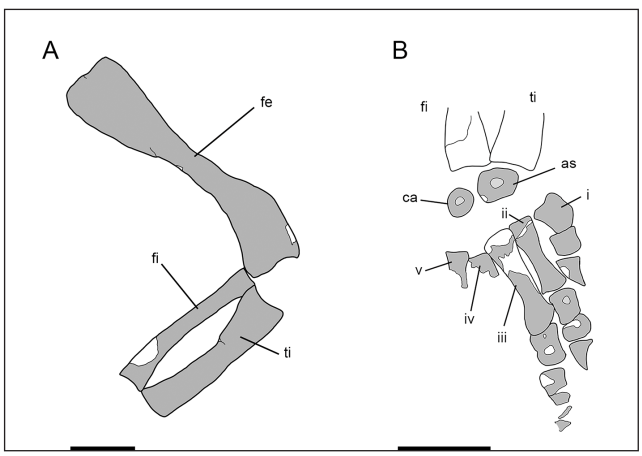

Fig. 4 - Specimen PZO 12106. A) drawing of the femur and crus, B) drawing of the tarsus and pes. Abbreviations: as) astragalus; ca) calcaneum, fe) femur; fi) fibula; ti) tibia; i-v) metatarsals 1-5; 1-3) pedal digits 1-3. Scale bars equal 5 mm.

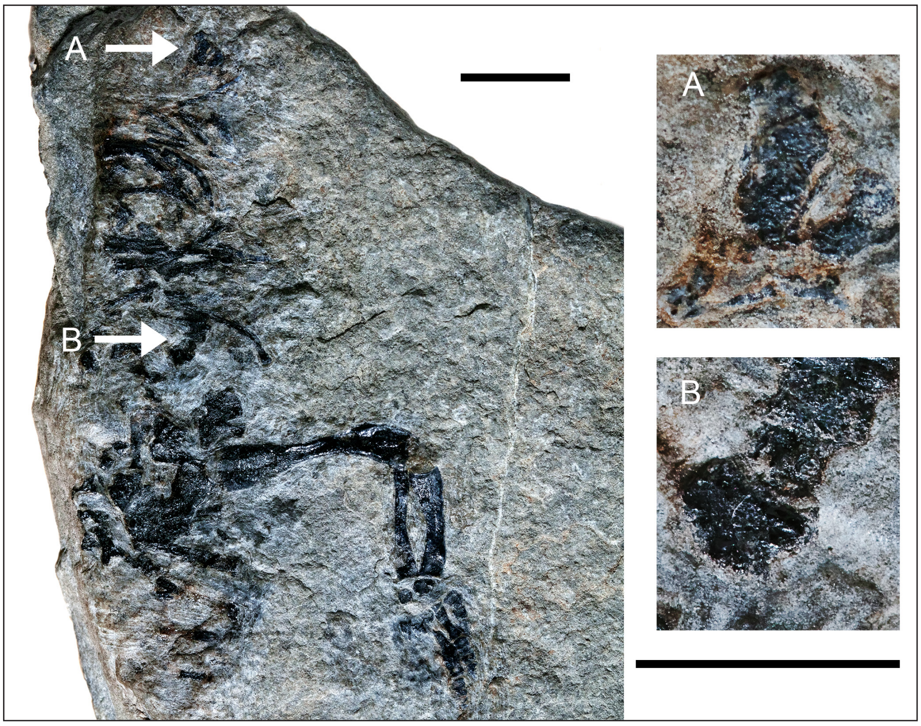

Fig. 5 - Specimen PZO 12106. A) position of the osteoderms indicated by the white arrows; B-C) detail of preserved osteoderms. Scale bars equal 10 mm (A) and 5 mm (B-C).

sub-elliptical outline with a slight dorsal concavity, the calcaneum is smaller and subcircular in outline. Metatarsals 1—3 are complete, their length is 1 mm, 3 mm and 4 mm, respectively. The first metatarsal is stout and much shorter than the others. It is wider than long, with expanded heads; the proximal head is wider than the distal one; both the second and third metatarsals show a straight shaft with slightly expanded heads. Only the proximal heads of the fourth and fifth metatarsal are preserved. The phalangeal formula can be reconstructed only for the first two pedal digits: 2, 3, the third pedal digit has more than three phalanges, but the exact number cannot be ascertained. Pedal phalanges are short, squared elements with expanded distal articular areas and slightly constricted in the middle, the penultimate phalanges of each pedal digit are wider than long. The ungual phalanges are triangular. The astragalus, the calcaneum and some phalanges show a thick margin and a central depression testifying that ossification was less advanced in the central portion of these bones.

Osteoderms. Some flat bone fragments of irregular shape are present among ribs and gastralia (Fig. 5). They show a coarse ornamentation, and are interpreted as osteoderms. A larger and more complete osteoderm lies lateral to the anteriormost preserved bones, approximately at the left margin of the mid trunk. It has a sub-triangular shape.

Discussion

The incompleteness of the skeleton, along with the poor preservation of many bones, makes the taxonomic assignment of specimen PZO 12106 very difficult. However, some characters of the preserved elements allow to attempt an assignment. The pattern of the tarsus, with only two ossified elements as well as the rounded shape of the calcaneum, might suggest affinity with coeval eusauropterygians, like neusticosaurs. However, the sygmoidal femur with expanded heads and the robust pedal digits, ending with a wide, triangular ungual phalanx differ significantly from those of neusticosaurs, which are much more gracile and with a small last pedal phalanx (Rieppel 1989, 2000; Sander 1989).

The overall size of the specimen, the dorsoventrally flattened dorsal region and the architecture of the hind limb, along with the presence of possible osteoderms around the body margins, represent strong similarities with the juvenile specimen of *Eusaurosphargis dalsassoi* Nosotti et Rieppel, 2003 described by Scheyer et al. (2017). This latter specimen (labelled as PIMUZ A3/4380 of the Paläontologisches Institut und Museum of Zürich, Switzerland) was collected from an outcrop of the Middle Triassic (Anisian—Ladinian) Prosanto Formation, in a locality near Davos, in the Eastern Swiss Alps (Furrer et al. 2008). *Eusaurosphargis dalsassoi* is very rare and, with the exception of the Davos speci-

	PZO 12106 (this study)	PIMUZ A3/4380
Femur length	17	17.5
Femur proximal width	4.7	5.5
Femur mid shaft width	2.2	2.6
Femur distal width	3.7	3.9
Tibia length	9.5	10.4
Fibula length	10	10.8

Tab. 1 - Measurements (in mm) of hindlimb bones of PZO 12106A compared with the same elements of, specimen PIMUZ A3/4380 attributed to *Eusaurosphargis dalsassoi* (data from Scheyer et al. 2017)

men, is only known by a disarticulated specimen and isolated bones from the Besano Formation/ Grenzbitumenzone (Anisian/Ladinian boundary) from Besano (Italy), and possibly from the Vossenfeld Formation (Anisian) from Winterswijk (The Netherlands) (Klein & Sichelschmidt 2014). The shape and size of the hind limb bones of specimen PZO 12106 are nearly identical to that of specimen PIMUZ A3/4380 (Tab. 1), both specimen lack ossified epiphyses of the femur, tibia and fibula, and show an incomplete ossification of the astragalus and of some pedal phalanges, indicating a similar growth stage. Both show also a very short first metatarsal (in PZO 12106, the length of the first metatarsal is one third and one fourth of that of the second and third metatarsal, respectively) and the pattern of the preserved elements of the tarsus and of the first pedal digit are identical to those of specimen PIMUZ A3/4380. Unfortunately, preservation does not allow to ascertain the presence or absence of the uncinated processes on the thoracic ribs, which represent a diagnostic feature that would have allowed an unequivocal assignment of specimen PZO 12106 to *Eusaurosphargis dalsassoi*. Thus, while reasonable, our identification remains tentative, and for this reason specimen PZO 12106 is classified as cf. *Eusaurosphargis dalsassoi* and for the same reason no scoring for a phylogenetic analyisis is attempted.

According to Scheyer et al. (2017) the overall anatomy supports a mainly terrestrial lifestyle for *Eusaurosphargis dalsassoi*, especially the limb bone structure, characterized by the robustness of the autopodial elements "with spade-like terminal phalanges instead of tapering ones" (Scheyer et al. 2017 p. 19). Moreover, according to Scheyer et al. (2017), a terrestrial life habit would explain the scarcity of findings of this species in localities like the Monte San Giorgio, in which fully terrestrial reptiles are extremely rare, while marine reptiles are abundant. A terrestrial interpretation of life habits for *E. dalsassoi* is also consistent with the taphonomy of PIMUZ A3/4380. The discovery of specimen PZO 12106 is significant because, if the identification is correct, it indicates that the basins of the Northern Dolomites, of the Besano Formation and Prosanto Formation during the middle—late Anisian shared not only several taxa of fishes (Tintori et al. 2016) but also the emerged lands surrounding these basin had in common several terrestrial diapsids. The question would arise, where the emerged land was located, where the reptile lived.

Palaeogeographic reconstructions and detailed stratigraphic studies indicate a significant acceleration of subsidence contemporary to a general transgressive phase during the deposition of the Plattenkalke Mb. (Buchenstein Fm.) in the entire area of the Eastern Southern Alps. This led to a general reduction of shallow water and emerged areas, the growth of strongly aggrading carbonate biuldups and a strong retreat towads south of the siliciclastic coastline. As a consequence the basement derived supply (muscovite and metamorphic quartz) decrease noticeably in the basinal succession (Ambata vs Buchenstein fms). The paleogeography of the Southern Alps (Fig. 6) was thus characterized by an archipelago of isolated carbonate platforms separated from each other by narrow and deep branches of sea (Assereto et al. 1977; Viel 1979a, 1979b; Gianolla et al. 1998; Gaetani 2010; Stefani et al. 2010). The islands were relatively small (a few kilometres in diameter) with the exception of the Platform of the Adige Valley. Evidence of emerged or marginal marine areas exist in the Po Plain (explorative wells of Legnaro and Amanda from ViDEPI Project), some subaerial volcanic centers were located in the Vicentinian Prealps (e.g. Recoaro area) and toward south (below the current Po Plain). On the other hand, coarse pietra verde deposits with core lapilli were found at the base of the Knollenkalk (Buchenstein Fm.) at Schadebach/Rio Schade, some tens of kilometres toward east (Gianolla et al. 2018). This coud suggest that another emerged land, probably a small island, could have been located also towards east or north east.

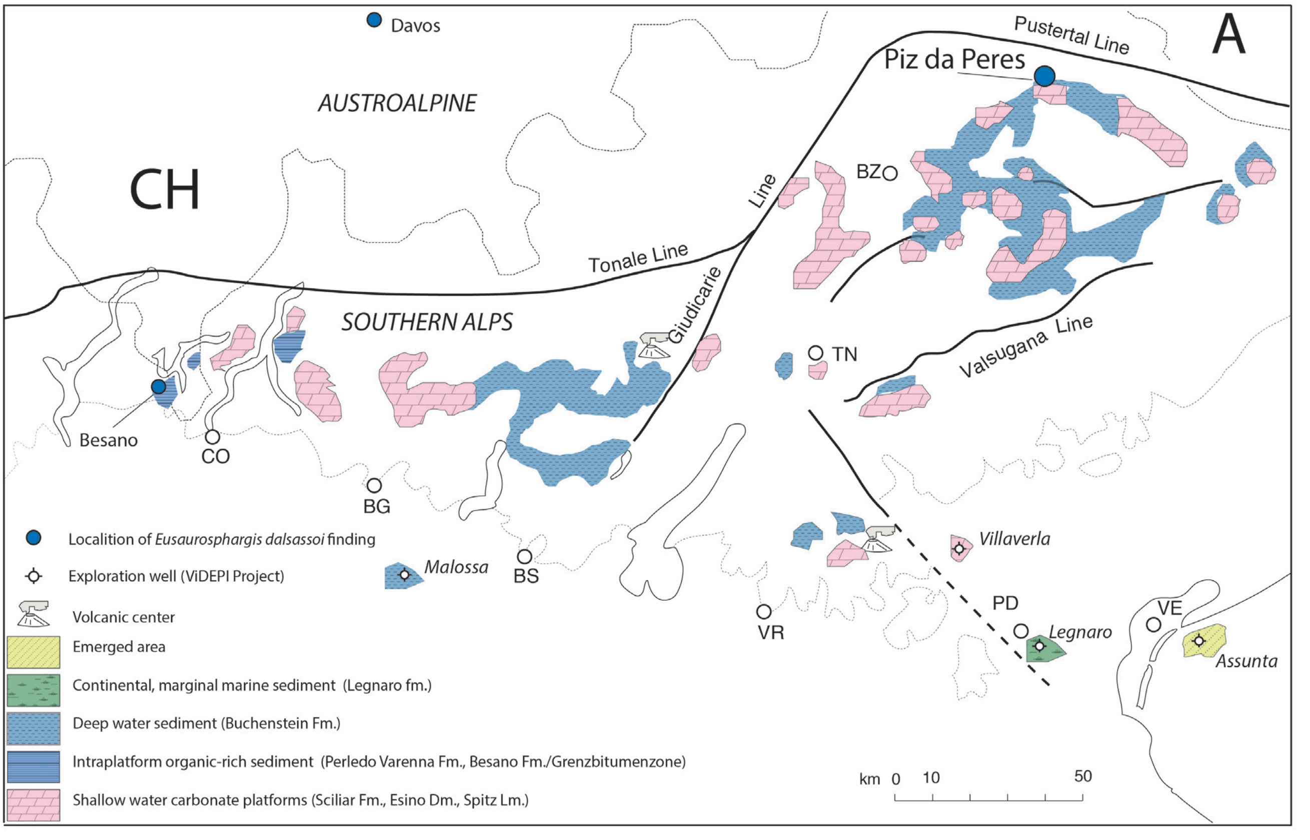

Fig. 6 - Schematic paleogeographic reconstruction of the Southern Alps during the deposition of the *Plattenkalke* member of the Buchenstein Formation.

Conclusions

The finding of specimen PZO 12106 is significant because it is the first terrestrial reptile collected in the Buchenstein of Northern Dolomites. The presence of a persistent continental area to the South and an archipelago of small islands not far from each other, may have allowed sporadic or random migration of terrestrial reptiles, even by island hopping. Small sized reptiles are rafters and can spread from mainland to islands, clinging for instance to floating vegetation even at the egg stage, as documented by various studies about the biogeography of reptiles of the New Guinea and Pacific region (Allison 1996; Gibbons 1985) and of the Mascarene islands (Austin Arnold & Jones 2004; Bauer 1990). The finding of specimen PZO 12106 indeed supports that terrestrial reptiles may have migrate from typically continental to insular environments.

Specimen PZO 12106 is of further paleobiogeographical and paleoecological significance because it testifies the presence of affinities between middle-late Anisian basins of the Northern Dolomites, of the Besano Formation and of the Prosanto Formation, not restricted to marine faunas, but also among the terrestrial reptiles that thrived in the emerged lands nearby.

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