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A new equatorial, very shallow marine sclerozoan fauna from the Middle Jurassic (late Callovian) of southern Israel

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ABSTRACT

Tropical Jurassic sclerozoan faunas are poorly known, yet they are critical to our understanding of Jurassic biogeography and the evolution of hard substrate communities. A diverse assemblage of hard substrate fossils is here described from subunits 53 and 54 of the upper Matmor Formation (Callovian) of Hamakhtesh Hagadol in the Negev Desert of southern Israel. This region was on, or very, near the equator during the Middle Jurassic. The fauna is dominated by flat, platter-shaped sponges (*Actostroma*?) and scleractinian corals (*Microsolena*), some of which have the depressed centers and raised rims of "microatolls" which form today in the shallowest subtidal zone associated with reef systems. The coral and calcareous sponge platters are encrusted on their top surfaces by one species of serpulid worm and many small coral and sponge recruits with narrow attachments and mushroom-shaped or conical skeletons growing upwards. The undersurfaces of the platters are encrusted by another serpulid species, at least two calcareous sponges, rare cyclostome bryozoans, oysters, plicatulid bivalves, and numerous thecideide brachiopods (the first known from the Jurassic of the region). The upper and undersurfaces of the platters are often bored by bivalves, forming the ichnospecies *Gastrochaenolites torpedo*. These borings were occasionally reoccupied by a nestling mytilid bivalve on the undersurfaces of the skeletal platters. This encrusting fauna of the Matmor Formation apparently lived in a shallow lagoon on the landward side of a coral reef. The fossils in the surrounding muddy sediments are primarily echinoids, oysters, and rhynchonellid and terebratulid brachiopods. This sclerozoan fauna is an evidence that Jurassic tropical hard substrate faunas were serpulid-rich and bryozoan-poor as predicted, but more diverse (at twelve species) than expected. This community was also ecologically divided into open and cryptic assemblages like its Jurassic equivalents in the temperate and subtropical waters of Europe and North America.

1. Introduction

Sclerozoans are animals which inhabit hard substrates, often by encrusting, boring, or nestling in cavities (Taylor and Wilson, 2002, 2003). Marine fossil sclerozoans are commonly found on hardgrounds (synsedimentarily-cemented seafloor sediments), rockgrounds (exposed surfaces of rocks lithified much earlier), and various biotic substrates including carbonate skeletons, wood, and other plant materials. Diverse sclerozoan communities are found in the marine fossil record throughout the Phanerozoic. The relatively constant physical parameters of this ecological niche, and the preservation of most sclerozoans *in situ* on these hard surfaces, has made them excellent subjects for studying community evolution (e.g., Wilson and Palmer, 1992) and the adaptations and competition between specific clades over time (e.g., McKinney, 1995).

The Jurassic saw a great increase in diversity and abundance of sclerozoan faunas worldwide (Taylor and Wilson, 2003). This was in large part due to the increase in carbonate hard substrates in shallow marine environments including hardgrounds (Palmer, 1982) and thick carbonate skeletons such as those of oysters, sponges and corals (Stanley and Hardie, 1998). There are dozens of systematic and paleoecological studies of Jurassic sclerozoan assemblages (see Taylor and Wilson, 2003), but almost all of them are in the relatively high northern paleolatitudes (>30°) of Europe and North America, or the equivalent southern paleolatitudes of India and Argentina. Prior to the present work there has been only one published study on a Jurassic sclerozoan fauna from tropical paleolatitudes, that of Feldman and Brett (1998) in Israel. If we are to understand the evolution of sclerozoan communities over time, we need more paleogeographic diversity in our studies to detect trends which may change with latitude and climate. Johnson and Baarli (1999) introduced larger questions of latitudinal diversity in the evolution of rocky-shore communities in an important summary paper, pointing out that we know little about paleolatitudinal gradients in critical intervals such as

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the Jurassic. The diverse and well-preserved Jurassic sclerozoan communities in Israel are thus important data points for the study of sclerozoan evolution.

This paper is a continuation of work undertaken in the last two decades that deals with the marine faunas of the Ethiopian Province. The Jurassic Period has been divided into two distinct faunal realms by biogeographers: the Boreal Realm, occupying the northern part of the northern hemisphere, and the much larger Tethyan Realm, that occupied the rest of the world (Arkell, 1956; Hallam, 1975). The Tethyan Realm (= the Tethys-Panthalassa Realm *sensu* Dommergues, 1987; see also Westermann, 2000) has been further subdivided into a number of faunal provinces, such as the Sub-Mediterranean, Mediterranean, Indo-Pacific and Ethiopian provinces, based on the amount of endemism displayed by the faunas in these areas. The Ethiopian Province is characterized by the presence of endemic taxa at the species, genus and family levels. It is recognizable from early in the Jurassic until the middle and possibly the end of the Cretaceous in India, Madagascar, East Africa and, at the end of the Jurassic, in South America. Its first occurrence seems to be in the shallow seas within rifts formed during the breakup of Gondwanaland, but it apparently ends at some unknown southern margin because none of its species are known in the contemporaneous deposits of Antarctica and New Zealand. This long term study began with a taxonomic revision of the brachiopod faunas of the Ethiopian Province (Feldman, 1987; Feldman and Owen, 1988; Feldman et al., 1991; Feldman et al., 2001). We are now in a position to study the paleoecology of various Jurassic marine communities in southern Israel (e.g. Feldman and Brett, 1998).

2. Location

The sclerozoan fauna described here was collected on the northern interior wall of Hamakhtesh Hagadol, a breached anticlinal form approximately 15 km long and 6 km wide, in the northeastern Negev Desert of Israel (Locality number C/W-226; N30° 56.083′, E34° 58.537′, 420 m elevation; Fig. 1). This outcrop is in the same area and within the same stratigraphic interval that Feldman and Brett (1998) did their work, but with a set of subunits they did not include in their study.

3. Stratigraphic and paleogeographic context

The sclerozoan assemblage was collected from subunits 53 and 54 (Goldberg, 1963) of the Matmor Formation (Late Callovian) in Hamakhtesh Hagadol. These subunits at this locality are indistinguishable. The boundary between them was originally designated by Goldberg (1963) as the base of an indurated marl, but it is not visible in this locality. Subunits 53 and 54 are easily marked, though, as being between the "Middle White Unit" and "First Upper White Unit" in Goldberg's (1963) scheme. Together they are here about 8 m thick, consisting of calcareous marl with local patch reefs of corals and calcareous sponges.

The Matmor Formation consists of 100 m of alternating marls and fossiliferous limestones (subunits 43–74 of Goldberg, 1963) above the Zohar Formation (Callovian) and below the Kidod Formation (Oxfordian) in southern Israel. Goldberg (1963) originally considered these subunits as the Matmor Member of the Zohar Formation and an unnamed member of the Kidod Formation. Hirsch and Roded (1996) revised this stratigraphy, noting that the marly units at the top of the Zohar and bottom of the Kidod were Late Callovian (*athleta* Zone) and distinct enough to have their own lithostratigraphic designation: the Matmor Formation. Hirsch and Roded (1996) cited co-occurrences of ostracods and foraminifers in the Matmor Formation to correlate them with the top beds of the Hermon Formation at Majal Shams in the Golan and the top of the Zohar Formation in Sinai.

During the Middle Callovian there was a maximum marine transgression in southern Israel that inundated most of the Arabian platform with typical "Zohar/Matmor" type carbonates yielding

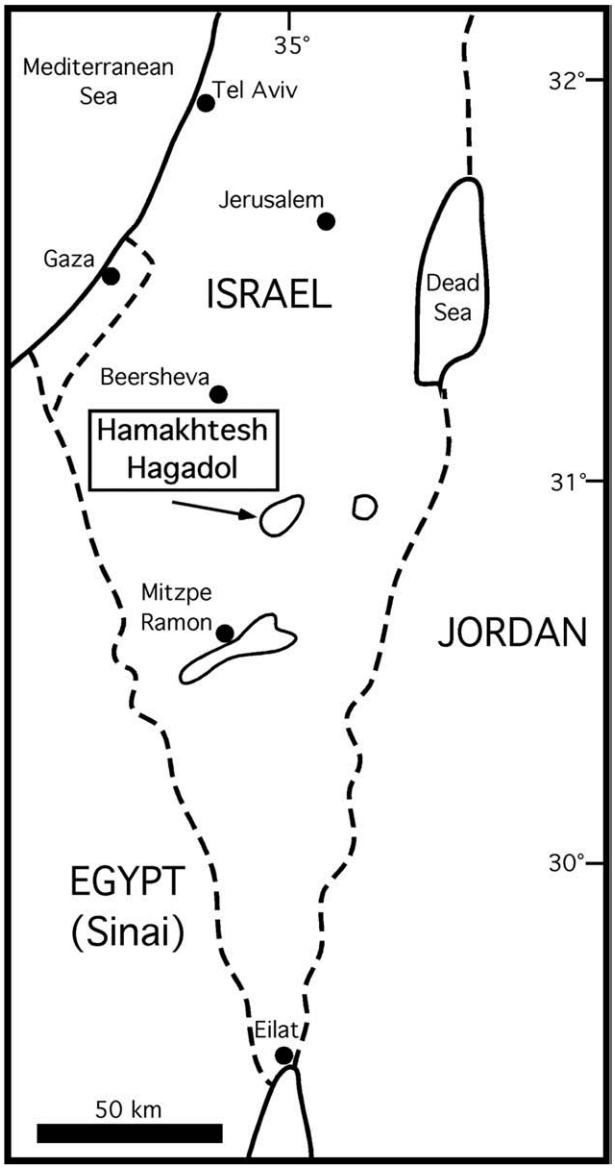

Fig. 1. Location of Hamakhtesh Hagadol, one of three major makhteshim in the Negev Desert, southern Israel. It is an erosionally-breached anticline in which are the exposures of the Middle Jurassic Matmor Formation studied here.

nerinacean gastropods, foraminiferans (*Kurnubia* lineage), brachiopods and abundant bivalves (e.g. *Eligmus*), mostly related to Ethiopian–Somalian taxa. The Ethiopian Faunal Province appears to have been colonized by brachiopods migrating from the north in the Early Jurassic that were then isolated for the remainder of the Jurassic. Subsequently these faunas evolved special morphological characters that distinguish them from their ancestors. In general, the faunas of Israel and Sinai are related to southern Tethyan shelf faunas and are strongly endemic in character.

During the Late Callovian this location would have been on or very close to the equator on the western coast of the Neotethys (Guiraud and Bosworth, 1999, Fig. 8A; Golonka, 2004, Fig. 8).

4. Paleoecological context

4.1. Coral platters and microatolls

The most common hard substrate in the Matmor Formation assemblage is an unidentified species of *Microsolena* (Family Microsolenidae). These corals usually have a platter-like corallum 2–20 cm