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FIRST RECORD OF TRIASSIC DINOSAUR FOOTPRINTS FROM THE LOWER SANDSTONE UNIT OF KERSA AREA, EASTERN ETHIOPIA

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Riassunto. Viene documentata per la prima volta in Etiopia la presenza di orme di Dinosauri nella "Lower Sandstone Unit" dell'area di Kersa, situata lungo la strada tra Diredaua e Addis Abeba (Etiopia orientale). Viene data la descrizione e l'illustrazione e vengono stabiliti confronti con impronte simili di altre regioni per tentare una possibile interpretazione. Lo studio comparativo ha portato ad ipotizzare che esse siano state lasciate da Teropodi primitivi e a supporre un'età Triassica superiore per i sedimenti in cui sono contenute.

Abstract. Dinosaur footprints are described from the Lower Sandstone Unit of Kersa area, eastern Ethiopia. These are thought to belong to an early branch of theropods, and reported for the first time from Ethiopia. The evidence supports a Late Triassic age for the Lower Sandstone Unit in eastern Ethiopia and also throws light on its probable depositional environment.

Location and geological setting.

The dinosaur footprints bearing sedimentary succession of rocks are exposed in Kersa area, eastern Ethiopia (Fig. 1). The area, lying on the motor highway from Addis Ababa to Diredawa, falls on the northern margin of the South Eastern Ethiopian Plateau. No other fossils are known so far from this unit in the studied area.

The sedimentary succession is a very small part of a thick Mesozoic sedimentary sequence of the order of 2,000 meters, that is exposed over large parts of northern, central and eastern Ethiopia. The sequence overlies either a Precambrian basement or Paleozoic clastics, and is covered by Tertiary volcanic rocks. It is subdivided into five lithostratigraphic units: the Lower Sandstone Unit (Adigrat Sandstone); the Shale and Gypsum Unit (Gohatsion Formation); the Limestone Unit (Antalo Limestone); the Shaly Sandstone Unit (Agula

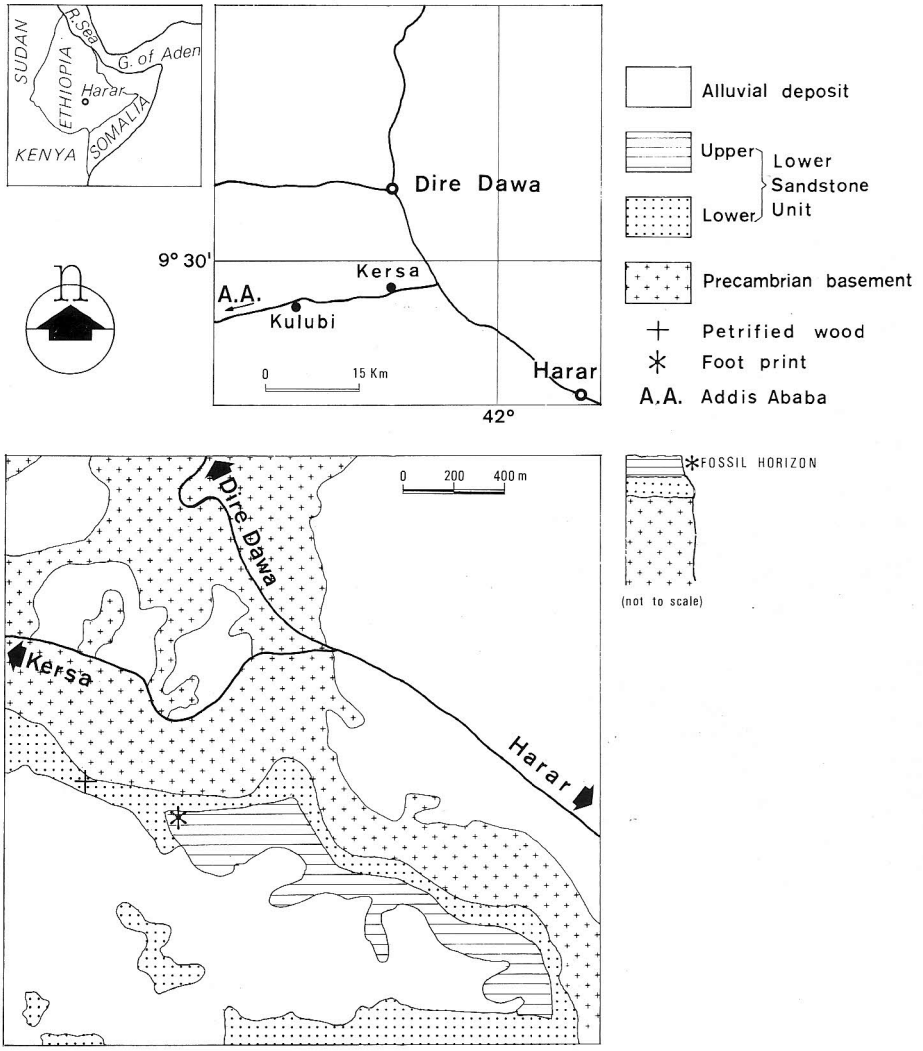

Fig. 1 – Location and geologic map of Kersa area, eastern Ethiopia, showing the stratigraphic position of fossil remains of dinosaur footprints.

Shale); and the Upper Sandstone Unit (Amba Aradam Formation) (Fig. 2). The sequence in all the above mentioned areas shows vertical and lateral variations, both in thickness of the constituent Units and their lithology, but is broadly correlative and the terminology and classification shown in Fig. 2 is generally applicable for all of these areas. The footprints described here were discovered in the Lower Sandstone Unit of Kersa area (Fig. 1, 2).

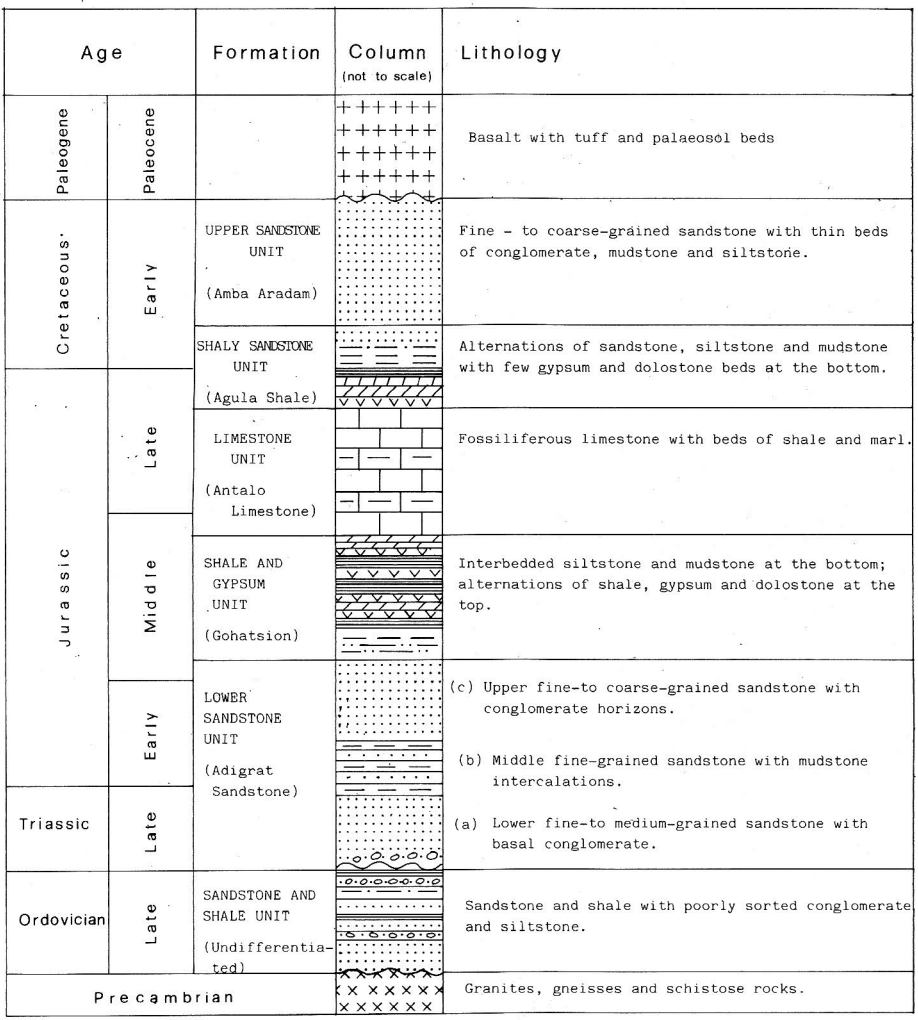

Fig. 2 – Generalized stratigraphy of the Paleozoic and Mesozoic strata of the North Western and South Eastern Ethiopian Plateaus.

General information on the Lower Sandstone Unit of Ethiopia.

In northern Ethiopia, the Lower Sandstone Unit, known as the Adigrat Sandstone, rests unconformably either on basement rocks or Paleozoic sedimentary rocks. The Paleozoic rocks are considered to be of Late Ordovician age (Elwerath, 1967; Saxena & Getaneh, 1983). The Lower Sandstone Unit in this area is divisible into three members, a lower sandstone, a middle shale and

an upper sandstone (Engles, 1966). It attains a maximum thickness of 650 m and represents transitional, deltaic and fluviatile environments of deposition. The age of the Unit in this area is considered to be Early to Middle Jurassic, based on the stratigraphic position of the Unit rather than fossil evidence. Conformably overlying it there is the Antalo Limestone which has been dated as Early Malm.

The Lower Sandstone Unit in central Ethiopia is also divisible into three members, a lower sandstone, a middle one with alternating beds of mudstone and sandstone, and an upper sandstone. The unit is as much as 700 m thick and represents fluviatile and deltaic depositional environments (Getaneh, 1979). Although the Unit contains carbonaceous debris and plant remains near its base, its age has not yet been definitely determined. It is overlain by gypsum and mudstone beds, the Gohatsion Formation, that ranges in age from Toarcian to Bathonian (Getaneh,1981). On this basis the Lower Sandstone Unit is considered as Early Jurassic in age.

In the eastern parts of Ethiopia, where the footprints were found, the Lower Sandstone Unit attains a thickness of up to 100 m. It consists of a lower member of sandstone and conglomerate, a middle member of interbedded sandstone, calcareous sandstone, shale and siltstone, and an upper member of sandstone (Beauchamp, 1977). Mühlen (1931) suggested a Late Triassic or Early Jurassic age for the Unit on the basis of some fossil fish teeth and bones found at the base of Mount Hakim near the town of Harar. Clift (1956) reported some poorly preserved molluscan fossils from the same locality but suggested no specific age for the Unit. Greitzer (1970) considered the unit to be of Liassic–Bajocian age on the basis of his study on the Harar and Diredawa area. Beauchamp (1977) assigned a Dogger age, largely based on literature survey, to the Lower Sandstone Unit of northern and eastern Chercher areas. These areas include the Kersa area, the locality under study. On the other hand, the Lower Sandstone Unit of southern Chercher, which is underlain by Paleozoic sedimentary rocks, was considered by Beauchamp, with no justification, to range in age from Permian to Dogger. The major parts of the Unit are considered to be of fluviatile and deltaic origin, and its uppermost part, according to Greitzer (1970), was deposited in a shallow, warm, epicontinental sea.

Scope of the present work.

The purpose of this paper is to document the occurrence of dinosaur footprints from the Triassic sediments of eastern Ethiopia (the first to be found in such sediments in Ethiopia) and to postulate the environmental conditions which allowed their preservation. From the nature of the footprints, some tentative interpretation can also be made of the age of these sediments.

Stratigraphic background.

The area around Kersa village has an extensive Precambrian basement consisting chiefly of granites, gneisses and schistose rocks of various types. It is unconformably overlain by arenaceous sedimentary rocks (Mesozoic). Fig. 1 shows a geologic map and a generalized columnar section of these sedimentary rocks at the site where the footprints were found. About 40 m of sandstone, assigned to the Lower Sandstone unit, is the only rock exposed here overlying the Precambrian basement. The Lower Sandstone Unit in the studied area is divisible into two sub–units, a lower sub–unit consisting of conglomerates, followed by alternating bands of fine–to medium–grained sandstone, calcareous sandstone, chalk, marl and sandy dolomite, and an upper sub–unit consisting of well sorted, medium–grained sandstone. The Lower Sandstone Unit has a gentle dip of 5° towards south and is frequently cross–bedded. At places (Fig. 1), pieces of silicified wood are found. Erosion over long periods of time has removed a large portion of the Lower Sandstone Unit, apparently to a level somewhere between the bottom of the lower member and top of the middle member, and exposed the footprints.

The footprints.

General description.

The footprints were found on the upper and exposed surface of the upper sub–unit of the Lower Sandstone Unit (Fig. 1). This may represent a horizon somewhere between the bottom of the lower member and the top of the middle member. Four footprints were discovered. Three of the prints, though clear, are strongly eroded and do not show much morphological detail and are therefore not useful for detailed study (Pl. 15A). The fourth footprint is well preserved and shows some morphological details more clearly (Pl. 15B). It shows three distinct digits (tridactyl), the central digit being the longest.

The maximum length, corresponding to the central digit is 10 cm, and the maximum breadth is about 15 cm. The footprint has a clear and well defined outline, though weathering has obliterated some of the morphological details. All three digits have rounded extremities and the foot is also rounded posteriorly. The number of phalanxes in each digit is not clear. The footprints are cast in the upper part of the Lower Sandstone Unit, which is well sorted and medium–grained. The posterior portion of the foot has left a much deeper impression compared to the anterior portion of the digits. This may indicate more weight of the body being on the ankle than on the toes.

Comparison and identification.

Since no bones or other skeletal remains were found associated with the footprints, it is very difficult to establish the exact identity of the animal which

left them. However, a comparative study is helpful in a general way and in establishing the identity of the animal in a broad way. Similar footprints are recorded from many places all over the world, the most notable occurrences being those of the Connecticut Valley and the Arizona desert, both from Upper Triassic sediments and thought to belong to primitive theropods (Colbert, 1961). Other places from where similar footprints are recorded are South America, particularly Argentina, England, South Africa and Botswana. A very exhaustive and detailed description of vertebrate footprints from England has been published by Sarjeant (1974). Mossan and Sarjeant (1983) describe many footprints from the Upper Triassic sediments of Nottinghamshire. Footprints of at least six kinds are described from there, but there are no associated fossils. Identification of the animal on the basis of the footprints alone, though done by some workers, is neither legitimate nor reliable, owing to the extreme variability of vertebrate footprints even within a single track (Sarjeant, 1974). It should be done only when supporting evidence from other skeletal remains is available. However, footprints alone do provide much useful information not only about the presence of the animal, but also about the nature of the sediments and the environment of deposition.

It is obvious that a more specific identification of the dinosaur cannot be made for the reasons outlined above, but it should be borne in mind that in the Connecticut Valley and the Arizona desert footprints of dinosaurs bearing a strong morphological similarity to the ones described in this paper, have all been identified as theropods with Triassic thecodont ancestors (Colbert, 1961). These were the predatory type of early dinosaurs, most successful during the closing stages of the Triassic.

Lately, dinosaur footprints and other tracks have also been assigned to ichnogenera and treated as trace fossils. Tucker and Burchette (1977) described Triassic dinosaur footprints from South Wales. There are two types of footprints, a small three–toed and a larger four–toed, both assigned to the ichnogenus *Anchisauripus* Lull. These footprints have close similarities with others from the Upper Triassic horizons in Europe and America, and are morphologically similar to the single well preserved footprint described here. This could therefore belong to the same ichnogenus, *Anchisauripus* Lull.

The sandstone slab with one well preserved footprint is deposited in the Geology Department Museum of the Addis Ababa University, Ethiopia.

Discussion.

The foregoing description makes it clear that the Lower Sandstone Unit of the Mesozoic sedimentary succession, known also as the Adigrat Sandstone, is variable, both laterally and vertically, in age as well as in the environment of deposition over large parts of eastern, central and northern Ethiopia. In short,

it represents a variable stratigraphic position and sedimentological facies. Its lower age limit is difficult to fix and the upper one is determined on the basis of the conformably overlying fossiliferous Antalo Limestone and few fossils found within it. No reliable fossils have been found so far. The discovery of these footprints is therefore not only significant as the first record of dinosaurs from Ethiopia, but also because of their marker value, as similar footprints are found in definite Upper Triassic sediments of the Connecticut Valley and the Arizona desert (Colbert, 1961), New Mexico (Baird, 1964), England (Sollas, 1879; Sarjeant, 1974; Tucker & Burchette, 1977; Whyte & Romano, 1981, and Mossan & Sarjeant, 1983), and support the same age for the Lower Sandstone Unit of this area. As at other places, the depositional environment, for the lower and middle members of the unit, may have been marginal lacustrine, river flood plain, a drying mud flat, etc., where fine–grained, moist and cohesive sediments were available at the time of formation of the footprints.

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PLATE 15

Triassic dinosaur footprints from eastern Ethiopia.

A) Fossil footprints on the sandstone.

B) A well preserved footprint.


A


SUPER
B