The paleoenvironments and paleobiology of the Miocene reefs of the Koronia Formation, Cyprus

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INTRODUCTION

The island of Cyprus is located in the eastern Mediterranean. It is well known for its Cretaceous ophiolite complex which crops out in the Troodos Mountains. The ophiolite complex is an assemblage of basic igneous and ultrabasic rocks which were generated along the constructive margins between spreading plates as one plate was over-ridden by the other, a process known as obduction (Robertson and Malpas, 1990).

My three areas of study were located along the northern margin of the Troodos ophiolite. The Miocene reefs are represented by the Koronia Formation which is Mid-Upper Miocene in age. The Koronia Formation was deposited on uplifted fault blocks as a result of extensional tectonics (Follows and Robertson, 1990).

The Koronia Formation is carbonate and is underlain by the siliciclastic Pakhna Formation which is Mid-Miocene in age (Figure 1). Kristin Wood worked on the Pakhna Formation north of the Troodos ophiolite exposure. Occasionally clasts of Koronia Limestone are found in the Pakhna indicating that the Koronia was deposited contemporaneously in part with the Pakhna. The Koronia mainly consists of reef limestone facies. Sandy and shelly limestone as well as framework cores range from coarse to fine-grained calcarenite. The Kalavasos Formation which overlies the Koronia Formation is mostly gypsum, and consists of selenite crystals with layers of alabaster (Figure 1). Ali Dunn worked on the Kalavasos Formation along the north flanks of the Troodos ophiolite exposure.

The purpose of this project is to gain a better understanding of the Miocene reefs of Cyprus by studying the Koronia Formation and its surrounding facies.

METHODS

Field Methods. The field work included descriptions and observations of the Koronia and its surrounding facies at each of the three sites (Figure 2). Samples taken represented the various reef facies and fossil organisms found in the Koronia Formation. Since there is little information about the Koronia Formation north of the Troodos ophiolite exposure, photographs were taken to help clarify the identification of the Koronia reef cores and their environment of deposition on uplifted fault blocks.

Laboratory Methods. Petrographic work was done to aid in the identification of fossils in the various facies of the Koronia. The thin sections were point-counted to measure the percent of fossils found. Thin sections and samples were photographed to aid in the illustration of the report.

FIELD OBSERVATIONS

The Koronia Formation consists of a series of patch reef cores with various facies relationships (Figure 3). On Kottaphi Hill (Figure 2) there is an excellent example of a large block of reef core which has fallen down the southeast side of the mountain, penecontemporaneous to faulting. The cores consist primarily of coralgal bindstone. The grains of the bindstone are composed of coralline algae, coral fragments, pectinid bivalves, serpulid tubes, foraminifers and other small shell fragments in a micritic matrix. Although the sediment is poorly sorted, it is well cemented by binding algae. Most cores are riddled with *Lithophaga* borings, indicating that the sediment was cemented as hard substrate on the sea floor.

One of the facies surrounding the reef cores is a coarse, shelly calcarenite. This coarse sediment is well sorted and fills in areas between boulders and margins.

Another lithology associated with the Koronia consists of a fine-grained, well-sorted calcarenite. This sediment is very moldic and does not have strong binding framework. As a result the rocks found in this sediment are less resistant than those found in the coralgal sediment.

Many variations of these three lithologies are found on the southwest side of Kreatos (Figure 2) and on the top of the mountain. Due to the numerous normal faults, little of the sediment found is in situ.

It is important to note that little coral is found in the Koronia reefs. A few small heads of *Porites* and *Tarballastrea* are located, but the coralgal binding substrate seems to generate the core of the build up.

The best example of reef talus is found on the northeast side of Kreatos, where there are two different kinds of reef talus. The talus found closest to the top of the mountain consists of subangular clasts generated from coralgal material. The clasts range from 2 cm to 85 cm in diameter. The clasts are full of borings and reefal material. They are poorly sorted and more resistant than the surrounding micritic matrix. This talus is deposited near the core of the build-up.

Further down Kreatos is another clast-rich facies. These clasts are smaller and more subrounded than subangular. The clasts consist of fine-grained calcarenite with very few shells and no indication of coral or algal binding material. The clasts are white and smooth as compared to the micritic matrix which has a sandy color. Trace fossils are found in the micritic matrix and clasts range in size from 3 cm to 20 cm in diameter.

INTERPRETATION OF FIELD OBSERVATIONS

The coralgal bindstone which makes up the reef cores was deposited in a fairly high energy environment. The bindstone was well cemented and provided a framework for *Lithophaga* to bore into. The poorly sorted shell fragments indicate that these cores were located in a shallow environment. The coarse, well-sorted shelly calcarenite was deposited and washed between the reef cores. The fine-grained calcarenite was deposited in the back reef environment which had a lower energy system.

The reef talus indicates what would have been the windward side of the reef system. The subangular clasts of bored reefal material were generated close to the coralgal environment. Further away, in what would have been deeper water, the clasts become more subrounded than subangular. The fine-grained clasts have very few shells and indicate deposition in a lower energy environment further away from the coralgal buildup.

DISCUSSION

The Koronia Formation can be compared with the Messinian patch reefs of the San Miguel de Salinas Basin in southeast Spain. This basin is located between Alicante, Murcia and Cartagena at the southeastern coast of Spain. The small isolated patch reefs found in the San Miguel de Salinas Basin thrived in a mixed carbonate-siliciclastic environment. Like the Koronia Formation, the Messinian patch reefs in Spain commenced growth when there was a reduced influx of terrigenous sediment and a rapid return to clear water conditions. This is evident by the reduced amount of siliciclastic deposition in inter-reef areas and the absence of terrigenous debris inside the reefs (Reinhold, 1995).

The Koronia Formation is also similar to the late Miocene deposits in the Fortuna Basin in southeast Spain. During the Miocene, the Fortuna Basin lay in the eastern part of the Betic Strait, the northern connection between the Mediterranean Sea and the Atlantic Ocean (Mankiewicz, 1995). The facies found at the Fortuna Basin are very similar to those found in the Koronia Formation in Cyprus. Mankiewicz (1995) describes facies like those found in the Koronia Formation as in the "keep-up" phase of reef growth. The "keep-up" phase is very important in understanding the paleoenvironment. The "keep-up" phase means that the reefs were healthy and growing close to sea level. Coralgal bindstones are the dominant facies in this phase. Some of the grains include coralline algae, coral fragments, echinoids, disarticulated bivalves and small and large benthic foraminifers (Mankiewicz, 1995).

CONCLUSIONS

The Koronia Formation was deposited on uplifted fault blocks as a result of extensional tectonics during the Mid-Upper Miocene. The Koronia Formation consists of a series of patch reef cores composed of coralgal bindstone. The micritic matrix indicates that the reef cores consists of many cavities which trapped and protected the micro-crystalline calcite in the high energy system. The Koronia Formation is similar to reef facies which were deposited in southeastern Spain during the Miocene. According to criteria developed by Mankiewicz (1995), the Koronia was deposited during the "keep-up" phase of reef growth, indicated by the coralgal bindstone. Thus the patch reefs were healthy and grew relatively close to sea level.

REFERENCES CITED

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SIMPLIFIED GEOLOGICAL SUCCESSION (SW CYPRUS)

	Holocene		Alluvium, beach barriers, caliche.
QUATERNARY	Pleistocene		Raised beaches & river terraces. Fanglomerates.
		Athalassa Fm (0-40m)	Sands & marls.
	Pliocene	Nicosia Fm (0-800m)	Marls.
	Miocene	Kalavasos Fm (0-150m) & Koronia Fm (0-150m)	Evaporites. Limestones, Patch reefs.
NEOGENE (Tertiary)		Pakhna Fm (0-700m)	Marls, sandstones & conglomerates.
		Terra Fm (0-100m)	Limestones.
	Oligocene	U. Lefkara Fm (0-200m)	Marls.
PALAEOGENE (Tertiary)	Eocene & Palaeocene	M. Lefkara Fm (0-450m)	Chalks, marls & cherts.
	Late Cretaceous	L. Lefkara Fm (0-75m) (Maastrichtian)	Marls, chalks.
		MAMONIA COMPLEX (Maastrichtian)	Moni & Kathikas melanges. Ayios Photios & Dhiarizos Groups.
MESOZOIC		Kannaviou Fm (0-650m) (Maastrichtian & Campanian)	Volcaniclastic sandstones & bentonitic clays.
		Perapedhi Fm (0-55m) (Campanian)	Radiolarite muds, & umbers.

Fig. 1. Simplified table of geological succession in Cyprus (after Greensmith, 1994, table 1).

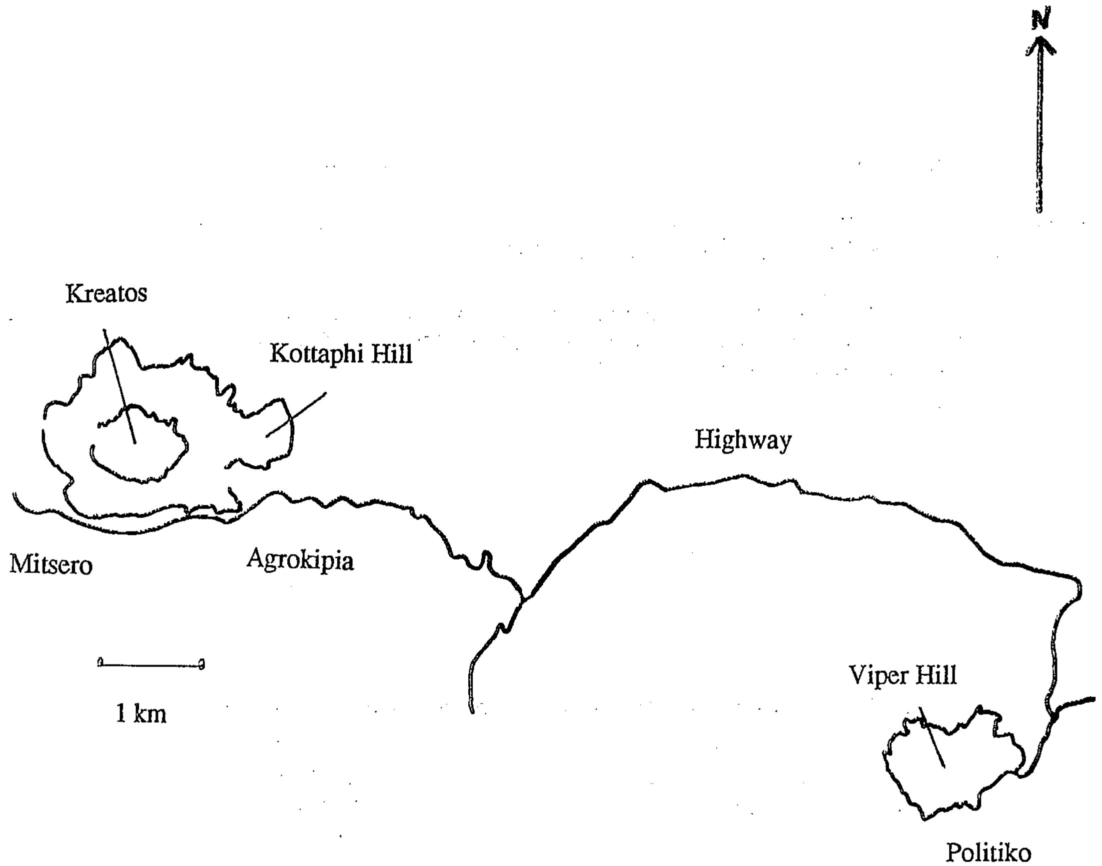

Fig. 2. Map indicating the three areas of study: Kreatos, Kottaphi Hill and Viper Hill.

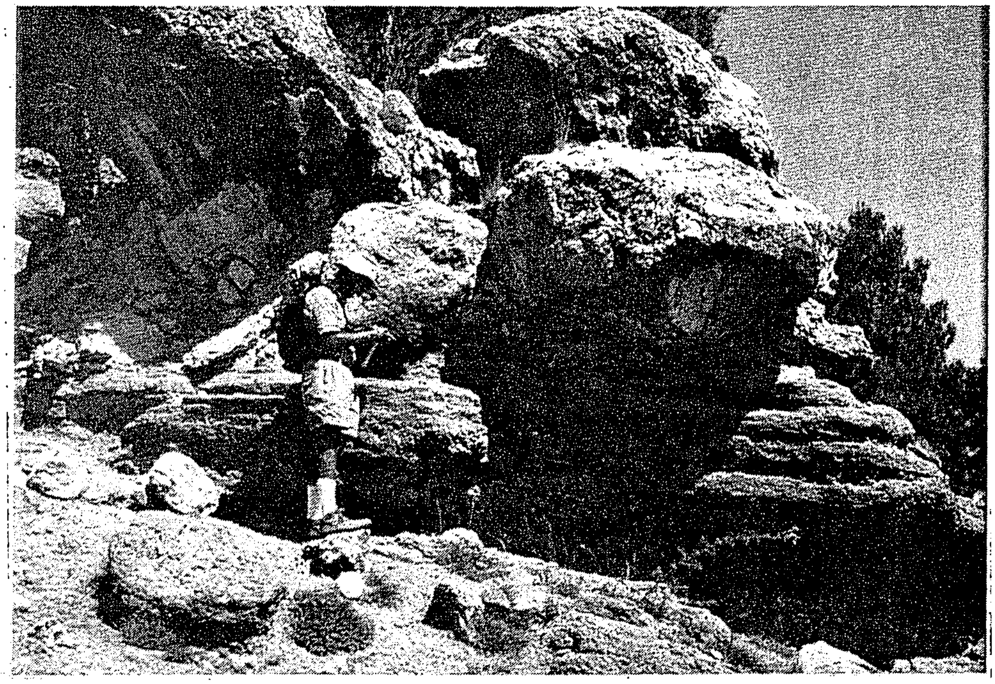

Fig. 3. Koronia reef cores found on large conglomerates of Pakhna on Viper Hill.