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THE LATE CRETACEOUS DINOSAUR TRACKSITE NEAR ALTAMURA (BARI, SOUTHERN ITALY)

II - *Apulosauripus federicianus* new ichnogen. and new ichnosp.

A new dinosaur ichnotaxon is described from the Altamura tracksite (Late Cretaceous, Southern Italy). It is named *Apulosauripus federicianus* n. ichnogen. and n. ichnosp. and is ascribed to a middle sized, quadruped hadrosaurid.

KEY WORDS: *Ichnofossils, Ichnosystematics, Dinosaurs, Cretaceous, Southern Italy.*

PAROLE CHIAVE: *Icnofossili, Icnosistemica, Dinosauri, Cretacico, Italia meridionale.*

Introduction

The Altamura outcrop is the first Southern Italy Dinosaur tracksite and the first signal on the presence of numerous dinosaurs in the area (Nicosia *et al.*, 2000). The tracksite, Late Cretaceous in age (probably Early Santonian, AA.VV., 1999), revealed a large number of middle sized dinosaur trackways most of them, at the moment, ascribed to quadruped herbivorous dinosaurs.

To individuate every studied trackway each one will be marked by a label and positioned on a quarry photo-mosaic. Each trackway is also scheduled by the collection acronym ACDL (Altamura Cava De Lucia) and a mark represented by the year of finding and a progressive number. Each footprint in a trackway will be individuated also by another number indicating the set and a letter "m" or "p" respectively for *manus* and *pes.* (e.g. the below described specimen is marked as ACDL 99/3, the trackway, and the set in Pl. 1, fig. 4 includes the footprints ACDL 99/3-10m and ACDL 99/3-10p).

The study methods are well known in the literature and we simply refer to papers of Leonardi (1987), Thulborn (1990) and Alexander (1976).

The very large number of footprints and trackways and the state of preservation of the printed surface obliged to plane a well timed and separate sequence of preparation and studies; in particular we will have to study a single trackway at once. Fortunately the availability of well-defined trackways allowed to state variability and extramorphologies inside the single taxon. The huge number of long trackways allows us

to try a new way for the ichnosystematics of dinosaurian footprints (see below). After a long time of real oversplitting the ichnosystematics seems at the moment to be paralysed as if the authors were terrified by the enormous variability of taxa. Most of the recent works are just devoted to the definition of environments and behaviours while ichnotaxa present within the outcrops are frequently neither figured nor described. Even if the largest caution needs, this way of thinking makes impossible a correct ichnotaxonomy and the stratigraphical use of the ichnotaxa.

Starting from this new outcrop we decided to change such approach giving rigid definition to the taxa and naming, if necessary, all of them that are really different from already named forms.

The first Altamura ichnotaxon is thus here described. It is represented by a complex of tracks and by a trackway some meters long, probably printed by a medium sized ornithopod. The track-maker is probably to be ascribed to a five meter long and two tons heavy hadrosaurid. The ichnotaxon is here described and named *Apulosauripus federicianus* new ichnogenus and new ichnospecies.

ICHNOSYSTEMATICS

Apulosauripus n. ichnogenus
(type ichnospecies *A. federicianus* n. ichnospecies)

Type level: as for the type ichnospecies.

Type locality: as for the type ichnospecies.

Derivatio nominis: from “Apulia”, the geological domain and “sauripus” a reptile footprint.

Diagnosis: trackway of a quadruped dinosaur, with very low pace-angulation. *Pedes* impressions slightly divergent with respect to the midline (positive rotation) while *manus* are forward directed and parallel to the midline. *Pes* and *manus* both (functionally) tridactyl. *Manus* less than half the size of the *pes*. The *manus* impressions are placed forward and medial to the *pedes*. No tail mark. Trackway relatively broad with a space between the interior margins of the footprints nearly 1/3 of the maximum width (wide gauge). Pace angulation very low both for *pedes* and *manus*. Stride/foot length 4:1.

Remarks: trackway slightly curving, made by at least 13 sets (some other sets are probably present but they are badly preserved and confused among other trackways), among them some are better impressed and show slightly different characteristics (see below for description of the variations).

Anyway if one analyses the literature on quadruped trackways with *manus* and *pedes* tridactyl, it is clearly impossible to ascribe our ichnofossil to a known ichnogenus.

Some footprints ascribed to *Amblydactylus* Stemberg, 1932 can remember the impression of our foot for the relative length of free digits, for the digits not divergent and mostly for the presence of a deeply impressed “heel” (more probably a big callous pad behind the digit impressions).

Comparing with ichnogenera referred to quadruped ornithischian (e.g. *Caririchnium* Leonardi, 1984) the extreme morphological diversity and the strong incongruity about pace-angulation, that in our case is quite low, and the others trackway parameters are evident.

Another datum that is highly contrasting with the existent literature is the constant divergence of the foot with respect to the midline. The divergence present in our trackway might be also due to the curvature, to the extremely slow speed on a muddy soil or to a peculiar gait but it seems too regular to be considered an extra-morphological character. Moreover most of the trackways up to this time ascribed to hadrosaurs have been erected on single tracks (see *Amblydactylus*) or based on biped trackways not comparable with our trackway.

***Apulosauripus federicianus* n. ichnospecies**

(Figs. 1-7; Pl. 1)

Type level: Late Cretaceous (Santonian), Altamura Limestone Formation;

Type locality: De Lucia quarry, Masseria Pontrelli, Altamura (Bari), Italy;



Fig. 1 – *Apulosauripus federicianus* new ichnogenus and new ichnospecies, the trackway ACDL 99/3.

– *Apulosauripus federicianus* icnogenere e icnospecie nuovi, la pista ACDL 99/3.

Material: one trackway of 13 sets and some isolated footprints;

Holotype: trackway ACDL 99/3;

Depository: Museo Archeologico di Altamura; (rubber-casts of three consecutive sets ACDL 99/3-5, -6, -7 and of set ACDL 99/3-10);

Derivatio nominis: from the name of the Emperor Frederic II, that restored the town of Altamura (“Federicus me reparavit” as written in the seal of the town).

Description: trackway of a reptile (Figs. 1-2), quadruped in gait with *pes* and *manus* usually in contact without overlap. *Pes* and *manus* both functionally tridactyl. *Manus* directed forward, *pes* slightly outwardly directed with respect to the midline. *Manus* impressions placed forward and medially with respect to the *pes* impressions. *Manus* half the size of the *pes*.



Fig. 2 – *Apulosauripus federicianus* new ichnogenus and new ichnospecies. Schematic drawing of the trackway interval ACDL 99/3-3 to 99/3-10.

– *Apulosauripus federicianus* icnogenere e icnospecie nuovi. Disegno schematico della porzione della pista da ACDL 99/3-3 a ACDL 99/3-10.

Trackway max width: 80 cm. Oblique pace: *pes* 67 cm, *manus* 74 cm. Stride: *pes* 105 cm, *manus* 103 cm. Pace angulation: *pes* 88°-120°, *manus* 80°-102°. Gleno-acetabular distance: 125 cm. Stride/*pes* length 4:1.

Manus: mesaxonic, digitigrade, functionally tri-dactyl. Angles between the digits: II-III= 60°; III-IV= 64°. Mean length: 14 cm. Mean width: 18 cm. The *manus* is broader than longer. The digits II and IV are roughly equal in length, the digit III, the longest, is prominent than the other ones. Digits are short and stumpy, with bluntly rounded claws and with a U-shaped outline. The proximal part of the footprint shows two asymmetrical lobes, the lateral one is greater and closer to the *pes* than the medial one.

Pes: mesaxonic, semiplantigrade with the impression of the “heel” (sole pad), only the *pedes* of sets 3 and 4 are digitigrade. Angles between the digits: II-III = 99°; III-IV = 71°. Mean length: 25 cm. Mean width: 26 cm. The *pes* is slightly broader than longer. The digits are roughly equal in length, though in some cases the digit III is slightly more prominent than the other ones. The digits are short and stumpy, with rounded hooves, U-shaped in outline. The proximal part of the *pes* is V-shaped. In the central part of the footprint, is present a transversal ridge separating “heel” and digit IV from the II and III. The length and the width of the free portion of the digits are difficult to measure due to the lack of evident pads.

Remarks: The trackway, six meters long in its better preserved portion, is composed by 13 sets. It begins and ends in an irregular way; it is possible to recognise other sets, but after they grow confused in other footprints or simply disappear. For this reason we will consider only the clearly recognisable portion. Thus the following detailed description is related to the portion of the trackway that begins with a set of the right side ,99/3-1, up to the 99/3-13.

Along the trackway, sets 1, 4, 5, 8, 10, 11 show *pes* breaking down the posterior ridge of the *manus* print, while sets 3, 6, 7 show *manus* and *pes* separated of 8-15 cm (Pl. 1, Fig. 1). In set 2 the *manus* is about 20 cm in front of *pes*. Sets 12, 13 are recognisable but the deep fracturing make impossible the description.

In 99/3-1p, -2p, -3p, -4p, -5p and -10p is clearly visible a transverse ridge separating a “heel” from digits (Pl. 1, Figs. 1-3).

One interesting feature is the evident lack of expulsion rims. This is very clear in the sets where the *pes* interferes with the *manus*. In these cases the posterior wall of the *manus* is interrupted but there was no filling of the *manus* cavity as it occurred if there had been a mud displacement.

The sets 2, 3, 4 are more deeply impressed. Here is possible to see the flattening and cracking of the superior lamina; in particular in 99/3-3p (Pl. 1, Fig. 1) is

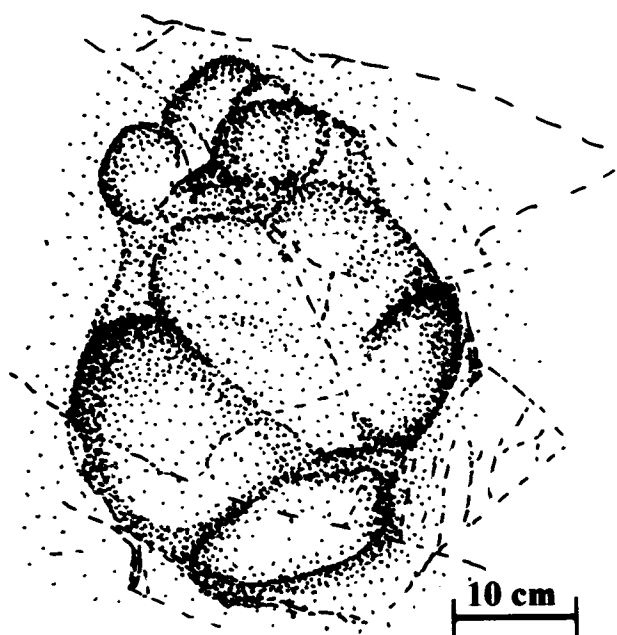


Fig. 4 – *Apulosauripus federicianus* new ichnogenus and new ichnospecies. Schematic drawing of the set ACDL 99/3-10.

– *Apulosauripus federicianus* icnogenere e icnospecie nuovi. Disegno schematico del set ACDL 99/3-10.

mal part. When footprints are well preserved (3p, 4p, 5p, 9p, 10p) is evident a transversal ridge joining the external side to the centre of the footprints and individuating the “heel”.

Discussion: an interesting characteristic of the trackway is a sedimentological feature showing that the footprints are impressed within a single layer of homogeneous fine sand. By the examination of natural breaks in 3p and 4p, corresponding to the points of greater charge is evident that only one layer more than 10 cm thick is thinned and reduced to millimetric thick lamina (Pl. 1, Figs. 1-2) while the underlying bed seems just slightly concave. This feature testifies that while the printed bed was almost plastic the preceding layer was already compacted at the time of printing.

The variability inside our trackway is obviously large and the state of preservation is quite bad, as it is usual for footprints impressed on carbonate sediments; such kind of preservation masks also the real structure of *pes*.

To overcome such problems we drew a synthetic sketch of a set in which are reported all the characters present in more footprints along the trackway; such method ensured a good even if idealised reconstruction of the tracks (Figs. 5-6). On these bases it is also easier to try a classification and a zoological attribution.

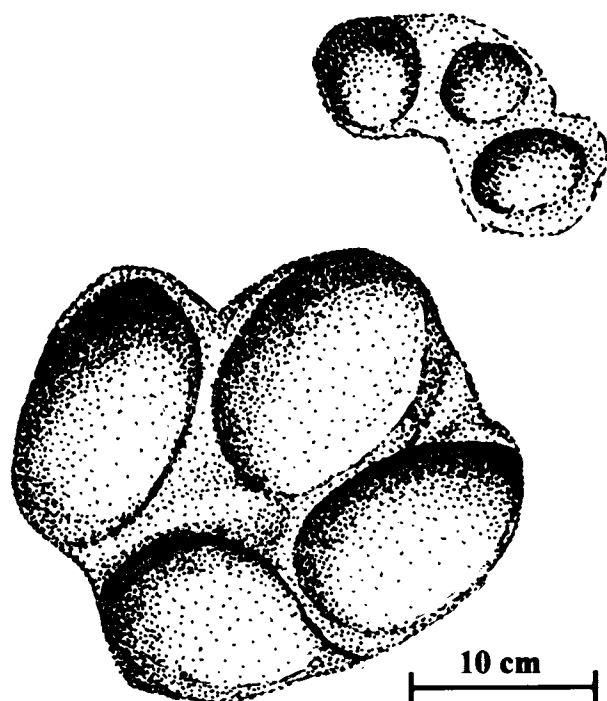


Fig. 5 – *Apulosauripus federicianus* new ichnogenus and new ichnospecies. Idealised synthetic drawing of a left set. The drawn characters are recognised in different footprints and reported on a single set.

– *Apulosauripus federicianus* icnogenere e icnospecie nuovi. Disegno sintetico di una coppia mano-piede. Il disegno riunisce caratteri presenti in varie impronte e in differenti coppie mano-piede in una sola coppia mano-piede ovviamente idealizzata.

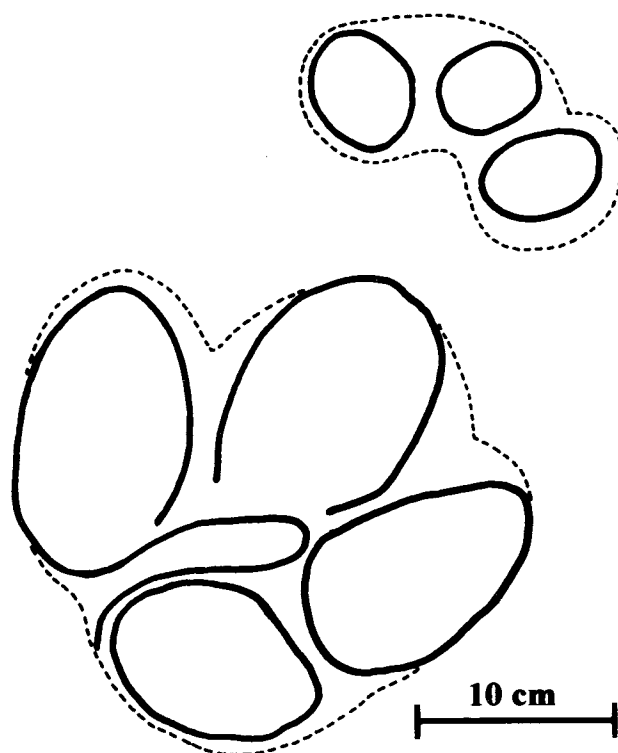


Fig. 6 – *Apulosauripus federicianus* new ichnogenus and new ichnospecies. Set drawn as a simple outline.

– *Apulosauripus federicianus* icnogenere e icnospecie nuovi. Una coppia mano-piede rappresentata schematicamente

From the general resulting structure (*manus* tridactyl and strongly digitigrade, *pes* tridactyl, V-shaped in the proximal part) we were oriented to search a comparison among the trackways ascribed to ornithopods.

In the literature there is a very small number of trackways ascribed to quadruped ornithopods. This lack can be ascribed to the small number of Late Cretaceous outcrops, to the type of gait that perhaps was prevailingly biped in those animals, or simply to the type of preservation or to the chance.

Among the few taxa to be taken into consideration there is *Hadrosaurichnus* Alonso, 1980 that is considered the footprint of a hadrosaur, showing an interesting character in the presence of the "heel", but it is biped and poorly preserved (Alonso, 1980). The same ichnotaxon is reconsidered by Leonardi (1994) as a theropod.

Hadrosaurichnoides igeensis Casanovas Cladellas *et al.*, 1993 has only feet impressions badly preserved and figured (Casanovas Cladellas *et al.*, 1993).

Both the known species ascribed to *Caririchnium* Leonardi, 1984 (*C. magnificum* Leonardi, 1984 and *C. leonardii* Lockley, 1987) differ from our material in shape and dimensions, in the trackways parameters and in the convergence of the *pedes*.

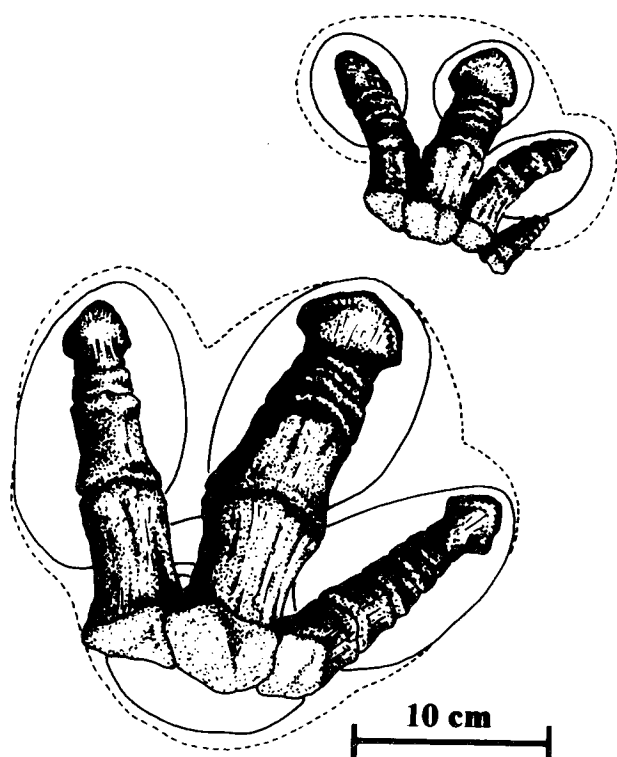


Fig. 7 – Drawing of the bone elements of *Edmontosaurus* redrawn on the idealised outline of a set. Bones are drawn as seen from the above (from Thulborn, 1990, redrawn and modified).

– Le ossa di mani e piedi di *Edmontosaurus*, viste dall'alto, ridisegnate sulla rappresentazione schematica di una coppia mano-piede (da Thulborn, 1990, ridisegnato e modificato).

The trackways figured by Moratalla *et al.* (1992, p. 152, fig. 3) and by Moratalla *et al.* (1994, p. 93, fig. 6), differ from our in trackway parameters, in the convergence of *pedes* and in the digits, very long and divergent.

The trackway figured by Bengoechea *et al.* (1993) differs from ours in all the main characters.

No one of the examined trackway shows so low pace-angulation and never the relative positions of *pedes* and *manus* are the same as in our material. Obviously all these differences as well as the large variability could be ascribed to the walking on a muddy carbonate sediments.

Zoological attribution: the trackmaker must be searched among quadruped animals, functionally tridactyl in *pes* and *manus*. Its glenoacetabular distance was nearly 120 cm, consequently the total length can reach about 5-6 m. The height at the hip was about 140 cm (mean value, according to the method of Thulborn, 1990). The total weight is evaluated between 900 and 1100 kg. Speeds evaluated with the methods of Alexander (1976) and of Thulborn (1990) are respectively of 2 and 3 Km/h, anyway typical of a very slow gait.

According to the data at our disposal, by the simple exclusion of theropods and sauropods and taking into consideration the Late Cretaceous age, it seems correct to ascribe the footprints to a quadruped advanced ornithischian. Our footprints differ also from the ones ascribed to thyreophorans. If we consider that iguanodontids seem to be already extinct at the Late Cretaceous our trackmaker can probably be ascribed to an ornithopod within the family Hadrosauridae. Such attribution seems also validated from the Late Cretaceous widespread world occurrence of this group of dinosaurs and from the recently discovered hadrosaur near Trieste, Italy (Dalla Vecchia, 2000), that is in the same Apulo-Dinaric unit. To test such attribution we redrew the *manus* and *pes* bones of *Edmontosaurus* (from Thulborn, 1990, fig. 6.35, modified) on the outline of our idealised set (Fig. 7).

Dinosaurs at sea-side, an unresolved problem

Fossil dinosaurs were almost unknown from Italy up to 12 years ago (Mietto, 1988). Today this scenario is dramatically changed. Frequent findings of dinosaur footprints and tracksites from Northern Italy (Leonardi & Avanzini, 1994; Mietto & Roghi, 1994; Roghi, 1994), from Tuscany and Liguria (Leonardi & Lockley, 1995; Sirigu & Nicosia, 1995), the beautiful specimen named *Scipionix samniticus* Dal Sasso & Signore, 1998 from near Benevento (Leonardi & Teruzzi, 1993; Dal Sasso & Signore, 1998) and hadrosaurid skeletal remains found near Trieste (Dalla Vecchia, 2000) reveal an unexpected frequency of these

animals on the shores of the "African promontory" (Channel *et al.*, 1979).

The Altamura outcrop, and the signalling of some other sites (not still verified but very reliable) from the Apulian carbonate platform, enlarge up to the southernmost Italy the widespread presence of dinosaurs.

If one considers also the classical sites of the Istrian Platform, areas palaeogeographically connected to the northern Italy (Boscarolli *et al.*, 1993; Mezga & Bajraktarevic, 1999; Leonardi, 2000) the resulting scenario is quite interesting. Today we can list in the Apulo-Adriatic-Dinaric region dinosaur bones and trackways from Late Triassic (Carnian to Norian), from Early Jurassic (Hettangian to Toarcian), from Early, mid and Late Cretaceous (Hauterivian-Barremian, Albian, Cenomanian, Santonian). Thus a continuous presence of dinosaurs (and of the necessary emerged areas) is testified in practice throughout the whole Mesozoic of the Apulo-Adriatic-Dinaric area (Leonardi, 2000).

Indeed in a region that, in the available palaeogeographic models, lacks evident connections with large land masses for thousands of kilometres and in which, with few exceptions, only marine sediments crop out (Dercourt *et al.*, 1993), the finding of terrestrial animals still remains difficult to explain. As a matter of facts the presence of dinosaurs suggests the need of widespread emerged areas, large enough for the pro-

duction of an amount of vegetal biomass sufficient for their feeding. Moreover constantly emerged areas need for nestling of these oviparous animals.

The previously considered marine landscape results thus unrealistic and the present palaeogeographic re-constructions will probably be changed in the next times, also taking into consideration the evident lack of migration ways between the various recognised platform areas, pull apart by deeper basins, and a sure dinosaur homeland.

On the other side the same problem seems to be common along the shores of the Western Tethys (Meyer & Pittman, 1994) and a unitary solution probably will have to consider deep changes in palaeogeographic models but also slight changes in the assumed living styles of dinosaurs.

Conclusions

An ichnotaxon is here described and erected as *Apulosauripus federicianus* new ichnogenus and new ichnospecies. The trackway is considered let by a medium sized ornithopod. Indeed the track-maker is probably to be ascribed to a six meter long and two tons heavy quadruped hadrosaurid. The finding of dinosaur footprints in southern Italy reveals unexpected scenarios along the shores of the Tethys Ocean.

SOMMARIO

In questo lavoro viene descritto un nuovo ichnotaxon di dinosauro quadrupede e funzionalmente tridattilo nel piede e nella mano, rinvenuto nel sito a impronte di Altamura (Cretacico superiore, Italia meridionale). Esso viene denominato *Apulosauripus federicianus* nuovo ichnogenere e nuova ichnospecie ed è riferibile ad un ornitopode avanzato, probabilmente un hadrosauride di taglia media.

Sono anche appena evidenziati i problemi di paleogeografia connessi alla presenza di dinosauri in sedimenti marini in tutto il Mesozoico del blocco Apulo-dinarico.

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PLATE

PLATE I

Apulosauripus federicianus new ichnogenus and new ichnospecies.

The light comes from the direction of the point of the chisel. Chisel length 19 cm.

Fig. 1 – right set 99/3-3, see thinning and cracking of the lamina;

Fig. 2 – left set 99/3-4, still evident thinning and cracking of the lamina at the point of maximum charge;

Fig. 3 – right set 99/3-5;

Fig. 4 – left set 99/3-10, very evident the transverse ridge.

TAVOLA I

Apulosauripus federicianus icnogenere e icnospecie nuovi.

La direzione di provenienza della luce è rappresentata dalla punta dello scalpello. Lunghezza dello scalpello 19 cm.

Fig. 1 – coppia mano-piede destra 99/3-3, sono evidenti l'assottigliamento e la rottura della lamina superiore;

Fig. 2 – coppia mano-piede sinistra 99/3-4; anche qui sono evidenti l'assottigliamento e la rottura della lamina superiore al punto di massimo carico;

Fig. 3 – coppia mano-piede destra 99/3-5;

Fig. 4 – coppia mano-piede sinistra 99/3-10, è ben visibile la cresta trasversale.

