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Chondrichthyans from the Menuha Formation (Late Cretaceous: Santonian–Early Campanian) of the Makhtesh Ramon region, southern Israel

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ABSTRACT

Exposures of the Menuha Formation (Santonian–Early Campanian, Mount Scopus Group) in the Makhtesh Ramon region of the southern Negev have produced numerous chondrichthyan teeth. The isolated teeth represent at least ten different species: *Cretalamna appendiculata*, *Cretoxyrhina mantelli*, *Squalicorax falcatus*?, *S. kaupi*, *Scapanorhynchus rapax*, *S. raphiodon*?, *Carcharias samhammeri*, *Carcharias* cf. *C. holmdelensis*?, and two other fish (*Hadrodus priscus* and a pycnodont). This assemblage has important implications for Late Cretaceous chondrichthyan palaeobiogeography. The majority of teeth were contained within a glauconite-rich, yellow-brown, soft chalk that included oysters (*Pycnodonte vesicularis*?), trace fossils (*Planolites*, *Thalassinoides*, and *Chondrites*), phosphatic peloids, and foraminiferans (globigerinids). The teeth were collected mainly through surface-sampling and sieving. The Menuha Formation probably represents a temperate to subtropical, shallow, open-shelf environment deposited during the formation of the Ramon anticline. Reworked conglomeratic chalks in the western section represent marginal facies derived from this structural uplift. With little to no published material describing the chondrichthyan fauna of the Menuha Formation, these data improve interpretations of its palaeoenvironment. Interpretation of the palaeoenvironment of the formation is important for understanding the larger stratigraphic/tectonic framework of the Ramon monocline region of southern Israel.

1. Introduction

The Menuha Formation (Late Cretaceous: Santonian–Early Campanian) in southern Israel records the earliest occurrence of tectonic activity within the Ramon anticline, forming the present erosive valley known as "Makhtesh Ramon" as an outcome of a sequence of erosive events evolving since the Late Cretaceous (Fig. 1; Avni, 1993). Found within the Mount Scopus Group, the Menuha Formation consists of white and yellow/brown chalk that is often glauconitic and sometimes conglomeratic or marly. The conglomerates were developed only as marginal facies in the vicinity of uplifted structures (monoclines) that contributed clasts of local origin, mainly from the underlying Judea Group (Avni, 1993).

This paper describes the chondrichthyan assemblage of the Menuha Formation for the first time and discusses its palaeoecological implications. Furthermore, it provides the context of the Late Cretaceous environment during the beginning of a large-scale tectonic event that formed the Ramon structure, one of the largest monoclines within the Syrian Arc deformed belt in the Levant (Krenkel, 1924; Bosworth et al., 1999).

2. Geologic setting

2.1. Makhtesh Ramon

The Makhtesh Ramon was formed in a series of tectonic events during the Cretaceous Period. The regional landscape evolved in three main stages: platform, island and continental (Avni, 1993). The platform stage began in the Triassic or earlier and lasted until the Late Cretaceous. During this stage, shallow seas and continental plain environments extended over the Negev through various transgressive-regressive phases. The island stage occurred between the Late Turonian and Eocene and was marked by several uplifting events (Syrian Arc-associated deformation) of the Ramon monocline above sea level, depositing sediments with multiple angular unconformities (Avni, 1993). Periodic erosion of the relief built up siliciclastics that accumulated within the Mount Scopus Group on the lower portion of the sloping flanks of the structure (Avni, 1993).

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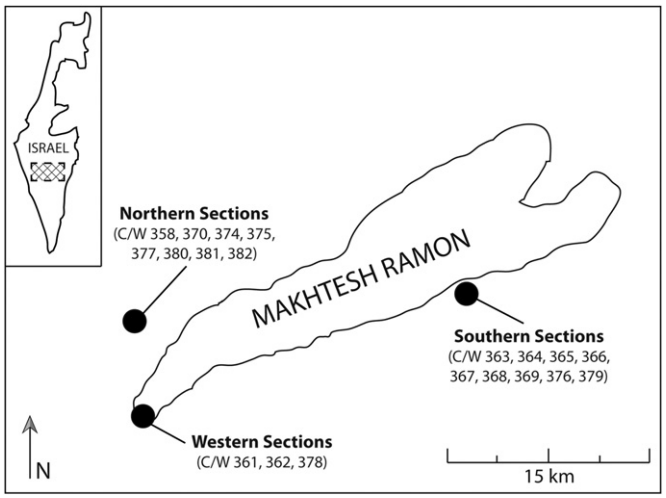

Fig. 1. General outline of the Makhtesh Ramon region in southern Israel. The three shark teeth sampling locations in the Menuha Formation with corresponding C/W numbers (Table 1) are noted.

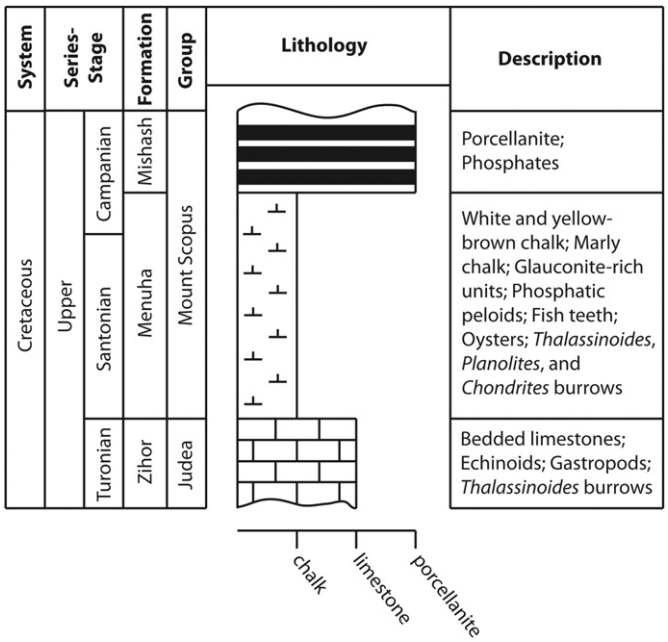

Fig. 2. Generalized stratigraphy and description of the Menuha Formation, situated between the Zihor and Mishash formations.

This erosive process began during the Early Santonian and continued into the Maastrichtian, truncating much of the carbonates within the Judea Group. This left an erosive valley, or small makhtesh, which developed within the eroded core of the Ramon monocline. Synclines on either side of the structure filled with thick sediments of the Menuha, Mishash, Ghareb, and Taqiya formations. Lower Eocene sediments were then deposited over the Mount Scopus Group and older beds (Avni, 1993). The continental stage (Oligocene–Early Miocene) marks a period of extensive exposure and erosion, reactivating the pre-existing erosion surface and further truncating the structure of the Triassic rocks. Later faulting uplifted the structure to its present elevation and created several depressions and domes (Avni, 1993).

2.2. Menuha Formation

The Menuha Formation (Mount Scopus Group) is characterized by organic-rich chalk reflecting deposition during Santonian–Early Campanian transgressive conditions (Fig. 2; Eshet and Moshkovitz, 1995). Previous studies (Friedman et al., 1977; Lewy, 1985) described the formation as also containing calcareous marls, phosphates, gypsum veins and quartz grains. Much of the focus pertaining to the Mount Scopus Group has been centred on the northern Negev and related to phosphate mining and other economic purposes (Flexer and Starinsky, 1970). A previous study by Lewy (1985) noted the appearance of fish teeth within the Menuha Formation; however, no accompanying descriptions are included. This study focuses on the Menuha Formation within the Ramon monocline region, with special attention being paid to the shark-bearing units.

2.3. Measured sections

The chondrichthyan material discussed in this study was collected within three areas around the Ramon monocline (Fig. 1). These regions are located north, south, and west of the erosive valley of Makhtesh Ramon. Three stratigraphic sections were measured in the northern region, near Wadi Aqrav, and two in the southern region. A previously existing section by Avni (1991, Section 18) was referenced when sampling from and analyzing the Menuha Formation in the western region.

The northern sections share a common glauconitic, yellow-brown chalk unit containing numerous fish teeth. This lithologic unit, corresponding to sampling locations C/W-370, 374, 377, 381, and 382 (Table 1), is widespread throughout the Wadi Aqrav area and contains roughly 95% of the fossilized shark teeth in the northern region. The base of the Menuha Formation here is indicated by one of two transitions: (1) limestone cobbles within a chalk matrix to glauconitic, yellow-brown chalk (Wilson et al., in press), or (2) chalky, marly limestone with numerous echinoids to glauconitic, yellow-brown chalk. Other notable fossils in the northern region include oysters (*Pycnodonte vesicularis*?) and trace fossils (*Thalassinoides* and *Chondrites*).

The fossil-bearing units in the southern region are defined by white, pebbly white, and conglomeratic chalk. These units correspond to sampling locations C/W-364, 366, 376, and 379 (Table 1). Oysters (*Pycnodonte vesicularis*?) and trace fossils (*Thalassinoides* and *Planolites*) are also found throughout.

The western region includes a conglomeratic unit of variable thickness. This unit contains pebble-sized limestone clasts within a yellow-brown chalk matrix. The lower portion contains no fossils, whereas the upper portion contains fish teeth. All of the teeth collected here were fragmented, implying that the unit had been reworked. The conglomeratic chalk represents a marginal facies deposited adjacent to the Ramon anticline uplift. This unit corresponds to sampling locations C/W-361 and 362 (Table 1).

2.4. Sedimentology

Much of the Menuha Formation chalk includes abundant glauconite, phosphatic peloids, and microteeth. Many of the samples also contain many irregular echinoid spines, although echinoid tests were not found. Several foraminiferan tests were also noted, including trochospiral, planispiral and biserial forms. Many of the tests have been recrystallized and are no longer identifiable; however, some are clearly globigerinids.

3. Collecting techniques

Specimens were collected using surface-sampling and sieving techniques. A 1.0-mm mesh size was used in the field. Additionally,