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

I - Geological framework.

A dinosaur footprint rich outcrop was recently discovered within the Altamura Limestone Formation in the so named "Apulian foreland". The geology of the area seems well established even if a plethora of lithostratigraphical names still gives rise to some confusion.

The outcrop is characterised by an enormous number of footprints (valued at about 30,000) and trackways printed on a single surface of about 15,000 m^2. The number of trackways and the area dimensions will need long time for the study that is just started. The planed timing of study allowed to like better producing a series of papers and a slow and progressive accumulation of data more than a study lasting some tens of years.

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

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

Foreword

A dinosaur footprint rich outcrop was recently discovered near Altamura, less than 40 km south of Bari, Italy (Fig. 1) within the Altamura Limestone Formation, a carbonate platform deposit, Late Cretaceous in age, typical of the so called "Apulian foreland" structural unit.

The outcrop is characterised by an enormous number of footprints and trackways printed on a single layer surface of about 15,000 m^2 (Fig. 2). The printed surface can be subdivided into three distinct portions that differs in the degree of trampling. Among them, the first, very small in respect to the whole area, is almost barren, the second, reaching a third of the surface, presents few trackways and the third one reaches a low to moderate degree of trampling (Lockley & Conrad, 1989). The latter, that easily could be defined moderately dinoturbated, shows a so high number of footprints that sometimes is quite difficult to individualise the single trackways.

Due to the track frequency and to the debris cover, the actual number of footprints is still unknown, so that we were only able to evaluate the number of footprints by statistical methods. To this end two areas of 28 and 40 m^2 were randomly selected, cleaned and carefully mapped, within the most printed portion of the surface. The number of tracks printed on these areas was of 110 for the first (Fig. 3) and 68 for the second. If these areas could be considered representative of the quarry portion in which footprints are more frequent, the resulting total might be evaluated about 39,000 footprints if we consider the first selected area and about 17,000 for the second. Consequently we cautiously consider a total number of about 30,000 footprints for the whole quarry. The surface is also characterised by a generalised lack of expulsion rims around the footprints. That lack seems to depend from a peculiar character of the fine calcareous sand on which the footprints were impressed or perhaps from a diagenetic phenomenon; apposite studies will be done after the preparation of the surface.

The tracksite is today under the tutor-ships of Land Authorities (Ministero per i Beni e le Attività Culturali, Soprintendenza Archeologica per le Puglie), contemporaneously the Geological Survey (Servizi Tecnici Nazionali, Servizio Geologico) has in progress the studies needing to erect the quarry as a Natural Heritage site.

The study of the geology and of the fauna was hampered by the condition of the outcrop and by the enormous amount of money needing to protect the surface against the weathering. As a matter of fact many small faults and fractures, pertaining to two cleavage systems (N 295° and N 315°) crossing each other originate a widespread breakage of the surface into small bits; these last ones under the weathering detach, creating some dangers for the preservation of the trackways. In such condition we were obliged to clean the surface in small portion, to be hardened before to

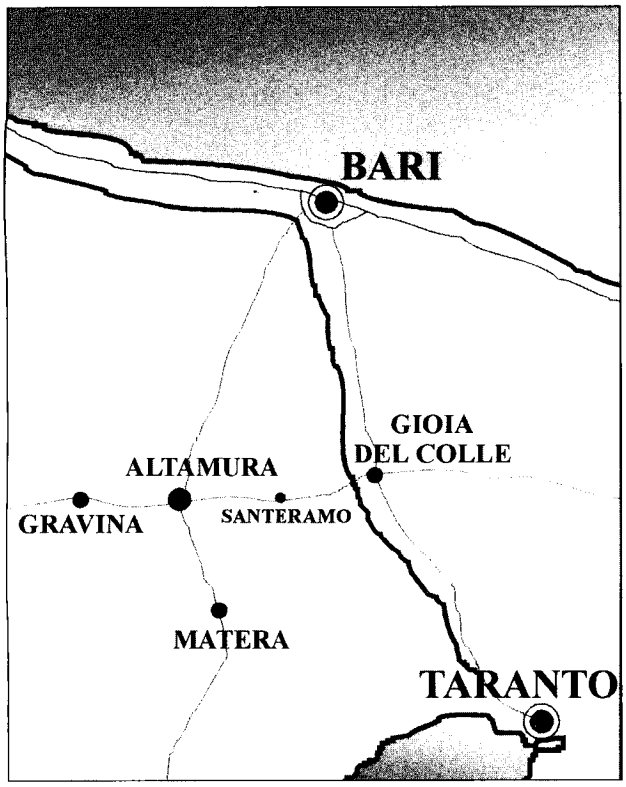

Fig. 1 – Location map of the outcrop.

– Ubicazione dell'affioramento.

pass to another portion. Consequently we were constrained to clean, to prepare and to restore a single trackway at a time; the ichnological study is thus possible just a trackway at once, at least up to the release of a specific grant.

Geological and stratigraphical setting

The tracksite was discovered on June 1999 and is located 4 Km east of Altamura (Bari, southern Italy), at the De Lucia quarry, near the Masseria Pontrelli, along the road SS. 171 from Altamura to Santeramo. The tracks are printed on the surface of a layer cropping out on the lowermost exposed bed in an abandoned limestone quarry.

The outcrop consists of a small anticline that lets the Cretaceous carbonate platform deposits to crop out for a small area, surrounded by the unconformably overlying Calcareniti di Gravina Formation, Pliocenic-Pleistocenic in age (Ciaranfi *et al.*, 1992). The age of the footprint bearing deposits is still debated being the cropping out limestone levels ascribed by different authors to Early Maastrichtian, Late Campanian, Early Santonian and Turonian (see below for the literature analysis). The whole Cretaceous succession, cropping out in the Murge area, was considered as deposited in marine environment on a single carbonate shelf, although the finding of a partial skeleton of a terrestrial reptile, the so called "Ruvo's varanoid" allowed to suppose the scattered presence of exposed land masses (AA. VV., 1999).

The Altamura area belongs to the Murge hills belt, a wide morphological carbonate plateau elongated in NW-SE direction, parallel to the Bradanic Trough. Murge belt is limited by the Tavoliere delle Puglie in the NW side and by Salentina Peninsula in the SE side (Fig. 4).

From a geodynamic-structural point of view Murge area belongs to the Apulian crustal block, a microplate of African origin, that constitutes the widest outcropping portion of the Apenninic-Dinaric foreland (or Adriatic foreland; AA.VV., 1999).

Murge carbonatic sediments deposited during the Cretaceous period on the northern side of the African palaeocontinent, corresponding to the Apulian Carbonate Platform palaeogeographic-structural unit (D'Argenio, 1974). Cretaceous carbonate layers form an extended monocline S-SW (Fig. 5) dipping on the western flank of a wider anticline dissected by numerous faults with extensional character whose trending is from W-E to NW-SE and SW-NE (Ricchetti, 1980).

The footprint bearing layer belongs to the Altamura Limestone Formation (Azzaroli *et al.*, 1968; Ciaranfi *et al.*, 1992). This formation is composed by carbonate sediments of inner shelf environment, with benthic Foraminifers associations, Algae ("Membro loferitico" according to Luperto Sinni & Borgomano, 1989) and locally by Rudist's (Radiolitidae and Hippuritidae) biostromal bodies and biohermas (AA.VV., 1999). The maximum thickness of the Altamura Limestone Formation is 1,000 m and its age ranges (?)Upper Turonian to Maastrichtian. The Altamura Limestone Formation lies paraconformably on the Bari Limestone Formation. The boundary between these formations can be marked by a bauxitic layer that testifies a temporary emersion (Bauxite di Spinazzola, Maggiore *et al.*, 1978a, 1978b; Iannone & Laviano, 1980; Luperto Sinni & Reina, 1996a; Luperto Sinni & Reina, 1996b). According to Azzaroli *et al.* (1968), Valduga (1965), Ricchetti (1975) the Bari Limestone Formation forms with the Altamura Limestone Formation the Salento and Murge Limestone Group.

Several biostratigraphic analyses about the Apulian Upper Cretaceous succession (Murge, Salento and Gargano promontory) led the authors to recognise two important stratigraphical gaps due to the lack of Lower Campanian and Lower Maastrichtian sediments (Luperto Sinni & Borgomano, 1989; Pieri & Laviano, 1989). On these bases Luperto Sinni & Borgomano (1989) distinguished two new units: Ostuni Limestone and Caranna Limestone. Other authors instituted, in the Salentina Peninsula, formal and informal units, coeval to the Altamura Limestone Formation. Such units contribute to complicate the exi-

Fig. 2 – Partial view of the printed surface.

– Panorama parziale della superficie a impronte.

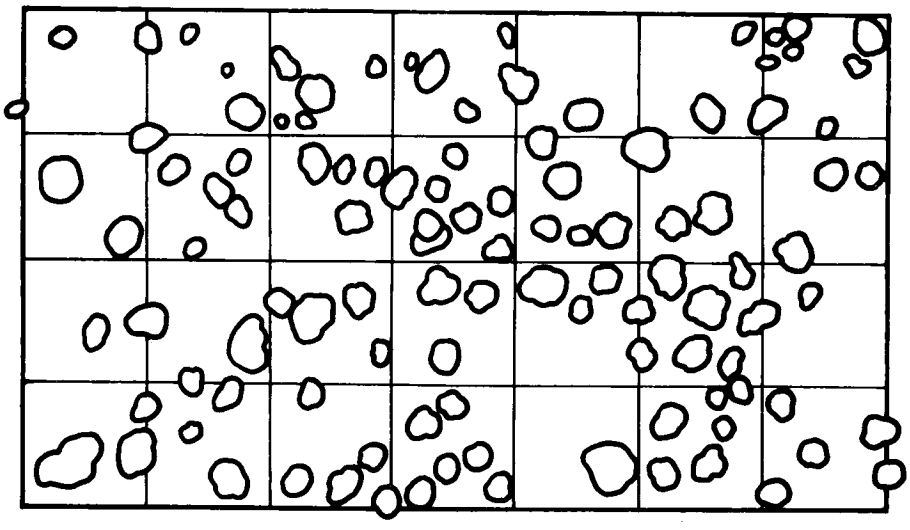

Fig. 3 – The degree of trampling in one of the selected area. Each square represents 1 m^2.

– Disegno schematico delle orme in un'area campione. Ogni quadrato rappresenta 1 m^2.

stent lithostratigraphic nomenclature (Melissano Limestone Fm., Martinis, 1967; Galatina Dolostone Fm., Rossi, 1969; S. Cesarea Limestone, Parente, 1994; Ciolo Limestone, Parente, 1994; Poggiardo Limestone, *sensu* Guarnieri *et al.*, 1990). Moreover recent works (Bosellini & Parente, 1994) suggested a variety of lithostratigraphic units, informally defined by Parente (1994); these units seem to permit a zoning of the platform margin.

Results of biostratigraphic researches (Luperto Sinni & Ricchetti, 1978; Reina & Luperto Sinni, 1993; Luperto Sinni, 1996; Luperto Sinni & Reina, 1996a, 1996b), based on micropalaeontological data, about the Altamura Limestone Formation allowed to recognize some macroforaminifer Upper Cretaceous Biozone. In particular *Scandonea samnitica* Biozone (Coniacian), *Murgella lata* Biozone and *Keramosphera tergestina* Biozone (Santonian), *Orbitoides tissoti* Biozone (Lower Campanian), *Murciella couvilleri* Biozone and *Raadshovenia salentina* Biozone (Upper Campanian), *Rhapydionina liburnica* Biozone (Upper Maastrichtian) were recognised.

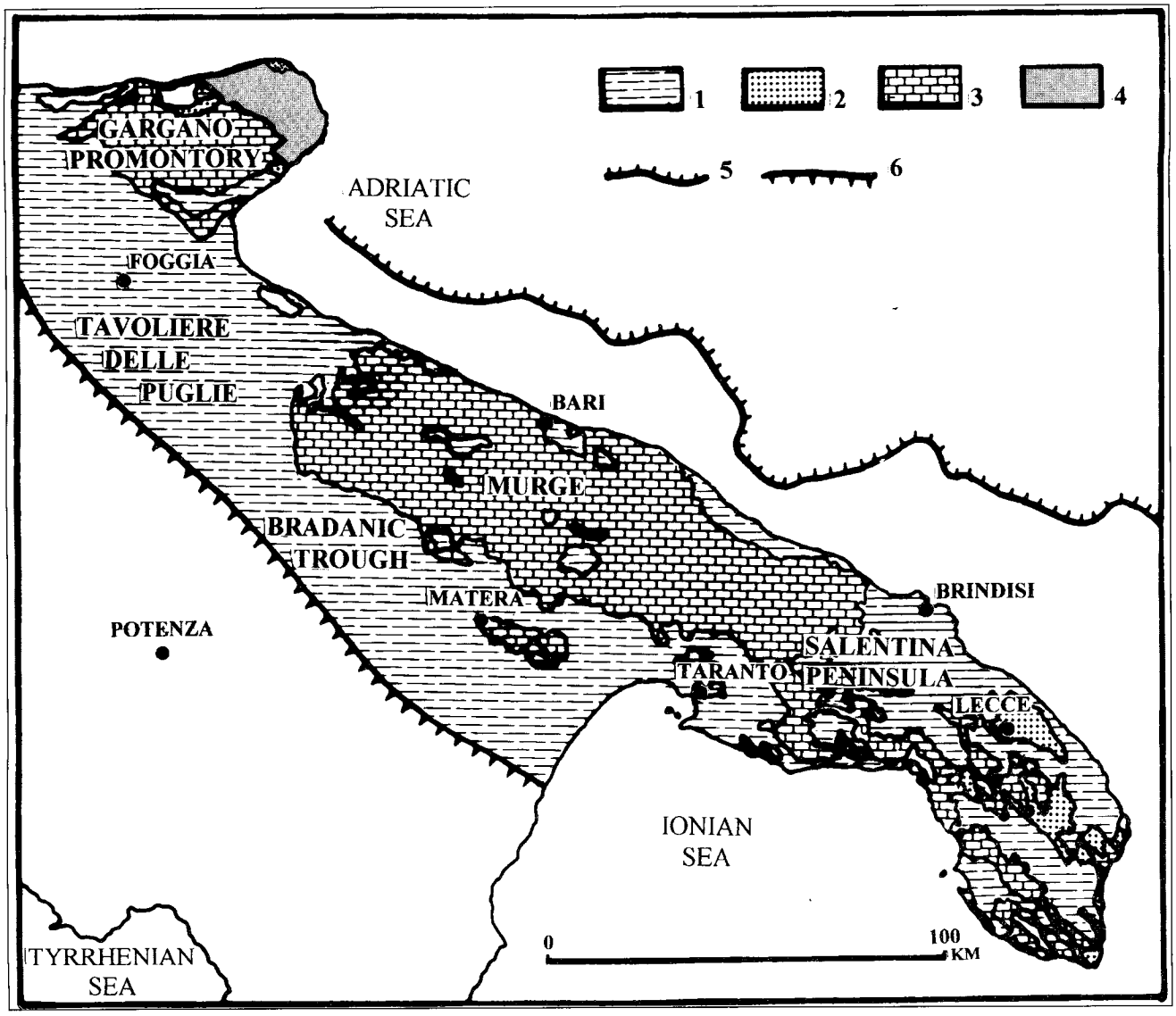

Fig. 4 – Simplified geological-structural map of the Apulian domain. 1) clastic sediments of the Bradanic Trough, PLIO-PLEISTOCENE; 2) carbonate, clastic and organogenic sediments, PALEOGENE-MIOCENE; 3) carbonate sediments of the Apulian Carbonate Platform, LATE JURASSIC-CRETACEOUS; 4) pelagic sediments of the easthern garganic basin CRETACEOUS; 5) north-eastern margin of the Apulian Carbonate Platform; 6) front of the Apenninic accretionary wedge (from Ricchetti, 1980, redrawn and slightly modified).

– Carta geologica schematica della Puglia. 1) depositi clastici della Fossa Bradanica, PLIO-PLEISTOCENE; 2) sedimenti carbonatici, clastico-organogeni, PALEOGENE-MIOCENE; 3) sedimenti carbonatici della Piattaforma Carbonatica Apula GIURASSICO SUPERIORE-CRETACICO; 4) depositi pelagici del Bacino est-garganico, CRETACICO; 5) margine nord-orientale della Piattaforma Carbonatica Apula; 6) fronte del prisma di accrezione appenninico (da Ricchetti, 1980, ridisegnato e leggermente modificato).

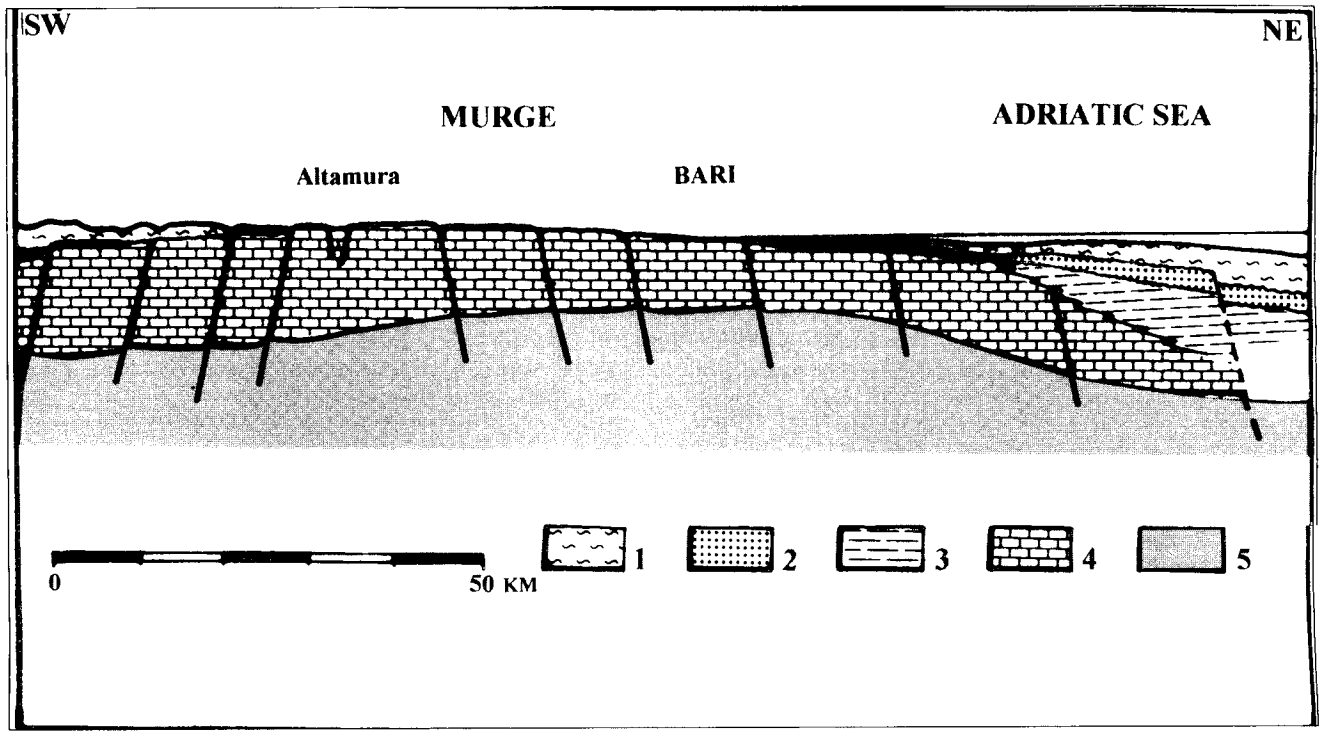

Fig. 5 – Simplified profile across the Apulia. 1) clayey, sandy and conglomeratic sediments of the Bradanic Trough, PLIO-PLEISTOCENE; 2) clastic carbonate and clastic organogenic sediments, PALEOGENE-MIOCENE; 3) pelagic sediments of the easthern garganic basin CRETACEOUS; 4) carbonate sediments of the Apulian Carbonate Platform, LATE JURASSIC-CRETACEOUS; 5) crystalline basement PRE-TRIASSIC (from Ricchetti, 1980; redrawn and simplified).

– Sezione geologica attraverso la Puglia. 1) depositi conglomeratici, sabbiosi ed argillosi della Fossa Bradanica, PLIO-PLEISTOCENE; 2) sedimenti carbonatici, clastico-organogeni, PALEOGENE-MIOCENE; 3) depositi pelagici del Bacino est-garganico, CRETACICO; 4) sedimenti carbonatici della Piattaforma Carbonatica Apula GIURASSICO SUPERIORE-CRETACICO; 5) basamento cristallino, PRE-TRIASSICO (da Ricchetti, 1980, ridisegnato e modificato).

The finding of *Rhapydionina liburnica* in the upper portion of the Altamura Limestone and of a closely related *Rhapydionina sp.* within the assumed following unit (Dolomie di S. Elia, Reina & Luperto Sinni, 1993) allowed the authors to outline palaeogeographic hypotheses on the geographic distribution of that genus. Moreover the type of sediments (dolomitic limestone, dolostone) and the monotypic occurrence of *Rhapydionina* leaded the authors (Luperto Sinni, 1996) to hypothesise hostile life-environments (shallow water, anomalous salinity, anoxic water), linked to the progressive emersion of the Apulian Carbonate Platform.

At the moment no further litho-biostratigraphic analyses are possible about the De Lucia quarry because previously works for the surface consolidation and preservation are necessary. The most recent work on the tracksite ascribe to the footprint bearing level an Early Santonian age (AA.VV., 1999).

Trackway and track-makers

The huge number of trackways crossing each other makes difficult the study of tracks and the definition of ichnotaxa and track-makers. To follow a trackway is necessary to select within overtrampled areas a single type of footprint arranged in a well-defined sequence. Thus at the moment we are limited by the enormous number of footprints in the definition of faunal composition.

At this stage of the study the fauna seems to be completely dominated by quadruped dinosaurs of different types and relatively small dimensions. As a matter of facts, in the first year trackways referable to theropods were not recognised (just a single badly preserved tridactyl footprint with slender digits), only one trackway might pertain to a very small sauropod while the few well prepared trackways can be ascribed to quadruped ornithischians.

Conclusions

The recent finding of numerous dinosaur trackways sheds light on some unexpected aspects of the palaeogeography of the Apulian platform during the Late Cretaceous. Indeed the Altamura outcrop represents a very important window on Late Cretaceous geography, opening questions of difficult resolu-

tion with important geodynamic implications. The presence of a huge number of herbivorous dinosaurs reveals at least the need of a quite large persistently emerged area, for feed and eggs deposition of such a large number of animals. Moreover to permit immigration and settling of such kind of advanced dinosaurs a connection between Apulia and larger emerged areas must be hypothesised after the Early Cretaceous, the spreading time of the ornithopods (Benton, 1993; Sereno, 1999).

SOMMARIO

Una superficie ricchissima di impronte di dinosauri è stata recentemente scoperta all'interno della Formazione del Calcare di Altamura nell'unità strutturale definita "Avampaese Apulo". La geologia dell'area è ben conosciuta anche se l'abbondanza di unità litostratigrafiche crea confusione nella nomenclatura stratigrafica.

L'affioramento, che viene attribuito al Santoniano basale e il cui studio è in corso, è caratterizzato da un enorme numero di impronte (stimate intorno alle 30.000) e piste conservate su una singola superficie di circa 15.000 m^2. Il numero delle piste e le dimensioni dell'area lasciano supporre lunghi tempi di studio. Il tempo previsto per lo studio ha portato a preferire l'elaborazione di una serie di lavori ed un lento e progressivo accumulo di dati piuttosto che un unico lavoro al termine di decine di anni di studio.

La presenza di dinosauri nel Cretaceo dell'Italia meridionale pone gravi problemi paleogeografici che richiederanno una revisione dei modelli attualmente proposti.

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