

# Smaller Benthonic Foraminifera from the Gahodleh Shales (Late Jurassic) of Somalia, and their Stratigraphic Significance

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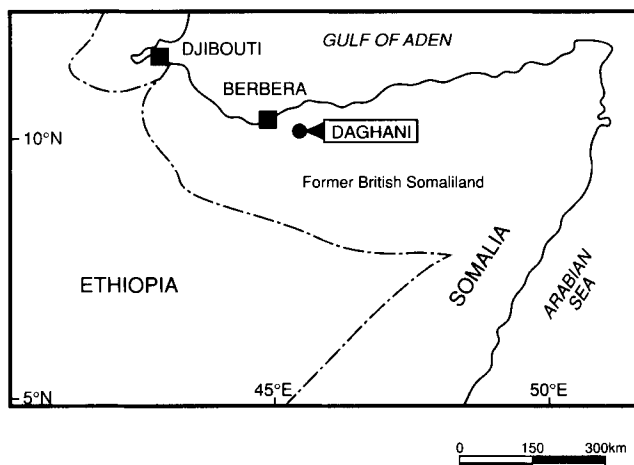
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## ABSTRACT

The smaller benthonic foraminifera identified by MacFadyen (1935) from the Gahodleh Shales of the former British Somaliland are reviewed, and several species are reidentified. The stratigraphic implications are discussed. *J. Micropalaeontol.*, 12 (2): 175-180, December 1993.

## INTRODUCTION

MacFadyen (1935) described twenty-four species of smaller benthonic foraminifera from Beds Ø214 and Ø215 of the Gahodleh Shales (MacFadyen, 1933) in the section exposed at Bihendula (Daghani) in the former British Somaliland (now part of the Somali Republic (Somalia)) (Figs. 1-2). He found the overlying Daghani Shales (MacFadyen, 1933) to be barren of foraminifera. MacFadyen (1935) identified the foraminifera from the Gahodleh Shales as *Trochammina* cf. *nitida* Brady (Bed Ø215, 1 specimen), *Haplophragmium agglutinans* (d'Orbigny) (Bed Ø214, 2 specimens), *H. pictonicum* Berthelin (Bed Ø214, 2 specimens), *Lagena streitbergensis* Gümbel (Bed Ø215, 1 specimen), *Nodosaria vetustissima* (d'Orbigny) (Bed Ø215, 4 specimens), *N. soluta* (Reuss) (Bed Ø214, 2 specimens; Bed Ø215, 5 specimens), *Frondicularia laevissima* Terquem (Bed Ø215, 1 specimen), *Triplasia somaliensis* sp. nov. (Bed Ø215, 1 specimen), *Vaginulina harpa* Roemer (Bed Ø214, 2 specimens; Bed Ø215, 1 specimen), *V. aff. flabellata* (Gumbel) (Bed Ø215, 1 specimen), *Cristellaria munsteri* (Roemer) (Beds Ø214 and 215, common), *C. gibba* d'Orbigny (Beds Ø214 and 215, fairly common (18 specimens altogether)), *C. prima* d'Orbigny (Bed Ø215, 6 specimens), *C. quenstedti* Gümbel (Bed Ø215, 15 specimens), *C. megastoma* Zwingli & Kübler (Bed Ø215, 4 specimens), *C. carinato-costata* Deecke (Bed Ø214, 2 specimens), *C. protracta* Bornemann (Bed Ø215, 3 specimens), *C. tricarinella* Reuss (Bed Ø214, 1 specimen), *C. triquetra* Gümbel (Bed Ø215, 2 specimens), *Epistomina elegans* (d'Orbigny) (Bed Ø215, abundant (86 specimens)), *E. reticulata* (Reuss) (Bed Ø214, frequent (24 specimens)), *E. ornata* (Roemer) (Bed Ø214, frequent (23 specimens); Bed Ø215 rare (6 specimens)), *Bullopore rostrata* Quenstedt (Bed Ø215, 3 specimens (adherent to shell fragments)) and *Nonion* cf. *fraasani* (Gümbel) (Bed Ø215, 1 specimen)). MacFadyen's specimens are housed in three cavity slides (640-642) in the Sedgwick Museum, Cambridge, where they have been examined by the author. His figures (drawings by Miss E.T. Talbot) are reproduced on Pl. 1. Curatorial details are included on the accompanying plate explanation. By reference to the modern literature, I have attempted to resolve the nomenclatorial problems alluded to by MacFadyen ("the determination of Jurassic foraminifera

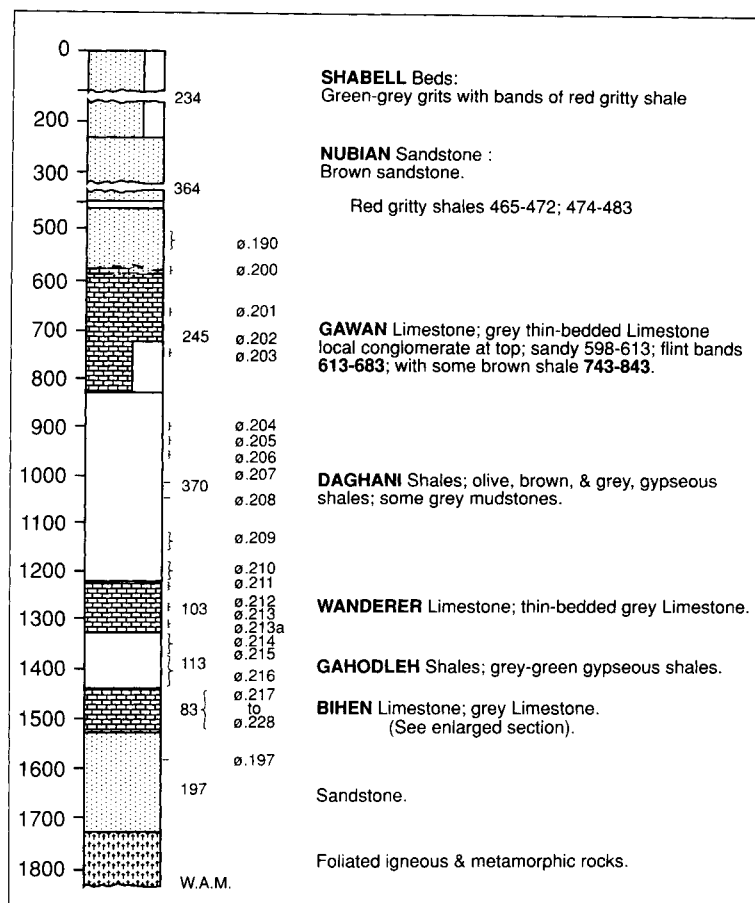


**Fig. 1** Location Map. During the Late Jurassic, much of the area shown on this map lay under a shallow sea, although deeper conditions prevailed in the Berbera Trough (immediately west of Bihendula (Daghani)) and in the sub-basin south of the El Hamurre Fault (running W-E at about 7°N on the other side of the Arabo-Somali Massif) (see, for instance, Arkell, 1956; Bosellini, 1992).

presents special difficulties at the present time, particularly as regards nomenclature ... due in large part to the confusion arising from the older literature ..."), and have reidentified several species, as indicated on Table 1.

## AGE AND PALAEOENVIRONMENTAL INTERPRETATION OF THE GAHODLEH SHALES

The Age of the Gahodleh Shales has been variously interpreted in the Somalian literature as "Argovian" (MacFadyen, 1935) or "Argovian" to Early Kimmeridgian (Furon, 1956; Barnes, 1976), apparently essentially on some somewhat inconclusive cephalopod evidence provided by Spath (1935) (the presence of indeterminate perisphinctid ammonites in Bed Ø214 of the Bihendula (Daghani) section, and of the belemnite *Belemnopsis tanganensis* (the precise age significance of which is doubtful) in both Beds Ø214 and 215). Although in the Somalian literature the stage name



**Fig. 2** The Measured Section at Bihendula (Daghani) (from MacFadyen, 1933). Lat. 10° 90' N., Long. 45° 10' E. Vertical scale 1: 10 000. Measurements in metres. Ø190 to Ø228 indicate samples collected by MacFadyen. The Gahodleh and Daghani Shales were analysed for foraminifera. The Daghani Shales proved unproductive.

"Argovian" has been used more or less consistently to denote Oxfordian/Kimmeridgian, this is neither appropriate nor advisable. The Argovian (stratotypified at Argovie in the Swiss Alps) is equivalent to the Late Oxfordian (see, for instance, Arkell (1956) and Dreyfuss (1956)), but the term has been used loosely to denote "Middle Jurassic" to "Corallian" (Harland *et al.*, 1982). As indicated on Table 3, I have interpreted the age of the Gahodleh Shales (as represented by Beds Ø214 and Ø215) as Late Oxfordian. This age is in accord with that assigned by Arkell (1956) on the basis of stratigraphic relationships. It is essentially based on the occurrence of the smaller benthonic foraminifer *Epistomina reticulata* sensu Shipp, 1989 (non *Rotalia reticulata* Reuss 1863), whose stratigraphic range is constrained by ammonite control (Middle to Late Oxfordian, Tenuiserratum to Regular Zones), (See Table 2.) A tentative correlation can be made with the 147Ma maximum flooding surface of Haq *et al.* (1987) (see also Bosellini, 1992).

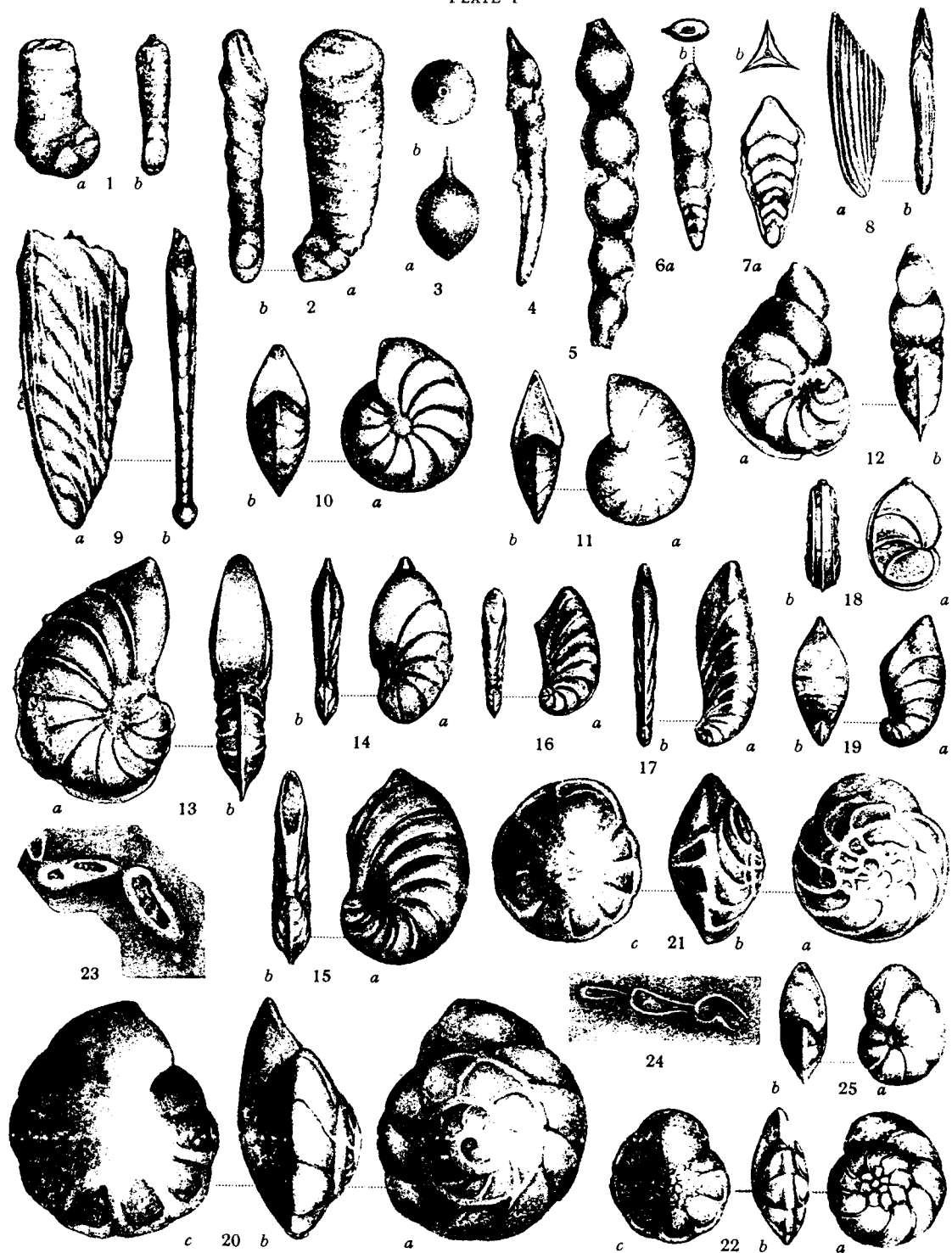
#### Palaeoenvironmental Interpretation

With regard to the palaeo-environmental interpretation of the Gahodleh Shales, a "shelfal" setting is suggested both by regional palaeogeographic reconstructions (Azzaroli & Fois, 1964; Bosellini, 1992) and by the local lithofacies (argillaceous, non-calcareous). The benthonic foraminiferal assemblages are entirely consistent with a shelfal interpretation. Such species as *Dentalina pseudocommunis* and *Lenticulina muensteri* s. l. were typically "mid" shelfal in the Jurassic, according to the palaeobathymetric range chart constructed by Johnson (1976) for the Lias of the Mochras Borehole, offshore U.K. Significantly, both "inner" shelf (*Citharina* spp.) and "outer" shelf (*Reinholdella* spp.) species are conspicuous by their absence.

#### Explanation of Plate 1

**Fig. 1** *Ammobaculites* sp. Bed Ø214. x 21. Sedgwick Museum Slide 642, Square 22. **Fig. 2** *Haplophragmium* ex gr. *inconstans* Bartenstein & Brandt. Bed Ø214. x 21. Sedgwick Museum Slide 642, Square 23. **Fig. 3** *Lagena streitbergensis* Gümbel. Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 20. **Fig. 4** *Dentalina pseudocommunis* Franke. Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 2. **Fig. 5** *Dentalina* sp. Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 1. **Fig. 6** *Fronidularia laevissima* Terquem. Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 6. **Fig. 7** *Triplasia somaliensis* MacFadyen. Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 21. **Figs. 8-9** *Citharina serratocostata* (Gümbel). Bed Ø215. x 46. Sedgwick Museum Slide 642, Squares 3 (Fig. 8) and 4 (Fig. 9). **Figs. 10-11** *Lenticulina muensteri* (Roemer) s.l. Bed Ø214. Fig. 10 x 37; Fig. 11 x 46. Sedgwick Museum Slide 642, Squares 12 (Figure 10) and 15 (Fig. 11). **Fig. 12** *Lenticulina prima* (d'Orbigny). Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 8. **Fig. 13** *Lenticulina quenstedti* (Gümbel). Bed Ø214. x 46. Sedgwick Museum Slide 642, Square 10. **Fig. 14** *Lenticulina ectypa* (Loeblich & Tappan). Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 9. **Figs. 15-16** *Planularia carinatocostata* (Deecke). Bed Ø214. x 46. Sedgwick Museum Slide 642, Square 14. **Fig. 17** *Astacolus major* (Bornemann). Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 7. **Fig. 18** *Planularia tricarinella* (Reuss). Bed Ø214. x 46. Sedgwick Museum Slide 642, Square 11. **Fig. 19** *Saracenaria triquetra* (Gümbel). Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 16. **Fig. 20** *Epistomina parastelligera* (Hofker). Bed Ø215. X46. Sedgwick Museum Slide 642, Square 17. **Fig. 21** *Epistomina reticulata* sensu Shipp. Bed Ø214. X46. Sedgwick Museum Slide 642, Square 18. **Fig. 22** *Epistomina mosquensis* Uhlig. Bed Ø214. x 46. Sedgwick Museum Slide 642, Square 19. **Figs. 23-24** *Bullopore rostrata* Quenstedt. Bed p215. x 46. Sedgwick Museum Slide 642, Square 24. **Fig. 25** ?*Lenticulina* sp. Bed Ø215. x 46. Sedgwick Museum Slide 642, Square 5.

PLATE I



Comparative Terminology of Smaller Benthonic Foraminifera from the Gahodleh Shales	
MacFadyen (1935)	This Paper
<i>Haplophragmium agglutinans</i>	<i>Ammobaculites</i> sp. (*)
<i>Haplophragmium pictonicum</i>	<i>Haplophragmium</i> ex gr. <i>inconstans</i>
<i>Lagena streitbergensis</i>	No change
<i>Nodosaria vetustissima</i>	<i>Dentalina pseudocommunis</i>
<i>Nodosaria soluta</i>	<i>Dentalina</i> sp
<i>Fronicularia laevis</i>	No change
<i>Triplasia somaliensis</i>	No change
<i>Vaginulina harpa</i>	<i>Citharina serratocostata</i>
<i>Vaginulina aff. flabellata</i>	<i>Citharina serratocostata</i>
<i>Cristellaria munsteri</i>	<i>Lenticulina muensteri</i> s.l.
<i>Cristellaria gibba</i>	<i>Lenticulina muensteri</i> s.l.
<i>Cristellaria prima</i>	<i>Lenticulina prima</i>
<i>Cristellaria quenstedti</i>	<i>Lenticulina quenstedti</i>
<i>Cristellaria megastoma</i>	<i>Lenticulina ectypa</i>
<i>Cristellaria carinato-costata</i>	<i>Planularia carinatocostata</i>
<i>Cristellaria protracta</i>	<i>Astacolas major</i>
<i>Cristellaria tricarinnella</i>	<i>Planularia tricarinnella</i>
<i>Cristellaria triquetra</i>	<i>Saraceneria triquetra</i>
<i>Epistomina elegans</i>	<i>Epistomina parastelligera</i>
<i>Epistomina reticulata</i>	No change
<i>Epistomina ornata</i>	<i>Epistomina mosquensis</i>
<i>Bullopore rostrata</i>	No change
<i>Nonion cf. fraasani</i>	<i>Lenticulina</i> sp.

**Table 1** Comparative Terminology of Late Jurassic Smaller Foraminifera from the Gahodleh Shale. \* = *Ammobaculites agglutinans* sensu Shipp, 1989 (non *Spirolina agglutinans* d'Orbigny, 1846).

AGE	REGION	SOMALIA (GULF OF ADEN)	YEMEN (SOUTH)	SAUDI ARABIA (RUB AL KHALI)
VALANGINIAN	E	GAWAN LIMESTONE	NAIFA	HABSHAN SALIL RAYDA THAMAMA
BERRIASIAN				
TITHONIAN	L M E			
KIMMERIDGIAN	L M E	DAGHANI SHALES	SABATAYN	HITH
		WANDERER LIMESTONE	LIMESTONE	ARAB
			SHALE	JUBAILA
OXFORDIAN	L M E	SAWER LIMESTONES GAHODLEH SHALES	MADBI	HANIFA
CALLOVIAN		BIHEN LIMESTONE	SHUQRA	TUWAIG MT.
BATHONIAN	L			ARAEJ

## REGIONAL CORRELATION (SOMALIA TO THE ARABIAN PENINSULA)

A lithostratigraphic correlation can be made between the Middle to Late Jurassic sections of Somalia and the Arabian Peninsula (which were at that time, prior to the rifting in the Gulf of Aden, contiguous). This correlation (Table 3) indicates that the Madbi Formation of the Yemen is partly equivalent to the Gahodleh Shales of Somalia, and is therefore at least in part of Oxfordian age. This in turn provides independent constraint on the ages of the overlying surface and subsurface formations of the Yemen, which was formerly lacking (ages being based on larger benthonic foraminiferal and palynomorph datums generally only loosely calibrated against standard ammonite zonations). This is important in that certain of the subsurface formations constitute important petroleum reservoirs in fields in the Marib Jawf Graben (see, for instance, Maycock (1987), Hurdeman *et al.* (1989) and Ali Tahera *et al.* (1992)).

## CONCLUSIONS

Reidentifications of some of the smaller benthonic foraminifera identified by MacFadyen (1935) from the Gahodleh Shales of Somalia enable a refinement of the stratigraphic interpretation of the formation. An Oxfordian age is assigned. An Oxfordian age is also assigned to the presumed equivalent Madbi Formation, which underlies petroliferous formations in the subsurface of the Marib Jawf Graben in the Yemen.

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## REFERENCES

**Table 3** Late Jurassic to Early Cretaceous Stratigraphic Correlation, Somalia to the Arabian Peninsula. Compiled from various sources, chiefly MacFadyen (1933), Beydoun (1964, 1970, 1988, 1991), Abbate *et al.* (1974), Barnes (1976), Ali Tahera *et al.* (1990), Bott (1992) and unpublished sources. Lithostratigraphic nomenclature follows the BP in-house usage. Madbi Limestone probably equivalent to lower ("platy") Naifa Formation of authors.

Age \ Species				Ammobaculites sp <sup>*</sup> <sub>3</sub>	Haplophragmium ex gr. inconstans	Dentalina pseudocommunis	Citharina serratocostata	Lenticulina quentstedti	Lenticulina ectypa	Astaculus major	Planularia tricarinella	Epistomina parastelligera	Epistomina reticulata <sup>*</sup> <sub>4</sub>	Epistomina mosquensis	
PORTLANDIAN			ANGUIFORMIS	L	TITHONIAN										
			KERBERUS												TRANSITORIUS
		OKUSENSIS													
		GLAUCOLITHUS													
		ALBANI													
KIMMERIDGIAN <sup>*1</sup>	L	FITTONI	SCRUPOSUS	M											
		ROTUNDA													
		PALLASIOIDES													PUSCHI
		PECTINATUS													PALMATUS
		HUDLESTONI													CILATA
	M	WHEATLEYENSIS	PENCILLIATUM & ROTHPLETZ	E											
		SCITULUS	VIMINUS												
		ELEGANS	TAPPLICATUS												
		GRAVESIA/ HYBONOTUM													
	E	AUTISSIODORENSIS	BECKERI	L	KIMM.										
		EUDOXUS	EUDOXUS												M
		MUTABILIS	ACANTHICUM												
		CYMODOCE	DIVISUM												
		OXFORDIAN	L												
REGULARE															
SERRATUM															
GLOSENSE															
TENUISERRATUM	TRANSVERSARIUM														
DENSIPLICATUM															
E	CORDATUM	CORDATUM	E												
	MARIAE	MARIAE													
CALLOVIAN	LAMBERTI		*2	CALLOVIAN											
	ATHLETA														
	CORONATUM														
	JASON														
	CALLOVIENSE														
	MACROCEPHALUS														

**Table 2** Stratigraphic Ranges of Selected Smaller Benthonic Foraminifera from the Gahodleh Shale. Compiled from various sources, chiefly Gradstein *et al.* (1989) (Central Asia) and Shipp (1989) and references therein (Europe). Ammonite zonation from Haq *et al.* (1987a-b) (Boreal) and Arkell (1956), Verma & Westermann (1984) and Enay *et al.* (1987) (Tethyan). Bold line indicates ammonite control, dashed line indicates no ammonite control. Shading indicates inferred age-range of sampled part of Gahodleh Shale. \*1 = sensu Anglico; \*2 = *Erymnoceras*, *Pachyermynoceras*, "*Prosciceras*" gr. *hatirae*, *Grossouviria* and *Proplanulitidae*; \*3 = *Ammobaculites agglutinans* sensu Shipp, 1989; \*4 = sensu Shipp, 1989.

- Abbate, E., Ficarelli, G., Pirini Radrizzani, C., Salvietti, A., Torre, A. & Turi, A., 1974. Jurassic Sequence from the Somali Coast of the Gulf of Aden. *Riv. ital. Paleont. Stratigr.*, Milano, **80**(3), 409-478.
- Ali Tahera, A., Sturgess, M., Maycock, I., Mitchell, G., Prelat, A., Numi, R. & Petricola, M., 1992. Looking for Yemen's Hidden Treasure. *Middle East Well Evaluation Rev.*, **12**, 12-29.
- Arkell, W.J., 1956. *The Jurassic Geology of the World*. Edinburgh (Oliver & Boyd).
- Azzaroli, A. & Fois, V., 1964. Geological Outlines of the Northern End of the Horn of Africa. *Proc. Twenty-Second Int. geol. Congr.*, **4**, 293-314.
- Barnes, S.U., 1976. Geology and Oil Prospects of Somalia, East Africa. *Amer. Assoc. Petrol. Geol. Bull.*, Tulsa, Oklahoma, **60**(3), 389-413.
- Beydoun, Z.R., 1964. *The Stratigraphy and Structure of the Eastern Aden Protectorate*. London (H.M.S.O. (Overseas Geology and Mineral Resources Supplement Series)).
- Beydoun, Z.R., 1970. Southern Arabia and Northern Somalia: Comparative Geology. *Phil. Trans. R. Soc.*, London, **A267**, 267-292.
- Beydoun, Z.R., 1988. *The Middle East: Regional Geology and Petroleum Resources*. Beaconsfield, Bucks. (Scientific Press).
- Beydoun, Z.R., 1991. *Arabian Plate Hydrocarbon Geology and Potential - a Plate Tectonic Approach*. Tulsa, Oklahoma (American Association of Petroleum Geologists).
- Bosellini, A., 1992. The Continental Margins of Somalia: Structural Evolution and Sequence Stratigraphy. In Watkins, J.S., Feng Zhiqiang & McMillen, K.J. (Eds.), *Geology and Geophysics of Continental Margins*, 185-206. Tulsa, Oklahoma (American Association of Petroleum Geologists).
- Bott, W.F., Smith, B.A., Oakes, G., Sikander, A.H. & Ibrahim, A.I., 1992. The Tectonic Framework and Regional Hydrocarbon Prospectivity of the Gulf of Aden. *J. Petrol. Geol.*, Beaconsfield, **15**(2), 211-243.
- Dreyfuss, M. (Dir.), 1956. Europe: France, Belgique, Pays-Bas, Luxembourg: Jurassique s. str. *Lexique Strat. Int.*, Paris, **I**(4aV).
- Enay, R. (Co-Ord.), 1987. Le Jurassique d'Arabie Saoudite Centrale. *Geobios, Mem. Spec.*, Lyon, **9**.
- Furon, R. (Dir.), 1956. Afrique: British Somaliland, Somalie Francaise, Somalia Italiana, Ethiopie-Erythree. *Lexique Strat. Int.*, Paris, **IV**(5).
- Gradstein, F.M., Gibling, M.R., Jansa, L.F., Kaminski, M.A., Ogg, J.G., Sarti, M., Thürow, J.W., von Rad, U. & Westermann, G.E.G., 1989. Mesozoic Stratigraphy of Thakkhola, Central Nepal. Halifax, Nova Scotia (Centre for Marine Geology, Dalhousie University).
- Haq, B.U., Hardenbol, J. & Vail, P.R., 1987a. Chronology of Fluctuating Sea-Levels Since the Triassic (250 Million Years Ago to the Present). *Science*, New York, **235**, 1156-1167.
- Haq, B.U., Hardenbol, J. & Vail, P.R., 1987b. New Chronostratigraphic Basis of Cenozoic and Mesozoic Sea-Level Cycles. *Spec. Publ. Cushman Found. foramin. Res.*, Washington, D.C., **24**, 7-14.
- Harland, W.B., Cox, A.V., Llewellyn, P.G., Pickton, C.A.G., Smith, A.G. & Walters, R., 1982. *A Geologic Time Scale*. Cambridge (University Press).
- Huurdeman, A.J.M., Breunese, J.N., Al-Asbahi, A., Lutgert, J.E. & Floris, F.L.T., 1989. Assessment of Halite-Cemented Reservoir Zones with a Combined Geological/Engineering Approach: a Case Study. SPE, Houston, Texas, **19603**.
- Johnson, B., 1976. Ecological Ranges of Selected Toarcian and Domerian (Jurassic) Foraminiferal Species from Wales. *Marit. Sediments spec. Publ.*, Halifax, Nova Scotia, **1B**, 545-556.
- MacFadyen, W.A., 1933. *The Geology and Palaeontology of British Somaliland, Part I: The Geology of British Somaliland*. Government of Somaliland Protectorate.
- MacFadyen, W.A., 1935. Jurassic Foraminifera. In MacFadyen, W.A., Dighton Thomas, H., Currie, E.D., Hawkins, H.L., Bather, F.A., Muir-Wood, H.M., Cox, L.R. & Spath, L.F. (Eds.), *The Geology and Palaeontology of British Somaliland, Part II: The Mesozoic Stratigraphy of British Somaliland*, 7-20. Government of Somaliland Protectorate.
- Maycock, I.D., 1987. Exploration and Development in Marib/Al Jawf Basin, Yemen Arab Republic. *Houston geol. Soc. Bull.*, **31**, 8.
- Shipp, D.J., 1989. The Oxfordian to Portlandian (Upper Jurassic). In Jenkins, D.G. & Murray, J.W. (Eds.), *Stratigraphical Atlas of Fossil Foraminifera*, 237-272. Chichester (Ellis Horwood Ltd.).
- Spath, L.F., 1935. Jurassic and Cretaceous Cephalopoda. In MacFadyen, W.A., Dighton Thomas, H., Currie, E.D., Hawkins, H.L., Bather, F.A., Muir-Wood, H.M., Cox, L.R. & Spath, L.F. (Eds.), *The Geology and Palaeontology of British Somaliland, Part II: The Mesozoic Stratigraphy of British Somaliland*, 205-228. Government of Somaliland Protectorate.
- Verma, H.M. & Westermann, G.E.G., 1984. The Ammonoid Fauna of the Kimmeridgian-Tithonian Boundary Beds of Mombasa, Kenya. *Contr. Life Sci. Div. R. Ont. Mus.*, Toronto, **135**.