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Late Lower and Middle Devonian miospores from Saudi Arabia

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Abstract

Late Lower and Middle Devonian miospores are identified in cuttings from well TRBH-1. A biostratigraphic zonation is proposed and compared with the miospore zonal scheme defined in Western Europe. All samples contained caved material. By graphic correlation with contemporaneous cored sequences previously analysed in Libya and Tunisia, the first appearance of *Geminospora lemurata*, a key species for defining the base of the Givetian, is evaluated.

1. Introduction

The present paper is mainly based on miospore analysis of cuttings samples from well TRBH-1 (WW-1) in the northern part of Saudi Arabia, approximately at 28°N, 43°E (Fig. 1) together with additional data obtained from two other wells (DMMM-45 and SDGM-211) in the eastern part of Saudi Arabia.

2. Miospore record

In well TRBH-1, most of the samples contain miospores. The interval between 1309 and 1348 ft belongs to the Jubah Formation and the interval 3399–3419 ft belongs to the Tawil Formation. Only the oldest sample (at 3596–3622 ft) corresponds to a ? Tawil Sandstone equivalent.

Miospores are more abundant, more diverse in composition and better preserved in the intervals 1309–1348 ft to 1900–1949 ft of the Jubah Formation than in older parts of the studied intervals.

The stratigraphic distribution of the most important taxa is listed on Fig. 2. Most of these taxa are well known from Devonian deposits in southern Euramerica and western Gondwanan regions and allow the recognition of several palynological events.

The oldest assemblage, from the Tawil Formation, is found in the lowermost part of the investigated borehole and corresponds to the presence of *Emphanisporites annulatus* (at 3596–3622 ft) and to the first occurrence of *Camarozonotriletes sextantii* (at 3199–3255 ft). Most of the specimens observed in these intervals, such as *Brochotriletes foveolatus*, *Tholisporites chulus*, *Emphanisporites rotatus*, *Synorisporites* spp., *Dictyotriletes emsiensis*, and *Diatomozonotriletes franklinii*, are smaller than 50 μm.

A similar assemblage occurring also in the Tawil Formation has been identified in the intervals 12540–12580 ft and 12520–12540 ft in well DMMM-45 as well as in core 15 at 14423 ft in well SDGM-211 approximately 100 km southeast of Dhahran (Steemans, 1995-this issue).

The next succeeding palynological event in well TRBH-1 occurring in the Subbat member of the Jauf Formation is marked by the first occurrence of *Rhabdosporites minutus* at 2579–2608 ft.

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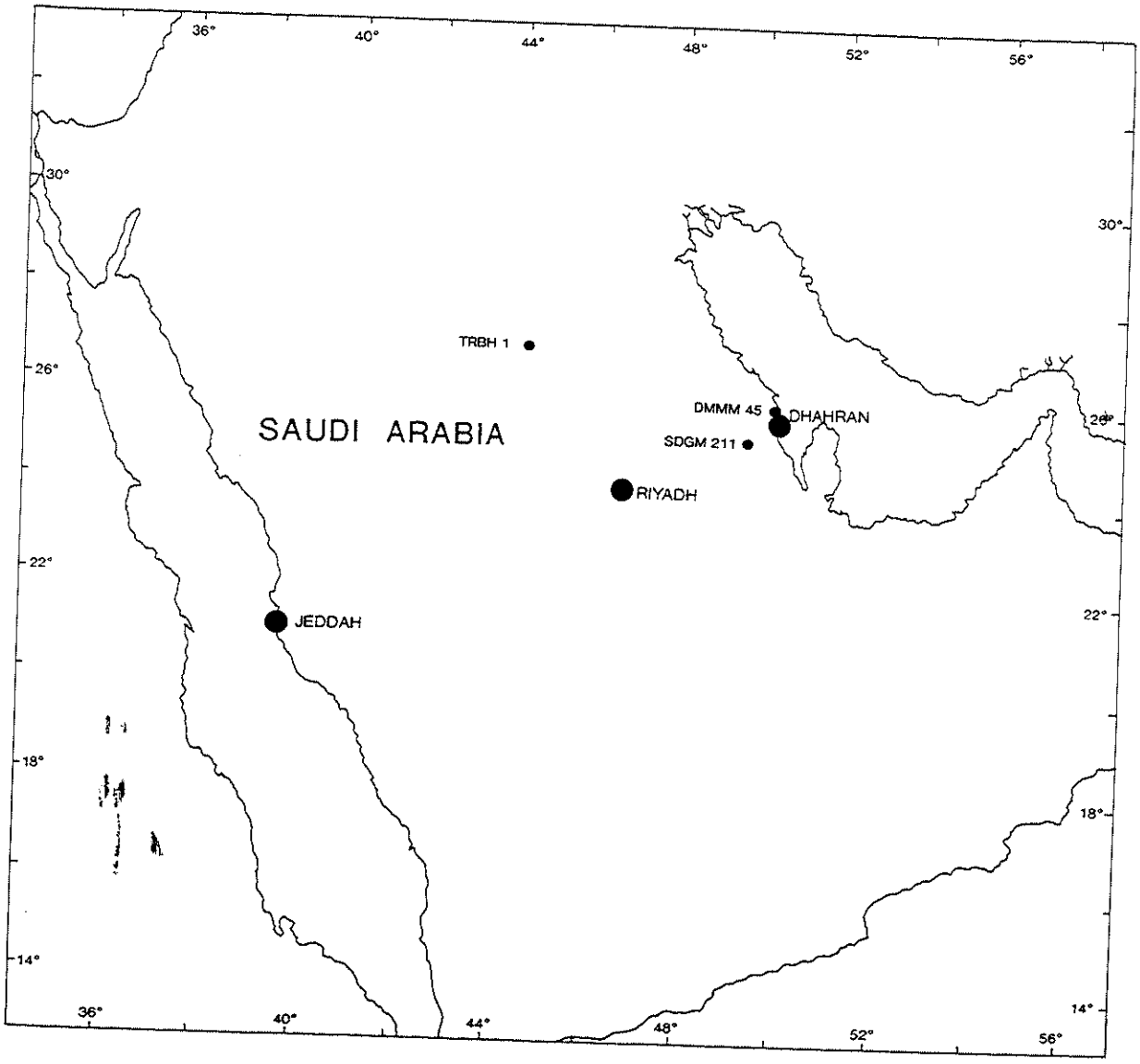


Fig. 1. Location of well TRBH-1.

The first records of *Acinosporites apiculatus* occur in a sample at 2274–2303 ft. From this interval upwards, the assemblages change in composition, particularly with the progressive introduction of large size and more spiny zonate and pseudosaccate species.

A few specimens of *Acinosporites apiculatus* were also recognized in the Jauf Formation at 12190–12210 ft of well DMMM-45 although the material there is poorly preserved.

The next palynological event in well TRBH-1 is the appearance of *Geminospora lemurata* in the Jubah Formation at 2087–2116 ft. This species occurs irregularly in many of the overlying younger samples. However, only above the interval 1713–1742 ft this species is commonly recorded. *Geminospora punctata*, which appears in other regions before the first occurrence of *Geminospora lemurata*, is here observed from the interval 1900–1949 ft and from the overlying deposits. It

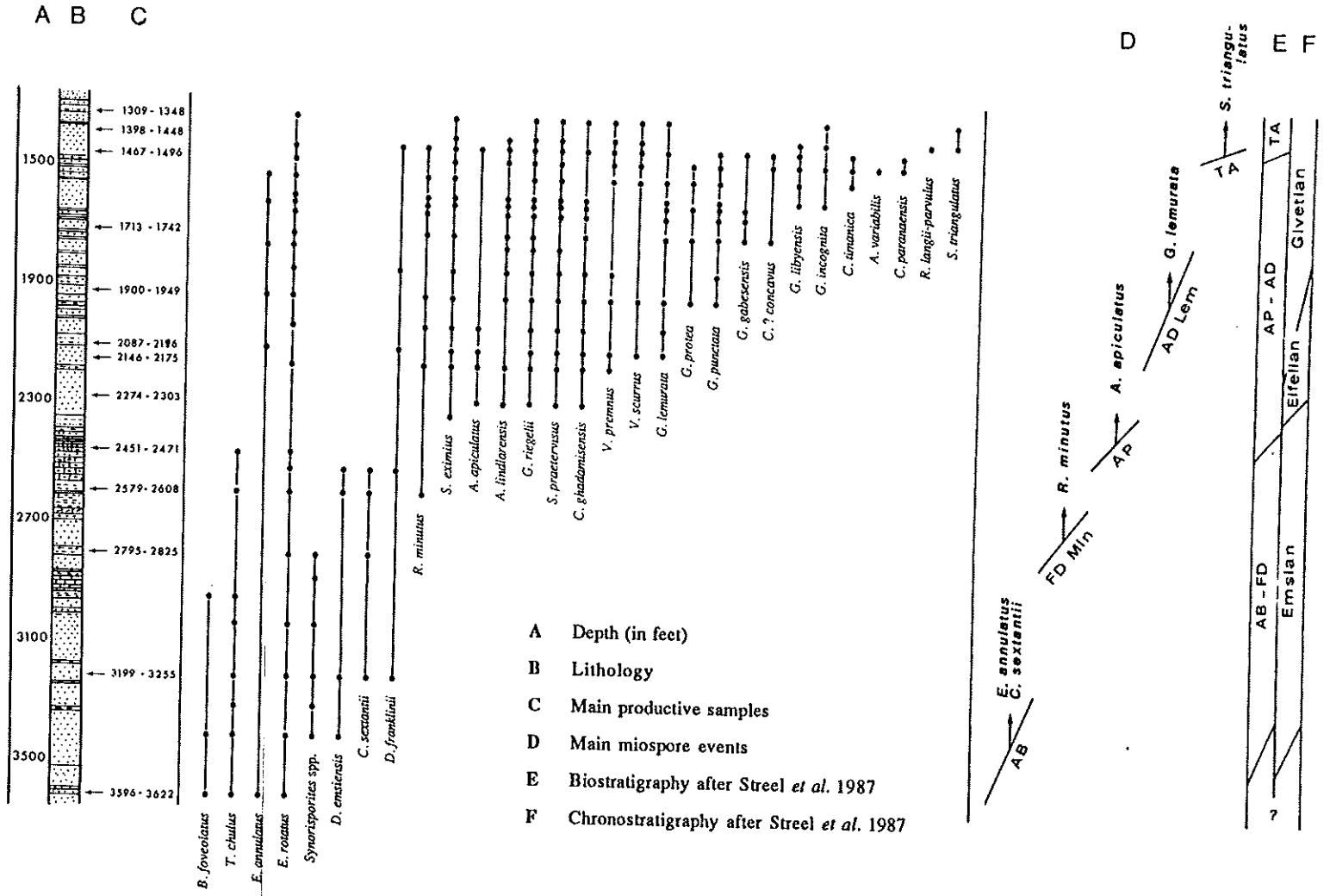
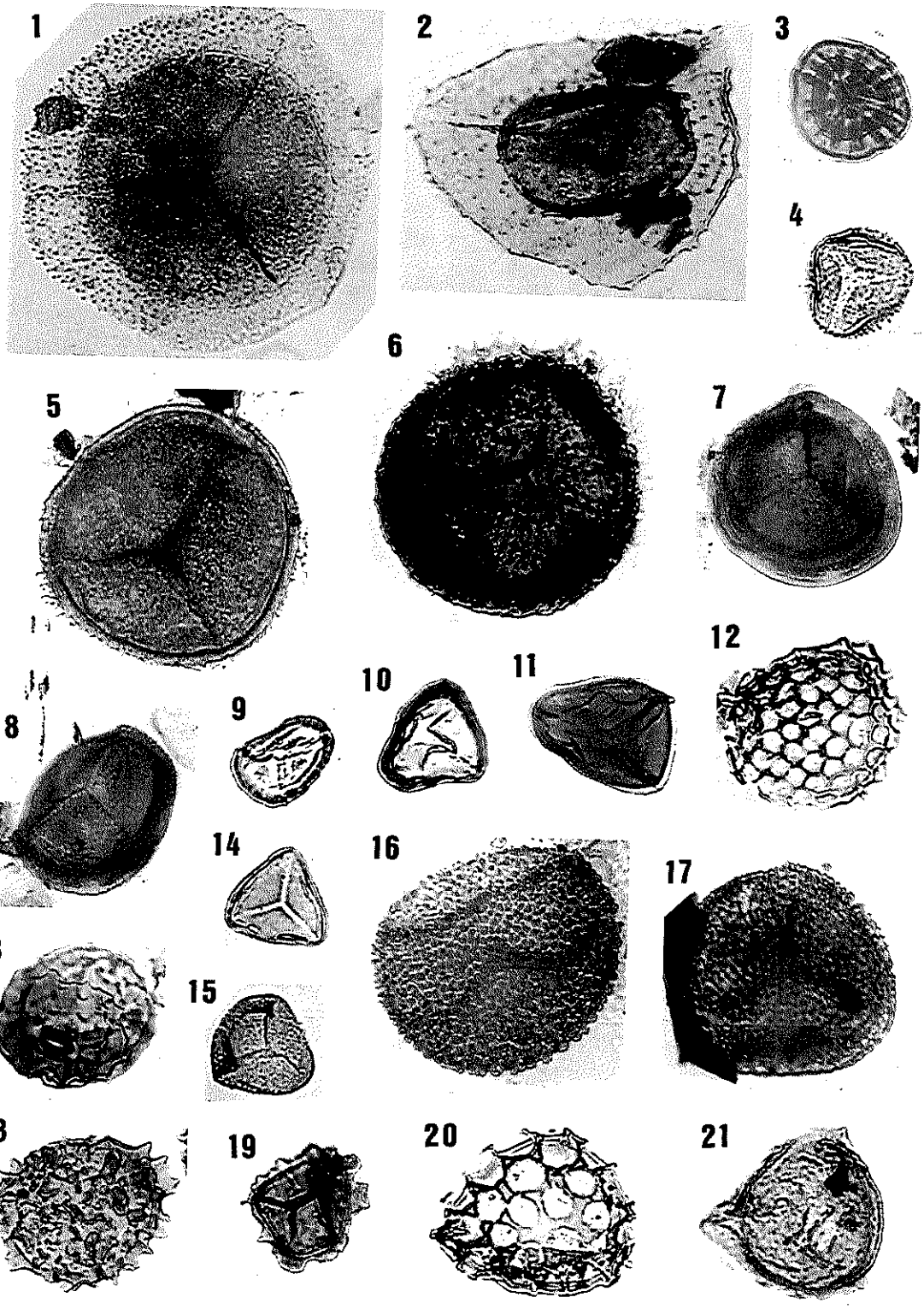


Fig. 2. Vertical distribution of main miospores and proposed chronostratigraphy in well TRBH-1.

PLATE I



is, therefore, suggested that the oldest specimens of *Geminospora lemurata* represent caved material (see below).

The youngest palynological event in well TRBH-1 is the first occurrence of *Samarisporites triangulatus*, recorded in the interval 1398–1448 ft in the upper part of the Jubah Formation.

3. Age of the samples

Recent investigations in the Tunisian–Libyan Hammadah Basin (Loboziak and Streel, 1989; Loboziak et al., 1992) have confirmed the applicability of the Western European Ardenne–Rhine miospore biozonation (Streel et al., 1987) in northern Africa. During most of the Devonian, these regions belonged obviously to the same, single phytogeographic area. References will thus be made to that European biozonation scheme in order to date the Saudi Arabian samples.

Amongst the species occurring in the lowermost examined intervals of well TRBH-1 is *Emphanisporites annulatus* which has the most recent appearance in the Ardenne–Rhenish Biozonation. This first appearance characterizes the base of Oppel Zone AB (*Emphanisporites annulatus–Brochotriletes bellatulus*) of Early Emsian age.

Rhabdosporites minutus, which first appears in the Jauf Formation in well TRBH-1 (at 2579–2608 ft), is known from the succeeding Emsian FD Oppel Zone (*Emphanisporites foveolatus–Verruciretusispora dubia*) from the base of the Interval Zone Min (*Rhabdosporites minutus*). Because of the lack of index species used in the reference biozonation, further subdivision of the interval between 3596–3622 ft and 2312–2322 ft is not possible and it is not practical to differentiate the AB and FD Oppel Zones. Both correspond to the *annulatus–sextantii* Assemblage Zone of Richardson and McGregor (1986). In the Ardenne and Eifel regions, the presence of characteristic brachiopods allows the Oppel Zones AB and FD to be dated as Emsian (Riegel, 1982; Riegel and Karathanasopoulos, 1982; Steemans, 1989).

PLATE I

Illustrated specimens magnifications × 500. The miospores locations in the slides are based on England Finder graticule coordinates. All specimens are from well TRBH-1 at the depths indicated. All figured specimens are housed in the Palaeontological Collections of the Natural History Museum, London, England. FM relates to reference number in that collection.

1. *Grandispora riegelii* Loboziak, Streel and Burjack, 1988. Slide 8052: G60/4, sample at 1467–1496 ft, FM 580.
2. *Grandispora protea* (Naumova) Moreau-Benoit, 1980. Slide 8060: P48/3, sample at 1713–1742 ft, FM 581.
3. *Emphanisporites annulatus* McGregor, 1981. Slide 8069: V45, sample at 1752–1801 ft, FM 582.
4. *Camarozonotriletes sextantii* McGregor and Camfield, 1976. Slide 8094: O52/1, sample at 2579–2608 ft, FM 583.
5. *Craspedispora ghadamisensis* Loboziak and Streel, 1989. Slide 295-1: K67/2, sample at 1732 ft, FM 584.
6. *Craspedispora paranaensis* Loboziak, Streel and Burjack, 1988. Slide 8052: E49/1, sample at 1467–1496 ft, FM 585.
7. *Geminospora punctata* Owens, 1971. Slide 7385: K53/3, sample at 1506–1555 ft, FM 586.
8. *Geminospora lemurata* (Balme) emend. Playford, 1983. Slide 8061: T54/1, sample at 1713–1742 ft, FM 587.
9. *Synorisporites tripapillatus* Richardson and Lister, 1969. Slide 8105: N27/4, sample at 2874–2904 ft, FM 588.
10. *Tholisporites chulus* (Cramer) McGregor var. *chulus* Richardson and Lister, 1969. Slide 8107: S54/2, sample at 2933–2963 ft, FM 589.
11. *Rhabdosporites minutus* Tiwari and Schaarschmidt, 1975. Slide 8061: O43/4, sample at 1713–1742 ft, FM 590.
12. *Dictyotriletes emsiensis* (Allen) McGregor, 1973. Slide 8094: E39/3, sample at 2579–2608 ft, FM 591.
13. *Chelinospora timanica* (Naumova) Loboziak and Streel, 1989. Slide 8052: H39/1, sample at 1467–1496 ft, FM 592.
14. *Camarozonotriletes?concavus* Loboziak and Streel, 1989. Slide 8057: L52, sample at 1644–1703 ft, FM 593.
15. *Diatomozonotriletes franklinii* McGregor and Camfield, 1982. Slide 8070: M53/3, sample at 1830–1850 ft, FM 594.
16. *Acinosporites apiculatus* (Streel) Streel, 1967. Slide 8082: P55/2, sample at 2146–2175 ft, FM 595.
17. *Acinosporites lindlarensis* Riegel, 1968. Slide 295-1: H67/1, sample at 1732 ft, FM 596.
18. *Verrucosisporites scurrus* McGregor and Camfield, 1982. Slide 8052: K48/3, sample at 1467–1496 ft, FM 597.
19. *Verrucosisporites premnus* Richardson, 1965. Slide 8042: Q54/3, sample at 1309–1348 ft, FM 598.
20. *Brochotriletes foveolatus* (Naumova) McGregor, 1973. Slide 8119: L38, sample at 3399–3419 ft, FM 599.
21. *Samarisporites triangulatus* Allen, 1965. Slide 8042: N47/2, sample at 1309–1348 ft, FM 600.

The same miospore assemblages have been recognized in the Ouan Kasa Formation and in the lowermost part of the Ouenine Group in well MG-1, north Hammadah Basin, Tunisia (Loboziak et al., 1992), as well as in the lowermost part (at 2103 ft) of the sampled interval of well A1-69, south Hammadah Basin, Libya (Loboziak and Streel, 1989).

The first appearance of *Acinosporites apiculatus* characterizes the base of the succeeding AP Oppel Zone (*Acinosporites apiculatus–Grandispora protea*). In the Eifel region, the first occurrence of this species is reported in the *serotinus* or *costatus patulus* Conodont Zones of Late Emsian age, immediately below the Emsian/Eifelian boundary (Streel and Loboziak, in press).

The first appearance of *Geminospora lemurata* corresponds to the base of Interval Zone Lem (*Geminospora lemurata*) within the AD Oppel Zone (*Acinosporites acanthomammillatus–Densosporites devonicus*) which overlies the Oppel Zone AP. In the Eifel region (Loboziak et al., 1991), the first occurrence of this species is reported within the *ensensis obliquimarginatus* Conodont Zone sensu Weddige (1984). A recent decision of the Subcommission on Devonian Stratigraphy proposes to define the base of the Givetian Stage within the same Conodont zone at a level slightly below the first appearance of *Geminospora lemurata*. Therefore Interval Zone Lem is of a Givetian age.

The absence of characteristic taxa in the samples from the intervals from 2274–2303 ft to 1456–1466 ft does not allow the recognition of the base of Oppel Zone AD. This interval is thus included in the undifferentiated AP–AD Opel Zones of latest Emsian to earliest Givetian age corresponding to the *douglastownense–eurypterota, velatus–langii, devonicus–naumovii* and lower part of *lemurata–magnificus* Assemblage Zones of Richardson and McGregor (1986).

In the Hammadah Basin, similar assemblages also containing large spiny zonate and pseudosaccate miospores including *Grandispora riegelii* and *Craspedispora ghadamisensis* are present in the Ouenine Group (most of the AOI Formation and the entire AOII Formation) in well MG-1 and from the interval 2039–1296 ft in well A1-69.

The first entry of *Samarisporites triangulatus* corresponds to the base of Oppel Zone TA (*Samarisporites triangulatus–Ancyrospora ancyrea*). In the Eifel region (Loboziak et al., 1991), the first occurrence of this species is found in the *ensensis–bipennatus* Conodont Zone of Early Givetian age. This Oppel Zone is equivalent to the upper part of the *lemurata–magnificus* Assemblage Zone and, perhaps, to the lowermost part of the *optivus–triangulatus* Assemblage Zone of Richardson and McGregor (1986).

The two youngest productive intervals (1398–1448 ft and 1309–1348 ft) belong therefore to the Early Givetian.

The TA Oppel Zone was not found in well MG-1 but is present between 1277 and 1109 ft in well A1-69 of the Hammadah Basin.

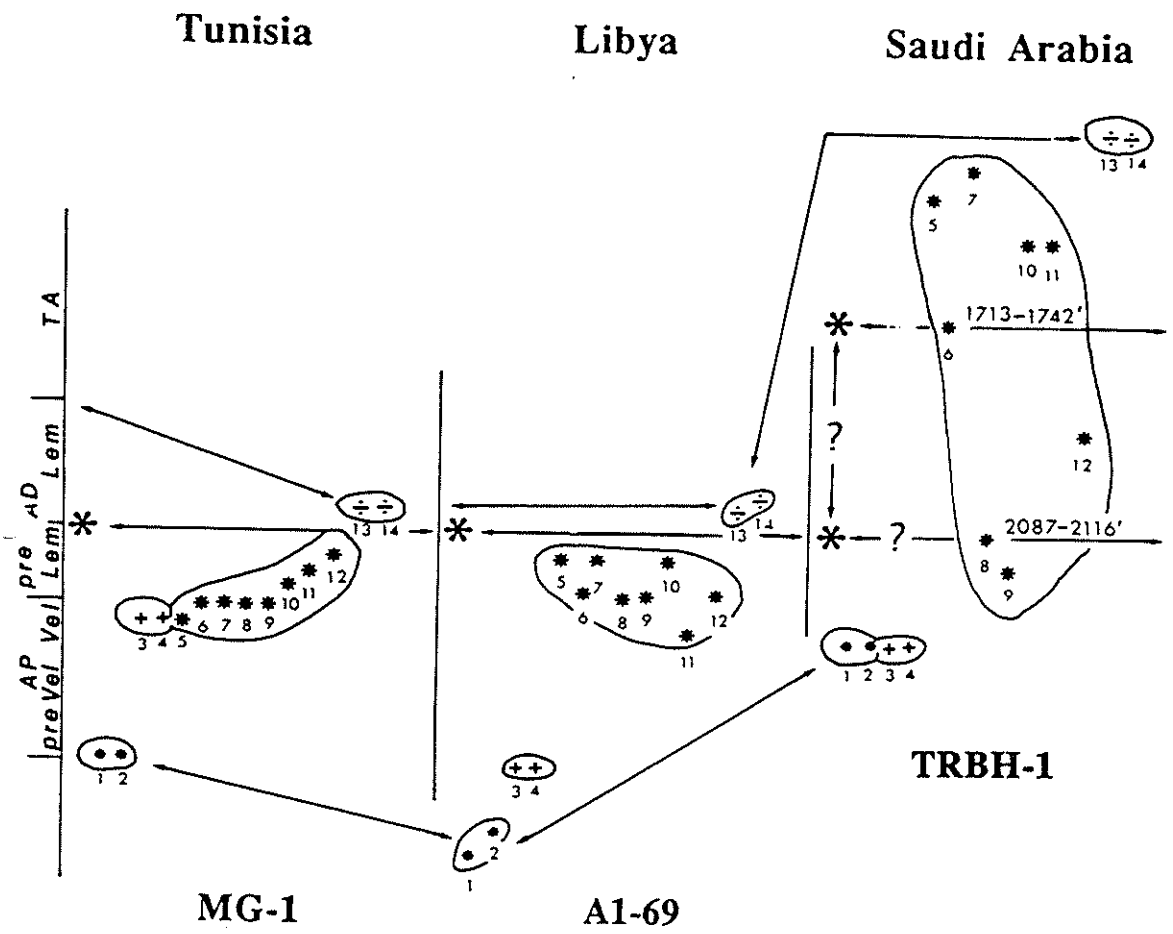
4. The first occurrence biohorizon of *Geminospora lemurata*

All analysed samples were derived from cutting samples and most appear to be contaminated by caved rock fragments from younger horizons. To evaluate the importance of this potential contamination, we have assumed that the sequence of first occurrences of several common species had to be similar in the TRBH-1 well area in Saudi Arabia and in cored sections in wells MG-1 and A1-69 in Tunisia and Libya, respectively. Amongst these frequent species (see below), *Geminospora lemurata* is obviously the most abundant and the most characteristic species in the Givetian–Frasnian rocks and has therefore the highest chance to be present as caved material in older sediments. We will here compare the distribution of this species and of four other groups of miospores both in the cuttings from well TRBH-1 and in the cores of wells MG-1 and A1-69.

These four groups are:

Group 1: *Acinosporites lindlarensis* and *Acinosporites apiculatus* which first occur at or near the base of Oppel Zone AP;

Group 2: *Craspedispora ghadamisensis* and *Grandispora riegelii* which first occur within the



✱ *Geminospora lemurata*

Group 1 • 1 *Acinosporites lindlarensis*
2 *Acinosporites apiculatus*

Group 2 + 3 *Craspedispora ghadamisensis*
4 *Grandispora riegelii*

Group 3 ✱ 5 *Chelinospora timanica*
6 *Camarozonotriletes ? concavus*
7 *Archaeozonotriletes variabilis*
8 *Verrucosisporites scurrus*
9 *Verrucosisporites premnus*
10 *Grandispora libyensis*
11 *Grandispora incognita*
12 *Geminospora punctata*

Group 4 ÷ 13 *Rhabdosporites langii-parvulus*
14 *Samarisporites triangulatus*

Fig. 3. Comparison of first occurrences of some groups of miospores in wells MG-1 and A1-69 (Hammadah basin) and well TRBH-1.

AP/AD Oppel Zones transition beds *. These two taxa are known so far only from western Gondwana and are fairly abundant, mostly in Interval Zone Lem;

Group 3: *Chelinospora timanica*, *Camarozonotriletes?concavus*, *Archaeozonotriletes variabilis*, *Verrucosisporites scurrus*, *Verrucosisporites premnus*, *Grandispora libyensis*, *Grandispora incognita* and *Geminospora punctata*, which first occur below but very near to the first occurrence of *Geminospora lemurata* (base of Interval Zone Lem); and

Group 4: *Rhabdosporites langii*, *Rhabdosporites parvulus* and *Samarisporites triangulatus*, all occurring distinctively above the first entry of *Geminospora lemurata*.

The first occurrence of *Geminospora lemurata* is utilised in Fig. 3 as a datum plane to correlate the three boreholes **. The stratigraphic scale (after Streel et al., 1987) is based on well MG-1, but it is easy to demonstrate that such a correlation line between the cores on one hand and cuttings on the other is meaningless for time stratigraphy.

Indeed, the representative species of Group 3 are stratigraphically dispersed in well TRBH-1 in comparison with the two cored sections in the other boreholes suggesting that the lowest occurrences in this borehole are probably the result of caving as also are the lowest recorded representatives of *Geminospora lemurata*. Although stratigraphically dispersed, the representatives of Group 3 are still found to occur between Groups 1/2 and Group 4. Caving processes have not completely altered the original succession but it might be appropriate to consider the interval between 1713–1742 ft in the middle of the Jubah Formation where *Geminospora lemurata* is more abundant, as the true first occurrence level of this species.

*In well A1-69, the first, poorly preserved, specimens of *Craspedispora ghadamisensis* and *Grandispora riegelii* have recently been found in a sample at 1850 ft rather than, respectively, in samples at 1700 ft and 1560 ft as formerly published.

**In well A1-69, the first occurrence of *Geminospora lemurata* (Loboziak and Streel 1989, fig. 2) was shown at level 1480 m where one single specimen was found with very fine grana. We prefer now to accept that the true first occurrence is at sample 1340 m where specimens with coarser grana are found.

5. Conclusion

Despite the problems linked to caving processes, the Western European miospore zonation can be used to date the Lower–Middle Devonian part of well TRBH-1.

The zonation which has been previously demonstrated to apply in the western part of Gondwana appears equally applicable to Saudi Arabia. Data must, however, be assessed with care and the first occurrences of characteristic species analysed to evaluate the probable range of uncertainties (see Fig. 2, D, for *Geminospora lemurata*).

Appendix 1. List of species

Acinosporites apiculatus (Streel) Streel, 1967
Acinosporites lindlarensis Riegel, 1968
Archaeozonotriletes variabilis (Naumova) Allen, 1965
Brochotriletes foveolatus (Naumova) McGregor, 1973
Camarozonotriletes?concavus Loboziak and Streel, 1989
Camarozonotriletes sextantii McGregor and Camfield, 1976
Chelinospora timanica (Naumova) Loboziak and Streel, 1989
Craspedispora ghadamisensis Loboziak and Streel, 1989
Craspedispora paranaensis Loboziak, Streel and Burjack, 1988
Diatomozonotriletes franklinii McGregor and Camfield, 1982
Dictyotriletes emsiensis (Allen) McGregor, 1973
Emphanisporites annulatus McGregor, 1961
Emphanisporites rotatus McGregor, 1961
Geminospora lemurata (Balme) emend. Playford, 1983
Geminospora punctata Owens, 1971
Grandispora gabesensis Loboziak and Streel, 1989
Grandispora incognita (Kedo) McGregor and Camfield, 1976
Grandispora libyensis Moreau-Benoit, 1980
Grandispora protea (Naumova) Moreau-Benoit, 1980
Grandispora riegelii Loboziak and Streel, 1989
Rhabdosporites langii (Eisenack) Richardson, 1960
Rhabdosporites minutus Tiwari and Schaarschmidt, 1975
Rhabdosporites parvulus Richardson, 1965
Samarisporites eximius (Allen) Loboziak and Streel, 1989
Samarisporites praetervisus (Naumova) Allen, 1965
Samarisporites triangulatus Allen, 1965
Tholisporites chulus (Cramer) McGregor, 1973 var. *chulus* Richardson and Lister, 1969
Verrucosisporites premnus Richardson, 1965
Verrucosisporites scurrus McGregor and Camfield, 1982

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