A NEW FEATHER FROM THE LOWER CRETACEOUS OF BRAZIL

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ABSTRACT. A semi-plume feather from the Nova Olinda Member of the Crato Formation (Aptian, Lower Cretaceous) of north-east Brazil is only the second feather reported from this remarkable lagerstätte. The new specimen is presumed to be preserved as an organic film in organic-rich, laminated limestones, and is from an unknown bird probably in the size range 150 to 300 mm.

AVIAN remains are extremely rare in the Mesozoic, so that even isolated occurrences of feathers are of interest. Although usually of little taxonomic importance, except to demonstrate unequivocally the presence of birds, the preservation of such organic structures as feathers is itself of interest. We here report on the occurrence of an isolated contour feather which is preserved as organic material, and shows relatively fine structures including the presence of barbules.

A feather was first reported from the Cretaceous of the Chapada do Araripe, Ceará, NE Brazil, by Martins-Neto and Kellner (1988) who noted the occurrence of a small flight feather from the Crato Formation (equivalent to the Crato Member of the Santana Formation of Martins-Neto and Kellner (see Martill and Wilby 1993 for full discussion of the stratigraphical nomenclature of these deposits)). This feather was later figured by Kellner *et al.* (1991). The new specimen is housed in the collection of the Department of Geology, University of Leicester, UK; No. LEIUG 114369.

This is only the third reported occurrence of avian remains from the Cretaceous of Brazil. Chiappe (1991) reported the occurrence of an avian carpometacarpus from the Upper Cretaceous Bauru Formation in addition to the feather noted above.

LOCALITY

The Crato Formation forms an arcuate outcrop on the south-eastern, eastern and north-eastern flanks of the Chapada do Araripe, in Pernambuco and Ceará, north-east Brazil (Martill 1993). The outcrop is almost continuous, and is fossiliferous in most places. The Chapada do Araripe is a plateau dominated by high sandstone cliffs of probable Cenomanian age, which overlie early Cretaceous and late Jurassic sediments. Exposures are good to excellent where streams have deeply incised the softer sediments.

The new find comes from a recently discovered locality of the Crato Formation close to the Tatajuba Reservoir some ten kilometres west of Nova Olinda (Text-fig. 1), which is the main area of commercial exploitation of the Crato Formation. This new locality, called the Mina de Antone Phillipe, is currently worked for large slabs of unweathered rock which are suitable for manufacturing table tops. The new specimen was collected by one of the quarry workers, and passed to the owner of the quarry. This was most fortunate, as the quarry lies outside the main commercial collecting area, and most fossils at this site are ignored (B. Filgueira, pers. comm.).

STRATIGRAPHY AND PALAEOENVIRONMENT

The Crato Formation is a series of finely laminated, organic-rich carbonates with intervening units of sands, silts and silty clays. Three distinct laminated carbonate units can be recognized: a lower Nova Olinda Member, the Barbalha Member and an upper Jamacaru Member (Martill and Wilby

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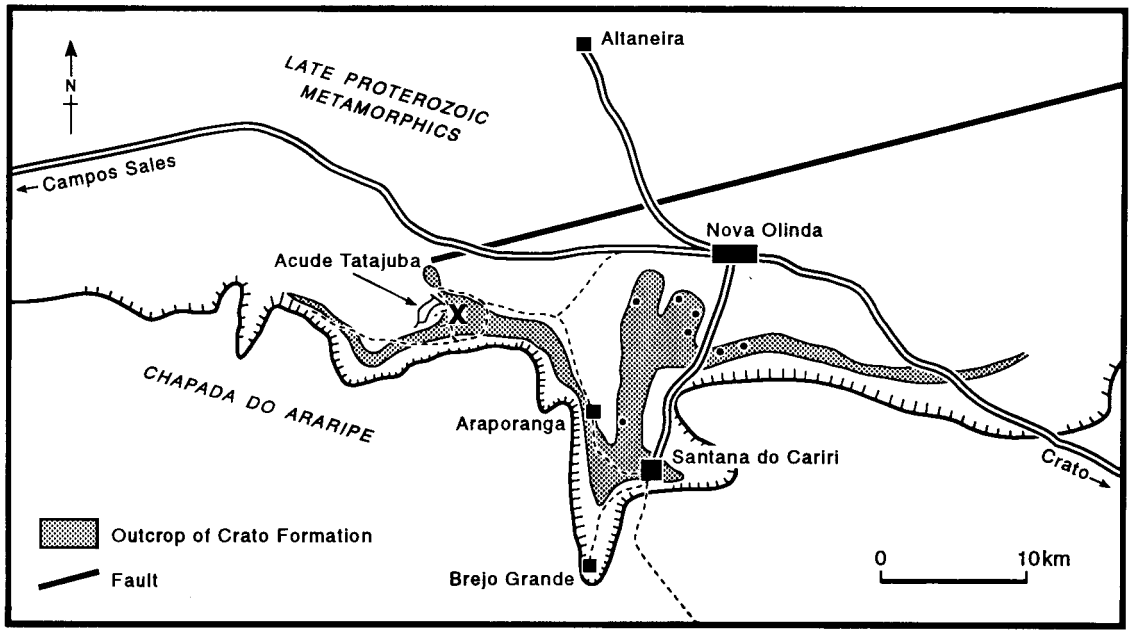


TEXT-FIG. 1. Sketch map showing the new locality in the Crato Formation where the new feather was discovered.

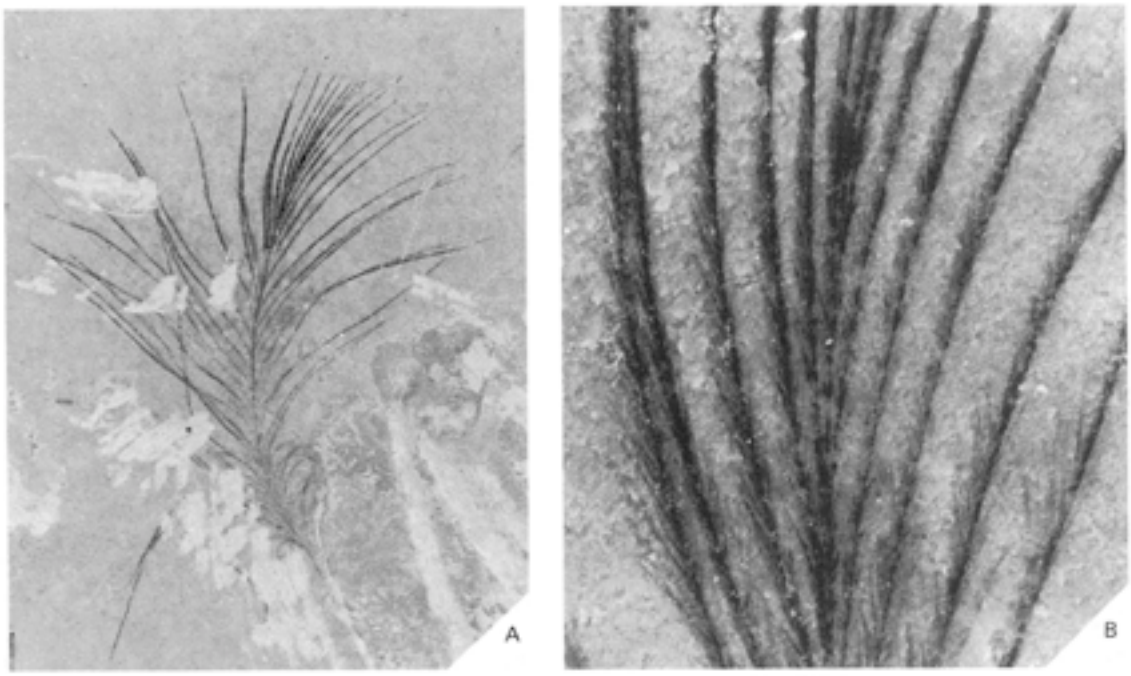
1993). The new feather comes from the Nova Olinda Member. In the region around Nova Olinda, this limestone forms a minor escarpment and is mined for ornamental stone. The mining techniques are labour intensive, and consequently many fossils, mainly the small fish *Dastilbe* and insects, are found. The Crato Formation at this locality is close to its unconformity on the underlying neo-Proterozoic basement, and was probably deposited close to the palaeoshoreline of the Crato lagoon.

The precise age of the Crato Formation is in some doubt due to a lack of diagnostic macrofossils, but palynological evidence suggests an Upper Aptian age (Pons *et al.* 1990).

The Crato Formation was deposited in a lagoon in an enclosed basin which may have had restricted access to marine waters to either the south or, perhaps less likely, to the west (Martill and Wilby 1993). The bottom waters of the lagoon were almost certainly anoxic and sulphate-reducing bacteria thrived in the bottom sediment. The surrounding region was arid (Maisey 1990) and clastic sediment input was minimal during deposition of the Nova Olinda Member. Mass mortalities of small fishes were frequent. The para-autochthonous fauna is restricted and consists of the gonorhynchiforme fish *Dastilbe elongatus* and a few insect larvae. Conchostracans are abundant at the base of the Nova Olinda Member, but they gradually disappear through the basal few metres due to a presumed increase in salinity. The most common fossils are those of animals and plants that were blown in, dropped in accidentally, or were predated while flying over the lagoon.

DESCRIPTION

The new feather is a semiplume which has been damaged somewhat since or during collection. The proximal part of the calamus is missing (Text-fig. 2A). The length of the preserved specimen is 21 mm measured along the slightly curved rachis. It has a maximum width of 18 mm, due in part to spreading of the barbs. The longest barbs are from 8 to 10 mm long. Barbules are visible on a number of barbs with both proximal and distal barbules being identifiable (Text-fig. 2B). Barbules are up to 0·04 mm long, with up to sixteen barbules per millimetre on those parts of the barbs where they can be easily counted. The feather resembles those from the posterior part of the



TEXT-FIG. 2. Photographs of the new feather; specimen number LEIUG 114369. A, the feather on a bedding plane of typical unweathered Crato Formation laminite. Nova Olinda Member, Crato Formation, Tatajuba, Ceará, NE Brazil. Notice the chisel marks, one of which has cut across the specimen; ×3·5. B, detail of the barbs and barbules in the distal region of the feather; *c.* ×35.

body of modern passerines and is comparable in size with birds of between 150 and 300 mm in length.

PRESERVATION

The feather is preserved flattened on a smooth bedding plane. A number of barbs have separated from adjacent barbs, and some are folded back towards the proximal end of the rachis. The overall colour of the feather is dark grey distally, to light grey proximally.

The first feather described by Martins-Neto and Kellner (1988) is preserved as a limonitic by-product of a weathered pyritic permineralization, a common occurrence for fossils from those parts of the intensely weathered Crato Formation which are worked for paving stone in the region of Nova Olinda. In contrast, the feather described here appears to be preserved organically, although no tests have been performed to prove this for fear of damaging the specimen further. An insect from the same locality as the new feather has been found with colour patterns preserved (Betimar Filgueira pers. comm.) and plant fossils are carbonized. Of note, however, is the greater fidelity of preservation at the new locality, as Kellner *et al.* (1991) reported that barbules are not visible in the first specimen.

The feather is remarkably similar in size, morphology, and preservation, to that figured by Talent *et al.* (1966) from the Valanginian to Aptian sequence of Koonwarra, Victoria, Australia.

OTHER OCCURRENCES OF MESOZOIC FEATHERS

Several authors have reported the occurrence of feathers from Mesozoic deposits, including some associated with skeletal remains, the most remarkable being those of *Archaeopteryx lithographica* from the Upper Jurassic of Bavaria (Ostrom 1984; Rietschel 1984). These examples still rank as the

oldest undisputed avian remains. Other feathers reported from the Mesozoic include a contour feather from the Lower Cretaceous (Berriasian to early Valanginian) of Montsech, Lerida Province, Spain (Ferrer-Condal 1954), and some rather unusual, probably primitive, feathers lacking barbules from the Upper Jurassic of the Karatau Mountains, Mongolia (Rautian 1978). However, some workers consider the supposed primitive feather described by Rautian (1978) is more likely to represent a benettitalean leaf, a common fossil in the Upper Jurassic deposits of Karatau (P. Wellnhofer pers. comm.). Rather more examples have been reported from the Lower Cretaceous, with some of the finest coming from the probably Hauterivian to Aptian of Mongolia (Kurochkin 1982). Both isolated feathers and examples associated with skeletal remains are reported from this latter locality, and in some of the better examples the colour pattern (but not the original colour) is retained (Kurochkin 1985).

Recent discoveries from the early Cretaceous (Barremian) of Las Hoyas, Spain, include skeletal remains with associated feathers (Sanz *et al.* 1988; Sanz and Buscalioni 1992). Three isolated feathers have been reported from the Lower Cretaceous Korumburra Group of Victoria, Australia (Talent *et al.* 1966; Waldman 1970). Ambers from the Lower Cretaceous of Lebanon have been described with feathers as inclusions (Schlee 1973), and Upper Cretaceous ambers from Alberta, Canada have also likewise been reported with feather inclusions (E. M. Pike, pers. comm.). For a general review of Mesozoic birds see Olson (1985).

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