PROCEEDINGS OF THE BIOLOGICAL SOCIETY OF WASHINGTON
109(2):349–352. 1996.

Marine fossil shark (Chondrichthyes) from nonmarine Eocene sediments, northeastern Kazakhstan

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Abstract.—A single tooth of the sand tiger shark, *Carcharias* sp., was collected from the upper Eocene Kusto svita in the Zaysan basin of northeastern Kazakhstan. The Kusto svita is nonmarine lacustrine strata with an extensive nonmarine biota of plants (especially charophytes) and terrestrial vertebrates (especially mammals). The shark tooth was apparently carried to the site by a predator/scavenger from the then-nearest seaway, more than 500 km to the northwest.

The Zaysan basin of northeastern Kazakhstan (Fig. 1) has an Upper Cretaceous-Miocene sedimentary fill dominated by freshwater shales, siltstones and fine sandstones deposited in and around ancient Lake Zaysan (Borisov 1963, Verzilin et al. 1980). The middle Eocene-middle Miocene strata here produce rich fossil assemblages of freshwater and terrestrial plants (charophytes and angiosperm leaves), invertebrates (ostracods, gastropods, unionid bivalves) and vertebrates (amiid and teleost fishes, salamanders, turtles, crocodylians, birds and mammals). We were thus surprised to find a single tooth of a marine selachian at a late Eocene site in the Zaysan basin. Here we document this fossil and suggest a probable mechanism for its transport from the marine to nonmarine environment.

Occurrence

During the summer of 1993, the fossil selachian tooth, KAN (Institute of Zoology, Kazakh Academy of Sciences, Almaty) 35 (12) 1660, was collected from screenwashed sediment at our locality K12 (UTM 387305E, 5260046N, zone 45), which is on the eastern bank of the Sarybulak River, downstream from the well known Eocene mammal locality called Sunduk (Russell & Zhai 1987, fig. 84). Locality K12 is in the Kusto svita in a bed of silty and sandy mudstone that is pale olive with dark yellowish orange limonitic mottling. This bed is 8 m below the top of the Kusto svita, which is approximately 50 m thick in this area.

Locality K12 produced an extensive vertebrate fossil assemblage now under study that includes an amiid fish, a trionychid turtle, a crocodylian, cylindrodontid and cricetid rodents, the hyaenodontid creodont *Hyaenodon,* and the anthracothere *Elomeryx.* Adjacent strata produce numerous charophytes (Kyansep-Romashkina 1980). Fossil mammals indicate the Kusto svita is of late Eocene age (Ergilian land-mammal "age" of Russell & Zhai 1987).

Description and Identification

KAN 35 (12) 1660 (Fig. 2). A single-cusped tooth missing much of root, which is heavily abraded. Crown tall (total length at least 21.9 mm), narrow, sharply pointed blade. Crown with distinctly sigmoidal outline in anterior view. Two cutting edges of

Fig. 1. Map of Kazakhstan showing location of Zaysan basin in the northeastern part of the country.

crown forming sharp, nearly parallel carinae extending almost to root. No lateral cusplets preserved, but crown base is missing where these would have been, if present at all. Crown enamel lingually smooth to very weakly striated longitudinally. Impossible to determine if root had transverse groove. Lingual face of root smooth and convex. Root not massive, but full extent cannot be determined.

This tooth is identical in form to the second upper anterior teeth of several kinds of lamniform sharks. Of the lamniform sharks with elongate anterior teeth, only the species of *Odontaspis, Carcharias* and *Isurus* have second upper anterior teeth that resemble KAN 35 (12) 1660. Unlike KAN 35 (12) 1660, the second upper anterior teeth of *Odontaspis* have cutting edges extending only down about one-half to two-thirds the distance from the apex of the crown. However, the lack of the entire root, so that the presence of lateral cusplets and a transverse groove cannot be established, make it possible that this tooth could be that of a mako, *Isurus,* though the presence of faint stria-

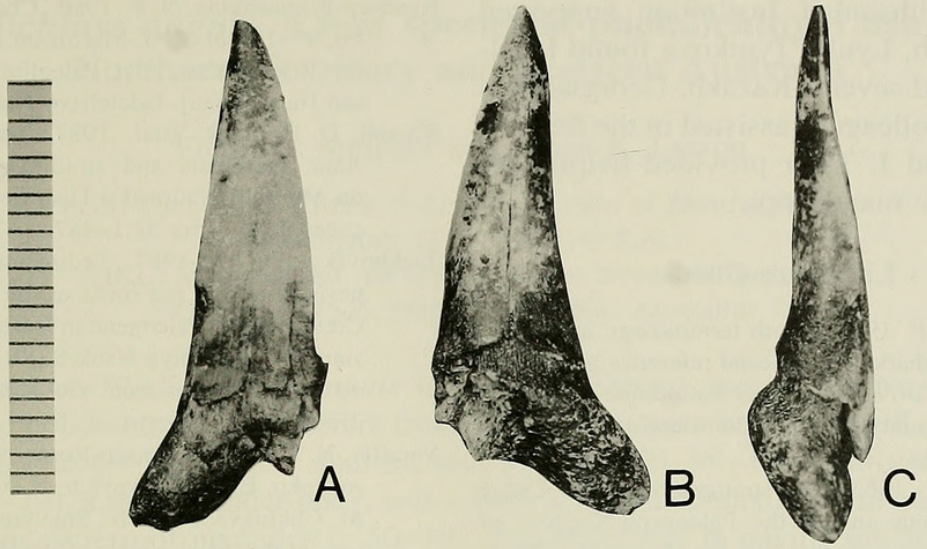

Fig. 2. Photograph of KAN 35 (12) 1660, incomplete tooth of *Carcharias* sp. from the Kusto svita in the Zaysan basin of northeastern Kazakhstan; A, labial; B, lingual; C, anterior. Approximately ×2; scale in mm.

tions on the lingual surface of the crown is characteristic of *Carcharias,* not *Isurus.* Closest resemblance of KAN 35 (12) 1660 is to anterior teeth of the sand tiger shark *Carcharias* (see Applegate 1965), to which we assign it as *Carcharias* sp.

Discussion

The species of *Carcharias* are marine sharks with a temporal range extending back to the beginning of the Late Cretaceous (Cenomanian) (Cappetta 1987, Welton & Farish 1993). The freshwater origin and fossil biota of the Kusto svita at site K12 excludes the possibility of the *Carcharias* tooth representing an animal that lived at the site, so it is not autochthonous to the deposit. Its allochthonous origin could not be as a fossil reworked from older sediments, simply because no such marine strata are present in or around the Zaysan basin (Borisov 1963). The youngest marine strata in this part of Kazakhstan are of Permian age, much older than the first known occurrence of *Carcharias.*

It seems most likely that this allochthonous shark tooth was brought to the site by a biological agent. During the late Eocene, the nearest marine water was the western Siberian seaway, with its eastern shoreline to the northwest of Semipalitinsk, about 500 km to the northwest of locality K12 (Tsekhovsky 1987, fig. 42). Sand tiger sharks are nearshore marine sharks that would have inhabited the shallow waters along the margin of such a seaway. Indeed, fossils of *Carcharias* and other lamniform sharks are known from Eocene-Oligocene strata in central and western Kazakhstan (Glikman 1964).

We propose that from this seaway a predator/scavenger—a crocodyle, bird or mammal—somehow carried the tooth to the site (probably by consumption), where it became fossilized out of context. At present no other explanation fits the data. The isolated nature of the tooth, the close association of this marine shark fossil with freshwater fossils and the lack of a sedimentary source from which it could have been reworked, make transport by a biological agent, probably predator/scavenger, the only reasonable explanation. To our knowledge, this is the first case in the fossil record of a probable predator/scavenger transport of a shark tooth from a marine environment to a nonmarine setting.

Acknowledgments

The National Geographic Society (Grant 5412-95) and the Charles D. Walcott Fund

of the Smithsonian Institution supported this research. Lyuba Tyutkova found locality K12, and several Kazakh, Georgian and American colleagues assisted in the field. V. Springer and J. Tyler provided helpful reviews of the manuscript.

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