Paleophytogeographic distribution of Devonian miospore assemblages

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SUMMARY
The review of the Emsian-Givetian miospore assemblages from the literature allows to evaluate the provincialism of assemblages on a worldwide scale during this interval. Coefficient of similarity is calculated between palynofloras from northern Euramerica, southern Euramerica, northwestern Gondwana, southwestern Gondwana and eastern Gondwana. The resulting low values correspond to low to moderate similarity of miospore assemblages during the considered interval. The provincialism may be explained by a latitudinal climatic gradient as no impassable palaeogeographic barrier is known during this time interval. It seems, however, that a progressive homogenization of the vegetation took place in Middle Devonian. This transition from provincialism to cosmopolitanism during the Devonian is not only shown by palynofloras but also by the palaeogeographic distribution of many other fossil groups. It is likely due to a decrease of the latitudinal climatic gradient.

Keywords: Palaeogeography, Devonian, Miospores, Gondwana.

INTRODUCTION

McGregor (1979) agreed that Devonian miospores had a cosmopolitan distribution, but he indicated that detailed palynological records show evidence of provincialism during the Devonian. McGregor and Playford (1992) suggested also certain cosmopolitanism in the Devonian land vegetation during Middle through Late Devonian time to allow considerable floristic interchange, although some provincialism should exist. Streel et al. (1990) noted that analyses of Euramerican miospore assemblages suggest vegetation differences between the northern and southern parts of Euramerica. According to Steemans et al. (2007), at least two main phytogeographical provinces existed in earliest Devonian (Lochkovian): western Gondwana and Euramerica. Steemans and Lakova (2004) defined the Early Devonian *sinuosus-zavallatus* Phytogeographic Province which is a subprovince of Euramerica covering the eastern part of the Caledonian Mountains. Marshall (1996) applied multivariate methods to analyse the global miospore distribution notably for Emsian and Givetian intervals. In the Emsian, the different regions where miospores have been encountered are linked at low levels and are quite distinct. The Emsian miospore assemblages are therefore characterized by a marked provincialism. The Givetian results demonstrate higher level linkage between regions, thus demonstrating an apparently progressive decrease in provincialism during the Devonian. Di Pasquo et al. (2007) defined the Afrosouthamerican Subrealm restricted between 55° and 75° S palaeolatitude in South America and Africa from the Middle to early Late Devonian.

COEFFICIENT OF SIMILARITY

A way to estimate most objectively the similarity between the miospore spore assemblages from different regions is the coefficient of similarity (CS) *sensu* Clark and Harteberg (1983)

for bioprovincialism evaluation. This simple and straight-forward approach is expressed by the formula:

$$CS = 2v/a+b$$

With *v*: number of species in common between the two compared assemblages; a and b: total number of species in each assemblage, respectively. CS has been calculated between northern and southern Euramerica, western, northwestern and eastern Gondwana for the Emsian-Givetian interval. It was based on the most substantial papers. Northern Euramerican miospore assemblages are described in four major papers from Arctic Canada, Spitsbergen and Eastern Europe (e.g. Avkhimovitch et al., 1993; McGregor and Camfield, 1982). Southern Euramerican miospores assemblages have been listed from 12 papers from Scotland, the Ardenne-Rhenish regions, Poland and Canada (e.g. McGregor, 1973; Richardson, 1965; Riegel, 1973; Turnau, 1986). Species occurring in southwestern Gondwana from Emsian to Givetian are discussed in 15 papers from South America (e.g. Daemon et al., 1967; Dino, 1999; Melo and Loboziak, 2003; Menéndez and Pöthe de Baldis, 1967). For the northwestern Gondwanan assemblages, the species from eight significant works, from Morocco to Saudi Arabia eastwards (e.g. Breuer, 2008; Massa and Moreau-Benoit, 1976; Moreau-Benoit, 1989), have been listed. In eastern Gondwana, Emsian-Givetian palynological records are described in four main papers from Antarctica and Australia (e.g. Hashemi and Playford, 2005; McGregor and Playford, 1992).

RESULTS

The total number of species in each region and the number of species in common between two compared regions are summarized in Table 1.

Number of species in common between 2 regions	northern Euramerica	southern Euramerica	southwestern Gondwana	northwestern Gondwana	eastern Gondwana
northern Euramerica	271	95	48	79	51
southern Euramerica	95	299	62	103	41
southwestern Gondwana	48	62	123	76	32
northwestern Gondwana	79	103	76	299	55
eastern Gondwana	51	41	32	55	198

Tab. 1 Matrix of numbers of species in common between two compared regions. The total numbers of species for each region are distributed diagonally.

The resulting CS is plotted between the different regions for the considered interval (Fig. 1). The most striking result is the low general values which correspond to a low to moderate similarity of miospore assemblages between the different considered regions according to criteria of Clark and Harteberg (1983). As suggested by Streel et al. (1990), the vegetation differences between northern and southern Euramerica are confirmed by a CS equal to 0.34. Northwestern Gondwana constituted an intermediate region that shared mainly taxa with Euramerica in the North and southwestern Gondwanan localities in higher latitudes. Enough similarities exist between Euramerican and Australian assemblages in Middle and Late Devonian to sustain long distance biostratigraphic correlation, but the low CS between eastern Gondwana and other regions may correspond to a single phytogeographic province as suggested by Streel and Loboziak (1996). The low to moderate CS in the whole Gondwana seems to point out the existence of different climate in Gondwana as no physical barriers is known during the Emsian-Givetian interval.

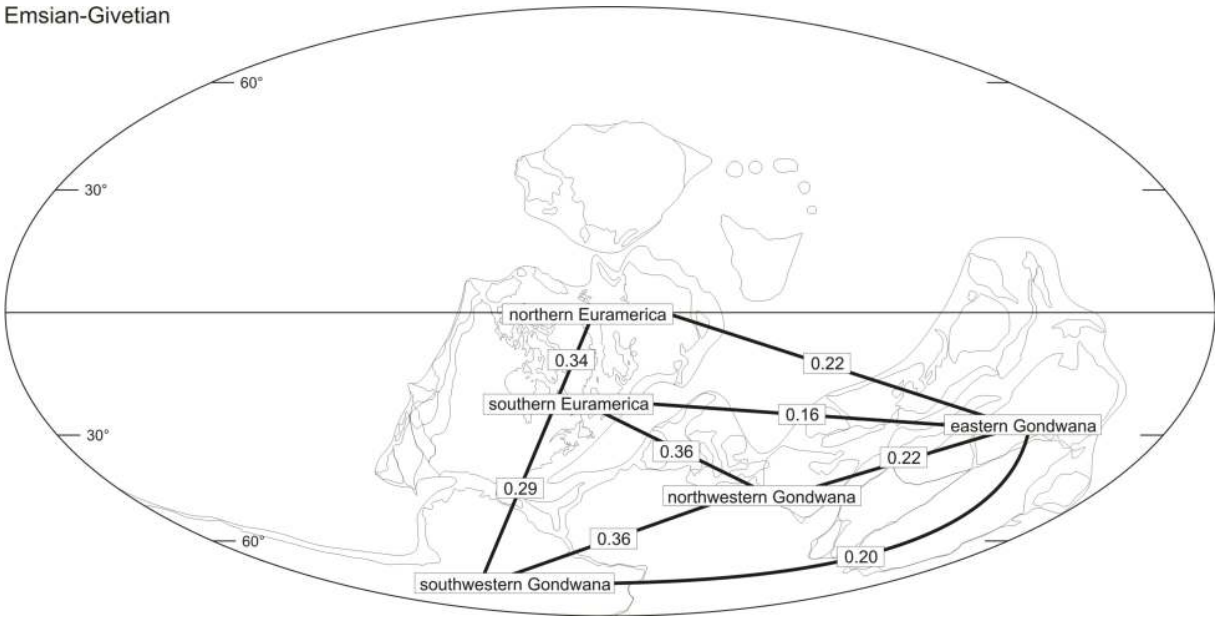

Fig . 1 Coefficients of similarity between the different regions calculated on the basis of Emsian-Givetian miospore assemblages. Palaeogeographic reconstruction modified after Scotese (2000).

CONCLUSIONS

An analysis of the palynological literature has allowed the calculation of CS in the Emsian-Givetian interval between palynofloras from coeval miospore assemblages from five regions (northern Euramerica, southern Euramerica, northwestern Gondwana, southwestern Gondwana, and eastern Gondwana). CS gives a good enough provincialism evaluation. The resulting low general values correspond to a low to moderate similarity of miospore assemblages between the different considered regions. The provincialism could mainly due to the latitudinal climatic gradient as the proximity of Euramerican and Gondwanan land masses as soon as Lochkovian should not prevent plant migration. Despite this certain degree of provincialism, floristic interchanges exist. The global calculation of CS should be moderated as it could not be calculated more precisely for each stage. It seems, however, that a homogenization of the vegetation took place from Emsian to Givetian. The transition from provincialism to cosmopolitanism during the Devonian is not only shown by palynofloras but also by the palaeogeographic distribution of other fossil groups. It is likely due to a decrease of the latitudinal climatic gradient.

REFERENCES

Avkhimovitch, V. I., Tchibrikova, E. V., Obukhovskaya, T. G., Nazarenko, A. M., Umnova, V. T., Raskatova, L. G., Mantsurova, V. N., Loboziak, S. and Streel, M., 1993. Middle and Upper Devonian miospore zonation of Eastern Europe. *Bulletin des Centres de Recherches Exploration-Production Elf Aquitaine*, **17**, pp. 79-147.

Breuer, P., 2008. Devonian miospore palynology in western Gondwana: an application to oil exploration. Unpublished PhD thesis, University of Liège.

Clark, D. L. and Harteberg, E. W., 1983. Palaeoenvironmental factors and the distribution of conodonts in Lower Triassic of Svalbard and Nepal. *Fossils and Strata*, **15**, pp. 171-175.

Daemon, R. F., Quadros, L. P. and Da Silva, L. C., 1967. Devonian palynology and biostratigraphy of the Paraná Basin. *In: Problems in Brazilian Devonian Geology*, Bigarella, J.J. (ed.), Boletim Paranaense de Geociências, **21/22**, pp. 99-132. Curitiba.

Dino, R., 1999. Palynostratigraphy of the Silurian and Devonian sequence of the Paraná Basin, Brazil. *In: Ordovician-Devonian palynostratigraphy in Western Gondwana: update, problems and perspectives*, Rodrigues, M. A. C. and Pereira, E. (eds.), Faculdade de Geologia da Universidade Estatal do Rio de Janeiro, Resumos expandidos, pp. 27-61. Rio de Janeiro.

Hashemi, H. and Playford, G., 2005. Devonian spore assemblages of the Adavale Basin, Queensland (Australia): descriptive systematics and stratigraphic significance. *Revista Española de Micropaleontología*, **37**, pp. 317-417.

Marshall, J. E. A., 1996. Vegetational history of Devonian spores. *In: Palynology: Principles and Applications*, Jansonius, J. and McGregor, D. C. (eds.), American Association of Stratigraphic Palynologists Foundation**,** pp. 1133-1141. Dallas.

Massa, D. and Moreau-Benoit, A., 1976. Essai de synthèse stratigraphique et palynologique du Système Dévonien en Libye occidentale. *Revue de l'Institut Français du Pétrole*, **41**, pp. 287-333.

McGregor, D. C., 1973. Lower and Middle Devonian spores of Eastern Gaspé, Canada. I. Systematics. *Palaeontographica, Abteilung B*, **142**, pp. 1-77.

McGregor, D. C., 1979. Spores in Devonian stratigraphical correlation. *In: The Devonian System*, House, M. R., Scrutton, C. T. and Bassett, M. G. (eds.), Palaeontological Association,Special Paper, 23, pp. 163-184. London.

McGregor, D. C. and Camfield, M., 1982. Middle Devonian miospore from the Cape de Bray, Weatherall, and Hecla Bay Formations of northeastern Melville Island, Canadian Artic. *Geological Survey of Canada, Bulletin*, **348**, pp. 1-105.

McGregor, D. C. and Playford, G., 1992. Canadian and Australian Devonian spores: zonation and correlation. *Geological Survey of Canada, Bulletin*, **438**, pp. 1-125.

Melo, J. H. G. and Loboziak, S., 2003. Devonian-Early Carboniferous miospore biostratigraphy of the Amazon Basin, Northern Brazil. *Review of Palaeobotany and Palynology*, **124**, pp. 131-202.

Menéndez, C. A., Pöthe de Baldis, E. D., 1967. Devonian spores from Paraguay. *Review of Palaeobotany and Palynology*, **1**, pp. 161-172.

Moreau-Benoit, A., 1989. Les spores du Dévonien Moyen et Supérieur de Libye Occidentale: Compléments-Systématique-Répartition stratigraphique. *Cahiers de Micropaléontologie*, **4**, pp. 5-32.

Pasquo, M., di, Amenábar, C. R. and Noetinger, S., 2007. The palaeobiogeographical significance of the spore *Grandispora pseudoreticulata* (Menéndez and Pöthe de Baldis) Ottone in the Middle to Late Devonian of Gondwana. Field Meeting of the IGCP 499-UNESCO 'Devonian land-sea interaction: evolution of ecosystems and climate', San Juan, Argentina, May 14-22, Serie de Correlación Geológica, INSUGEO, Universidad Nacional de Tucumán, Special Volume, pp. 91-101.

Richardson, J. B., 1965. Middle Old Red Sandstone spore assemblages from the Orcadian basin north-east Scotland. *Palaeontology*, **7**, pp. 559-605.

Riegel, W., 1973. Sporenformen aus den Heisdorf-Lauch- und Nohn-Schichten (Emsium und

Eifelium) der Eifel, Rheinland. *Palaeontographica, Abteilung B*, **142**, pp. 78-104.

Scotese, C.R., 2000. Atlas of Earth History. PALEOMAP Project. http://www.scotese.com/earth.html.

Steemans, P., Lakova, I., 2004. The Moesian Terrane during the Lochkovian - a new palaeogeographic and phytogeographic hypothesis based on miospore assemblages. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **208**, pp. 225-233.

Steemans, P., Wellman, C. H. and Filatoff, J., 2007. Palaeophytogeographical and palaeoecological implications of a miospore assemblage of earliest Devonian (Lochkovian) age from Saudi Arabia. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **250**, pp. 237-254.

Streel, M., Fairon-Demaret, M. and Loboziak, S., 1990. Givetian-Frasnian phytogeography of Euramerica and western Gondwana based on miospore distribution. *In: Palaeozoic Palaeogeography and Biogeography*, McKerrow, W. S. and Scotese, C. R. (eds.), Memoirs of the Geological Society of London, 12**,** pp. 291-296.

Streel, M., Loboziak, S., 1996. Middle and Upper Devonian miospores. *In: Palynology: Principles and Applications*, Jansonius, J. and McGregor, D. C. (eds.), American Association of Stratigraphic Palynologists Foundation**,** pp. 575-587. Dallas.

Turnau, E., 1986. Lower to Middle Devonian spores from the vicinity of Pionki (Central Poland). *Review of Palaeobotany and Palynology*, **46**, pp. 311-354.