Archaeology & History in Lebanon Issue fifteen : Spring 2002, p. 82-86

Shells of Unicellular Organism (Foraminifera) Date the Rock Formations of Lebanon

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Dedication

Prof. Ziad Beydoun led the way for our modern understanding of the geology of Lebanon. His respect of the past works done in the field and his modern research and dissertation are an example of scientific probity and application. We stand in his shadow grateful for his example and hope future generations of Lebanon geologists follow the path. He was a friend, a teacher and mentor and an outstanding authority on Middle Eastern geology.

Since the earliest attempts at the turn of the twentieth century of drawing the geologic map of Lebanon, field geologists have been faced with the monotonous endless succession of buff, red and grey, thick and massive sedimentary rock layers that blend in the landscape. Careful surveying using the tools of the day - a hammer, a hand lens, a compass, a note book, a sturdy pair of legs, and a strongly scrutinizing pair of eyes with whatever available means of transport albeit donkeys' backs - began the adventure of geology in Lebanon. These pioneers sometimes ignored or derided by the younger generations of Lebanon geologists, saw well, recorded well and proved accurate by today's advanced techniques and standards in geology. For the geology of Lebanon seemingly benign and simple as an open book, holds many puzzles and conundrums waiting to be solved.

The prime tasks of mapping the exposed rock formations in Lebanon involved the age dating of single or multi-layered packages of sedimentary and/or volcanic rocks. These rock formations, about 2 kms thick, had to be dated, classified and orderly mapped. The then used tools of age dating in the early decades of the past century, involved primarily the systematic collection of large fossils of shells and other invertebrates from individual rock layers. The results were dependable as long as variations in the rock layers in colours, and composition matched the fossil changes along the studied rock column. In monotonous thick rock successions with rare large fossils as is the case of outcrops of the core of Mount Lebanon, age dating relying on the few large fossils became tentative and often inadequate.

Meanwhile a revolution in sedimentary geology and paleontology was occurring in the surrounding oil provinces of the Middle East. The oil geologists came to rely more and more on fossilised microorganisms for age dating as they are always present in the sedimentary carbonate rock formations with varied assemblages and percentages. Unlike large fossils, these critters are more or less consistent in their occurrences throughout the sedimentary rock column.

At present as we follow the footsteps of the pioneers of the geology of Lebanon, we look into

these rock formations and try to age date as accurately as possible the most difficult ones. We borrow the techniques of micropaleontology used by the oil geologists of the Middle East and the extended world oil provinces. Such reliable age dating unlocks the gates of direct applications in local oil exploration, ground water exploitation, and environmental applications of land reclamation and other engineering projects.

Foraminifera

Foraminifera are unicellular organisms with elaborate solid calcite shells that provide clues to the discrete ages and environment of deposition of their host sedimentary layers. Their habitat in the past and present includes oceans and seas. Locally, they had inhabited the Neotethys Sea covering Lebanon for the past 210 M.A until its rise above sea level and have been preserved in its exposed and subsurface rock formations.
Regionally, the Neotethys covering Lebanon for much of its geological history extended across the surrounding areas of the Middle East and carried an abundant variety of foraminifera species that characterized at different geologic times habitats close to or distant from shorelines. As it retreated from the region and left exposed the landmass of the Middle East, old and young rock formations carrying these microfossils formed a network of correlation across the region.

Why are foraminifera so useful and important? The earliest species that appeared 570 M.A ago had a simple shell architecture that got gradually more complex in more evolved younger species. Such marked evolutionary changes place individual species in a particular geologic time and indirectly age date their host sedimentary layer. They are also invaluable past and present ecology, and climate indicators. Indeed, these unicellular protozoans are thermometers and sunlight recorders in the surface and near surface waters of the seas. They occupy two distinctive habitats: the first close to shorelines in the "neritic" zone where the individual species are relatively large and are called benthic foraminifera. The second distant from the shoreline in the "pelagic" zone where the individual species are called planktonic foraminifera and are lighter and smaller in size.

Planktonic species occur worldwide in the broad latitudinal temperature belts. They float in the surface or near-surface waters of the open ocean, but can reach depths of 20m (fig. 1).

Their wide distribution and rapid evolution are a reflection of their successful colonisation of the pelagic realm. When this wide geographical range through the late Mesozoic and in the Cenozoic is combined with a short vertical time range they make excellent index fossils at both the family and generic levels (fig.1).

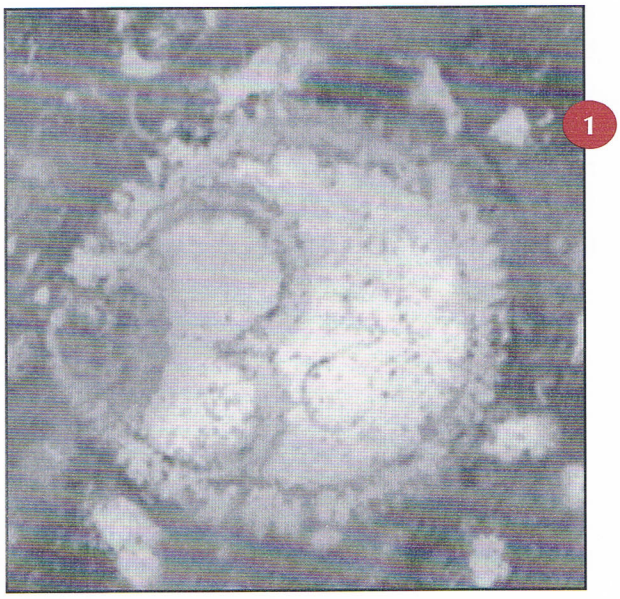

Fig. 1 Planktonic foraminifera *Orbulina suturalis*

"Larger" benthic foraminifera confined mainly to low-latitude areas since the Mesozoic (230 M.A - 65 M.A) until present are most prolific in warm, shallow-water situations, often in association with coralgal reefs7. They are adaptable to distal habitats from shorelines and can reach water depths of 80m (fig. 2).

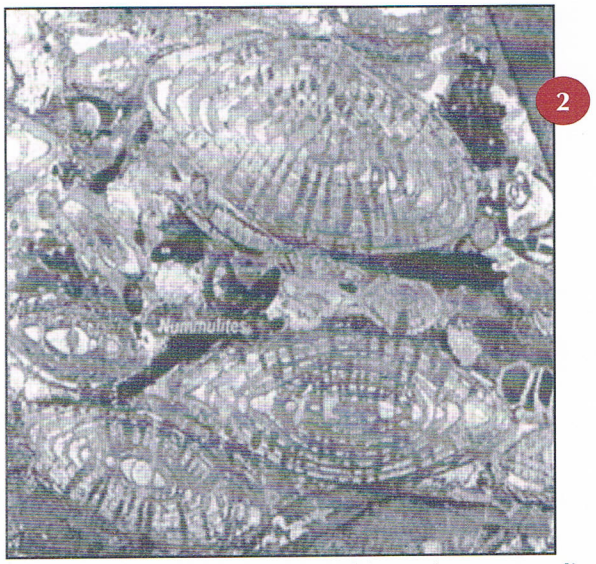

Fig.2 Larger foraminifera in thin section *Nummulites*

They occurred abundantly in the shelf limestones of the Neotethys and are readily available for study when thin-sections of the limestones are prepared for any geological purpose (fig. 2).

They are invaluable markers of older habitats when in conjunction with other fossils (particularly algae and corals). Also their age dating of sedimentary layers from the regional Neotethys, is more fine tuned where they occur in conjunction with the planktonic foraminifera. They are dominant throughout the sedimentary rock section of Lebanon, whereas planktonic foraminifera are present in the topmost sedimentary rock formations of the last 55M.A.

Foraminifera in the Limestones of Lebanon

MESOZOIC (230M.A-65M.A)
JURASSIC (195M.A - 140M.A)/CRETACEOUS
(140M.A - 65M.A)

Current research of the "larger" benthic foraminifera from carbonate rock formations exposed in the core of central Mount Lebanon deals with several unsolved problems. Two of these include: the accurate location of the Jurassic/Cretaceous boundary in the Lebanon sedimentary rock column and the timing of the first volcanic emissions disrupting the Lebanon platform during the Late Jurassic (fig. 3).

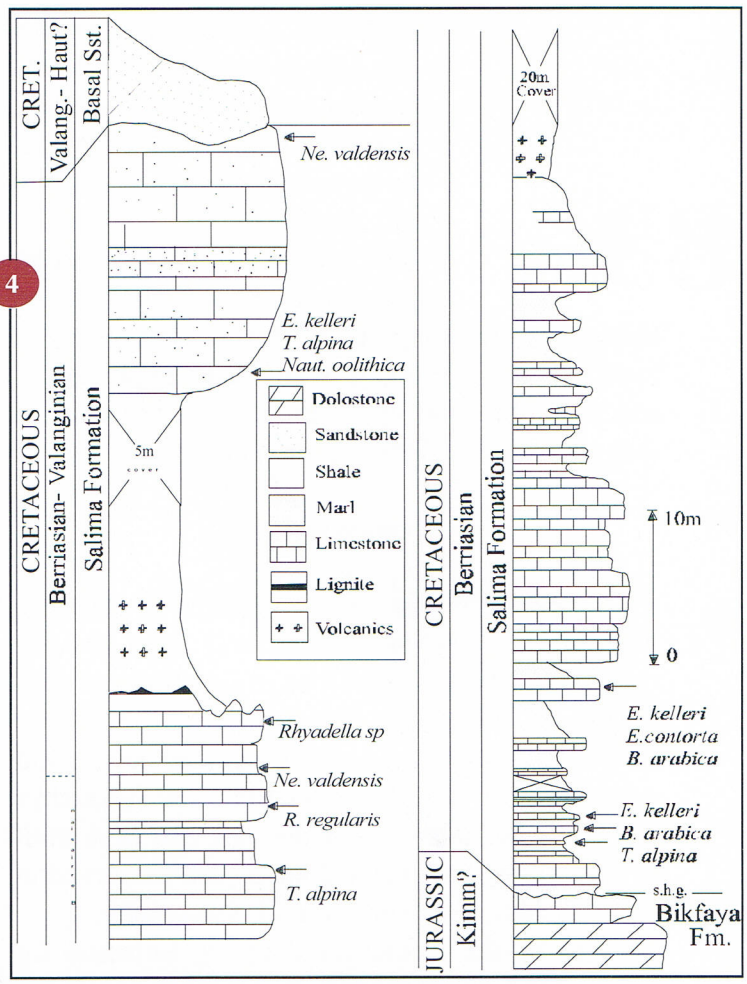

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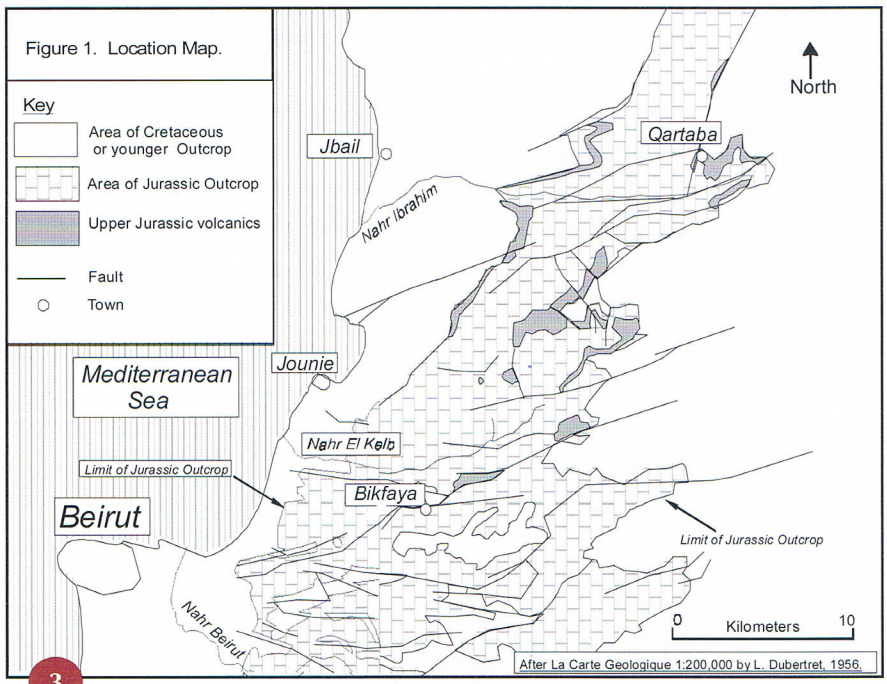
Fig. 3 **Location map of studied Upper Jurassic outcrops in Central Lebanon and standard established Jurassic/Cretaceous boundary.**

Fig. 4 **Lithologic section of the 100m+ of carbonates of the basal Cretaceous below the "Cretaceous Sandstone" and the main diagnostic larger benthonic foraminifera.**



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In the Lebanon landscape, the pine wood groves rising from red sandstones repose on a thick and massive blue grey carbonate (limestone and dolostone) column. Such visual break noted in the geologic maps of Lebanon marks the contact of the Jurassic and Cretaceous. Until the publication of our results, this contact was considered by Lebanon geologists as the recognisable boundary separating the Jurassic carbonates below from the Cretaceous sandstones and carbonates above. But, our study of the "larger" benthic foraminifera from the last preserved 100m+ of the carbonates underlying the Cretaceous sandstone challenged the position of the said boundary. Indeed, the foraminiferal assemblages of these carbonate layers indicated a younger Cretaceous "Berriasian-Valanginian" age of 140 M.A -125M.A instead of a Late Jurassic age older than 140 M.A ago. This recent dating placed the boundary of the Jurassic/Cretaceous at the base

of the 100m+ carbonates rather than at the base of the sandstones (Fig. 4). It also implied that the first retreat of the Neotethys Sea from the Lebanon platform occurred in the later years of the Early Cretaceous during the Valanginian time 125M.A ago and not at the onset of the Cretaceous time of 140M.A ago as previously thought (fig. 5).

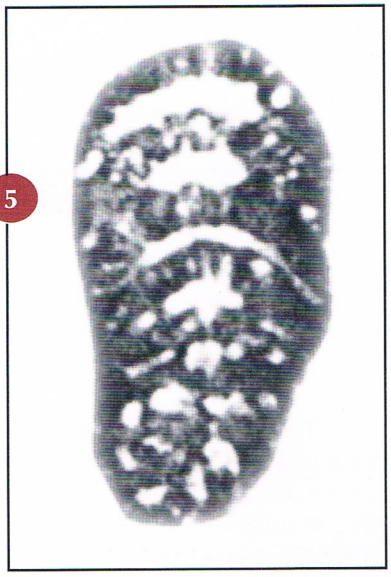


Fig. 5 Larger benethic foraminifera of late Jurassic-Early cretaceous age. *Anchispirocyclina*

A Late Jurassic carbonate rock formation associated with volcanic rocks and exposed in north and central Lebanon breaks the generally monotonous succession of the Jurassic exposures. Until present, the local and regional geologist had assumed it is of an Oxfordian (160 M.A) age. However, our present study of the "larger" benthic foraminifera from several sites of this rock formation in central Lebanon (Fig. 3) drew our attention to two major new findings. The first, in which two different communities coexisted in separate niches of environments of deposition created by concurrent volcanic eruptions. The second, where both assemblages indicated unequivocally an Early Kimmeridgian age (150M.A) to the rock formation. These observations emphasize the role of the "larger" benthic foraminifera as sensitive recorders to their environment of deposition and define the moment the Lebanon platform was first disrupted by volcanic eruptions 150 M.A ago.

CENOZOIC (65M.A-Present Day)

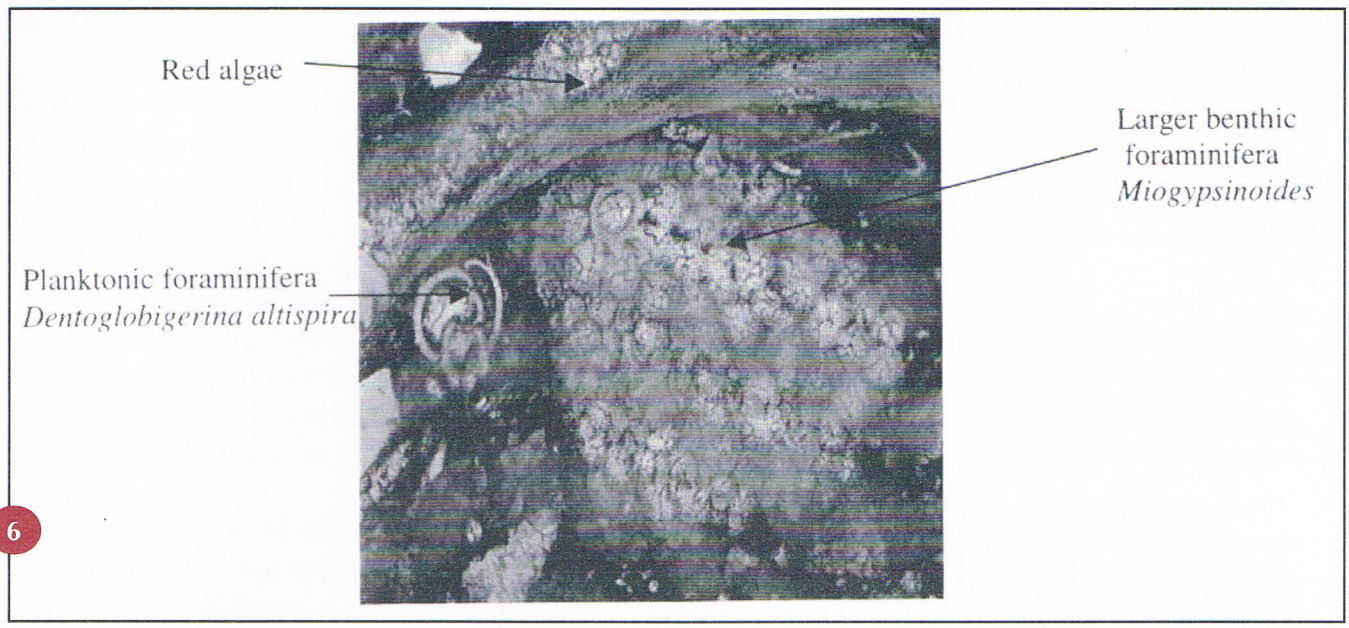
TERTIARY (65M.A-1.8M.A) - Miocene (22.5M.A-6M.A)

Since the Neotethys Sea advanced again above the continental sandstones of the Late Early Cretaceous time 118M.ago, the Lebanon platform remained submerged without major upheavals. But, during the Cenozoic time, the platform was subjected to advances and retreats of the sea leading to the momentous rise of Mount Lebanon. "Larger" benthic and planktonic foraminifera of a Miocene carbonate rock formation by the coast of Lebanon and fringing the foothills of Mount Lebanon tell the tale and restore the sequence of events that occurred during that time. Both groups occurred in various ratios of abundance in the limestone layers of the formation, describing the marine conditions prevailing at the time and the proximity of the shoreline relative to the open sea. Also, their combined presence in the Miocene rock formation age dated accurately its successions of carbonate layers.

In the past, the Miocene carbonates were assigned a Vindobonian age (15.5M.A-13.5M.A). At present, our ongoing studies of the "larger" benthic and planktonic foraminifera (fig.6) show a broader age range beginning with the Langhian and ending by the Tortonian (15M.A-7.5M.A). The age of the assemblages confirm that the Lebanon platform rose 13M.A ago at the end of the Langhian time and beginning of the Serravallian time. For in that time, newly emerged Cretaceous and Jurassic sedimentary layers became exposed to marine erosion and were reduced to boulders, gravel, and pebbles. Today these remnants resemble a dry wall structure that supports and carries the above Serravallian carbonates. Its presence signals the latest rise of Mount Lebanon and retreat of the sea during the Miocene. By the Serravallian time, the sea had advanced again across the Lebanon platform, but its progression was stopped at the rising foothills of the newly born mountain chain. Serravallian and Tortonian outcrops by today's western foothills of Mount Lebanon mark the position of the old Miocene shoreline.

The combination of "large" benthic and planktonic foraminifera in various percentages in the Miocene rock formation indicated a narrower warm shallow water platform than the one of the Mesozoic. Such geometry explains the coexistence of these two groups under open marine conditions close to the shoreline. Past the Tortonian time, the then offspring of the Neotethys Sea, The Mediterranean had taken shape and the old Miocene shoreline began to move westward close to its present day position (fig. 5).

Finally, our contribution to the understanding of the timing of some rock formations in Lebanon through the study of their microfossils,



solves parts of the old conundrums of Lebanon geology. In the same spirit of scientific endeavour and curiosity we hope to continue in the tradition of the major works of L. Dubertret [8,9] and reviews of Z. Beydoun [10,11].

Bibliography

1. BouDagher-Fadel, M.K., Banner, F.T. and Whittaker, J.E. 1997. *Early Evolutionary History of Planktonic Foraminifera*, (British Micropalaeontological Society Publication Series, Chapman & Hall Publishers), 269pp.

2. Kennett, J.P. and Srinivasan, M.S., 1983. *Neogene Planktonic Foraminifera, A Phylogenetic Atlas*. Hutchinson Ross Publishing Company, Pennsylvania: 265p.

3. BouDagher-Fadel M.K., Rose, E.P.F., Bosence, D.W.J. and Lord, A.R. 2001. "Lower Jurassic foraminifera and calcified microflora from Gibraltar, western Mediterranean". *Paleontology*, 44, 601-621.

4. Noujaim-Clark, G. & BouDagher-Fadel, M.K. 2001. "The larger benthic foraminifera and stratigraphy of the upper jurassic/lower cretaceous of Central Lebanon". *Revue de Micropaléontologie*, 44 (3), 215-232.

5. Noujaim-Clark, G., & BouDagher-Fadel M.K., 2002 in press: ""Larger" Foraminifera Assemblages and Stratigraphy of the Upper Jurassic Bhanness Complex Formation; Central Lebanon". In *Revista Espanola di Micropaleontologia.*

6. BouDagher-Fadel, M.K. and Noujaim Clark, G. In preparation. "On the Middle to Late Miocene of Central Coastal Lebanon". *Revue de Micropaléontologie.*

7. BouDagher-Fadel, M.K., Noad, J.J. and Lord, A.R. 2000. "Larger foraminifera from Late Oligocene - Earliest Miocene reefal limestones of North East Borneo". *Revista Española de Micropaleontología*, 32(3), 341-362.

8. Dubertret L. 1929. *Cartes Géologiques du Liban au 50.000e*. Beirut.

9. Dubertret L. 1975. "Introduction à la carte géologique à 1/50000 du Liban". *Notes et Mémoires sur le Moyen-Orient*, 13, p.345-402.

10. Beydoun Z.R. 1977. "The Levantine countries: the geology of Syria and Lebanon (maritime regions)". In: *The Oceans Basins and Margins, 4A, the Eastern Mediterranean*, A.E.M.Nairn, W.H.Kanes and F.G. Stehli (eds) Plenum Press, New York, Ch. 7A, p.319-353.

11. Beydoun, Z. R. 1988. *The Midle East: Regional Geology and Petroleum Resources*. Scientific Press Ltd. pp. 1-292.

Fig. 6 **Thin section micrograph of the Miocene carbonates of Chekka, including planktonic and larger benthonic foraminifera.**