Foraminiferal biofacies of the Pakhna Formation (Miocene) on the northern Troodos margin, Cyprus

Kristin D. Wood
Department of Geology, Binghamton University, P.O. Box 6000, Binghamton, NY 13902-6000
Faculty Sponsors:
James Sorauf, Binghamton University
Mark Wilson, The College of Wooster
H. Allen Curran, Smith College

INTRODUCTION

Little has been published on the Pakhna Formation on the northern margin of the Troodos ophiolite in Cyprus. The intent of this research is to help fill this void in the sedimentological and paleontological literature of this region.

Deposition of the Pakhna began in early Miocene and was terminated in late Miocene with the beginning of the evaporitic deposition of the Messinian Kalavasos Formation (Follows and Robertson, 1990, p 208). In many areas the Pakhna overlies the pelagic carbonates of the Lefkara Formation. However, in some places it laps directly onto the pillow lavas of the Troodos massif. Localized block faulting associated with the ophiolite resulted in the deposition of the reefal Koronia Limestone onto the Pakhna in many areas (Follows and Robertson, 1990, p 211). Still, in some areas, the Pakhna is overlain by Messinian gypsum, and in many others, is covered only by Pleistocene and recent sediments.

METHODS

Three sections of Pakhna were studied and sampled in the field:

1. Kottaphi Hill, north of Agrokipia, GPS reading: N35^0 2.99'; E33^0 9.14'
2. Gypsum Canyon Roadcut, northwest of Mitsero, GPS reading: N35^0 4.13'; E33^0 6.52'
3. "Viper Hill", south of Politico, GPS reading: N35^0 1.53'; E33^0 14.36'

Samples of each of the field-determined lithologies of Kottaphi Hill and Gypsum Canyon Roadcut were disaggregated and sifted for foraminifera. Identifications to the generic level were made with the intent of producing a comprehensive faunal list and using the presence of certain foraminifera to determine depositional environments. The high- energy, channelled, cross-stratified section at Viper Hill illustrates the high degree of regional lateral variation of the Pakhna, but will not be dealt with here.

STRATIGRAPHY AND LITHOLOGY

Kottaphi Hill. In this area, the Pakhna is bounded below by the Lefkara Chalks. The lower contact is obscured by talus and was defined for the purpose of creating a stratigraphic column (Figure 1) as the top of the highest exposed Lefkara. At the top of the sequence, Pakhna chalks grade upward into Koronia Limestone.

The lowest definable unit in this section is comprised of a poorly bedded, poorly indurated, brown-gray calcareous mudstone with some siliciclastic detritus as well as flecks of carbonaceous material. The second definable unit begins at 38.0 m where the mudstone takes on a grayer cast and becomes more resistant. Clasts (up to 3 cm) of the same calcareous mudstone appear in this unit along with the first appearance of calcareous bioclastic sandstone interbeds.

The grains within the sandstone are poorly sorted and include quartz, oblong clasts of the same calcareous mudstone lithology, and various skeletal fragments from the Koronia and were most likely deposited during pulses of localized faulting. The most conspicuous skeletal grains include echinoid spines, bivalve fragments, algal fragments and rare coral fragments. In the line of the section, these beds range from 2 to 3 cm thick with a spacing of about 1 m. It should be noted that extensive localized lateral variation makes it impossible to trace these beds for extended distances. Many thicken and thin, or pinch out within tens of meters from the line of section. Near the top of this unit, the sandstone beds thicken, become more fossiliferous and contain larger mudstone clasts.

At 44.1 m, a particularly thick bioclastic sandstone appears as a single unit. The composition is very similar to the interbeds in the lower unit but has more shell fragments and oblong claystone clasts of up to 20 cm. This unit has a greater than average thickness and extensive lateral variability, with its thickness ranging from 20 cm in the line of section to 50 cm in locally adjacent areas. It also serves to divide the lower interbedded claystone/sandstone unit and a similar upper unit of interbedded claystone/sandstone that overlies the bioclastic sandstone.

In this upper unit, the interbeds are thicker than those below and appear with significantly higher frequency. In some places, mudstone units are thinner than the sandstone beds. The mudstone in this unit is similar to the rocks below but has a greener tint indicating a change in clay mineral and iron oxide composition.

The claystone gives way to a series of chalk units at 47.5 m. The first unit consists of a fining upward, brownish chalk with oblong clasts of the green calcareous mudstone (up to 10 cm) with the same lithology as the unit below. Above this lies a white, channeled chalk with convoluted bedding and a non-uniform thickness. In the line of section the unit measured 40 cm. Also present are clasts ranging up to 15 mm of the same white chalk. The top of the Kottaphi Hill section was defined at the base of a channel-form clastic chalk unit that grades upward into the Koronia Limestone. Clasts are considerably more common in this unit and range up to 8 cm. The channel proportions are about 1.5 m wide and 1 m deep.

Gypsum Canyon Roadcut. Here the 10.34 m exposed section of Pakhna is capped unconformably by massive Messinian Gypsum. The lower contact is not visible; however, Lefkara chalks are present at a stratigraphically lower position within 30 m to the west of the area of this section.

The first 1.85 m of the section is comprised of a massive gray calcareous mudstone with a character similar to that of Kottaphi Hill. Above this unit, a series of interbedded mudstone and calcareous bioclastic sandstones gives way at 2.57 m to a zone of massive mudstone alternating with smaller zones of laminated mudstones with thicknesses of about 25 cm. At 4.28 m, a bioclastic sandstone unit with a maximum thickness of 6 cm separates the lower massive/laminated from a similar unit with alternating massive and laminated mudstone. The upper and lower mudstone units are basically the same, with the presence of secondary, crosscutting gypsum veins in the upper unit as the major difference. The upper mudstone unit continues to 10.34 m to the contact with the massive gypsum.

It should be noted that despite the similarities between the Gypsum Canyon Roadcut and Kottaphi Hill lithologies, a detailed correlation is not possible because of the extensive local tectonic activity occurring during the depostion of the Pakhna Formation (Follows and Robertson, 1990, p 211).

DESCRIPTION AND INTERPRETATION OF FORAMINIFIFERAL BIOFACIES

Kottaphi Hill. Samples from each of the defined lithologies of the Kottaphi Hill section were disaggregated and sifted for foraminifera. Numbers preceded by the letter K denote the locations from which particular samples were studied. In all samples, both benthic and planktonic assemblages were found. At this outcrop, the relative abundance of the planktonic foraminifera exceeds that of the benthic variety in all samples studied. However, the diversity of benthic fauna far exceeds that of the planktonics (Table 1). Although identification of all genera is incomplete at this time, there are at most only 4 unidentified planktonic genera present.

Orbulina is the most abundant genus found in all of the foraminifera-bearing samples. *Globigerina* and a few other closely allied, unidentified planktonic genera are only slightly less abundant. Although this holds true for the whole section, the relative number of total foraminifera decreases up the section. The presence of both *Orbulina suturalis* and *O. universa* provides a lower age limit of middle Miocene to the section. Iaccarino (1985, p 290) places the *O. suturalis* datum in mid-Langhian (lower Middle Miocene) and the *O. universa* datum near the base of the Serravallian (Middle

Table 1. Benthic and planktonic genera identified at Kottaphi Hill

Benthic		Planktonic
Uvigerina	*Cassidulina*	*Orbulina*
Lenticulina	*Quinqueloculina*	*Globigerina*
Elphidium	*Cycloforina ?*	*Globorotalia*
Bolivina	*Sigmoilinita*	
Heterolepa	*Pleurostomella*	
Cibicides	*Siphonina*	
Anomalina	*Hansenisca*	
Planorbulina	*Saracenaria*	
Vaginulinopsis	*Asterigerinata*	
Globobulimina	Genus A cf. *Nodosaria*	
Spiroplectinella	Genus B cf. *Planularia*	
Spiroloculina		

Table 2. Benthic and planktonic genera identified to date at Gypsum Canyon Roadcut

Benthic	Planktonic
Uvigerina	*Orbulina*
Elphidium	*Globigerina*
Bolivina	
Heterolepa	
Cibicides	
Anomalina	
Spiroplectinella	
Cassidulina	
Cycloforina ?	
Sigmoilinita	
Melonis	
Asterigerinata	

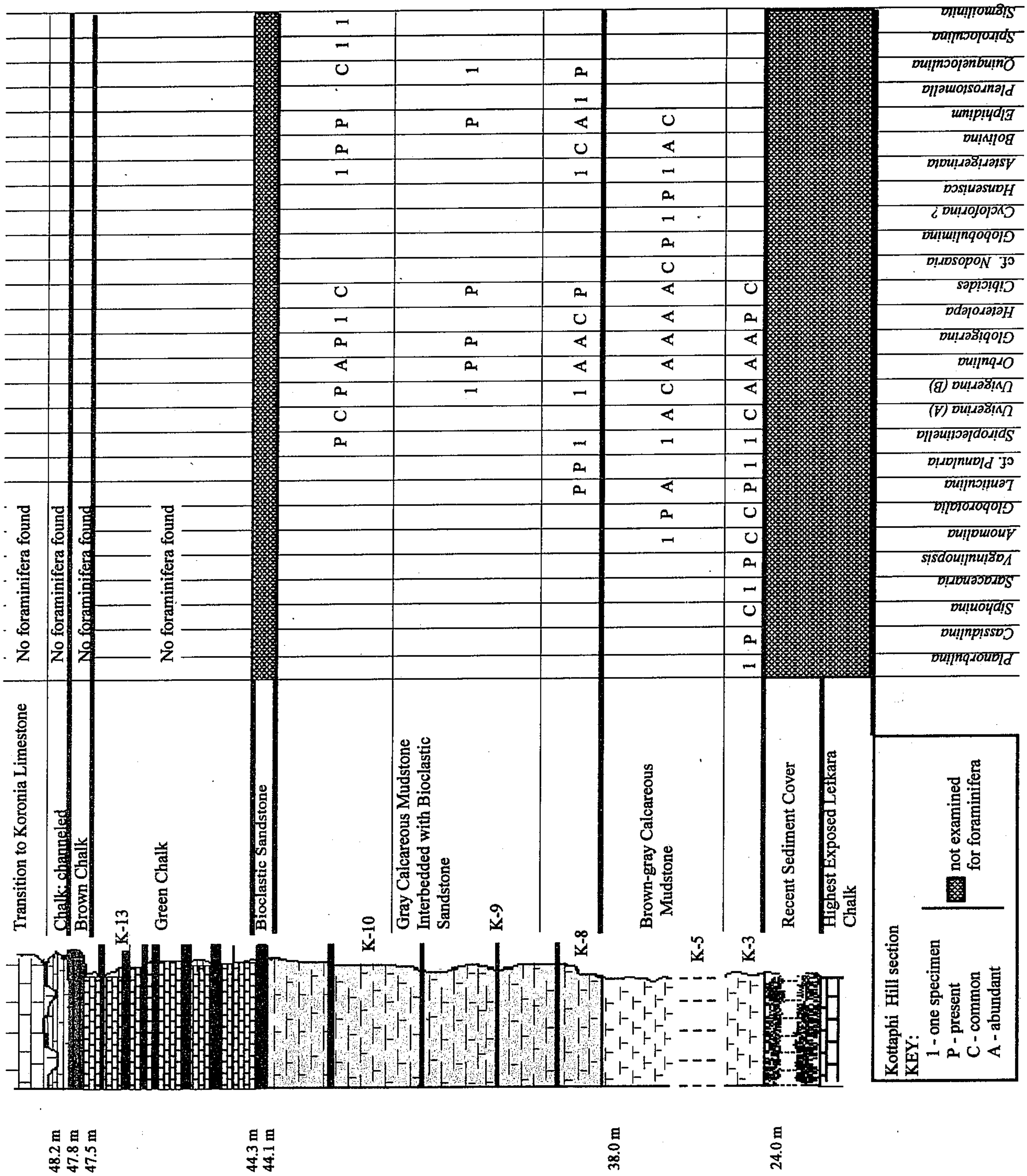
Transition to Koronia Limestone
Chalk: channeled
Brown Chalk
K-13
Green Chalk
Bioclastic Sandstone
K-10
Gray Calcareous Mudstone Interbedded with Bioclastic Sandstone
K-9
K-8
Brown-gray Calcareous Mudstone
K-5
K-3
Recent Sediment Cover
Highest Exposed Leikara Chalk
No foraminifera found
No foraminifera found
No foraminifera found
No foraminifera found
48.2 m
47.8 m
47.5 m
44.3 m
44.1 m
38.0 m
24.0 m
Planorbulina
Cassidulina
Siphonina
Saracenaria
Vaginulinopsis
Anomalina
Globorotalia
Lenticulina
cf. Planularia
Spiroplectinella
Uvigerina (A)
Uvigerina (B)
Orbulina
Globigerina
Heterolepa
Cibicides
cf. Nodosaria
Globobulimina
Cycloforina ?
Hanseniscа
Asterigerina
Bolivina
Elphidium
Pleurostomella
Quinqueloculina
Spiroloculina
Sigmoilina
Kottaphi Hill section
KEY:
1 - one specimen
P - present
C - common
A - abundant
not examined for foraminifera

Figure 1.

Miocene). Other authors have defined the first appearance of *Orbulina* at the beginning of middle Miocene (Kennett and Srinivasan, 1983, p 4; Boersma, 1978, p 74).

In the lowest samples (K-3, K-5, see figure 1), *Uvigerina* is the most abundant benthic genus and is represented by at least two species. Other common genera from section K-3 include *Anomalina, Siphonina,* and *Cibicides.*

In sample K-5, *Cibicides* increases in abundance and the genera *Lenticulina, Bolivina* and *Heterolepa* appear in relatively high numbers . *Elphidium* and genus A cf. *Nodosaria* also make first appearances here and are relatively common. Sample K-8 shows a dramatic decrease in the uvigerinid fauna, but by the level of sample K-10, the uvigerinids again become common, although they are still less abundant than in K-3 and K-5. Also at level K-8, *Elphidium* becomes abundant, *Heterolepa* remains common, and *Cibicides* and *Bolivina* decline. Planktonic foraminifera still dominate at this level, but compared to the lower samples, overall numbers decrease and continue to do so further up in the section.

Sample K-10 shows a rise in the relative abundance of *Uvigerina,* but not to the levels attained in samples K-3 and K-8. Although the first appearance of *Quinqueloculina* occurred in sample K-8, it is relatively common here.

Gypsum Canyon Roadcut. Table 2 shows a list of currently identified foraminifera. At this time, identifications of a number of genera are incomplete. In general, the diversity of the planktonic fauna is considerably greater than in Kottaphi Hill and many of the unidentified benthic foraminifera occur in significant numbers. Although many genera are common to both outcrops, any correlation at this point is subject to considerable error.

Interpretation of Kottaphi Hill. It is generally agreed that modern foraminiferal environments may be used to interpret paleoenvironments as far back as the Miocene (Haynes, 1981, p 250; Murray, 1991, p 304) and are used here. The most relevant benthic genera for this analysis are *Uvigerina, Bolivina,* and *Lenticulina.* Depths for modern costate uvigerinids, which are present in Pakhna beds, are consistent with shelf to at least lower slope environments, with a particularly high abundance on the outer shelf and upper slope (Haynes, 1981 p 211,213). For the modern, small, smooth specimens of *Bolivina* present in the samples, Haynes (1981, p. 213) gives a maximum depth equivalent to the outer shelf. Since *Bolivina* appears in abundance at the level of sample K-5, it would constrain the depositional environment at this level to depths associated with outer slope environments. The presence of *Lenticulina* adds a further constraint with a minimum modern environmental occurrence of outer shelf (Murray, 1991, p 325). Up section into the calcareous mudstone/ bioclastic sandstone unit, the uvigerinids decline drastically and only regain a small portion of their previous status and *Lenticulina* disappears. This, combined with the general decrease in the overall planktonic fauna, suggests a environment for this unit that is shallower than the outer shelf.

In conclusion, the depositional environment of the Pakhna in the Kottaphi Hill area is interpreted as outer shelf near the bottom of the sequence with progressively shallower environments upward, culminating in chalk deposition at the top and finally the transition into Koronia reefal beds. This depositional history is consistent with idea of Koronia reefal buildup onto upthrown blocks of Pakhna (Follows and Robertson, 1990, p 208) and the increasing frequency of calcareous bioclastic sandstone up section may also record that uplift.

REFERENCES CITED

Boersma, A., 1978, Foraminifera, *in* Haq, B.U., and Boersma, A., *eds*., Introduction to marine micropaleontology: New York, Elsevier North-Holland, p. 19-77.

Follows E. J., and Robertson, A. H. F., 1990, Sedimentology and structural setting of Miocene reefal limestones in Cyprus, *in* Malpas, J., Moores, E. M., Panayiotou, A., and Xenophontos, C., *eds*., Ophiolites: Ocean Crustal Analogues, Proceedings of the Symposium "Troodos 1987": Nicosia, Cyprus, The Geological Survey Department and Ministry of Agricultural and Natural Resources, p. 207-215.

Haynes, J. R., 1981, Foraminifera: New York, Wiley & Sons, 433 p.

Iaccarino, S., 1985, Mediterranean Miocene and Pliocene planktic foraminifera *in* Bolli, H., Saunders, J. B., and Perch-Nielson, K., *eds.*, Plankton stratigraphy: Cambridge, Cambridge University Press, p. 283-314.

Kennett, J. P., and Srinivasan, M. S., Neogene planktonic foraminifera: A phylogenetic atlas: Stroudsburg, Pennsylvania, Hutchinson Ross Publishing, 265 p.

Murray, J. W., 1991, Ecology and paleoecology of benthic foraminifera: New York, Wiley &Sons, 397 p.