

bulbous biform elements. The two morphotypes intergrade and coexist mainly in the *triangulatus-catillus* Zone. *Contagisporites optivus*, *Craspedispora ghadamesensis*, *Dictyotriletes hemeri*, *Elenisporis gondwanensis*, *Grandispora douglastownensis*, *Scylaspora rugulata* and *Zonotriletes rotundus* are the most characteristic species to disappear in the *triangulatus-catillus* Zone. The general diversity of the spore populations begins to decrease from the base of this assemblage. The large apiculate and spinose zonate-pseudosaccate spores show a quantitative decrease. They seem to be replaced with numerous small patinate specimens (mainly *Cymbosporites*). *Geminospora lemurata* and *Samarisporites triangulatus* are also abundant. The cryptospores are very uncommon. *Artetmopyra* vanishes at the base of the assemblage and leaves *Gneudnaspora divellomedia* var. *divellomedia* as the last survivor of this group. The megaspores are very diverse in both Saudi Arabia and North Africa; they include notably *Contagisporites optivus* and *Verrucisporites ellesmerensis*. Other megaspores are described in Steemans *et al.* (2011b).

Comparison with reference biozones. *Samarisporites triangulatus* is a widespread species and seems to appear almost at the same time everywhere. In Euramerica, the *triangulatus-catillus* Zone corresponds to the TA Opperl Zone of Streeel *et al.* (1987) in spite of the absence of *Ancyrospora ancyrea* var. *ancyrea* in the studied sections. The co-occurrence of *Contagisporites optivus* and *Samarisporites triangulatus* could indicate in part the *optivus-triangulatus* Assemblage Zone of Richardson and McGregor (1986). Although it is generally correlated with the TCo Opperl Zone of Streeel *et al.* (1987), *C. optivus* appears from the underlying TA Opperl Zone in Belgium (Steeemans *et al.* 2011b). Nevertheless, the use of megaspore species for correlation is hardly reliable since they are recovered from few types of deposit environments.

Stage. Middle–Upper Givetian.

Samarisporites triangulatus Interval Zone

Reference section. Borehole A1-69 (from 1293.0 to 1277.0 ft).

Distribution. Jubah Formation, Saudi Arabia. Awaynat Wanin II Formation, North Africa.

Zone base definition. Its lower boundary is based on the first occurrence of *Samarisporites triangulatus*.

Cymbosporites catillus Interval Zone

Reference section. MG-I (from 2247 to 2212.5 m).

Distribution. Jubah Formation, Saudi Arabia. Awaynat Wanin II Formation, North Africa.

Zone base definition. Its lower boundary is based on the first occurrence of specimens belonging to the *Cymbosporites catillus* Morphon.

Ancyrospora langii–*Chelinospora concinna* Assemblage Zone

Reference section. MG-I (from 2205 to 2160.6 m).

Distribution. Upper Jubah Formation, Saudi Arabia. Uppermost part of the Awaynat Wanin II Formation and the Awaynat Wanin III Formation, North Africa. Its upper stratigraphical limit of this assemblage is presently unknown, as it occurs at the highest depth sampled.

Zone base definition. Its lower boundary is based on the first occurrence of *Chelinospora concinna*.

Description. In addition to the first occurrence of *Chelinospora concinna*, this assemblage is mainly distinguished from the underlying *triangulatus-catillus* Zone by the inception of the common species *Ancyrospora langii* and *Emphanisporites laticostatus*. *Geminospora lemurata*, *Samarisporites triangulatus* and the *Cymbosporites catillus* Morphon are still represented in large amounts. The general diversity of the spore populations is still decreasing. The large apiculate and spinose zonate-pseudosaccate continue their quantitative decline started in the *triangulatus-catillus* Zone. The cryptospores are very uncommon, with a unique species, *Gneudnaspora divellomedia* var. *divellomedia*. The monoete spores are above all present with the monoete form of *Geminospora lemurata*. The megaspores are still present in number, including notably *Verrucisporites ellesmerensis*. The feature of grapnel-tipped spines seems to be more and more frequent with the reappearance of *Ancyrospora* genus and the presence of rarer specimens of *Hystricosporites*.

Comparison with reference biozones. This assemblage is the equivalent of the TCo Opperl Zone of Streeel *et al.* (1987) since *Samarisporites triangulatus* and *Chelinospora concinna* are found together. The *langii-concinna* Zone

FIG. 56. Chart comparing the new biozonation with the reference spore zonations from Euramerica and Saudi Arabia. As there are any outcrops or sections that allow to correlate the different biozones, biostratigraphical correlations illustrated here are approximative. *Operational palynological zonation of Al-Hajri *et al.* (1999) updated according to PB (pers. obs.).

STAGES	Richardson and McGregor (1986)	Streef <i>et al.</i> (1987)	This paper		Al-Hajri <i>et al.</i> (1999)*	
FRASNIAN	<i>ovalis-bulliferus</i>	(IV)	B β	?	D1	
			B α			
			A			
		BM				
		BJ				
GIVETIAN	<i>optimus-triangulatus</i>	TCo		<i>langii-concinna</i>	D2	
	?	TA		<i>triangulatus-catillus</i>		
	<i>lemurata-magnificus</i>	AD	Lem	<i>lemurata-langii</i>		<i>catillus</i>
			Ref	<i>rugulata-libyensis</i>		<i>triangulatus</i>
<i>devonicus-naumovae</i>	Mac	<i>incognita</i>				
?		Vel		<i>rugulata</i>		
EIFELIAN	<i>velata-langii</i>	AP	net	<i>svalbardiae-eximius</i>	D3	
	<i>douglastownensis</i> <i>-eurypterota</i>		Pro			
			ked	<i>annulatus-protea</i>		
			Cor			
EMSIAN	<i>annulatus-sextantii</i>	FD	Min	<i>lindlarensis-sextantii</i>	D3B	
			Pra	<i>ovalis-biornatus</i>	<i>asymmetricus</i>	D3/D4
			Fov		<i>milleri</i>	
		AB	<i>ovalis</i>			
PRAGIAN	<i>polygonalis-emsiensis</i>	PoW	Su	<i>papillensis-baqaensis</i>	D4	
			Pa β	?		
			Pa α			
			W			
			Po			

also corresponds in part to the *optivus-triangularatus* Assemblage Zone of Richardson and McGregor (1986).

Stages. Upper Givetian – lower Frasnian.

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