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Theropod (Reptilia, Dinosauria) footprints in the Albian (Lower Cretaceous) of the Quieto/Mirna river mouth (NW Istria, Croatia) and dinosaur population of the Istrian region during the Cretaceous

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ABSTRACT - Theropod (Reptilia, Dinosauria) footprints are described from Albian (Lower Cretaceous) limestones of Quieto/Mirna river mouth (Istria, Croatia). Sedimentology and paleoenvironments as shown by the outcrop are considered. All available data about the presence of dinosaurs in Istria during the Cretaceous are reported.

RIASSUNTO - Vengono descritte delle impronte di dinosauro teropode provenienti dai calcari albiani (Cretaceo inferiore) della foce del fiume Quieto/Mirna (Istria, Croazia). Vengono considerate la sedimentologia e le condizioni paleoambientali testimoniate nell'affioramento. Sono riportati tutti i dati disponibili sulla presenza dei dinosauri in Istria durante il Cretaceo.

K e y w o r d s: Ichnology, Dinosauria, Theropoda, Albian, Lower Cretaceous, Carbonate sedimentology, Istria, Croatia.

INTRODUCTION

The presence of dinosaur footprints in an area at the mouth of Quieto/Mirna river (NW Istria; Fig.1) has long been known to fossil collectors but not to paleontologists and it has not been adequately documented in the paleontological literature. Calligaris (1988) is the only one who reported on, very briefly, this subject. This situation led to the removal of nearly all the footprints on the part of fossil sellers before it were possible to scientifically describe them *in situ*. The "not large in size theropod footprints from an unspecified area in Istria" which are kept at the Museum of Natural History of Milan, as Leghissa and Leonardi (1990, p. 12) reported, are very likely to belong to this outcrop. As Leghissa and Leonardi said "the person who offered the samples to the Museum refused to provide their localization" (p. 12) which, however, according to various sources collected in Trieste, was the mouth of Quieto/Mirna river. In addition to this, both shape and size of the footprints as well as the appearance and the thickness of the layer correspond. One of these footprints has been illustrated by Pinna (1985, p. 208). The photographs taken by one of us (A. Tarlao) are currently the only evidence of the better preserved trackway - and of another one intersecting it - (Fig. 2). Two single footprints from this fossiliferous level but from different trackways, and now available for investigations, will be described below.

F.M. Dalla Vecchia dealt with the paleontological part, A. Tarlao collected the specimens as well as some data on the field, G. Tunis dealt with both sedimentology and stratigraphy of the outcrop.

Since the Istrian region is bilingual, both Italian and Croatian names have been reported, when available, for each locality.

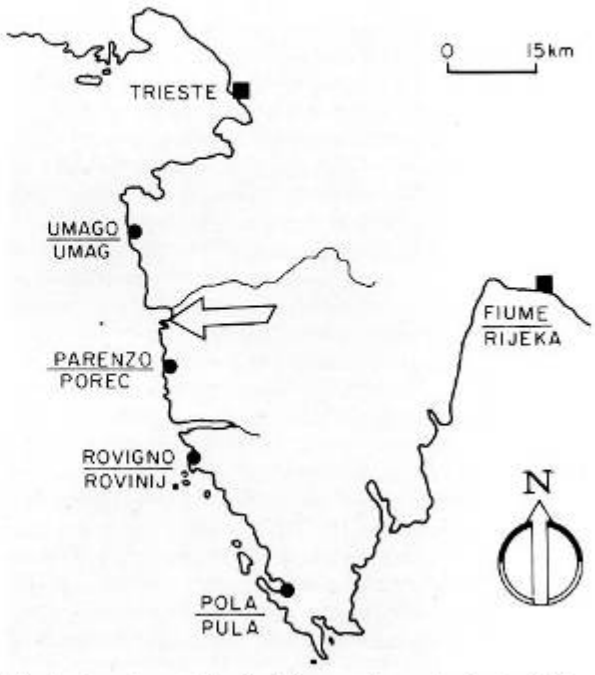

Fig. 1 - Location of the fossiliferous site at the Quieto/Mirna river mouth.

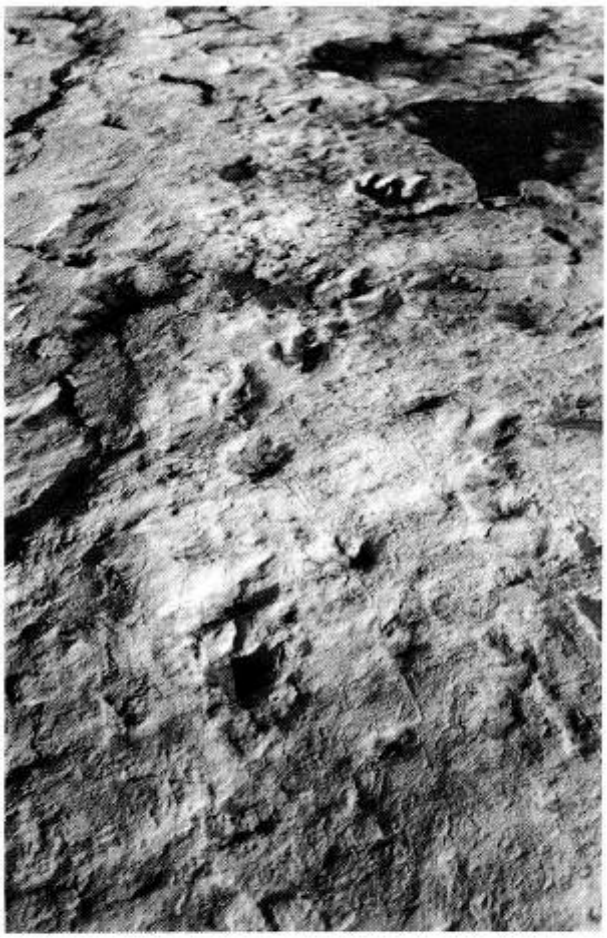

Fig. 2 - The main trackway, now completely removed. The footprint of the Tarlao collection belonged to this trackway.

PALEONTOLOGICAL DESCRIPTION

One footprint of the main trackway which had not been removed by fossil sellers was collected by one of us (A. Tarlao) in 1977, thus preventing it from being lost (sold or distroyed), and it is now part of his personal collection. The footprint is available to anyone interested to study it. It is preserved on a yellow limestone slab 27 x 27 x 2.5 cm in size. The footprint (Figs. 3, 4A) is tridactyl, mesaxonic, with a median digit much longer than the two outer ones. Its length, as measured from the hind end of the "heel" to the preserved end of the median (III) digit, is 225 mm; its maximum width, as measured between its outer digits, is about 130 mm. The preserved part of the digit III is about 145 mm long and the two outer digits are about 95 mm long. The digit III becomes abruptly narrower on its distal end and presents here a pointed shape. The terminal point, corresponding to the claw track, is not complete because of a fracture in the slab. The maximum width of the digit (48 mm) is reached in correspondence to the point where the other two digits end. The outer margin of the left outer digit, which appears to be better impressed than the right one, is slightly inwardly bowed but the digit impression is actually straight. Its maximum width is about 35-38 mm. The track of right outer digit presents the same width of the left one and is outwardly bent. Both outer digits diverge a little being almost parallel to the axis of the digit III

Fig. 3 - The footprint of the Tarlao collection *in situ* before its removal. (x 0.2).

(each outer digit forms with it an angle of about 10°). There is not any evidence of claw track on the right outer digit. May be a very light claw impression, more evident in the picture of the footprint before its removal, can be seen on the left digit. No pads are clearly visible though the "plantar" part of the digits was rather swelling. However, the silicone rubber mould shows the presence of some particularly evidentiated areas (Fig. 4A). The track of the "heel" is quite visible especially on the left side but it is markedly less impressed than the anterior part of the pes; on the right side there is not a marked track of the "heel" but a shallow, elongated and backwardly oriented furrow, probably due to the dragging of the pes. Alternatively, it might be the track of the digit I, usually smaller

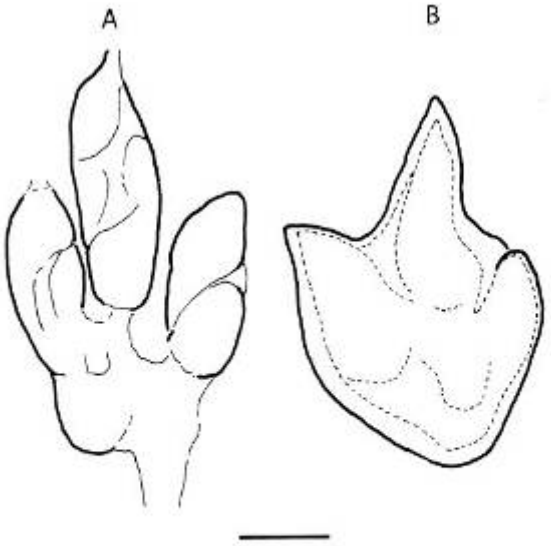

Fig. 4 - A) Drawing of the footprint of the Tarlao collection. B) drawing of the footprint from the Speleovivarium of Trieste. Scale bar: 5 cm.

and backwardly oriented, especially in Theropoda; in this case the described footprint would be the impression of the left pes, the left digit would be the digit IV and the right digit would be the digit II. To support the belonging of the footprint to the left pes there are also position and shape of the "heel" and the outward bending of the right digit (see Haubold, 1971, Figs. 40, 41, 47). Between the left digit and the apex of the "heel" there is a weak indentation. A clear displacement rim of the waterlogged substrate can only be observed on the left side of the footprint. In this part of the foot impression the maximum depth is 20 mm whereas, on the opposite side, the maximum depth is about the half of this value. This, along with the furrow left by the left part of the "heel", might suggests that the pes leaned on the left side and anteriorly. If it were the print of the left pes, this would be compatible with a slightly swinging lateral movement of the body related to the running of the animal, with a higher anterolateral pes support. In order to better understand and confirm our speculations it would have been necessary to observe the footprint *in situ* along with the other ones left by the same animal. Currently this is not possible because the removal and dispersion of the footprints.

The general morphology of the described track, the comparatively elongated digits, the presence of claws, the low interdigital angle and size, allow us to ascribe it to a medium-sized theropod dinosaur (Haubold, 1971; Leonardi, 1984, 1989; Pittman, 1989). As previously observed, Leghissa and Leonardi (1990) had come to the same conclusion regarding the footprints kept at the Museum of Natural History in Milan.

A large slab with a footprint exposed at the Speleovivarium of Trieste was submitted to us to be described (Fig. 5). This footprint is tridactyl, mesaxonic, with the digit III markedly longer than the outer ones, and is smaller than the one described above since it is 205 mm long. It belong then to a different trackway and to a slightly shorter in size individual. Though the footprint is well evident because it is quite deeply impressed in the sediment, its state of preservation is not good. The outline of digits is not easily identifiable, especially along the inner margins of outer digits. Its width, as measured from one distal end to the other of the two lateral digits, is 140 mm and, in its central part, it is 20 mm deep. The angle of divergence between digit III and the outer ones is about 30° for the left one and about 15° for the rigth one. A drawing of this footprint (Fig. 4B) has been reported together with that of the other described track, to allow a direct comparison of the two. The digit III is pointed at the end but a claw impression is not clearly distinguishable; also the left digit is pointed at the end. The latter is outwardly bent. On the left margin of the footprint there is a slight indentation just distal to the apex of the "heel". The two above-mentioned characteristics are typical of the theropod footprints of Early Cretaceous age described by Pittman (1989). According to this Author, the footprint in question would belong to the right pes as the outwardly bent digit is usually the medial (II) one. The comparison with the tracks illustrated by Pittman (1989) and Haubold (1971) permits to regard the attribution to theropods as likely also in this case. There are, however, some doubts, mainly due to the high angle of divergence of the left digit and the low slenderness of the outer digits. Alternatively, it might be the track left by a small bipedal ornithischian. Sometimes it is very hard to distinguish between footprints belonging to small theropods and those belonging to small biped ornithischians (Leonardi, 1984). Another tridactyl footprint which was removed by fossil sellers seems to testify the presence of ornithischian tracks in the same surface. This print is nearly as wide as long, digit III is stocky and relatively short, lateral digits are short and stocky too, the angle of divergence between digits is relatively high. However, currently we can observe these features only on a photograph (Fig. 6).

On visiting the outcrop where footprints were collected, currently placed within a camping site, it was possible to identify what is left of the fossiliferous level. Three tridactyl footprints, very badly preserved, were identified here which have "survived" *in situ* just because of their bad state of preservation. Two tracks belongs to the same trackway, are in succession and are WSW directed; the

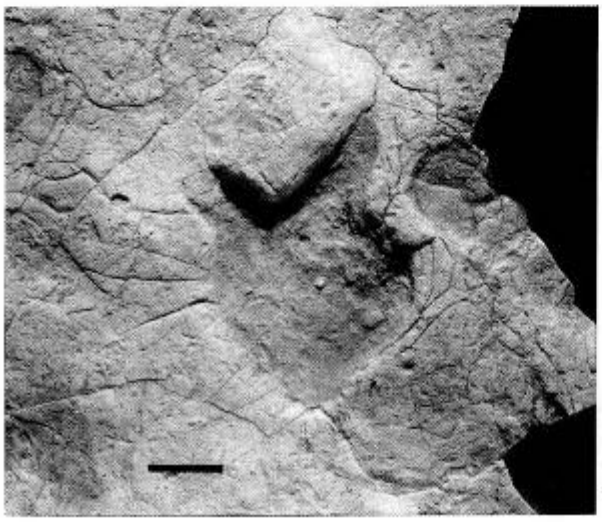

Fig. 5 - The footprint of the Speleovivarium of Trieste. Scale bar: 5 cm.

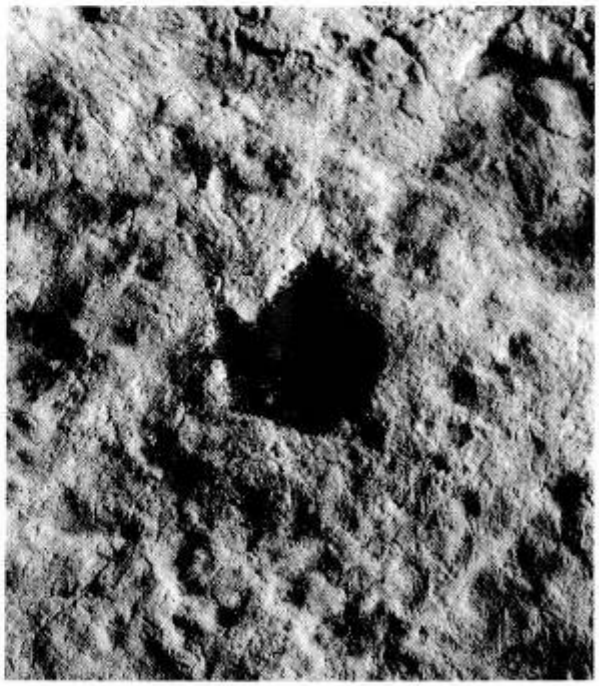

Fig. 6 - The single footprint perhaps impressed by a bipedal ornithischian, before its removal (about x 0.15).

third one is single, nearly parallel to the others but oriented to the opposite way at a distance of about 1.8 m (Fig. 7). This one (Fig. 8A) is 210 mm long with a very elongated digit III (115 mm). The print of the left outer digit is loosely impressed and pratically unrecognizable. The track of the right digit is very wide at its base but tapers rapidly becoming pointed at the apex. The angle of divergence is low (about 15°). The right part of "heel" impression is recognizable which has an indentation between his apex and the right lateral digit. The hindmost of the two consecutive footprints is partially preserved (Fig. 8B); there are the impressions of the pointed ends of the lateral digits and most of the digit III print. The preserved portion is 120 mm long and the digit III is about 105 mm

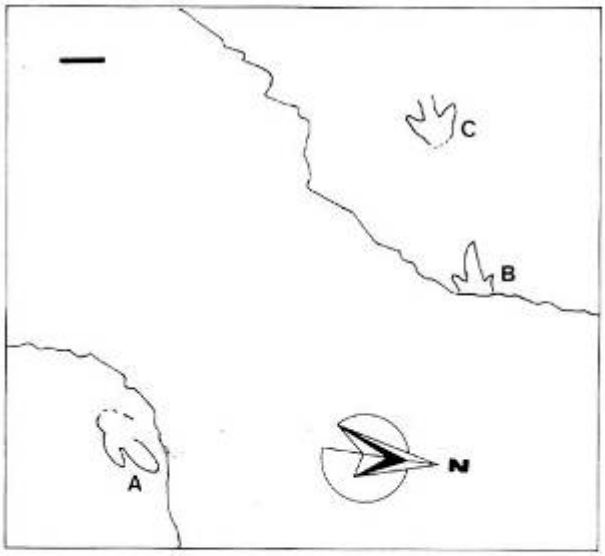

Fig. 7 - Drawing of all the footprints still present in the outcrop (A, B and C = see Fig. 8). Scale bar: 10 cm.

long. The distal part of the latter is bent towards the right. The angle of divergence of the outer digits to the digit III seems relatively high (about 28°- 35°). The distal part of digit III in the subsequent footprint is not impressed and its lenght cannot be therefore accurately measured (Fig. 8C). The preserved part of the footprint is 165 mm long, measuring 107 mm in lenght from the apex of the outer digits to the "heel"; at the distal end of the lateral digits it is 103 mm in width. The impressions of the two outer digits are pointed but rather short and stocky; the interdigital angle (II- III and III-IV) is 25°-28°. The distance between the points of the two right outer digits (oblique pace) is 56 cm. The longitudinal axes of the two footprints are pratically on the same straight line and the oblique pace is therefore coincident with the pace.

As for its general outline and interdigital angle, the single track is similar to the previously described footprint of the Tarlao collection and is attributed to a medium-sized theropod. The other two footprints are similar in size and in the relatively high angle of divergence to the track from the Speleovivarium and therefore the same conclusions can be drawn on them as those previously reported for the latter.

SEDIMENTARY ENVIRONMENT AND AGE OF THE SEQUENCE

A continuous and detailed sampling of carbonate rocks was performed along the short outcropping section (about 120 cm thick) where the dinosaur footprints can be observed (Fig. 9). The purpose of this work was to describe the sedimentological features occurring immediately before and after the episode characterized by the presence of dinosaurs.

The analysis of the thin sections (4.5 cm large) point out shallow marine platform carbonates deposited in subtidal, intertidal and also supratidal environments. Predominant facies are thin bedded pelletal mudstone/wackestone and fossiliferous wackestone/packstone typical of intertidal to shallow subtidal environment. As for this fenestral fabric and rare vadose structures are very significant. The lower part of the examined section (sample A, B, C; 10 cm) is mainly composed of intertidal to supratidal limestones: these can be assigned to a very restricted environment which exhibits the alternation of intertidal to supratidal sediments. Strangely, the layer containing the footprints (sample D) gives evidence of the "relatively" more open environment within the entire section. The overlying three

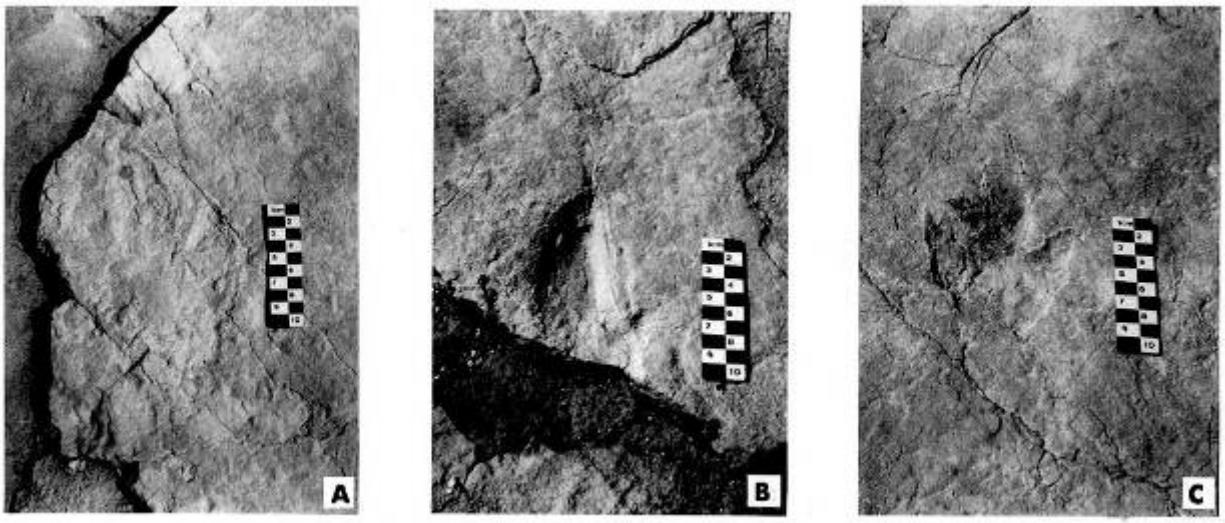

Fig. 8 - The footprints still *in situ* seen individually: A) single footprint; B) posterior footprint of the trackway; C) anterior footprint of the trackway. Scale bar: 10 cm.

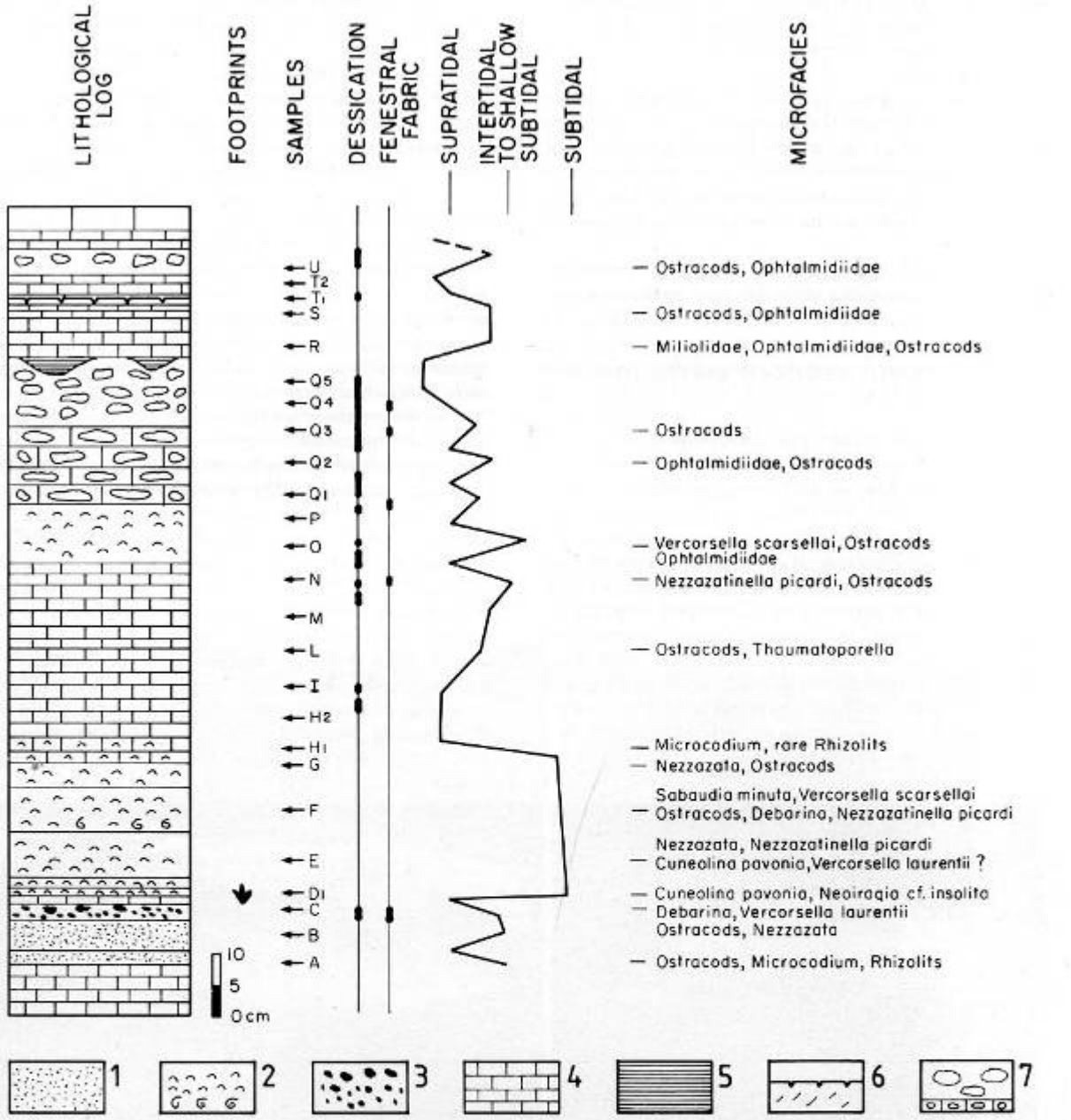

Fig. 9 - Lithology and evolution of sedimentary environments at the outcrop of Quieto/Mirna river mouth. 1) Pelletal limestone; 2) fossiliferous mudstone- wackestone- packstone, sometimes with fragments of bivalves; 3) packstone- grainstone; 4) mudstone-wackestone; 5) clay; 6) desiccation breccia and cracks; 7) emersion breccia (flat pebble) and breccia-like limestone.

layers (sample E, F, G; globally 18 cm thick) are also subtidal limestones.

Probably, the preservation of the footprints is related to this small transgressive event. The link with sea level fluctuations and tracks preservation needs to be tested in the other tracksites.

Owing to the presence of *Vercorsella laurentii, Nezzazatinella picardii, Sabaudia minuta, Vercorsella scarsellai, Debarina* sp., *Cuneolina pavonia parva* and *Neoiraqia* cf. *insolita,* the age can be dated back to the lower part of Late Albian. In particular, *Neoiraqia* cf. *insolita* was identified on the surface with footprints.

Above the level with dinosaur footprints a tendencing shallowing upward microcycle (23 cm thick; sample H1, H2, I) is characteristic. Herein *Microcodium* and rhizoturbation have been observed as well desiccation features are evident at the top of layer I. Other three very short cycles with alternation of intertidal and supratidal limestones occur. The rhythms of shallowing-upwards short sequences are composed by biomicrite, pelletal or weakly skeletal (ostracods, benthic foraminifers) wackstones, wackstone characterized by fenestral fabric and rare vugs filled with vadose crystal silt, and also by intraformational breccia (desiccation breccia, desiccation cracks or erosional features).

Desiccation cracks on the surface of fenestral limestone, intraformational breccia with clayey matrix and a thin discontinuous layer of greenish clayey marl appear

near the top of the section (Q2, Q3, Q4). The breccia consists of poorly sorted, big in size angular fragments or pebbles of pelletal and fenestral limestones from the next underlying beds.

According to Tišljar *et al.* (1983), sporadically and locally more or less marked emergences of the carbonate platform occurred at the end of the Late Aptian as well in the lowermost Albian. The layer of emersion breccia with marly and clayey matrix documents that these environmental conditions occurred also in the lower part of the Late Albian.

Above the layers characterized by temporary emersion, shallow marine carbonates point out once again a restricted and peritidal environment (sample R, S, T1, T2).

DINOSAUR POPULATION OF ISTRIA DURING THE CRETACEOUS

The medium-sized theropod footprints described in this paper contribute to increase both the taxonomic diversity and the geographic and stratigraphic distribution of the dinosaurs which had populated Istrian region. This abundance of dinosaur evidences has not been recorded in the specialized literature: it is to be noted that the latest compendium on Dinosauria (Weishampel *et al.*, 1990) reports simply the presence of "Theropod footprints" from the "Neocomian" of Croatia and mentions as the only reference a study by Bachofen-Echt (1925b) (see Weishampel, 1990, p. 104). Most informations about dinosaur tracks in Istria has been briefly reported in sedimentological, stratigraphic or divulgative papers. The result is that the knowledge of Istrian dinosaurs is characterized by some confusion. Therefore we thought it would be necessary to shortly report what has already been published in some journals which are difficult to be found, poorly distributed or linguistically hard to understand.

Bony dinosaur remains were found in ?Lower Barremian limestones around Rovigno/Rovinij (SW Istria) (Boscarolli *et al.*, 1993). There are vertebrae, rib fragments, part of an ilium, of a scapula and of the long bones of the limbs as well as several other unidentified bony fragments, belonging to different individuals (Fig. 10) (Dalla Vecchia, in prep.). Differently from the sites with dinosaur tracks, these limestones do not seem to be deposited in a marine tidal environment but, probably, in a lacustrine environment (Venturini, pers. com.).

Large tridactyl tracks (25-35 cm long) of Late Barremian age (see Velić and Tišljar, 1987) and belonging to more individuals, are present on the Salsa/Pogledalo Promontory of the main Brioni/Brijun island (SW Istria), next to Barbana/Barban promontory. These footprints have been only recentely discovered; they have never been described but only briefly mentioned and, partly, photographically documented (see, for example, Velić and Tišljar, 1987 and Ferrari, 1992). One of the Authors (Dalla Vecchia) made a brief excursion on this locality at the beginning of April 1993 without having the possibility, however, to carry on a detailed survey of the footprints. They present comparatively elongated and thin digits provided with claws, with the digit III longer than the outer ones and usually low interdigital angle (Fig. 11A-D). Sometimes, one of the two outer digits has an outwardly bent distal ending (Fig. 11A; 12)(the medial digit, according to Pittman, 1989, p. 145) and an indentation just distal to

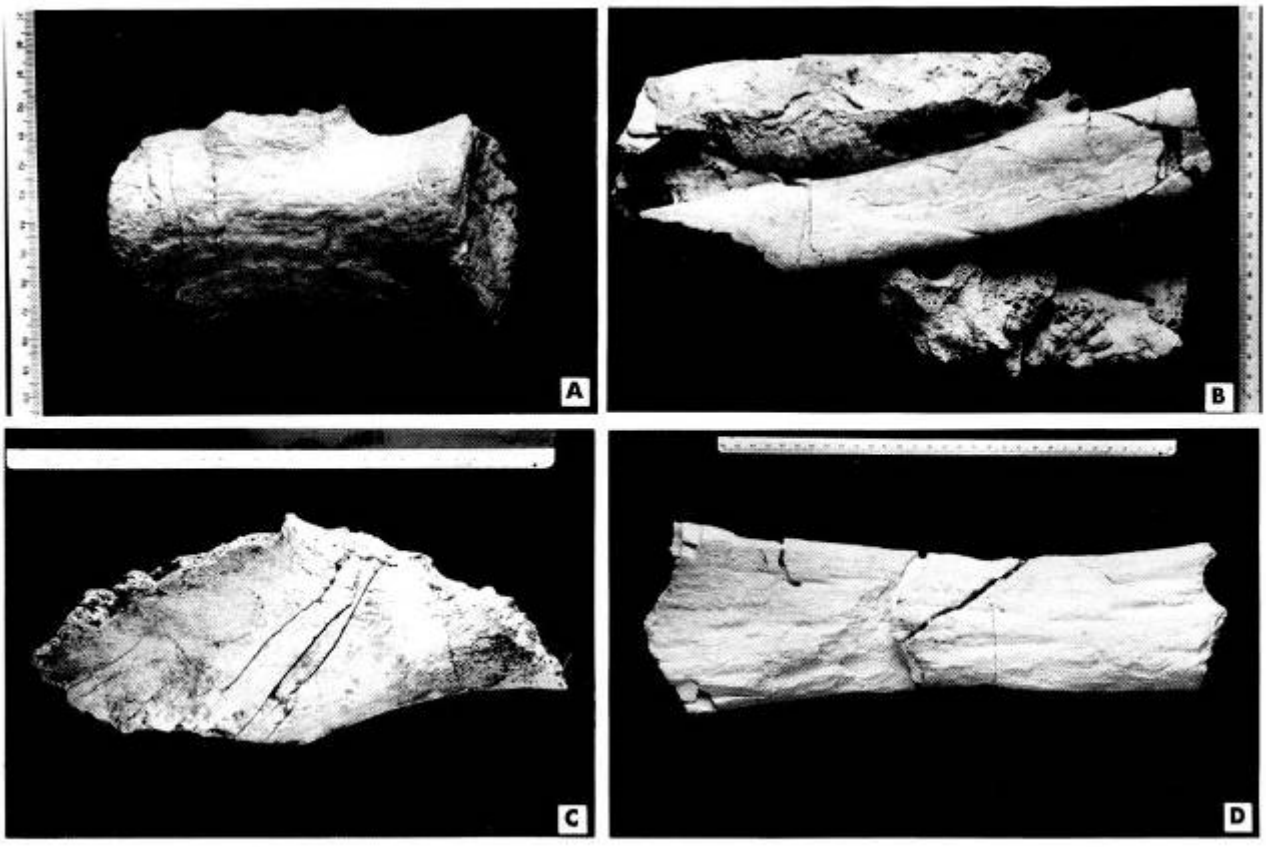

Fig. 10 - Bony remains of dinosaurs (?Lower Barremian, near Rovigno/Rovinij). A) caudal vertebra; B) dorsal rib fragment; C) part of ilium; D) part of long bone of the limbs. The scale bar is centimetric; its complete lenght is 30 cm.

the apex of the "heel" (Fig. 11B).The tracks are deeply impressed and, in some cases, much deformed, probably because of the high amount of water in the original carbonate mud. Sometimes there is not the impression of the "heel" (Fig. 11C-D). Only two footprints clearly belong to the same trackway (Fig. 12).

On the main Brioni/Brijun island there are also the tracks discovered by Bachofen-Echt (1925a,b) and mentioned by Weishampel (1990). They should be placed next to the Rocca promontory ("Kap Rocca", Bachofen-Echt, 1925b), "utmost projection of a south-oriented peninsula". It can be referred, from the Author's indications, that the fossiliferous layer is a quarry basal bed. It was not possible to surely identify what Bachofen-Echt defines Rocca promontory and the location of the fossiliferous outcrop remains uncertain. The layers containing the tracks might also have been removed or ruined. The description by Bachofen-Echt mentions many single, deeply impressed footprints and trackways. The better preserved trackway was composed of 5 tridactyl footprints, each being 26 cm long and 19 cm wide; the pace length was 96 cm. The footprints were placed next to the axis of the trackway and the "heel" was deeply impressed. Surprisingly, the impression of a web linking the digit II point to that of digit III was observed by Bachofen-Echt. However, by analogy with similar structures observed in other dinosaur tracks, very likely this "web print" can be considered a sedimentary structure (Leonardi, pers. com.). Therefore, it is not related to the morfology of the foot of the dinosaur. Another trackway was found which was almost parallel to this one and composed of 5 smaller tridactyl footprints. On the same layer surface many other trackways were presents (even formed by 10 consecutive tracks) which crossed one another and, according to Bachofen-Echt, had been impressed by 5-7 different, varying in size individuals. The smallest track was 13 cm long and 8 cm wide, the largest was 33 cm long. Pace length of the smallest individual was 40 cm, that of the largest one was of 140 cm. The German paleontologist identified also on this same surface but on other layers too, some short, wide tracks with the impression of 5 nails, which seemed sometimes to overlap. The better preserved track was 14 cm long and 15 cm wide.

Bachofen-Echt ascribed all the tridactyl footprints to *Iguanodon*. It should be noted that when the communications on Brioni/Brijun dinosaur tracks were written, Ichnology was still going through a pioneering phase and almost all the large tridactyl footprints were indiscriminately attributed to *Iguanodon* (see Delair, 1989). Leghissa and Leonardi (1990) and the already mentioned Weishampel (1990) believe, according to what can be inferred by the illustrations made by Bachofen-Echt (1925b), that

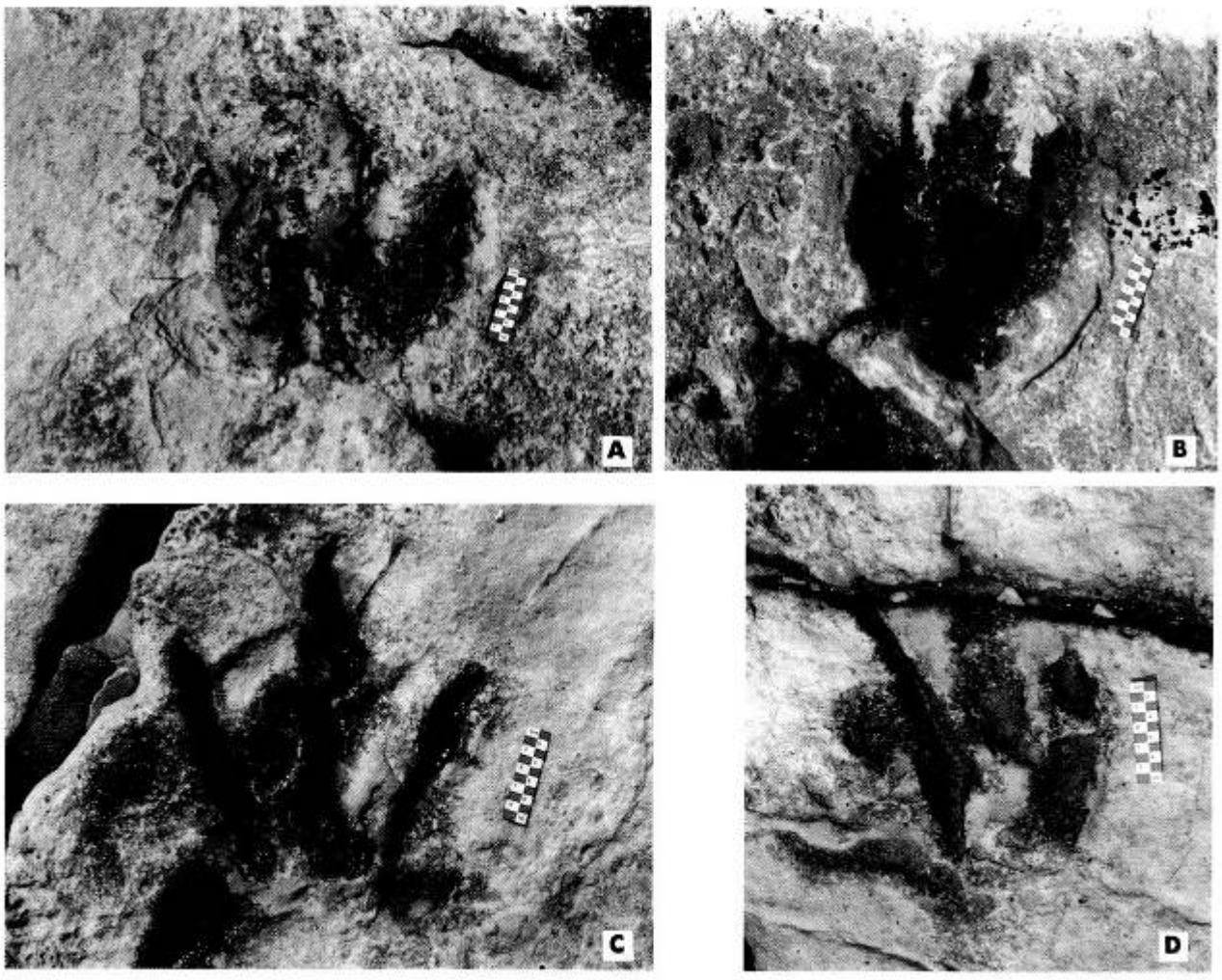

Fig. 11a-d - Footprints of large theropods outcropping along the coast of Salsa/Pogledalo promontory, main Brioni/Brijun island. Upper Barremian. Scale bar: 10 cm.

Fig. 12 - The fossiliferous surface of Salsa/Pogledalo promontory with the more evident trackway. Upper Barremian. Scale bar (to the left of the main footprint): 10 cm.

the footprints belong to theropods. This seems to be the most likely attribution. The German paleontologist attributed, on baron Nopcsa suggestion, the circular tracks to large turtles. Leghissa and Leonardi (1990) point out the similarity with tracks left by sauropod dinosaurs. Of course, in order to make a correct identification of these tracks an *in situ* detailed study should be necessary.

The age of the trackways is indicated by Bachofen-Echt as "Neocomian", since he believed that the whole main Brioni/Brijun island had been formed by rocks deposited during this time span. Leghissa and Leonardi (1990), on the basis of the Carta Geologica d'Italia, Foglio 77A (1935) corrected the dating in Lower Cenomanian. Recent studies (Velic´ and Tišljar, 1987) date the limestones of this island to Barremian and to Albian, with a limited presence of Lower Aptian. It would be possible to know if the tracks described in 1925 are Barremian or Albian only by identifying with certainty the Rocca promontory.

Always on the main Brioni/Brijun island some dinosaur tracks are present in two different levels of Early Albian age (Polšak, 1965; Velic´ and Tišljar, 1987; Velic´ *et al.*, 1989). These levels outcrop in two different localities of the southern part of the island, next to Ploče promontory (Baia di Laura) and to Plješivac promontory. About the former site the literature mentions few data, whereas about the latter we only know that there are "reptilian footprints" in it. Polšak (1965) ascribed, with some doubts (see the explanation of plate 1), some of the tracks of Ploče promontory to *Iguanodon,* basing its attribution on the work by Bachofen-Echt (1925b). In Polšac opinion there were two types of track, belonging to "different animals" (p. 493). The Authors who later on described, always briefly, these prints have always agreed with the interpretation provided by Polšak. They too evidentiated the presence of two "different species" (Velic´ and Tišljar, 1987, p. 165). The only illustration of these tracks was provided by Polšak (1965, Pl. 1, Fig. 1). It is a tridactyl footprint probably 25-30 cm long, with the outer digits forming a relatively low angle of divergence to digit III, and with a rather elongated "heel" print. Unfortunately, the elongation of the digit III, as well as the presence of claws, cannot be established on the only basis of that photograph. However, the attribution to a theropod dinosaur is once again plausible. Other data on the outcrop of Ploče promontory are contained in a recently published divulgative paper (Ferrari, 1992). The outcrop is a dismissed quarry with extended and rich in tracks layer surfaces exposed. The outcrop features well correspond with those described by Bachofen-Echt regarding the Rocca promontory outcrop. Rocca promontory might be then the same place as Ploče promontory. However, according to Ferrari, here the tracks are always single and "never grouped together to form trackways" (p. 131).

In the near-by islet of Fenoléga (near Promontore/Premantura promontory) several tracks can be found which have been attributed to the Lower Turonian or to the Upper Cenomanian (Gogala, 1975; Gogala and Pavlovec, 1978; Leghissa and Leonardi, 1990; Paunovic´, 1983; Tišljar *et al.*, 1983). The latter dating is the more plausible.Tišljar *et al.* (1983) ascribed an about 20 m long trackway composed of circular -elliptical tracks to a ornithopod or a carnosaur dinosaur on the basis of the works of Gogala (1975) and Gogala and Pavlovec (1978). These Authors, however, did not provide a detailed description of the tracks. Recentely, Leghissa and Leonardi (1990) have attributed the trackway to a sauropod dinosaur, which is certainly more correct, since the trackway was clearly impressed by a quadrupedal animal (Fig. 13). Next to this trackway, on the same layer surface, there are other trackways composed of tridactyl footprints, smaller than the previous ones, attributed by Tišljar *et al.*. (1983) to coelurosaurs, more precisely to the family Ornithomimidae (p. 29).

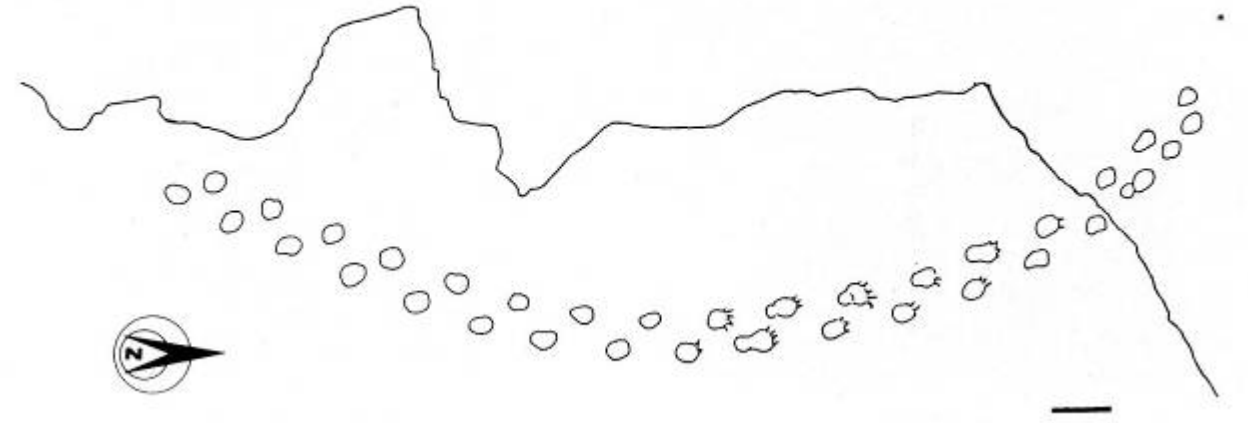

Fig. 13 - The sauropod trackway of the islet of Fenolega (Upper Cenomanian). After Leghissa and Leonardi (1990), modified. Scale bar: 1 m.

These tracks were noted also by Leghissa and Leonardi (1990) who identified them, however, as belonging to "perhaps younger" sauropods (p.12). One of us (A. Tarlao), who had visited the islet, confirmed their presence and their probable identification as medium-small size theropod footprints. However, the attribution to a given family is risky in the light of the present knowledge on Theropoda. Because of the poor distribution of the study by Leghissa and Leonardi, we report the parameters of the main (sauropod) trackway: "pace angulation M 96°; stride M 117 cm, oblique pace about 80 cm; external trackway width about 90 cm; internal width M 20 cm, with positive values; gauge M 47 cm. The sets nearly always are in total overlap, that is to say the foot covers up completely the hand; sometimes it looks as if there were overstep with marginal overlap. the greatest length of the set in the later case is about 72 cm. The manus is considerably smaller than the pes; about 1/2 as area; morphological details are not known. The hind footprints are slightly elliptical (40 x 30 cm); they give sometimes, particularly in the central part of the trackway, the impression of sharp and pointed toes. The toe I seems always clearly directed medially, that is rather rare in this type of footprints; toes II-III-IV are directed forwards with a low digit divarication; toe V is small, without nail and directed laterally, nearly backwards." (p. 6). Leghissa and Leonardi (p. 16) seem to be inclined to attribute the tracks to a form similar to *Camarasaurus*.

Finally, Boscarolli *et al.* (1993) reported the presence of dinosaur tracks also in the Senonian of Southern Istria, which is still to be adequately verified.

The observations made by one of the Authors (A. Tarlao) induce to think that there may be dinosaur tracks and trackways in many other Istrian localities.

CONCLUSIONS

The presence of dinosaurs has been therefore evidentiated along nearly the whole Istrian coast and for almost the whole Cretaceous (Fig. 14). Sauropods, small and large theropods and, perhaps, bipedal ornithischians are represented in this fossil record. Large terrestrial animals were, then, customary goers of the tidal flats and the shoals of the Istrian part of the Dinaric carbonate platform. In Southern Alps dinosaur tracks are present in a similar paleoenvironmental context in the Norian Dolomia Principale Fm. of Pelmetto Mt. (Mietto, 1988) and in the Liassic Calcari Grigi Fm. of Rovereto (Leonardi and Lanzinger, 1992). The relative abundance of signs of the presence of dinosaurs in Istria induce us to believe that tidal flats and coastal areas constituted for long timespans the margins of an extended land, provided with vegetation and fresh water to support a population of large animals. The identification and delimitation of this extended land, which has not been up to now recognized as such but hypothesized, only recentely, just on the basis of the presence of large reptiles (Leghissa and Leonardi, 1990; Tišljar *et al.*, 1983), along with a review of the paleogeography of the so-called African Promontory (Apulia or Adriatic microplate) might be the object of future research on this subject. The provenance of Istrian dinosaurs (from the North or from the South?), detectable through the study of their similarities to known faunae, might be investigated by studying above all the bony remains.

The trackways of Istrian dinosaurs can be identified because the layers containing them outcrop along the coastline where the wave action does not allow the formation of a soil and the covering with vegetation. The subhorizontal position of layers allows the exposition of wide, easily detectable surfaces. These factors are fundamental for the retrieval of fossil tracks; as a matter of fact, though the outcropping of the same layers in the inner regions of Istrian peninsula, dinosaur tracks have never reported in them. If there had not been now a coastal line, the fossil record of Istrian dinosaurs would have never been discovered. One would wonder then about the extent of ichnologic evidence hidden in regions geologically similar to Istria - mainly as far as Lower Cretaceous is concerned - for istance, Julian and Carnic Pre-Alps.

The preservation of tracks on the sea shore has also considerable disadvantages: the works aimed at preparing the coastal areas for touristic purposes and the very presence of thousands of tourists led and will continue to lead to the deterioration or removal of the tracks. Wave action, with all the related phenomena, determines their erosion and corrosion as well as the biological aggression of the part of algae and molluscs. The protection or a detailed survey and casting of the dinosaur tracks is therefore absolutely necessary before they are irremediabily ruined or definitively cancelled.

While printing this article, G. Tunis and S. Venturini collected new data which show that the bony remains found south of Rovigno/Rovinji are possibly of Early Albian age.

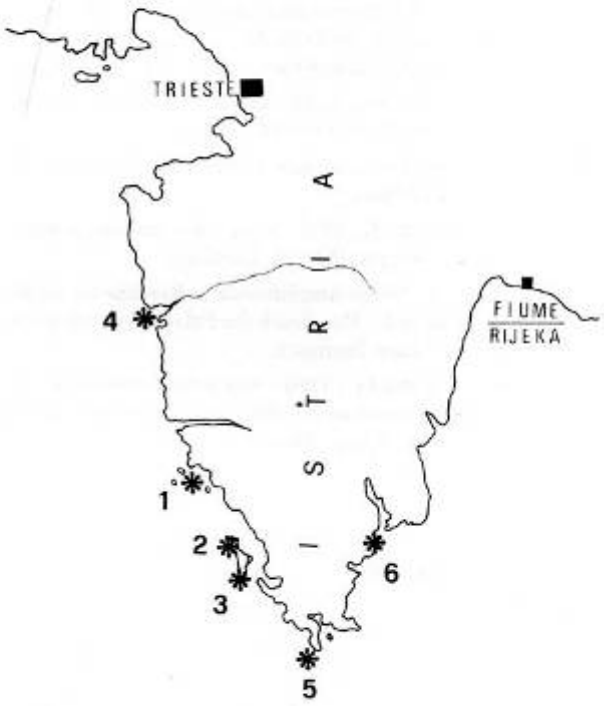

Fig. 14 - Sites reported in the literature with evidences of dinosaurs in Istria. 1) Near Rovigno/Rovinij, ?Lower Barremian; 2) Salsa/Pogledalo promontory, Upper Barremian; 3) Ploče and Plješivac promontory, Lower Albian; 4) Quieto/Mirna river mouth, Upper Albian; 5) Fenolega islet, Upper Cenomanian; 6) near Carnizza, Senonian.

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