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# Further news to the Lower Permian palaeoichnology of the Brembana Valley (Orobic Basin, Southalpine)

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**Abstract:** The new discoveries of the tetrapod footprints from Brembana Valley (Lombardy, Southalpine) permit to extend the knowledge about the Lower Permian ichnoassociation of the Orobic Basin. This ichnoassociation consists of *Camunipes cassinisi* Ceoloni et al., 1987, *Amphisauropus latus* Haubold, 1970, *A. imminutus* Haubold, 1970, *Varanopus curvidactylus* Moodie, 1929 and *Dromopus lacertoides* (Geinitz, 1869). Besides, with the discovery of *C. cassinisi*, the presence of this ichnospecies is documented, in the Orobic Basin, for the first time out of Scioc Valley (close to Brembana Valley), area where it is extremely abundant. The new data should confirm the very low biodiversity during the Lower Permian and ascribe it to the Rabejac Faunal subage (FsA).

**Riassunto:** I nuovi ritrovamenti di impronte di tetrapodi dalla Val Brembana (Bacino Orobico, Lombardia) permettono di estendere le conoscenze sull'ichnoassociazione del Permiano inferiore del Bacino Orobico. Questa ichnoassociazione è composta da: *Camunipes cassinisi* Ceoloni et al., 1987, *Amphisauropus latus* Haubold, 1970, *A. imminutus* Haubold, 1970, *Varanopus curvidactylus* Moodie, 1929 e da *Dromopus lacertoides* (Geinitz, 1869). Inoltre, con la scoperta di *C. cassinisi* nel Bacino Orobico viene documentata la sua presenza in zone differenti dalla Val di Scioc (limitrofa alla Val Brembana) dove risulta estremamente abbondante. Queste nuove scoperte confermerebbero la bassissima biodiversità durante il Permiano inferiore ed il suo inserimento nella sottoetà faunistica di Rabejac.

**Key words:** Brembana Valley, ichnoassociation, Lower Permian, Orobic Basin

## INTRODUCTION

Palaeoichnological researches effected in the Permian outcrops of the Southalpine region have been submitted for a long time to deep analyses. The lack of vertebrate remains in the Southalpine is known so Amphibians and Reptiles footprints are important in the Permian deposits because are the only meaningful fossils that have discovered with great abundance. Recently, in particular, a new approach to palaeoichnology, with special regards to the stratigraphical

potentiality shown by the ichnites, has been proposed (CONTI *et al.* 1997, AVANZINI *et al.* 2001). Detailed researches have been carried out in the historical areas of the Lower Permian of Trompia Valley (Brescia Region) and relating to the Upper Permian of Trentino Alto Adige for a long time, but in the last years the Orobic Basin has begun to be intensely studied, too. We refer particularly to the zones of the Gerola-Varrone Valleys (CASSINIS *et al.* 2000, NICOSIA *et al.* 1999, 2000, SANTI & KRIEGER 1999), Scioc Valley and only recently, the high Brembana Valley (SANTI

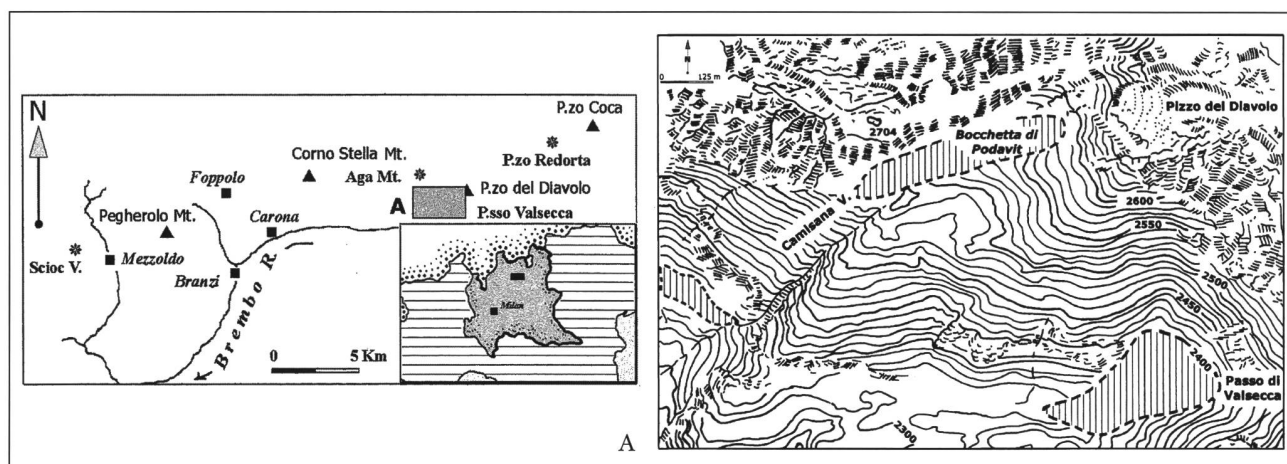


Fig. 1-1A - Main fossiliferous localities in the bergamasc sector of the Orobic Basin. 1A. Schematic topographic map of the fossiliferous zones (vertical lines) in Brembana Valley.



Fig. 1-1B - Particular of the Lower Permian fossiliferous outcrops at the Bocchetta di Poddavista (Brembana Valley).

2001, SANTI & KRIEGER 2001), too. Now this short note will analyse the ichnofossils coming from Bocchetta di Poddavista and Pizzo del Diavolo-Passo di Valsecca (high Brembana Valley) (Figs 1-1A-1B).

**GEOLOGICAL-STRATIGRAPHICAL SETTING AND PREVIOUS DISCOVERIES: A SHORT REVIEW**

The Orobic Basin is one of the main Permian basins generated by a pull-apart tectonics at the end of the Hercynian orogeny in the Southern Alps (Fig. 2). In that basin the Lower Permian outcrops are well distributed, as well as in the neighbouring area of Trompia Valley. East to the Adige River few outcrops with peculiar ichnofauna (Tione Basin, Tregiovo Basin - CASSINIS & DOUBINGER 1991,

B

1992, CASSINIS *et al.* 1988, CASSINIS & NERI 1990, CONTI *et al.* 1997, 1999) are individuated.

Former studies with geological characters were effected by GÜMBEL (1880) and by MELZI (1891) and, only some years later the detailed analyses were effected by PORRO (1931, 1932) and by DE SITTER & DE SITTER-KOOMANS (1949). They published a geological map utilising the surveys of JONG (1928), COJIN (1928), KLOMPÉ (1929), WENNEKERS (1930) and DOZY (1935). More recently further studies have been advanced by CASATI & GNACCOLINI (1967), BONSIGNORE *et al.* (1971), CASSINIS *et al.* (1988), CASATI & FORCELLA (1988), CADEL *et al.* (1996) and by JADOUL *et al.* (2000) referring to the publication of the «Provincia di Bergamo» geological map at the scale 1:50000 and by GIANOTTI *et al.* (2001).

Fig. 3 shows a chronostratigraphical scheme relating to the Lower Permian of the Orobic Basin. The Permian is characterised by two cycles of sedimentation. The first one (?Upper Carboniferous-Lower Permian) is defined by the Collio Formation and Ponteranica Conglomerate deposition. The Collio Formation is a volcano-sedimentary suc-

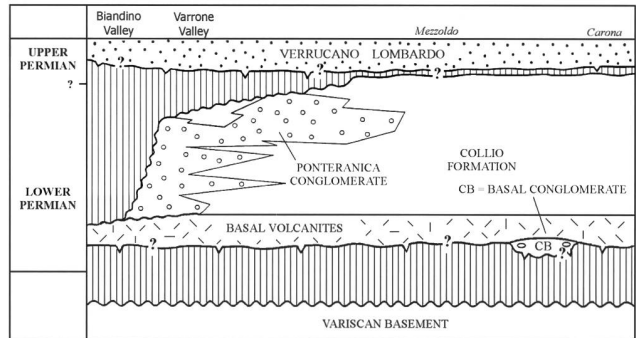


Fig. 3 - Chronostratigraphic scheme of the Permian deposits in the Orobic Basin (by CASSINIS *et al.* 2000 mod.). Vertical lines define a gap of sedimentation.

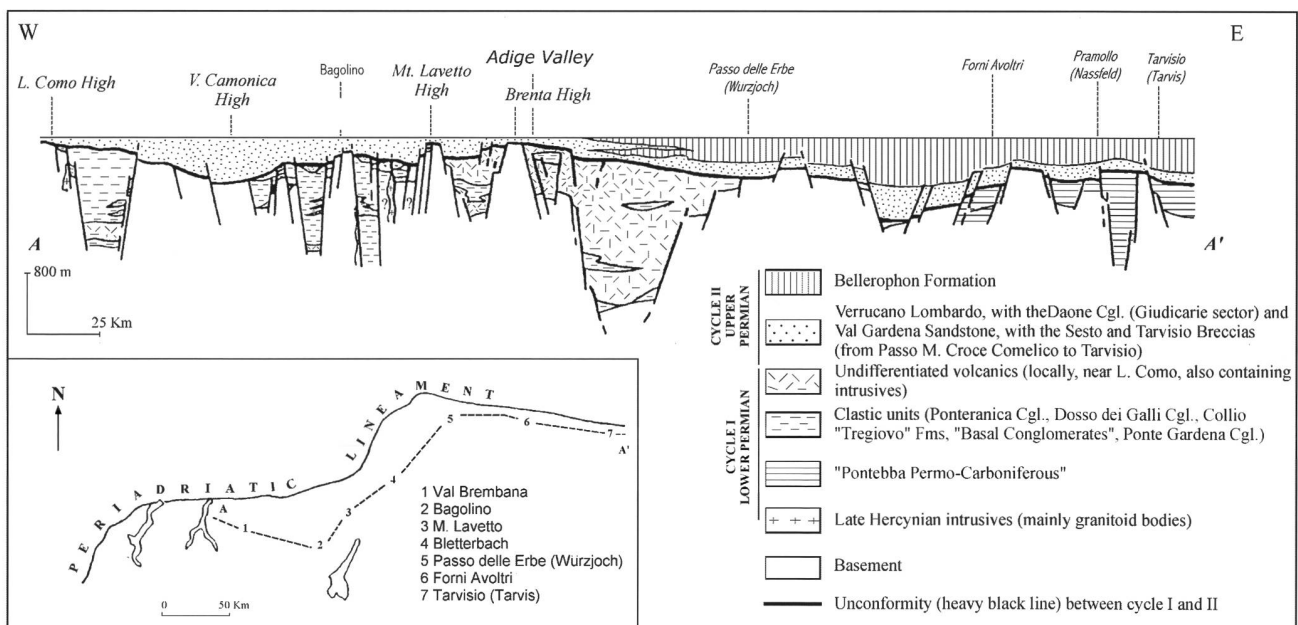


Fig. 2 - Palaeogeographic scheme of the Southalpine at the end of the Permian (by CASSINIS *et al.* 2000 mod.).

cession that in its better exposition in Trompia Valley where lies upon a volcanic deposits, reaches about 1500 m in thickness. The sedimentary part is commonly known as «Collio s.s.». Locally, in the Orobic Basin, the «Collio» unconformably lies on the Basal Conglomerate or more broader, directly upon the Variscan Basement. In the Brembana Valley the «Collio s.s.» lies upon a volcanic deposits like in Trompia Valley. In its lower part it is defined by an interfingering between the volcanic sediments (lavas and tuffs) and terrigenous ones (siltstones and sandstones); in the upper one besides these sediments, the formation is characterised by coarser sediments laid down in lacustrine and alluvial environments. The mostly pelitic highest part of the «Collio» is indicated as «Scisti di Carona» by DE SITTER & DE SITTER-KOOMANS (1949). The sediments that compose this lithosome are very rich in ichnites (vertebrates and invertebrates) and rare floras (*Walchia* sp.). The «Scisti di Carona» interfinger with coarser deposits of alluvial-fan of the Ponteranica Conglomerate (CASATI & GNACCOLINI, 1967; GIANOTTI *et al.* 2001).

The second cycle (Upper Permian), separated by the first one by a clear regional angular unconformity (IGCP 203 Group 1986, CASSINIS *et al.* 1988, 1999, 2000) linked to a gap of uncertain age (CASSINIS *et al.* 2000, CASSINIS *et al.* in press), is defined by conglomerates, sandstones and subordinately, by reddish pelites of the Verrucano Lombardo. The Permian ends with its deposition.

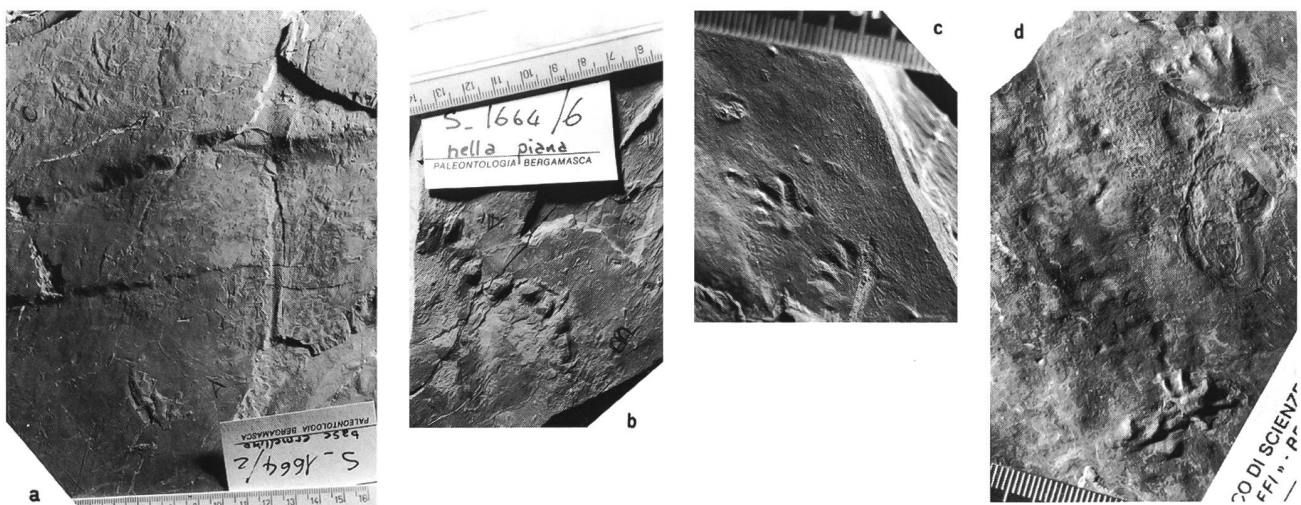
Referring to the ichnites discovered in the Orobic Basin and more in particular in Brembana Valley, the former studies effected by DOZY (1935) on the fossils from the Bocchetta di Poddavista or «Podavit» brought to ascribe them to the *Anhomoiichnium orobicum* Dozy, 1935 and *Onychichnium escheri* Dozy, 1935. Further, these footprints were reconsidered by HAUBOLD (1971), that validated the ichnogenus *Anhomoiichnium* and considered *incertae sedis* (?*Actibates*) the second one. The recent revision effected by

HAUBOLD (1996) upon these ichnites has brought to a new classification. In fact, the ichnogenus *Anhomoiichnium* has been considered invalidated because these prints are simply identified as extramorphological tracks of *Batrachichnus salamandroides* (Geinitz, 1861).

Some years after this first discoveries, the researches undertaken again in the area around Bergamo (north of Milan), in particular CASATI & GNACCOLINI (1967) discovered different tracks in Scioc Valley, NE of Ornica (west to Brembana Valley). CEOLONI *et al.* (1987), trying to identify the faunistic composition of the Collio Formation in the Southalpine, for the Orobic Basin proposed an ichnoassociation composed by: *Amphisauropus latus* Haubold, 1970, *Amphisauropus imminutus* Haubold, 1970, ?*Laoporus dolloi* (Schmidgen, 1929) and Lepidosauria ind. The ichnospecies *L. dolloi*, as well as the ichnogenus *Anhomoiichnium*, actually doesn't result valid anymore because its prints are the extramorphological footprints of *A. latus* (NICOSIA *et al.* 2000 for a detailed discussion). Recently different studies have been advanced by SANTI (2001), SANTI & KRIEGER (2001), ARDUINI *et al.* (in press) and by KRIEGER & SANTI (in prep.) about footprints from Scioc Valley, Aga Mt., Bocchetta di Poddavista and Passo di Valsecca (Brembana Valley).

## THE NEW TRACKS FINDINGS

During the last excavation in the summer of 2000, a great quantity of vertebrate footprints characterised by hundreds of tracks, reverse-prints and trackways kept in the Museo Civico di Scienze Naturali in Bergamo, were gathered (Pl.1). Besides the vertebrates footprints different invertebrates tracks were discovered. The footprints come from black pelitic layers of the upper part of «lower Collio» and seldom from the mostly arenaceous strata. In a first analysis the ichnoassociation seems to be com-



**Plate 1** – a. *Dromopus lacertoides* (Geinitz, 1869). Pizzo del Diavolo. Reverse-prints manus-pes left.  
 b. *Amphisauropus latus* Haubold, 1970. Pizzo del Diavolo. Reverse-prints manus-pes.  
 c. *Camunipes cassinisi* Ceoloni *et al.*, 1987. Bocchetta di Poddavista. Reverse-prints couple manus-pes left.  
 d. *Camunipes cassinisi* Ceoloni *et al.*, 1987. Bocchetta di Poddavista. Reverse-prints couple manus-pes left.

posed by *Amphisauropus latus* Haubold, 1970, *Amphisauropus imminutus* Haubold, 1970, *Varanopus curvidactylus* Moodie, 1929 and *Dromopus lacertoides* (Geinitz, 1869). Together with this ichnofauna, a great quantity of prints ascribed to *Camunipes cassinisi* Ceoloni et al., 1987 have been discovered. This last is an important presence because it should show with certainty the association between this ichnospecies and the other over mentioned ones, only recently revealed (SANTI 2001, SANTI & KRIEGER 1999). In fact, the discovery of *Camunipes cassinisi* was documented only in Scioc Valley (ARDUINI *et al.* in press) and rarely in the Trompia Basin (CEOLONI *et al.* 1987, CONTI *et al.* 1999), but not still in the neighbouring sectors, as for example Brembana Valley. In other zones of the Orobic Basin, in the upper part of the Collio Formation (Gerola-Varrone Valleys west to the area of Bergamo) which is decidedly reddish, notwithstanding the lacking of *C. cassinisi* is noted, but footprints of *Varanopus curvidactylus*, morphologically similar, are mostly abundant.

The *Camunipes* presence in the lower part of the «Collio» and its probable lacking in the upper one puts some questions. Here we remember that actually the problem of the validity of the genus *Camunipes* isn't still solved, at the light of its strong morphological similarity with *Varanopus curvidactylus* even if it is smaller in size respect to the last, with V digit much separated by the IV one and decidedly reversed backward. It is Haubold's opinion (pers. comm.) that *C. cassinisi* could be a «subjective synonym» of *Varanopus*, *Erpetopus* and *Dromopus*, the commonest ichnogenera in the Lower Permian of North America and Europe. Nevertheless, against how much proposed by this author, our most important question is:

«Is it possible that *Camunipes*, being morphologically different by *Varanopus*, should be considered a synonym, when in literature exist similar, different cases where a different ichnospecies is instituted (*Dromopus lacertoides* and *Dromopus didactylus*), even for prints which are morphologically similar but different in size (*Amphisauropus latus* and *Amphisauropus imminutus*)?»

Two of us stay working to the possible relation between *Camunipes* and *Varanopus* (KRIEGER & SANTI in prep.).

In this note we prefer to consider the nomenclature useful at the present time, keeping the two ichnogenera separated and waiting for a clearly revision.

The high Brembana Valley ichnoassociation, very similar to the one of the Trompia Basin, is referable to the Lower Permian and the Rabejac Faunal subage in the CONTI's *et al.* (1997) opinion and it confirms the low biodiversity in taxa pertinent to this period. In comparison to the Trompia Basin ichnoassociation *Dromopus didactylus* Moodie, 1930 is lacking and becomes, on the contrary, a monotypic form present in the highest strata of the Collio Formation in the Brescia Region and in the Tione Basin. On the base of these new data, the extreme Amphibians rarefaction, noted also in neighbouring areas, and the possible restriction of *C. cassinisi* in the lower strata of the Collio Formation becoming, maybe, an endemic ichnospecies, should result confirmed.

If the most logic explanation of the Amphibians lacking is linked to their clear decrease, documented also in the continental Lower Permian of Europe by the bones remains, the lowest biodiversity of ichnotaxa, common to all the Permian outcrops of the world, is still difficult to explain, but we can advance three hypotheses:

- a) it is a systematic artifice (on the base of the ichnofossils, impossibility to discriminate the taxa below the family) (LUCAS 1998)
- b) it is a stratigraphic artifice (sediments don't represent the Lower Permian but only a smaller time interval)
- c) it is a preservation artifice (facies where the ichnofossils are preserved were «particular facies» where a small part of the Reptilians fauna lived).

Finally, a further probable purely regional explanation known as «deposition time compression» advanced by NICOSIA *et al.* (2000) could reside in the highest speed of sedimentation that brought to the Collio Formation deposition (4-5 M.A. referring to the last radiometric data, SCHALTEGGER & BRACK 1999, CASSINIS *et al.* in press) and that prevented the stable formation in the time of the right habitat for the trackmakers radiation. It is difficult to indicate which one of the hypotheses should be considered mostly valid, only future researches will bring news on this question.

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