

## STRUNIAN

Maurice STREEL<sup>1</sup>, Denise BRICE<sup>2</sup> & Bruno MISTIAEN<sup>2</sup>

(2 figures)

1. *Université de Liège, paléobotanique, paléopalynologie et micropaléontologie, Sart-Tilman B18, B-4000 Liège 1, Belgium.*
2. *Laboratoire de paléontologie stratigraphique FLST & ISA – UMR 8014 du CNRS, 13 rue de Toul 59046, Lille Cedex, France.*

**ABSTRACT.** The uppermost Famennian Substage or Strunian has been used widely and internationally in a chronostratigraphic sense since the nineteenth-century based on macrofossils described from the Etroeungt area and fauna. A new definition based on microfossils with distinct reference sections for neritic and pelagic facies is proposed to International agreement.

**KEYWORDS:** Strunian, uppermost Famennian, Etroeungt, macrofauna, microfauna, microflora, reference sections, neritic, pelagic

**Reference to this paper:** Streel, M., Brice, D. & Mistiaen, B., 2006. Strunian. In Dejonghe, L., ed., Current status of chronostratigraphic units named from Belgium and adjacent areas, *Geologica Belgica*, Brussels, 9/1-2: 105-109.

### 1. Name

Strunian (English), Struniaan (Dutch), Strunium (German), Strunien (French).

### 2. Age

This uppermost Substage of the Famennian (see #5) ranges from about 363 to about 360 Ma (Trapp *et al.* 2004)

### 3. Author

The term “Strunien” was introduced by de Lapparent (1900, p. 860) and later considered as a stage by Barrois (1913, p.16) and Mailleux & Demanet (1928). (See also Brice & Mistiaen 2003)

### 4. Historical type area

As stated by Sartenaer (1997) “the Strunian rests upon solid foundations”, the Etroeungt Limestone (“Calcaire d’Etroeungt”), of which the stratotype is located in the Parcq quarry in Etroeungt near Avesnes (Department of the North, France).

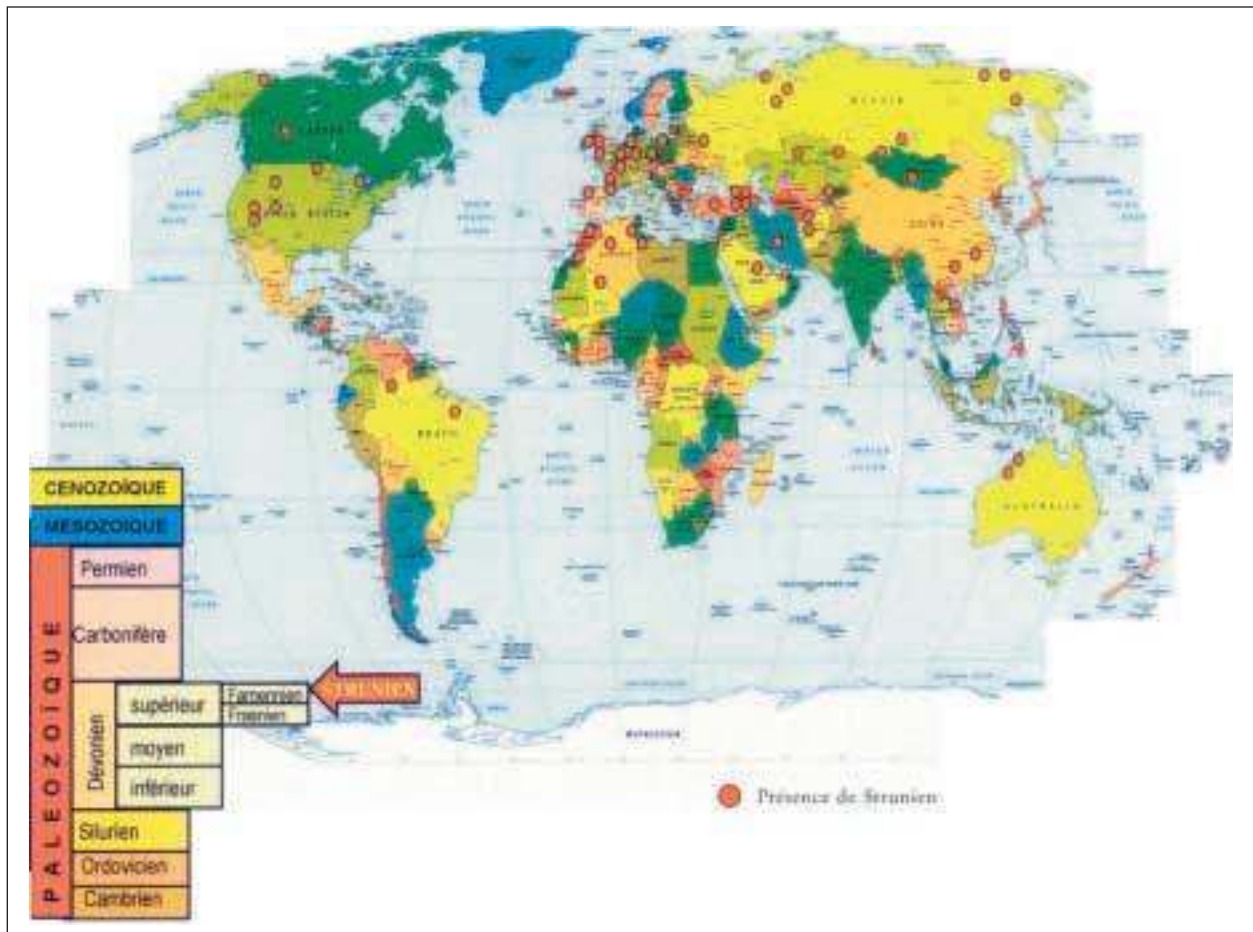
The geological map of France (Avesnes, 1:50.000 edition 1967, revision Delattre, Polvêche, Waterlot) uses the term “Strunien” with the connotation “h<sub>1</sub>a”. Conil *et al.* (1964) and Conil & Lys (1980) proposed the Avesnelles railroad trench as a parastratotype.

### 5. Description

The 24.05 m thick Etroeungt Limestone has been described bed by bed by Gosselet (1857), formally named “schistes et calcaire d’Etroeungt” by the same author in 1860 and the description updated by Sartenaer & Mamet (1964). Later, Mamet *et al.* (1965) suggested to extend lower the base of the Strunian to the first appearance of the foraminifer *Quasiendothyra kobetusana*. Conil *et al.* (1976) proposed an even lower base, at the first appearance of the miospore *Retispora lepidophyta*.

### 6. Historical background

The terms Strunian and Etroeungt have been (and are still) used widely and internationally (Fig. 1) in a chronostratigraphic sense for beds containing a transitional fauna between the late Devonian and early Carboniferous (Nicollin & Brice, 2004). Until 1990, Franco-Belgian and Russian authors have often considered the Strunian as belonging to the lowermost part of the Carboniferous System in opposition with the proposals made at the Heerlen Congress (1935) which were accepted generally by the German authors. The I.U.G.S. Devonian-Carboniferous Working Group (Paproth & Streel, 1984), after more than ten years of activities, recommended a GSSP for the base of the Carboniferous System at the base of Bed 89 of the section La Serre (Montagne Noire, southern France), i.e. at the base of the conodont *Siphonodella sulcata* in a section displaying an evolutionary lineage of *S. praesulcata* to *S. sulcata*. A decision was ratified by the



**Figure 1.** Geographical distribution of Strunian outcrops with brachiopods, goniatites and foraminifers fauna (after Brice & Mistiaen, 2003, Fig. 13).

I.U.G.S. in 1990 (Paproth *et al.*, 1991). This stratigraphic level has become consequently the top of an uppermost Famennian Substage.

For several years, an informal international Working Group has been considering a definition for the base of this Substage (Streel *et al.*, 1998). The most recent proposal (Streel, 2004) made during the 2004 International Congress at Florence (Italy) and still to be ratified by postal ballot by the Titular Members of the Subcommittee on Devonian Stratigraphy, was to define the base of the uppermost Substage of the Famennian at the base of the conodont zone *Late expansa* which is considered by Streel *et al.* (2004) to be an equivalent of the base of the foraminifer *Quasiendothyra kobeitusana kobeitusana* Zone.

## 7. Lithology

See Famennian, Thorez *et al.*, same volume.

## 8. Sedimentology

See Famennian, Thorez *et al.*, same volume.

## 9. Palaeontology

The Etroeungt macrofossils are traditionally described (See Dehée, 1929; Lemaître, 1933) as the Etroeungt Fauna.

During Strunian time, the Stromatoporoids in Western Europe (according to B. Mistiaen), begin to recover diversity after a large regression which started before the Frasnian/Famennian (F/F) boundary. All the recognized genera typically belong to the stromatoporoid assemblage n°3 (Stearn, 1987; Stearn *et al.*, 1987; Cockbain, 1989; Mistiaen & Weyer, 1999) with only genera already present during Givetian and Frasnian. Stromatoporoids of the Order Clathrodictyida are the most frequent, particularly

genera such as *Anostylostroma*, *Atelodictyon*, *Clathrodiction*, *Gerronostroma* (and probably *Petridiostroma* and *Schistodiction*) but some other genera *Clathrocoilona*, *Stromatopora*, *Trupetostroma* are also present. The dendroid genus *Amphipora* considered for a long time to be extinguished at the F/F boundary (Kellwasser event), is also present (Mistiaen, 1997)

The Tabulate coral fauna (according to B. Mistiaen), largely developed during Givetian and Frasnian, is poorly represented during the Upper Famennian. Only *Yavorskia* and several species of *Syringopora* are usually observed (Tourneur *et al.*, 1989)

Concerning the Rugose Corals from the Etroeungt area (according to J.C. Rohart, in Milhau *et al.*, 1997), Carpentier, Vaughan, Salée and Dehée gave sketches or short descriptions. Names given below refer to these works but need further systematic revisions. Most species are: *Clisiophyllum omaliusi* Haime, *Clisiophyllum* sp. *Campophyllum flexuosum* (Goldfuss), *Campophyllum* sp. nov. Poty, 1984 (pl. 2, fig. 4), *Paleosmilia aquisgranense* (Frech), *Caninia dorlodoti* Salée in Dehée, 1929 (non Salée, 1912), *Tabulophyllum* sp. nov. Poty, 1984 (pl. 1, fig. 8 a-b)".

Recently (Poty *et al.*, in press) wrote that, in the Namur-Dinant Basin, the first marked radiation of Rugosa started in the upper part of the *Eoendothyra regularis* Foraminiferal Zone, approximately at the base of the Strunian Substage sensu Conil *et al.* (1986). This radiation marks the base of the RC0 Zone. It is characterized by the appearance of Clisiophyllids (i.e. corals developing an axial structure of clisiophylloid type, a character usually typical of Carboniferous taxa), and of *Campophyllum* Milne-Edwards & Haime. Most of these rugose coral species disappeared in the lower part of the *Eoendothyra* "with radial inner layer" Foraminiferal Zone but some gave rise to those reappearing in a second radiation, from the uppermost *Eoendothyra* "with radial inner layer" Foraminiferal Zone to the lower part of the *Quasiendothyra kobeitusana* Foraminiferal Zone. The most common corals of the second radiation are *Campophyllum flexuosum* (Goldfuss), *Campophyllum gosseleti* Weyer, *Clisiophyllum omaliusi* Haime, *Dibunophyllum praecursor* Frech, and *Palaeosmilia aquisgranensis* (Frech), the latter two being homeomorphs of Viséan Rugosa. These two distinct coral radiations allow the recognition of the two new subzones RC0 $\alpha$  and RC0 $\beta$ , the last-one encompassing the new suggested Strunian base defined higher in 5. Unfortunately Famennian coral faunas are almost entirely endemic, and corals found in other parts of Eurasia usually belong to other taxa.

Among the Brachiopods (according to D. Brice), Orthids, Athyrids and Spiriferids are found in the Strunian with some species belonging to genera known from the upper Devonian (Frasnian and Famennian) and in some cases from below such as *Schizophoria*, *Aulacella*, *Composita*, *Cleiothyridina*, *Cyrtina*, *Cyrtospirifer*. These taxa are associated with several genera, which occur, in the latest Famennian such as *Lamellosathyris*, *Prospira* (*Prospira struniana* Gosselet, 1879, in Brice, 1997), *Sphenospira*

(determination J.P. Nicollin). Rhynchonellids are usually rare and they are represented by *Centrorhynchus* which appears in the upper Famennian and *Araratella* (an index genus of Strunian according to Sartenaer & Plodowski, 2003). Chonetids and strophomenids are well represented at some levels. Among the Productids, Legrand-Blain (1990) and Legrand-Blain (in Mistiaen *et al.*, 1998), recognize: (?) *Mesoplica* (*s.l.*) *nigraeformis*, *Spinocariniifera* (*Spinocariniifera*) aff. *lotzi*, *Spinocariniifera* (*Seminucella*) sp., *Semiproductus irregularicostatus* in the Strunian.

## 10. Chronostratigraphy

See Famennian, Thorez *et al.*, same volume.

## 11. Geochronology

See Famennian, Thorez *et al.*, same volume

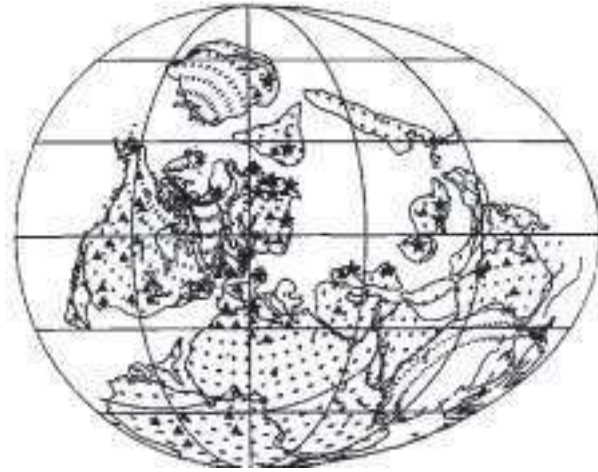
## 12. Structural setting

See Famennian, Thorez *et al.*, same volume.

## 13. Reference sections

1. In the Chanxhe section (Ourthe valley, eastern Belgium) the Late *expansa* conodont Zone is present but, until very recently, the base of the zone was unknown in the area. However new data from the Refrath 1 borehole (Bergisches Land, western Germany) now fills this gap in our knowledge. The conclusion is that the base of the Late *expansa* conodont Zone and the base of the *Q. k. kobeitusana* (Df3 $\epsilon$ ) foraminifer Zone are obviously much closer than previously thought. The Chanxhe section may be considered therefore as an excellent reference section for the neritic facies where correlation with continental facies by miospores is well documented. Such correlation can be applied to widespread regions in Eurasia (Fig. 2) particularly in Belarus and Timan-Pechora (Durkina, Dreesen & Strel, in Strel 2001, tab. 2).

2. The base of the Late *expansa* Zone has been intensively investigated in the Carnic Alps by Perri & Spalletta (1998 and new unpublished data). Four sections are studied: Rio Boreado (RB), Casera collinetta di Sotto A (CSA), Malpasso (ML) and Sentiro Storico A (SSA). In all four sections, *Bispathodus ultimus*, *Pseudopolygnathus marburgensis trigonicus* and *Palmatolepis gracilis. gonioclymeniae* occur at the same level. The Malpasso section (Spalletta & Perri 2001), which also contains ammonoids (Korn 1998), might serve as a reference section for the pelagic facies. However, the correlation between the base of the late *expansa* and the base of the Wocklumeria Zone is still uncertain. Although this correlation has been suspected



**Figure 2.** Geographical distribution of characteristic foraminifers and miospores of the Strunian substage (after Streel *et al.*, 1998, Fig. 3).

- ▲ Retispora lepidophyta Zones
- ★ Quasiendothyra kobeitusan Zone

for a long time, it is however not conclusively demonstrated that the “Wocklum German Stufe” base can be correlated with the latest Middle or with the earlier Late *expansa* Zone.

The geographical distribution of Strunian outcrops is shown in figure 1.

## 14. Main contributions

Regarding the old original concept of the Etrœungt or Strunian we recommend the following papers: Conil *et al.* (1964), Conil & Lys (1980), Gosselet (1857), Lemaître (1933), Mamet *et al.* (1965), Sartenaer & Mamet (1964). The new proposed concept of the Strunian and the available reference sections are mainly cited in the following papers: Brice & Mistiaen (2003), Nicollin, & Brice (2004), Sartenaer (1997), Streel *et al.* (1998 and 2004).

## References

- BARROIS, C., 1913. Note sur quelques sondages profonds exécutés entre Douai et Arras par la Compagnie de Châtillon – Commeny. *Annales de la Société géologique du Nord*, 42 : 2-20.
- BRICE, D., 1997. Clarification sur la position systématique de *Spirifer strunianus* Gosselet, 1879, brachiopode du Famennien supérieur de l’Avesnois (N. France). Emendation du genre *Eobrachythyris* Brice, 1971. *Geobios*, Mém. Spécial, 20 : 67-73.
- BRICE, D. & MISTIAEN, B., 2003. Le Dévonien : ses subdivisions. Le Strunien un sous-étage du Famennien ? *Annales de la Société géologique du Nord*, 2<sup>ème</sup> série 10 : 97-109.
- COCKBAIN, A., 1989. Distribution of Frasnian and Famennian Stromatoporoids. *Memoir Association Australasian Palaeontologists*, 8 : 339-345.
- CONIL, R., DREESEN, R., LENTZ, M.A., LYS, M. & PLODOWSKI, G., 1986. The Devono-Carboniferous transition in the Franco-Belgian basin with reference to Foraminifera and Brachiopods. *Annales de la Société géologique de Belgique*, 109: 19-26.
- CONIL, R. & LYS, M., 1980. Strunien in « Les étages français et leurs stratotypes ». *Mémoires du B.R.G.M.*, 109 : 26-35.
- CONIL, R., GROESSENS, E. & PIRLET, H., 1976. Nouvelle charte stratigraphique du Dinantien type de Belgique. *Annales de la Société géologique du Nord*, 96: 363-371.
- CONIL, R., LYS, M. & PAPROTH, E., 1964. Localités et coupes types pour l’étude du Tournaisien inférieur (Révision des limites sous l’aspect micropaléontologique). *Mémoires de l’Académie Royale de Belgique, Classe des Sciences*, coll in 4<sup>e</sup>, 2<sup>ème</sup> série, 15 (4) : 1-81.
- DEHÉE, R., 1929. Description de la faune d’Etrœungt. *Mémoire de la Société Géologique de France*, 11: 1- 64.
- DE LAPPARENT, A., 1900. *Traité de Géologie*. 4<sup>ème</sup> édition, 3 volumes, Paris.
- GOSSELET, J., 1857. Note sur le terrain dévonien de l’Ardenne et du Hainaut. *Bulletin de la Société géologique de France*, 14 : 364-374.
- GOSSELET, J., 1860. Mémoire sur les terrains primaires de la Belgique, des environs d’Avesnes et du Boulonnais, Paris.
- KORN, D., 1998. Ammonoid stratigraphy of late Famennian rocks in the Carnic Alps. in M-C. Perri and C. Spalletta (Eds) *Southern Alps Fieldtrip Guidebook, ECOS VII. Giornale di Geologia*, 60, Spec. Issue : 123-124.
- LEGRAND-BLAIN, M., 1990. Les brachiopodes Productacés *Spinocarinfera nigra* (Gosselet, 1888) et formes voisines dans le Dévono-Dinantien du Nord de la France et de la Belgique. *Annales de la Société géologique du Nord*, 2<sup>ème</sup> série, 1 : 29-52.
- LEMAÎTRE, D., 1933. Description des stromatoporoides de l’assise d’Etrœungt. *Mémoire de la Société Géologique de France*, 9, 1(20): 1- 32.
- MAILLEUX, E. & DEMANET, F., 1928. L’échelle stratigraphique des terrains primaires de la Belgique. *Bulletin de la Société belge de Géologie*, 38 : 124-131.
- MAMET, B., MORTELMANS, G. & SARTENAER, P., 1965. Réflexions à propos du Calcaire d’Etrœungt. *Bulletin de la Société belge de Géologie*, 74 (1) : 41-51.
- MILHAU, B., MISTIAEN, B., BRICE, D., DÉGARDIN, J.M., DERYCKE, C., HOU, HONGFEI, ROHART, J.C., VACHARD, D. & WU, XIANTAO, 1997. Comparative faunal content of Strunian (Devonian) between Etaoucun (Guilin, Guangxi, South China) and the stratotype area (Etrœungt, Avesnois, North of France). *Proceedings 30<sup>th</sup> Intern. Geol. Congress*, 12 : 79-94.
- MISTIAEN, B. 1997. Découverte du genre *Amphipora* Schulz, 1883, dans le Famennien terminal, “ Strunien ” de

- la carrière du Parc à Etrœungt, stratotype du Calcaire d'Etrœungt et ailleurs en Avesnois (Nord de la France). *Compte Rendu de l'Académie des Sciences de Paris*, 324, IIa : 655-662.
- MISTIAEN, B., MILHAU, B., DÉGARDIN, J.M., DERYCKE, C., HOU, HONGFEI, ROHART, J.C., VACHARD, D. & WU, XIANTAO. 1998. Famennien terminal (Strunien) d'Etrœungt (Avesnois, Nord de la France) et d'Etaoucun (Guanxi, Chine du Sud). Incidences paléogéographiques des données relatives aux stromatopores et ostracodes. *Annales de la Société géologique du Nord*, 2<sup>ème</sup> série 6 (3) : 97-104.
- MISTIAEN B. & WEYER D., 1999. Late Devonian stromatoporoid from the Sudetes Mountains (Poland) and endemicity of the Upper Famennian to Uppermost Famennian (= "Strunian") stromatoporoid fauna in western Europe. *Senckenbergiana lethaea*, 79 (1): 51-61.
- NICOLLIN, J.P. & BRICE, D., 2004. Biostratigraphical value of some Strunian (Devonian, uppermost Famennian) Productidina, Rhynchonellida, Spiriferida, Spiriferidina brachiopods. Elsevier, *Geobios*, 37 : 437-453.
- PAPROTH, E. & STREEL, M., 1984. The I.U.G.S. Devonian-Carboniferous Working Group : a report on activities, 1978-1984. *Courier Forschungs Institut Senckenberg*, 67: 5-9.
- PAPROTH, E., FEIST, R. & FLAJS, G., 1991. Decision on the Devonian-Carboniferous boundary stratotype. *Episodes*, 14 (4): 331-336.
- PERRI, M.-C. & SPALLETTA, C., 1998. Late Famennian conodonts of the Malpasso section (Carnic Alps, Italy) in M.-C. Perri and C. Spalletta (Eds) Southern Alps Fieldtrip Guidebook, ECOS VII, *Giornale di Geologia*, 60, Spec. Issue: 228-233.
- POTY, E. 1984. Rugose corals at the Devonian-Carboniferous boundary. *Courier Forschungs Institut Senckenberg*, 67: 29-35.
- POTY, E., DEVUYST, F.X. & HANCE, L., in press. Upper Devonian and Mississippian Foraminiferal and Rugose Coral zonations of Belgium and Northern France: a tool for Eurasian correlations. *Geological Magazine*.
- SARTENAER, P., 1997. Is the term Strunian worth being properly defined, and thus kept? I.U.G.S. *Subcommission on Devonian Stratigraphy Newsletter*, 14: 9-10.
- SARTENAER, P. & MAMET, B., 1964. Le Calcaire d'Etrœungt à Etrœungt. *C.R. 5<sup>ème</sup> Congrès International de Stratigraphie et de Géologie du Carbonifère*, Paris, 9-12 septembre 1963, 2 : 755-761.
- SARTENAER, P. & PLODOWSKI, G. 2003. Reassessment of the Strunian genus *Araratella* Abramian, Plodowski and Sartenaer, 1975 in the northern Gondwanaland (Rhynchonellida, Brachiopoda). *Courier Forschungsinstitut Senckenberg*, 242: 329-348.
- SPALLETTA, C. & PERRI, M.-C., 2001. Subdivision and substages of the Famennian, an opinion and possible candidates for the upper part. I.U.G.S. *Subcommission on Devonian Stratigraphy Newsletter*, 18 (Frankfurt meeting May 2001): 64-66.
- STEARNS, C.W., 1987. Effect of Frasnian-Famennian extinction event on the stromatoporoids. *Geology*, 15 : 677-679.
- STEARNS, C.W., HALIM-DIHARDJA, M.K. & NISHIDA, D.K., 1987. An Oil-Producing Stromatoporoid Patch Reef in the Famennian (Devonian) Wabamun Formation, Nordmandville Field, Alberta. *Palaios*, 2 : 560-570.
- STREEL, M., 2001. The Uppermost Famennian around the World (definition, biostratigraphical and sedimentological context). I.U.G.S. *Subcommission on Devonian Stratigraphy Newsletter* 18 (Frankfurt meeting May 2001): 55-61.
- STREEL, M., 2004. Subdivision of the Famennian Stage into four Substages and correlation with the neritic and continental miospore zonation. *SDS Business Meeting Florence*, August 23, 2004, long abstract.
- STREEL, M., BELKA, Z., DREESEN, R., DURKINA, A.V., GROOS-UFFENORDE, H., HANCE, L., HARTKOPF-FRÖDER, C., HAYDUKIEWICZ, J., KORN, D., PERRI, M.-C., PIECHA, M. & SPALLETTA, C., 2004. Relation of the neritic microfaunas and continental microfloras with the conodont and other pelagic faunas within the latest part of the Famennian, with a few, new additional data and a synthetic correlation chart. *SDS Business Meeting Florence*, August 23, 2004, long abstract.
- STREEL, M., BRICE, D., DEGARDIN, J.-M., DERYCKE, C., DREESEN, R., GROESSENS, E., HANCE, L., LEGRAND-BLAIN, M., LETHIERS, F., LOBOZIAK, S., MAZIANE, N., MILHAU, B., MISTIAEN, B., POTY, E., ROHART, J.-C., SARTENAER, P., THOREZ, J., VACHARD, D. & BLIECK, A., 1998. Proposal for a Strunian Substage and a subdivision of the Famennian Stage into four Substages. *I.U.G.S. Subcommission on Devonian Stratigraphy, Newsletter* 15 (Bologna meeting June 1998): 47-52.
- TOURNEUR, F., CONIL, R. & POTY, E., 1989. Données préliminaires sur les Tabulés et les Chaetetides du Dinantien de la Belgique. *Bulletin de la Société belge de Géologie*, 98 (3/4) : 401-442.
- TRAPP, E., KAUFMANN, B., MEZGER, K., KORN, D. & WEYER, D., 2004. Numerical calibration of the Devonian-Carboniferous boundary: Two new U-Pb isotope dilution-thermal ionization mass spectrometry single-zircon ages from Hasselbachtal (Sauerland, Germany). *Geology*, 32 (10): 857-860.

Manuscript received on 11.11.2004 and accepted for publication on 23.02.2005.