

Chitinozoan implications in the palaeogeography of the East Moesia, Romania

Marioara Vaida^{a,1}, Jacques Verniers^{b,*}

^a Geological Institute of Romania, 1 Caransebes St., Bucharest 32, 78 344, Romania

^b Research Unit Palaeontology, Department of Geology and Pedology, Ghent University, Krijgslaan 281/S8, B-9000 Ghent, Belgium

Received 5 August 2005; received in revised form 29 March 2006; accepted 6 April 2006

Abstract

Palaeomagnetic data from Moesia are absent and previous palynological and macrofaunal studies could not show clearly the palaeogeographical position of Moesia between the larger palaeocontinents Gondwana, Baltica, or Avalonia. Cutting samples from three boreholes on East Moesia (SE Romania) have been investigated in this study using S.E.M technique. Chitinozoan assemblages prove the presence of Wenlock–Ludlow (possibly Homerian and Gorstian), Pridoli, and Lochkovian. Those of the last have a pronounced distribution in North Gondwanan localities; one of them, *Cingulochitina plusquelleci*, is illustrative only in North Gondwanan regions. These chitinozoans argue that East Moesia and probably West Moesia were in good communication with the Irbarmaghian Domain of the Northern Gondwana palaeocontinent.

© 2006 Elsevier B.V. All rights reserved.

Keywords: Chitinozoans; Pridoli; Lochkovian; Palaeogeography; East Moesia; Romania

1. Introduction

The Moesian Platform lies in the foreland of the Carpathians and of the Balkans. Its basement is divided by the Intra-Moesian Fault (IMF) (Fig. 1) into two major blocks: East and West Moesia. These two sectors of the platform are unequal in surface area and show differences in the stratigraphy of the sedimentary cover, as well as in their basement structure. The Palaeozoic sediments do not crop out in Moesia and borehole evidence indicates that the heterogeneous basement rocks are overlain by a

sedimentary cover including Palaeozoic, Mesozoic and Cenozoic deposits. The core material has been used for palynological investigations in the hereby study. The main purpose of the present investigation is an attempt to elucidate the palaeogeographical affinities of the Moesian Platform (East Moesia) using chitinozoans, as a good implement in palaeocontinental reconstruction. In this context, the present palynological study has to include the revision of the old palynological data, which have been identified according to the systematic classification available earlier, in order to refine the Palaeozoic biostratigraphy and the provinciality of Moesia chitinozoans on the territory of Romania. The identified chitinozoans species, given their correct ages, and the common and predominantly palaeogeographical spreading of these species could demonstrate the palaeoposition of Moesia during different times of Palaeozoic (though

* Corresponding author. Tel.: +32 9 264 46 14; fax: +32 9 264 46 08.

E-mail addresses: Mari.Vaida@igr.ro (M. Vaida), Jacques.Verniers@UGent.be (J. Verniers).

¹ Tel.: +40 21 318 13 28; fax +40 21 318 13 26.

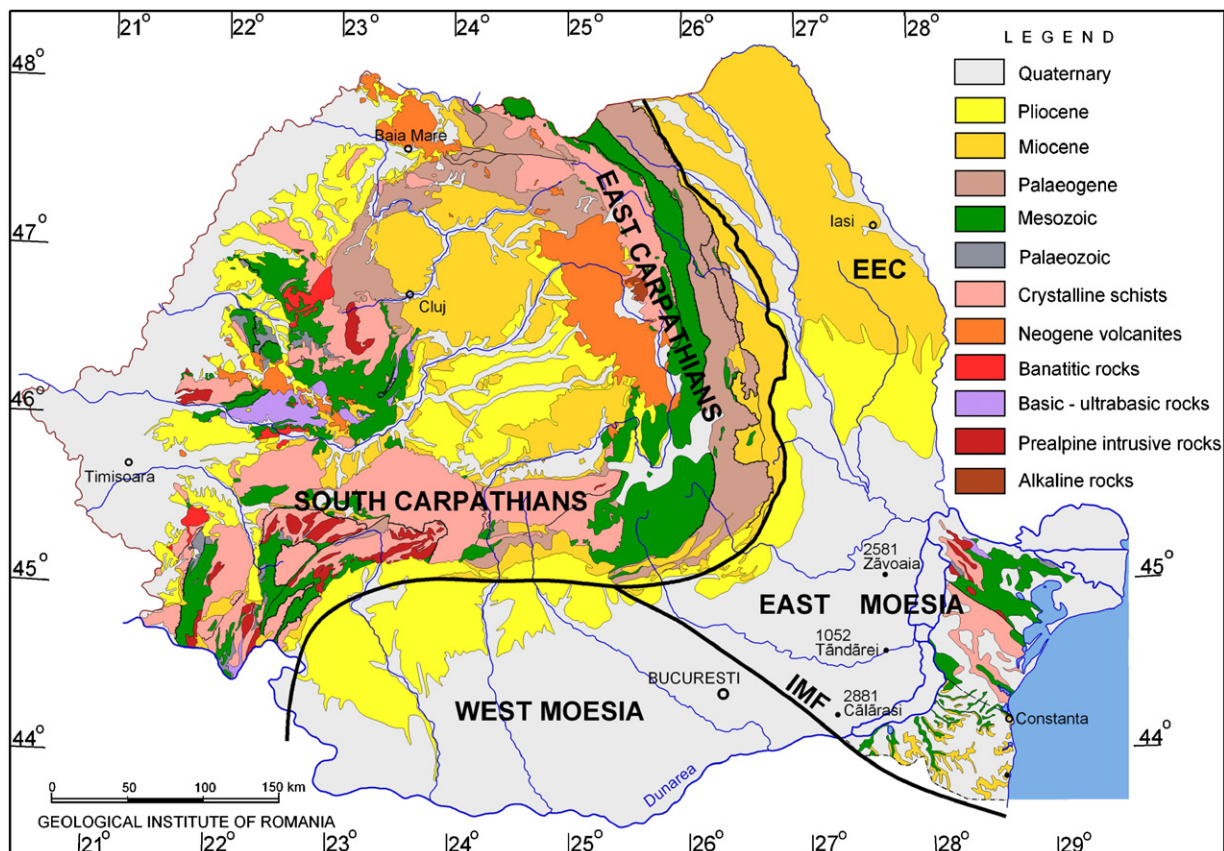


Fig. 1. Schematic geological map of Romania with the spreading area of the Moesian Platform and the location of the studied boreholes (2581 Zăvoaia; 1052 Țândărei; 2881 Călărași). Abbreviations: *IMF*—Intra-Moesian Fault; *EEC*—East European Craton.

not in the latest Devonian, when the evolution of these microfossils had stopped).

2. Palaeozoic stratigraphy of Moesia

The Moesian Platform is only known from boreholes. These penetrated the Cenozoic, Mesozoic and Palaeozoic, and in some places the Precambrian basement rocks. Palaeozoic sedimentary cover could be dated Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian based on macro- and microfauna.

2.1. Palaeozoic sediments

2.1.1. Cambrian

Lithologically, the Cambrian fossiliferous sediments are represented by black argillite overlying a nonfossiliferous quartzitic complex. The trilobites, brachiopods and merostomate bryozoans in the black shales of West Moesia document the lower and middle part of the Middle Cambrian (Mutiu, 1991). In East Moesia acritarchs could

prove the Cambrian age (Iliescu, unpublished data, Archives of Geological Institute of Romania).

2.1.2. Ordovician

The black argillites and grey-greenish glauconitic siltstones of East Moesia contain macrofauna and palynomorphs of Tremadocian, Arenig, Caradoc and Ashgill ages (Murgeanu and Spasov, 1968; Beju, 1972; Paraschiv and Beju, 1973; Jordan, 1981; Jordan and Spasov, 1989; Jordan, 1990, 1992). The *hirundo* graptolite biozone and the inarticulate brachiopod *Lingulella* aff. *davisii* are present. The Ordovician in West Moesia is documented by acritarch and chitinozoan assemblages: in both parts of Moesia, the “O¹” and “O³” palynomorph biozones have been recognized by Beju (1972). The presence of these marine palynomorphs suggests the Upper Ordovician and also deposition in a shallow, epicontinental marine basin, with a terrigenous sedimentation. The basement of Moesia is heterogeneous; there is lithological and palaeontological evidence common for the whole of Moesia that suggests that it became a single domain of

sedimentation since the Cambrian or, in some places, earlier than the Cambrian and has continued until the Ordovician.

2.1.3. Silurian

The Silurian facies is represented by graptolitic shale in the lower part, mixed with other sediments in the upper part. In East Moesia, the “shelly fauna” levels contain graptolites, while in West Moesia the “shelly fauna” levels are devoid of that group. In the latter, a shelly fauna contained many fossil groups as brachiopods, trilobites, tentaculites, corals, crinoids, bryozoans, bivalves and ostracods. In the green siltstones of the West Moesia acritarchs, miospores, and chitinozoans have been recognized, and according to the faunal lists available at that time they indicate a Llandovery age. Moreover, the *insectus* graptolite biozone described by Iordan (1981) in two boreholes from East Moesia is assigned to the Llandovery (Telychian) (Verniers et al., 1995). In the black shale of East Moesia, dark-grey and black argillite of the Wenlock *centrifugus-murchisoni* and *lundgreni* graptolite biozones were identified (Paraschiv, 1974; Iordan, 1981). In West Moesia a Wenlock shelly fauna was recorded from black slate with sandstone and green siltstone interbeds comprising brachiopods, trilobites, tentaculites, corals, crinoids, bryozoans, bivalves and ostracods. Palynologically, the black shales are proven to be Wenlock in East Moesia with chitinozoans by Beju (1972) and in West Moesia by the acritarchs, chitinozoans and miospores. Evidence from boreholes shows that Ludlow sediments are widely distributed in Moesia. In the graptolitic shale facies of East Moesia either black argillite was found or the light grey argillite with interbeds of fine grey-whitish limy sandstone. In it a mixed fauna occurs of bivalves, orthocone cephalopods, brachiopods, crinoids and graptolites. The *scanicus*, *nilssoni* and *bohemicus* graptolite biozones have been recorded (Iordan, 1971; Iordan and Rickards, 1971). Additionally, acritarchs, chitinozoans and miospores were found in East Moesia, as well as in West Moesia (Beju, 1972; Iordan et al., 1985). The Přídolí has been identified in the mixed facies of the graptolite shale facies. In boreholes of East Moesia bivalves, cephalopods and palynomorphs (acritarchs, chitinozoans) were found. The *ultimus* graptolite biozone is present (Iordan, 1988, 1992). In the West Moesia, the Přídolí is documented by brachiopods, trilobites, tentaculites, corals, crinoids, bryozoans, bivalves, ostracods and palynomorphs.

The Lower Palaeozoic sequences are dominated by clastic rocks (argillite, shale, siltstone, sandstone, and quartzite). A reducing environment characteristic for euxinic basins is postulated by the black shale and a

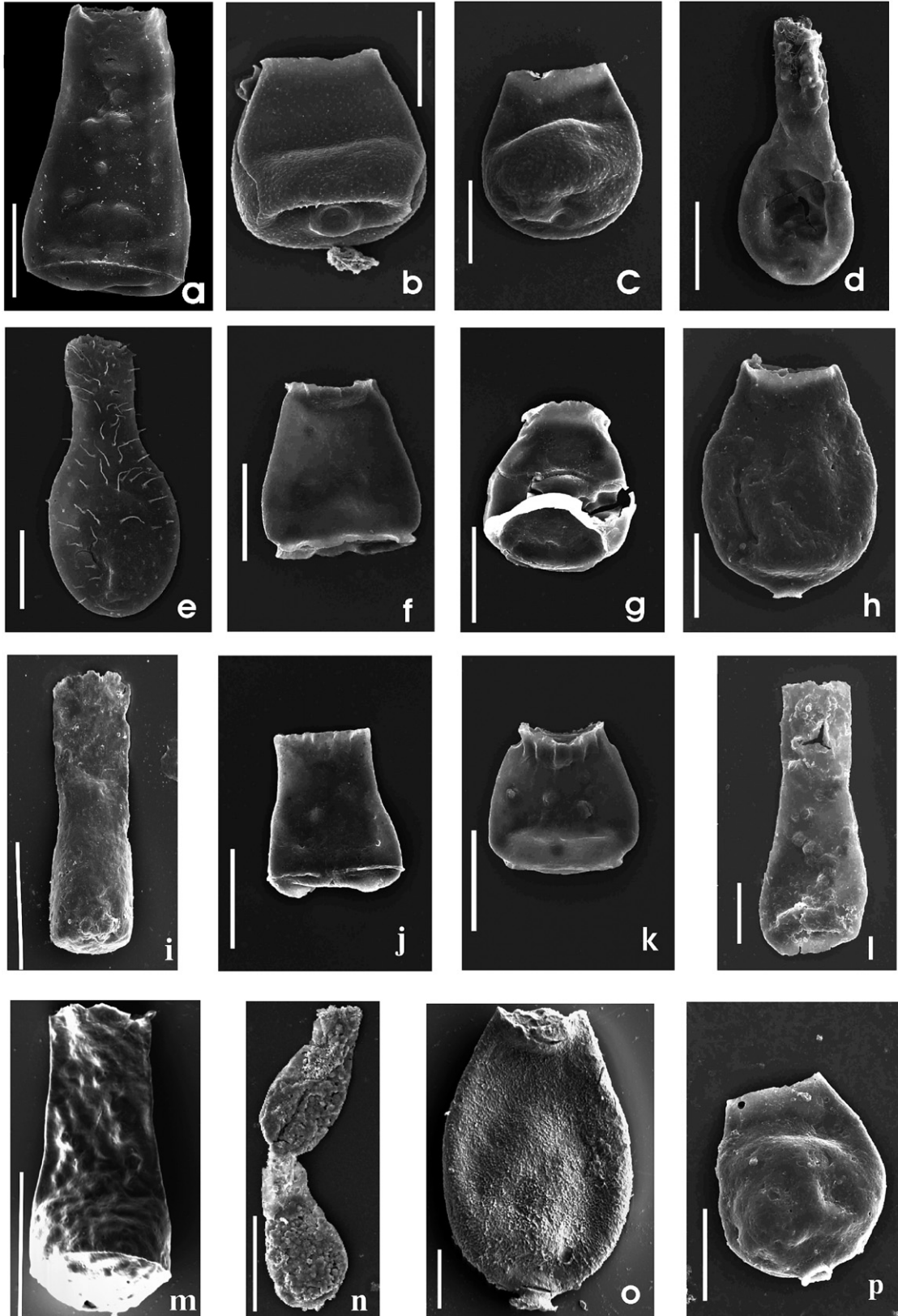
neritic sedimentation in shallow water is suggested by the “shelly fauna” facies.

2.1.4. Devonian

The Devonian of the Moesian Platform is represented by a basal argillitic facies (Lochkovian–Emsian), a middle, gritty facies (Eifelian) and an upper carbonate-evaporitic facies (Givetian–Famennian) (Paraschiv, 1979). Devonian stages have been established based on faunal assemblages consisting of brachiopods, tentaculites, trilobites, bivalves, ostracods, conodonts, placoderm fishes, psilophythal plants, as well as palynological assemblages (Iliescu, 1971; Beju, 1972; Iordan, 1981). The *Icriodus woschmidti* conodont biozone and the *Novakia acuaria* tentaculite biozone have been recorded (Paraschiv, 1979). The Kellwasser Bioevent (F/F) is supposed to be present in the Upper Devonian sediments of Moesia (Iordan, 1999), this hypothesis being supported by the extinction of the proetids, trilobites, tentaculites, atrypids, brachiopods, corals, as well as by the presence of the dark bituminous limestones, which represent evidence of this bioevent. The biostratigraphical studies indicate that a neritic epicontinental sea existed in the Moesian Platform during the Lower Devonian, with rapid terrigenous sedimentation suggesting tectonic subsidence. The regression of the sea during the Eifelian is indicated by the deposition of quartzitic sandstones in the Moesian Platform, this being followed by a transgression of the sea in the Givetian, which could continue into Lower Carboniferous.

2.1.5. Carboniferous

The Carboniferous of the Moesian Platform consists of carbonate sediments at the base and terrigenous deposits of paralic type in its upper part. The stages of Carboniferous system have been established on the basis of conodont zones and index fossils like brachiopods, gastropods, bivalves, orthoceratids, goniatites, fenestrellids and other bryozoans, corals and foraminifers, crinoids, plant debris, fish scales (Iordan et al., 1987; Iordan, 1999). The Devonian–Carboniferous boundary is in a continuous sequence and facies, where the conodont *Siphonodella isostycha* documents the Tournaisian of the dark limestones (Paraschiv, 1974). The Tournaisian carbonate facies Mississippian rocks show that the environment of sedimentation was similar as in the Middle and Upper Devonian. The upper terrigenous-paralic formations indicate an abrupt change in conditions of sedimentation. The carbonate platform environment was replaced by a terrigenous-continental one, due to the Sudetic movements preceded by the Bretonic events (Paraschiv, 1974, 1979; Iordan, 1992).



3. New palynological investigations

The chitinozoan assemblages have been recorded from the boreholes located in the East Moesia, SE Romania. Core samples were collected from three boreholes: the 2881 Călărași borehole (depths: 4439.00 m to 4441.00 m; 4589.00 m and 4982.00 m), the 2581 Zăvoaia borehole (depth 3232.10 m to 3233.10 m) and the 1052 Țândărei borehole (depth 2006.00 m to 2007.00 m).

Precise determinations of chitinozoans can be difficult using optical light microscopy (LM) due to the opacity of the Moesian material. Previous studies were unfortunately often insufficient to determine accurately the chitinozoans. In the present study, new borehole material from East Moesia has been processed palynologically and new chitinozoans from Silurian and Devonian age were obtained and studied using scanning electron microscopy. The samples were processed in the palynological laboratory of the Ghent University. Currently, 10 g of fine-grained rocks have been dissolved, according to the standard palynological method for extraction of chitinozoans from rocks as described by Paris (1981) and Verniers (1983). Even as the chitinozoans are often black, neither oxidation with acid nitric nor separation with heavy liquids were used, and only studied under S.E.M. (scanning electron microscope) of the following types: JEOL JMS 6400 (Ghent University), Philips XL 30 ESEM (Royal Belgian Institute of Natural Sciences, Brussels) and Hitachi S-3500 N (Bristol University, U.K.).

3.1. Lower Devonian chitinozoans

Lochkovian chitinozoans have been recognized in the investigated core material of Călărași borehole, East Moesia, at depths: 4439.00 m to 4441.00 m and 4589 m. The argillitic formation revealed a new chitinozoan assemblage, most of them being in a good state of preservation. At the level of –4439 m amongst the most important identified species occur *Eisenackitina bohemica* (Eisenack, 1934) (*Eisenackitina* cf. *bohemica*, Fig. 2, b, c). *Eisenackitina bohemica* (Eisenack, 1934), was defined in the Klouk section, the GSSP of the base of the Lochkovian and also the Devonian. Its stratigraphic range covers the whole Lochkovian (Paris et al., 2000). It was

observed in Bohemia, Czech Republic (Paris, 1981), France, Armorican Massif (Paris, 1981), Northern France, Artois (Paris, 1986), Montagne Noire (De Bock, 1982); Morocco, in the Rabat region (Oued Bou–Regreg) (Rahmani, 1983); Podolia, Ukraine (Paris and Grahn, 1996); in the Palencia Province of Spain (Schweineberg, 1987); Algeria, Tunisia, Libya, Poland, Gaspé, Nova Scotia (Paris et al., 2000). It has been recognized in the Moesian Platform, Bulgaria (Lakova, 1985, 1993, 1995, 1999) and recently in Romania (Vaida and Verniers, 2004; Vaida et al., 2005). *Eisenackitina* gr. *bohemica* was also found in the Boomerang area, Bolivia (Le Hérissé et al., 2004). *Eisenackitina* cf. *bohemica* is quoted in the Amazonas Basin, Brazil (Grahn and Paris, 1992; Grahn and Melo, 2003) as well *Eisenackitina* aff. *bohemica* (Azevedo-Soares and Grahn, 2005).

Cingulochitina plusquelleci Paris, 1981 (Fig. 2, f, g, k) has been found at the depths of –4589.00 m and the interval between –4439.00 m and –4441.00 m. However, comparing the frequency and the preservation state of *Cingulochitina plusquelleci* in these two depths or intervals, the latter is much better represented and with well preserved specimens at the depth of –4589.00 m, than in the interval 4439.00 m to 4441.00 m, together with *Cingulochitina ervensis* Paris, 1979 (in Babin et al., 1979) and *Cingulochitina serrata* (Taugourdeau and de Jekhowsky, 1960). At the depth of –4589 m *Urochitina simplex* is absent. We interpret that in the study area *Cingulochitina plusquelleci* persisted above the last occurrence of *Urochitina simplex*. The occurrence of *Cingulochitina plusquelleci* in the Pragian is mentioned by Paris (1981) for *Cingulochitina* cf. *plusquelleci* identified in the Armorique Formation, Finistère. Otherwise, a slight inconsistency exists between the Lochkovian chitinozoans of the Moesian Platform and the global chitinozoan biozonation of the Devonian (Paris et al., 2000), as it was mentioned by Lakova (1999). *Cingulochitina plusquelleci* was observed in the Lochkovian of the Armorican Massif in the lower part of the Saint-Cénére Formation (Paris, 1976, 1981), the Armorique Formation (uppermost Lochkovian) (Paris, 1980), the upper part of the Haye-du-Puits Formation, the Saint-Germain-sur-Ay section and at the base of the Néhou Formation (Lochkovian) (Paris, 1981). It was also mentioned from the Mehaiguéne Formation,

Fig. 2. Chitinozoans from East Moesia— the scale bar=50 μ m. a, m. *Cingulochitina ervensis* (Lochkovian, Călărași borehole, 4439.00 m to 4441.00 m), b, c. *Eisenackitina* cf. *bohemica* (Lochkovian, Călărași borehole, 4439.00 m to 4441.00 m), d. *Angochitina chlpaci* (Lochkovian, Călărași borehole, 4439.00 m to 4441.00 m), e. *Angochitina filosa* (Lochkovian, Călărași borehole, 4439.00 m to 4441.00 m), f, g, k. *Cingulochitina plusquelleci* (Lochkovian, Călărași borehole, 4439.00 m to 4441.00 m), h, p. *Urnochitina urna* (Přídolí, Zăvoaia borehole, 3232.10 m to 3233.10 m), i, l. *Conochitina* cf. *subcyatha* (Wenlock, Țândărei borehole, 2006.00 m to 2007.00 m), j. *Cingulochitina serrata* (Lochkovian, Călărași borehole, 4439.00 m to 4441.00 m), n. *Linochitina* cf. *kloukensis* (Přídolí, Zăvoaia borehole, 3232.10 m to 3233.10 m), o. *Urnochitina kameli* (Přídolí, Zăvoaia borehole, 3232.10 m to 3233.10 m).

Algeria (Boumendjel, 1987) and from Bulgaria (Lakova, 1985). *Cingulochitina plusquelleci* is often coexisting with *Fungochitina lata* and *Urochitina simplex*. The former species was however not yet found in the studied boreholes, but it is present in the 5082 Mangalia borehole (Vaida and Verniers, 2005; Seghedi et al., 2005). The occurrence of *Cingulochitina plusquelleci* in the assemblage is very important, even if it is not the index species of a biozone. Its distribution is well documented but only in localities situated along the Northern Gondwana margin (Paris et al., 2000).

Cingulochitina ervensis (Paris, 1979 in Babin et al., 1979) (Fig. 2, a, m) was identified in the Lostmarch Formation (Přídolí), the Pors-ar-Vouden section, Finistère (Paris in Babin et al., 1979), the Saint-Pierre-sur-Erve, Armorican Massif (Boumendjel, 1987), the Saint-Germain-sur-Ay section (Lochkovian) (Paris, 1981), the Ougarta, Zeimlet, Dkhissa Formations, Algerian Sahara (Boumendjel, 1987); Podolia, Ukraine (Paris and Grahn, 1996), Libya (Jaglin and Paris, 2002), Romania, Bulgaria, the Boomerang area, Bolivia (Le Hérisse et al., 2004), the Solimões Basin, northern Brazil (Grahn et al., 2003) and the Amazonas Basin, Brazil (Grahn and Melo, 2003; Azevedo-Soares and Grahn, 2005).

Cingulochitina serrata (Taugourdeau and de Jekhowsky, 1960) (Fig. 2, j) is described from the Algerian Sahara (Taugourdeau and de Jekhowsky, 1960) and Spain (Cramer, 1964). It was also found in the Upper Silurian in Florida (Cramer, 1971). The other areas are Portugal, Armorican Massif (Přídolí and Lochkovian) (Paris, 1981), Libya (Jaglin and Paris, 2002), Romania, Bulgaria, the Boomerang area, Bolivia (Le Hérisse et al., 2004), the Tarija Basin, northwestern Argentina (Grahn and Gutiérrez, 2001), the Solimões Basin, northern Brazil (Grahn et al., 2003) and the Amazonas Basin, Brazil (Grahn and Paris, 1992; Grahn and Melo, 2003; Azevedo-Soares and Grahn, 2005).

Angochitina filosa Eisenack, 1955 (Fig. 2, e) was found by Eisenack (1955) in the Upper Silurian–Lower Devonian of the Baltic area (in the *Beyrichia* Limestone). In Spain it is quoted in the upper part of the Formigoso Formation and in the lower part of the San-Pedro Formation, Ludlow–Přídolí (Cramer, 1964, 1967). It was also identified in a Ludlow–Přídolí assemblage in a borehole from Florida (Cramer, 1973). In the Contentin area (France), it occurs at the Silurian–Devonian boundary (Rauscher and Robardet, 1975); Poland, Lower Devonian (Wrona, 1980); in the Mehaiguéne Formation, Algeria, Přídolí-basal Lochkovian and Lochkovian (Boumendjel, 1987). Recently, *Angochitina filosa* was also quoted in the Boomerang area, Bolivia (Le Hérisse et al., 2004), in the Tarija

Basin, northwestern Argentina (Grahn and Gutiérrez, 2001), in the Amazonas Basin, Brazil (Grahn and Paris, 1992; Grahn and Melo, 2003; Azevedo-Soares and Grahn, 2005), Solimões Basin, northern Brazil (Grahn et al., 2003) and in Romania, Moesian Platform.

Angochitina chlupaci Paris and Laufeld, 1981 in Paris et al., 1981 (Fig. 2, d) was described from the Klouk and Karlstejn sections (Czech Republic) and its appearance is above the Přídolí–Lochkovian boundary. In the Moesian Platform (Lochkovian), Bulgaria as well as in Romania, it was also discovered. Other chitinozoans are present in the assemblage, but only determined to the generic level as *Eisenackitina* spp., *Ancyrochitina* spp. and *Angochitina* spp.

3.2. Silurian–Přídolí

The present study presents new data for the black shales of the late Silurian–Přídolí in the 2581 Zăvoaia borehole, previously dated palynologically by Beju (1972). The palynological content indicated well preserved chitinozoans in the core sample from the interval between 3232.10 m and 3233.10 m depth. Nevertheless, the index species was not identified but instead some accompanying species with stratigraphic value were observed.

Urnochitina urna (Eisenack, 1934), a species indicative for the entire Přídolí is present in the assemblage (Fig. 2, h, p). This is an accompanying species of *Margachitina elegans* biozone of Silurian, characteristic of middle and upper Přídolí (Verniers et al., 1995) and has its FAD (first appearance datum) in the lowermost part of the Přídolí (Kříž et al., 1986). It should be noted that *Urnochitina urna* range into the basal Lochkovian, Podolia, Ukraine (Paris and Grahn, 1996). *Urnochitina urna* (Eisenack, 1934) was described from Bohemia and established its occurrence in Přídolí from Karlštejn and Dworetz sections (Eisenack, 1934). It was found in Spain (Cramer, 1964; 1967; Cramer and Diez, 1978; Degardin and Paris, 1978; Schweineberg, 1987; Priwalder, 1997); Morocco, in the Přídolí part of the Bou Regreg section outside Rabat (Rahmani, 1983); Sahara (Taugourdeau and de Jekhowsky, 1960; Magloire, 1967). Its presence is also well documented for: Libya (Jaglin and Massa, 1985; Jaglin and Paris, 2002), Tunisia (Grignani, 1967), Algeria (Taugourdeau and de Jekhowsky, 1960; Boumendjel, 1987), France, Montagne Noire (De Bock, 1982), Armorican Massif (Paris, 1981; Paris and Le Hérisse, 1992), Bohemia (Eisenack, 1934; Paris et al., 1981; Kříž et al., 1986). It occurs also in Bolivia (Cramer et al., 1974), Poland (Wrona, 1980), Northern France (Paris, 1986) and Canada, Quebec (Achab and Asselin, 1993).

Urnochitina kameli Boumendjel, 1987 (Fig. 2, o) is also a very diagnostic species for Přídolí. The latter was described from the Algerian Sahara, in the Mehaiguène Formation (Přídolí) by Boumendjel (1987). In the Upper Silurian of the Algerian Sahara, Taugourdeau and de Jekhowsky (1960) and Magloire (1967) mentioned only the presence of *Urnochitina urna*. The coexistence of these two important species *Urnochitina urna* and *Urnochitina kameli* was demonstrated for the first time by Boumendjel (1987). *Urnochitina kameli* has also been recorded from the Upper Přídolí of the Montagne Noire (De Bock, 1982) and in the Přídolí of Libya (Jaglin, 1986; Jaglin and Paris, 2002). In the Boomerang area, Bolivia, the presence of *Urnochitina* cf. *Urnochitina kameli* was demonstrated by Le Hérissé et al. (2004). It is also identified in the present study in Romania.

Linochitina cf. *klonkensis* Paris and Laufeld, 1981 in Paris et al., 1981 (Fig. 2, n) is restricted to the Přídolí in the Klonk and Karlštejn sections, Bohemia (Paris et al., 1981); Podolia, Ukraine (Paris and Grahn, 1996). Not yet described in Bulgaria. For the Romanian part of Moesia, *Linochitina klonkensis* is for the first time mentioned in the present paper. *Linochitina* aff. *L. klonkensis* is quoted also in the Amazonas Basin, northern Brazil (Grahn and Melo, 2003).

Bursachitina krizi (Paris and Laufeld, 1981 in Paris et al., 1981) was described from the Klonk section, Upper Přídolí, Czech Republic. It also occurs in the Přídolí of Bulgaria (Lakova, 1999). *Eisenackitina lagenomorpha* (Eisenack, 1931) is present in the Baltic area, in the *Beyrichia* Limestone (Eisenack, 1955). It was reported from southern Sweden (Eisenack, 1964); Estonia, in the upper Gorstian, Ludfordian and Přídolí (Nestor, 1990); England, Ludlow, upper Gorstian to lower Ludfordian (Sutherland, 1994), Ronquières–Monstreux area, Brabant Massif, Belgium (Verniers et al., 2002). Other associated genera are *Plectochitina* spp., *Fungochitina* spp. and *Ancyrochitina* spp.

3.3. Silurian–Wenlock–Ludlow

In the 2881 Călărași borehole at the depth of –4982.00 m, the following chitinozoans were identified: *Conochitina pachycephala* Eisenack, 1964, *Conochitina tuba* Eisenack, 1964, *Conochitina claviformis* Eisenack, 1931, *Conochitina* spp., *Sphaerochitina* spp. and *Ancyrochitina* spp. This palynological assemblage recognized in the interval of –4982.00 m of the 2881 Călărași borehole, demonstrates a Wenlock–Ludlow (Gorstian), possibly Lower Ludlow (Gorstian) in age. The *Conochitina pachycephala* Eisenack, 1964, *Conochitina tuba* Eisenack, 1964 and *Conochitina* cf. *subcyatha* Nestor,

1982 (Fig. 2, i, l) occur in the 1052 Țândărei borehole, at the interval between –2066.00 m and –2067.00 m and they document the Upper Wenlock (Homerian) in age. Nevertheless, they have no palaeogeographic significance, being fairly cosmopolitan species and well known in the stratigraphic interval mentioned above.

4. Palaeogeography

In the Moesian Platform, the palaeomagnetic data are completely missing. Additionally, the old palynological data and most of macrofauna are not relevant in order to establish the palaeogeographical position of Moesia during the Palaeozoic. A northern Gondwanan affiliation of Moesia, Romania was suggested by palynomorphs (acritarchs, chitinozoans and miospores) (Beju, 1972; Iliescu, 1975; Iordan et al., 1985; Vaida and Verniers, 2005; Vaida et al., 2005) and macrofaunas (Iordan, 1971; Iordan and Rickards, 1971; Iordan et al., 1985). On the other hand, Middle Cambrian trilobites recognised in the West Moesia indicate affinities with England, Bohemia, Scandinavia, Poland (Mutiu, 1991; Iordan, 1999). Based on this argument, some authors have considered that the whole Moesia is a part of Baltica (Rushton and McKerrow, 2000; Stamfli and Borel, 2002). Nevertheless, it is known that the Moesian Terrane is a peri-Gondwana piece (as defined by Scotese and McKerrow, 1990; Haydutow and Yanev, 1997; Smith, 1999; Scotese, 2002) (see references in Seghedi et al., 2005; Yanev et al., 2005), but in this hypothesis it is not well demonstrated whether the whole of Moesia shows the same palaeogeographical affinity. The Peri-Gondwanan affinities have been demonstrated in Bulgaria for the Middle Ordovician sediments mainly integrated in the Balkan and Moesia Terrane (as defined by Haydutow and Yanev, 1997), based on the Bohemian type assemblage of trilobites (Gutiérrez-Marco et al., 2003). Torsvik and Cocks (2004) grouped Moesian Terrane with the Hellenic Terrane (Greece and adjacent areas) and placed them in the peri-Gondwana area, as the data from Bulgaria summarized by Yanev (2000), suggest that Moesia carried peri-Gondwanan rather than Baltic trilobites and also relatively high-latitude acritarchs during the Ordovician. These terranes, including Moesia, separated from the core of Gondwana perhaps in the latest Silurian. Oczlon (2004), in his recent Palaeozoic Terrane map of Europe, considered Moesia as a piece of East European Craton. Steemans and Lakova (2004) have shown that the Moesia was close to southern Laurussia during the Lower Devonian, and its position is indicated by the presence of the *sinuosus–zavallatus*

(S–Z) miospore Province, restricted for Avalonia and western part of Baltica. The authors explained the presence of the chitinozoans and acritarchs which clearly showed a North Gondwanan affinity, joint to S–Z miospore Province, by the migration of these palynomorphs, allowed by the Rheic Ocean around the Silurian–Devonian boundary. The closure phase of Rheic Ocean had started at the beginning of the Devonian (Plusquellec et al., 1997).

Only the Silurian (Přidolí) and Devonian (Lochkovian) chitinozoans from the studied boreholes of East Moesia show striking similarities to those of Armorican Massif, Montagne Noire, France, Algerian Sahara, Tunisia, Rabat region, Morocco, Libya, north-west Spain, Portugal, Bulgaria, Bohemia, Czech Republic. These areas have in common the chitinozoans listed above. Moreover, the distribution of *Cingulochitina plusquellecti* is restricted only to those areas located along the Northern Gondwana margin (Paris et al., 2000). Thus, it is supposed that at the levels Přidolí and Lochkovian, the East Moesia basin was in a good connection with Northern Gondwanan basins, respectively with the so-called “Ibarmaghian Domain”. The last was defined by Plusquellec et al. (1997) as a realm for Devonian fauna. The Ibarmaghian Domain, already isolated since in Ordovician (Paris, 1998: p. 475), corresponded to the southern margin of the Rheic Ocean and is composed of two main areas: the Maghreb region (Morocco, Algeria, Libya), this area being considered as an equivalent for North-Saharan region *sensu* Racheboeuf (1990), and the Ibero-Armorican region, which includes the central and north-west parts of Spain and Portugal, as well as the middle and the northern part of the Armorican Massif. The affinity between the Ibarmaghian Domain with other northern Gondwana regions, including Romania and Bulgaria, is also mentioned by Jaglin and Paris (2002). It is known that the whole Moesian Terrane within Bulgaria belongs to West Moesia. Based on the palynological similarities between Bulgarian and Romanian areas (see references in Lakova, 1993, 1995, 1999), we might suppose that both sectors have the same palaeogeographic affinity.

5. Conclusions

The Wenlock–Ludlow, possibly Lower Ludlow (Gorsian) (succession of 2881 Călărași borehole, at depth –4982.00 m), the Upper Wenlock (Homerian) (succession of 1052 Țândărei borehole, at depth –2066.00 m to –2067.00 m), Přidolí (succession of 2581 Zăvoaia borehole, at depth –3232.10 m to –3233.10 m) and Lochkovian, Lower Devonian (succession of 2881

Călărași borehole, at depths –4439.00 m to –4441.00 m and –4589.00 m) are documented by the chitinozoan associations in East Moesia. This conclusion significantly modifies the previous known ages based on acritarchs, chitinozoans and spores. The chitinozoans of Wenlock–Ludlow age are fairly cosmopolitan species and are not characteristic for one or the other palaeocontinent. In contrast, distinctive affinities are shown by the Přidolí and Lochkovian chitinozoan assemblages. Chitinozoans from East Moesia are predominantly represented in typical North Gondwana Terrane: Bohemia, Czech Republic, Armorican Massif, Montagne Noire, Algerian Sahara, Tunisia, Rabat region, Morocco, Libya, north-west Spain, Portugal and Bulgaria. Besides, one of them, *Cingulochitina plusquellecti*, with a very short range in Lochkovian, has a distribution limited only to the North Gondwanan areas. Similar palynological data supporting the same hypothesis come from assemblages in the 5082 Mangalia borehole, East Moesia, where *Cingulochitina plusquellecti* and *Fungochitina lata* are only quoted in one palaeocontinent, North Gondwana (Vaida and Verniers, 2005). Palaeontological arguments, including the chitinozoans already mentioned, demonstrated the North Gondwanan affinity for the West Moesia, Bulgarian territory. Corroborating palynological data from Romania, East and West Moesia, and Bulgaria (West Moesia), clearly indicate a common North Gondwanan affinity. They demonstrate that East Moesia and probably West Moesia have been in a free communication with Northern Gondwana and the putative Ibarmaghian Domain. The sea was closing in the Silurian and no differences can be seen in mid-Devonian.

Acknowledgements

We would like to thank reviewer Yngve Grahn for the constructive remarks and the improvement of the submitted manuscript. The authors kindly thank Randell Stephenson, Vrije Universiteit Amsterdam, for his assistance in improving English of the manuscript. Funding for this contribution has been provided by the bilateral project BIL 01/34 between the Science and Innovation Administration of the Ministry of the Flemish Community of Belgium, Ghent University, and the Department of European Integration and International Relations of the Ministry of Education and Research of Romania, Geological Institute of Romania, Bucharest and by the national project 34/7.09.2005 of the Ministry of Economy and Commerce, Romania. The authors thank project IGCP 503. Marioara Vaida benefited of a European Commission grant in Brussels and Bristol. Assistance from Sabine

Van Cauwenberghe in the sample preparation is very much appreciated.

References

- Achab, A., Asselin, E., 1993. Upper Silurian and Lower Devonian chitinozoan microfaunas in the Chaleurs Group, Eastern Canada. *Special Papers in Palaeontology* 48, 7–15.
- Azevedo-Soares, H.L., Grahn, Y., 2005. The Silurian–Devonian boundary in the Amazonas Basin, northern Brazil. *Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen* 236, 79–94.
- Babin, Cl., Deunff, J., Melou, M., Paris, F., Pelhate, A., Plusquellec, Y., Racheboeuf, P.R., 1979. La coupe de Pors-ar-Vouden (Pridoli de la Presqu'île de Crozon). *Massif armorican, France. Lithologie et Biostratigraphie. Palaeontographica, Abteilung A* 164 (1–3), 52–84.
- Beju, D., 1972. Zonare si corelare a Paleozoicului din Platforma Moesica pe baza asociatiilor palinoprotistologice. *Petrol si gaze, Bucuresti* 23 (12), 714–722.
- Boumendjel, K., 1987. Les chitinozoans du Silurien supérieur et du Dévonien du Sahara Algerien cadre géologique, systematique, biostratigraphie). Doctoral thesis, University thesis, University of Rennes I, 181 pp. (unpublished).
- Cramer, F.H., 1964. Mikroplancton from three Palaeozoic formations in the province of León (NW Spain). *Leidse Geologische Mededeelingen* 30, 255–361.
- Cramer, F.H., 1967. Chitinozoans of a composite section of upper Llandoveryian to basal Lower Gedinian sediments in northern Leon, Spain. A preliminary report. *Bulletin de la Société Belge Géologie*, 69–129 (Brussels).
- Cramer, F.H., 1971. A Palynostratigraphic Model for Atlantic Pangea during Silurian time. *Mém. Mémoires du BRGM (Paris)* 73, 229–235.
- Cramer, F.H., 1973. Middle and upper chitinozoan succession in Florida subsurface. *Journal of Paleontology* 47 (2), 279–288.
- Cramer, F.H., Diez, M., 1978. Iberian Chitinozoans. I. Introduction and summary of Pre-Devonian data. *Palinologia Num. Ext.*, vol. 1, pp. 149–201.
- Cramer, F.H., Diez, M., Cuerda, A.J., 1974. Late Silurian chitinozoans and acritarchs from Cochabamba, Bolivia. *Neues Jahrbuch für Geologie und Paläontologie. Monatshefte* 1–12.
- De Bock, F., 1982. Présence de chitinozoaires dans le passage siluro-dévonien de la Montagne Noire sud-orientale (Hérault, France). *Geobios* 11, 769–777.
- Degardin, J.M., Paris, F., 1978. Présence de chitinozoaires dans le passage siluro-dévonien de la Montagne Noire sud-orientale (Hérault, France). *Geobios* 11, 769–777.
- Eisenack, A., 1931. Neue Mikrofossilien des baltischen Silurs I. *Paläontologische Zeitschrift* 13, 74–118.
- Eisenack, A., 1934. Neue Mikrofossilien des baltischen Silurs III. Und neue Mikrofossilien des böhmischen silurs. *Paläontologische Zeitschrift* 16, 52–76 (Berlin).
- Eisenack, A., 1955. Chitinozoen, Hystrichosphaeren und andere Mikrofossilien aus dem Beyrichia Kalk. *Senckenbergiana Lethaea* 36, 156–188.
- Eisenack, A., 1964. Mikrofossilien aus dem Silur Gotlands. Chitinozoen. *Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen* 120, 308–342.
- Grahn, Y., Gutiérrez, P.R., 2001. Silurian and Middle Devonian Chitinozoa from the Zapla and Santa Bárbara Ranges, Tarija Basin, northwestern Argentina. *Ameghiniana* 38, 35–50.
- Grahn, Y., Melo, J.H.G., 2003. Silurian–Devonian chitinozoan biostratigraphy along the Urubu, Uatumã and Abacate rivers in the western part of the Amazonas Basin, northern Brazil. *Bulletin of Geosciences* 78, 373–391.
- Grahn, Y., Paris, F., 1992. Age and correlation of the Trombetas Group, Amazonas Basin, Brazil. *Revue de Micropaléontologie* 35, 20–32.
- Grahn, Y., Loboziak, S., Melo, J.H.G., 2003. Integrated correlation of Late Silurian (Pridoli s.l.)–Devonian chitinozoans and miospores in the Solimões Basin, northern Brazil. *Acta Geologica Polonica* 53, 283–300.
- Grignani, D., 1967. Correlation with Chitinozoa in the Devonian and Silurian in some Tunisian well samples. *Review of Palaeobotany and Palynology* 5, 315–325.
- Gutiérrez-Marco, J.C., Yanev, S.N., Sachanski, V.V., Rabano, I., Lakova, I., San José Lancha, M.A., Díaz Martínez, E., Boncheva, I., Sarmiento, N.G., 2003. New biostratigraphical data from the Ordovician of Bulgaria. In: Albanesi, G.L., Beresi, M.S., Peralta, S.H. (Eds.), *Ordovician from Andens. INSUGEO. Seie Correlación Geológica*, vol. 17, pp. 78–85. Tucumán.
- Haydutow, I., Yanev, S., 1997. The protomoesian microcontinent of the Balkan Peninsula— a peri-Gondwanaland piece. *Tectonophysics* 272, 303–313.
- Iliescu, V., 1971. Asocia ții Palinologice Devoniene (Forajul Smirna-Platforma Moesică). *Studii Și Cercetări de Biologie. Seria Botanica* 23 (5P), 367–374 (București).
- Iliescu, V., 1975. A Pridolian (uppermost Silurian) palynoprotistologic assemblage from the Moesian Platform— Romania. *Dari de seama ale ședintelor*, 3. *Palaeontologie LXII*, 187–193 (Bucharest).
- Iordan, M., 1971. Graptoliti din forajul Țândărei (Platforma Moesică). *Dări de seamă ale ședintelor. Paleontological LVIII*, 31–47 (Bucuresti, in Romanian).
- Iordan, M., 1981. Study of Silurian and Devonian faunas from the Eastern part of the Moesian Platform. *Mem. Inst. Geol. Geofiz.*, 30, 115–222 (thesis presented on the 16 April 1977, Iași).
- Iordan, M., 1988. Biostratigraphy of the Devonian in Romania. *Devonian of the World. Proc. 2nd Intern. Symp. Devonian System, Calgary – 1987, Canada*, vol. 14 (1). Canadian Society of Petroleum Geologists, Calgary.
- Iordan, M., 1990. Biostratigraphic guide marks in the Lower Palaeozoic strata of the Moesian Platform, Romania. *Abstracts. IGCP Programme, Project 216 and 303— Global Biological Events. Precambrian–Cambrian Event Stratigraphy*, Oxford. Sept.
- Iordan, M., 1992. Biostratigraphic age indicators in the Lower Palaeozoic successions of the Moesian Platform of Romania. *Geologica Carpathica* 43 (4), 231–233.
- Iordan, M., 1999. Biostratigraphy of the Palaeozoic in the Moesian Platform. *Excursion Guide of The Joint Meeting of Europrobe Tesz, Pancardi and Georift Projects “Dobrogea the interface between the Carpathians and the Trans-Europe Suture Zone”, Tulcea 1999: Geology and structure of the Precambrian and Palaeozoic basement of North and Central Dobrogea. Mesozoic history of North and Central Dobrogea. Romanian Journal of Tectonics and Regional Geology* 77 (2), 18–23.
- Iordan, M., Rickards, B., 1971. Nota asupra graptoliților din Platforma Moesică. *Dări de seamă ale ședintelor*, vol. LVII (1969–1970), 5–10, Bucuresti (in Romanian).
- Iordan, M., Spasov, H., 1989. Lower Palaeozoic (Cambrian–Silurian) sediments of the Moesian Platform. *XIV Congress CBGA Sofia 1989*, pp. 702–705. Abstracts.
- Iordan, M., Iliescu, V., Visarion, A., Baltreș, A., Săndulescu, E., 1985. Litho- and biostratigraphy of the Paleozoic sequences in the Opreșor and Gârla Mare boreholes (south-western part of the Moesian

- Platform). D.S.Inst. Geol. Geofiz., vol. LXIX'51982, pp. 5–28. Stratigraphie.
- Jordan, M., Tomescu, C., Antonescu, E., Ilescu, V., Iva, M., Bitoianu, C., Vaida, M., 1987. Formations jurassiques et paleozoiques superieures du forage Dobromiru-Dobrogea de sud (SE de la Plateforme Moesienne). Dări de Seamă ale Institutului de Geologie și Geofizică, 72 – 73/4, Stratigraphie, 19-44, București.
- Jaglin, J.C., 1986. Nouvelles espèces de Chitinozoaires du Pridoli de Libye. Revue de Micropaléontologie 29 (1), 44–54.
- Jaglin, J.C., Massa, D., 1985. Biostratigraphie des chitinozoaires du Pridoli de Libye et implication sur la signification biologique du groupe. E.U.G. III Strasbourg. Terra Cognita, p. 262.
- Jaglin, J.C., Paris, F., 2002. Biostratigraphy, biodiversity and palaeogeography of late Silurian chitinozoans from A1-61 borehole (north-western Libya). Review of Palaeobotany and Palynology 118, 335–358.
- Kříž, J., Jaeger, H., Paris, F., Schönlaub, H.P., 1986. Pridoli—the Fourth subdivision of the Silurian system. Jahrbuch der Geologischen Bundesanstalt 129, 291–360.
- Lakova, I., 1985. Chitinozoan from the Pridolian and Gedinian in Borehole R-1 Dălgodelci (North-West Bulgaria). Review of the Bulgarian Geological Society XLVI, 213–220 (part 2).
- Lakova, I., 1993. Biostratigraphy of Lochkovian Chitinozoans from North Bulgaria. In: Molyneaux, S., Dornig, K. (Eds.), Contributions to Acritarch and Chitinozoans Research. Spec. Pap. Palaeontol., vol. 48, pp. 37–44. London.
- Lakova, I., 1995. Chitinozoans, Acritarchs and Tubular and Filamentous Macerals from R-119 Kardam well, Moesian Platform, NE Bulgaria. Comptes rendus de l'Académie bulgare des Sciences, Tome 48, Geologie, Stratigraphie, nr.5, 55–58.
- Lakova, I., 1999. Joint chitinozoan and acritarch biostratigraphy of the Pridoli and Lochkovian from Moesian Platform, Bulgaria. Geologica Carpathica, Special Issue, vol. 50, pp. 48–49. Bratislava, extended abstract.
- Le Hérisse, A., Perez-Leyton, M., Paris, F., Morales, R., Racheboeuf, P.R., 2004. Marine palynomorphs from the Siluro-Devonian transition and lower Devonian in the Boomerang area, Bolivia. XI International Palynological Congress. Polen (antes An. Asoc. Palinol. Leng. Esp.), 14, p. 146.
- Magloire, L., 1967. Etude stratigraphique par la palynologie, des depots argilo-gréseux du Silurien et du Dévonien inférieur dans la region du Grand Erg occidental (Sahara algérien). Int. Symp. Devonian Syst. II, pp. 473–491. Calgary.
- Murgeanu, G., Spasov, Hr., 1968. Les Graptolites du forage Bordei Verde (Roumanie). Bulg. Acad., Com. of Geol. Bul. Geol. Inst. Series Paleont, K.H., Sofia, vol. VII, pp. 229–239.
- Muti, R., 1991. On the presence of Cambrian in the Moesian Platform (Romania). Revue Roumaine de Géologie 35, 75–85 (Bucharest).
- Oczlon, M.S., 2004. Restoration and origin of Caledonian terranes along the south-western margin of Baltica. Avalonia–Moesia Symposium and Workshop on the Early Palaeozoic Orogens of the Trans European Suture Zone, 9–11 October, Ghent/Ronse, Belgium, pp. 24–25. Abstract book.
- Nestor, V., 1982. Chitinozoan zonal assemblages (Wenlock, Estonia). In: Kaljo, D., Klaamann, E. (Eds.), Communities and biozones in the Baltic Silurian. Acad. Sci. Estonian SSR. Valgus, Tallinn, pp. 84–138 (in Russian).
- Nestor, V., 1990. Silurian Chitinozoans. In: Kalio, D.L., Nestor, H. (Eds.), Field Meeting Estonia 1990. An Excursion Guidebook. Est. Acad. Sci. Tallinn, pp. 80–83.
- Paraschiv, D., 1974. Studiul stratigrafic al Devonianului și Carboniferului din Platforma Moesică la vest de râul Argeș. Studii Tehnice și Economice— Institutul Geologic. Seria J, Stratigraphie, 12, 165 pp. (București, in Romanian).
- Paraschiv, D., 1979. Platforma Moesica si zacamintele ei de hidrocarburi. Ed. Acad. R. S. R., Bucuresti, 182 pp.
- Paraschiv, D., Beju, D., 1973. Contribuții la cunoașterea stratigrafiei Cambro-Ordovicianului din Platforma Moesica. Rev. Petrol și Gaze 8, 465–471 (Bucuresti).
- Paris, F., 1976. Les Chitinozoaires in: Les schistes et calcaires éodéviens de Saint Cénére (Massif Armorican), France). Sédimentologie, Paleontologie, Stratigraphie. Mém. Soc. géol. miner. Bretagne, 19, 93-133, Rennes.
- Paris, F., 1980. Les chitinozoaires in les schistes et calcaires de l'Armorique (Dévonien inférieur, Massif Armorican). Sédimentologie, paleontologie, stratigraphie. Mémoires de la Société Géologique et Minéralogique de Bretagne 23, 111–128.
- Paris, F., 1981. Les chitinozoaires dans le Paléozoïque du Sud-Ouest de l'Europe (Cadre géologique—Etude systématique—Biostratigraphie). Memoires de la Societe Geologique et Mineralogique de Bretagne, Rennes, 496 pp.
- Paris, F., 1986. Les Chitinozoaires. In: Racheboeuf, P.R. (Ed.), In Le Groupe de Liévin, Pridoli-Lochkovien de l'Artois (V France). Biostratigraphie du Paléozoïque, vol. 3, pp. 55–61.
- Paris, F., 1998. Early Palaeozoic palaeobiogeography of northern Gondwana regions. Acta Universitatis Carolinae. Geologica 42, 473–483.
- Paris, F., Grahn, Y., 1996. Chitinozoa of the Silurian–Devonian boundary sections in Podolia, Ukraine. Palaeontology 39, 629–649 (part 3).
- Paris, F., Le Hérisse, A., 1992. Palaeozoic in Western Brittany (Outline of the armorican geological history and geological itinerary in the Crozon Peninsula). Cahiers de Micropaléontologie 7, 5–28.
- Paris, F., Laufeld, S., Chlupáč, I., 1981. Chitinozoa of the Siluro-Devonian boundary stratotypes in Bohemia. Sveriges Geologiska Undersökning. Ser. Ca 51, 1–29.
- Paris, F., Winhester-Seeto, T., Boumendjel, K., Grahn, Y., 2000. Toward a global biozonation of Devonian chitinozoans. Courier Forschungsinstitut Senckenberg 220, 39–55 (Frankfurt a. M.).
- Plusquellec, Y., Boumendjel, K., Morzadec, P., Paris, F., 1997. Les faunas dévoniennes d'Ougarta dans la paléogéographie des régions maghrébo-européennes. Annales de la Société Géologique du Nord 5, 123–128.
- Priwalder, H., 1997. SEM-Revision of a Chitinozoan Assemblage from the Uppermost San Pedro Formation (Pridoli), Cantabrian Mountains (Spain). Jahrbuch Geologische Bundesanstalt, A, Heft 140 (1), 73–93.
- Racheboeuf, P.R., 1990. Paléobiogéographie de la marge nord-gondwanienne au Dévonien inférieur et moyen: nouvelles données déduites des Brachiopodes, Chonetacés. Comptes Rendus de l'Académie des Sciences de Paris 310, 1481–1486.
- Rahmani, K., 1983. Etude Palynologique du Paléozoïque (Ordovicien, Silurien, Dévonien) de la Région de Rabat (Oued Bou-Regreg), Maroc. Notes et Memoires du Service Geologique 324 Rabat.
- Rauscher, R., Robardet, M., 1975. Les microfossiles (Acritarches, Chitinozoaires et spores) des couches de passage du Silurien au Dévonien dans le Contentin (Normandie). Annales de la Société Géologique du Nord 95 (2), 81–92 (Lille).
- Rushton, A.W.A., McKerrow, W.S., 2000. Cambrian fossils from Moesian platform and their relationship to the trans-European suture (abstract volume). Joint Meeting of Europrobe (TESZ) and Pace Projects, Zakopane, pp. 71–72.
- Schweineberg, J., 1987. Silurische Chitinozoen aus der Provinz Palencia (Kantabrisches Gebirge, N-Spanien). Göttinger Arbeiten Geologie und Paläontologie 33, 1–94 (Göttingen).
- Scotese, C.R., 2002. Palaeomap Project. <http://www.Scotese.com>.

- Scotese, C.R., McKerrow, W.S., 1990. Revised world maps and introduction. *Memoirs of the Geological Society of London* 12, 1–21.
- Seghedi, A., Vaida, M., Iordan, M., Verniers, J., 2005. Palaeozoic evolution of the Romanian part of the Moesian Platform: an overview. *Geologica Belgica* 8 (4), 99–120.
- Smith, A.G., 1999. Gondwana: its shape, size and position from Cambrian to Triassic times. *Journal of African Earth Sciences* 28 (1), 71–97.
- Stamfli, G.M., Borel, G.D., 2002. A plate tectonic model for the Paleozoic and Mesozoic constrained by dynamic plate boundaries and restored synthetic oceanic isochrones. *Earth and Planetary Science Letters* 196, 17–33.
- Stemans, P., Lakova, I., 2004. The Moesian Terrane during the Lochkovian — a new palaeogeographic and phytogeographic hypothesis based on miospores assemblages. *Palaeogeography, Palaeoclimatology, Palaeoecology* 208, 225–233.
- Sutherland, S., 1994. Ludlow Chitinozoans from the Type Area and Adjacent Regions. Monograph of the Palaeontological Society, London. 144 pp.
- Taugourdeau, P., de Jekhowsky, B., 1960. Répartition et description des Chitinozoaires siluro-Dévonien de quelques sondages de la C. R.E.P.S., et de la S.N. Repal au Sahara-Rev. *Inst. Fr. Pétrole*, vol. 5, pp. 1199–1260.
- Torsvik, T.H., Cocks, L.R.M., 2004. Earth geography from 400 to 250 Ma: a palaeomagnetic, faunal and facies review. *Journal of the Geological Society (London)* 161, 555–572.
- Vaida, M., Verniers, J., 2004. Early Devonian (Lochkovian) chitinozoans from the Moesian Terrane, SE Romania. The XI-th International Palynology Congress, Polen (antes An. Asoc. Palinol. Leng. Esp.), Granada, July, vol. 14, 148.
- Vaida, M., Verniers, J., 2005. Biostratigraphy and palaeogeography of Lower Devonian chitinozoans, from East and West Moesia, Romania. *Geologica Belgica, Avalonia–Moesia Symposium* 8 (4), 121–130.
- Vaida, M., Seghedi, A., Verniers, J., 2005. Northern Gondwanan affinity of Moesian Terrane based on chitinozoans. *The Carpathians/Pannonian Special Volume. Tectonophysics* 410, 379–387.
- Verniers, J., 1983. The Silurian of the Mehaigne area (Brabant Massif, Belgium); Lithostratigraphy and features of the sedimentary. *Professional Papers Géologique de Belgique* 203, 1–117.
- Verniers, J., Nestor, V., Paris, F., Dufka, P., Sutherland, S., Van Grootel, G., 1995. A global Chitinozoa biozonation for the Silurian. *Geological Magazine* 132 (6), 629–643 (Cambridge).
- Verniers, J., Van Grootel, G., Louwye, S., Diependaele, B., 2002. The chitinozoan biostratigraphy of the Silurian of the Ronquières–Monstreux area (Brabant Massif, Belgium). *Review of Palaeobotany and Palynology* 118, 287–322.
- Wrona, R., 1980. Upper Silurian–Lower Devonian Chitinozoa from the subsurface of southern Poland. *Palaeontologia Polonica* 41, 103–165.
- Yanev, S., 2000. Palaeozoic terranes of the Balkan Peninsula in the framework of Pangea assembly. *Palaeogeography, Palaeoclimatology, Palaeoecology* 161, 151–177.
- Yanev, S., Lakova, I., Boncheva, I., Sachanski, V., 2005. The Moesian and Balkan Terranes in Bulgaria: Palaeozoic basin development, palaeogeography and tectonic evolution. *Geologica Belgica* 8 (4), 185–192.