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Ostracods and lithofacies of the Middle/Upper Devonian boundary stratotype (Puech de la Suque, Montagne Noire, France)

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Key words. – Ostracods, Microfacies, Givetian, Frasnian, GSSP, Montagne Noire.

Abstract. – This paper discusses ostracods and their environmental setting close to the Givetian/Frasnian boundary in the Puech de la Suque Global Stratotype Section and Point. The ostracod fauna belongs exclusively to the Eifelian mega-assemblage and is largely dominated by Podocopina instars. Consequently, the majority of the 33 species recognised and illustrated is described in open nomenclature. The abundance of instars also indicates that most of beds are related to storm deposition. The composition of the fauna suggests a regression in the late Givetian followed by a transgression at the beginning of the Frasnian. Only one ostracod assemblage collected in the upper part of the section indicates a deeper setting below the storm wave base. Eight taxa disappeared in two steps near the Givetian / Frasnian boundary, probably in relation to the Frasnes Event.

The sedimentological analysis confirms that the section is constituted principally of storm deposits and reveals in addition the presence of numerous reddish hardgrounds highlighting an important condensation of the sequence.

Ostracodes et lithofaciès du stratotype de la limite Dévonien moyen/Dévonien supérieur (Puech de la Suque, Montagne Noire, France)

Mots-clefs. – Ostracodes, Microfaciès, Givétien, Frasnien, GSSP, Montagne Noire.

Résumé. – Le stratotype de la limite Dévonien moyen/Dévonien supérieur coïncidant par définition avec celui des étages Givétien et Frasnien a été choisi au Puech de la Suque, en Montagne Noire. L'étude d'un millier d'ostracodes et de leur environnement sédimentaire montre que cette coupe est composée principalement de tempestites distales et intermédiaires. La faune d'ostracodes appartient au méga-assemblage de l'Eifel et est largement dominée par des formes larvaires de Podocopina. La majorité des 33 espèces recensées et illustrées est en nomenclature ouverte.

L'accroissement de la diversité des ostracodes dans la partie supérieure du Givétien pourrait être due à une évolution régressive de la sédimentation, les tempestites étant de moins en moins distales. Cinq espèces d'ostracodes disparaissent au niveau de la limite Givétien/Frasnien (bancs 42a et 42a') et trois autres quelques centimètres plus haut, entre les bancs 42a' et 42b. Ces disparitions sont probablement à mettre en relation avec l'événement Frasnes qui est lié à une élévation rapide du niveau marin. Du reste, la diversité des ostracodes dans la base du Frasnien est à nouveau très faible et pourrait témoigner d'un retour à des conditions plus distales. Militerait aussi en faveur de cette hypothèse, un second changement de la composition ostracodique au sommet de la coupe (banc 47). Celle-ci est plus diversifiée avec l'apparition de 5 genres et 8 espèces dont 3 appartiennent aux Thlipsuracea. Seul cet assemblage est en place et il indique un environnement marin calme situé sous le niveau d'action des vagues de tempêtes.

L'analyse sédimentologique confirme que la coupe est principalement composée de tempestites et elle montre en outre la présence de nombreux hardgrounds rougeâtres témoignant de l'importante condensation des couches. Par comparaison avec les environnements actuels, on peut estimer la profondeur du dépôt à quelques 150-300 m.

INTRODUCTION

Devonian and Carboniferous ostracods from the Montagne Noire, southern France, have been the subject of several studies since the end of the 1970's. Chronologically, Groos-Uffenorde [*in* Feist and Groos-Uffenorde, 1979] described 65 species from the Emsian of the Pic de Vissou and of the Cabrière area. Lethiers and Feist [1991] described the same number of species from the Devonian/Carboniferous transitional beds and from the base of the Dinantian of Puech de la Suque. Casier and Préat [1996] recorded 43 species in the upper Eifelian and lower Givetian of the Pic de Vissou quarry. Lethiers and Casier [1995, 1996a,b, 1999] described 113 ostracod species in the Frasnian/Famennian boundary stratotype located in the upper quarry of Coumiac. Lethiers *et al.* [1999] recorded 34 species at the same levels in the La Serre section. Finally Casier *et al.* [2001, 2002] described 72 species close to the Devonian/Carboniferous boundary in the

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Puech de la Suque section and 71 species in the Devonian/Carboniferous boundary stratotype of La Serre.

Our paper describes ostracods collected during 1999 and 2001 from the Middle/Upper Devonian boundary stratotype section located at Puech de la Suque. This section corresponds by definition to the Givetian/Frasnian boundary stratotype. With the study of ostracods from the Eifelian/Givetian boundary stratotype at Mech Irdane, in Morocco [Milhau, 1996; Casier *et al.,* 2007], our paper ends a series of studies concerning ostracods related to new boundary stratotypes from the Eifelian to the base of the Tournaisian. The difficulties to collect ostracods and particularly of adult stages near the Middle/Upper Devonian boundary have postponed this publication for several years.

GEOLOGICAL SETTING

The Middle/Upper Devonian Global Stratotype Section and Point (GSSP), which coincides by definition with the Givetian/Frasnian boundary, has been selected in the Montagne Noire by the Subcommission on Devonian Stratigraphy (SDS), in 1985. The decision was ratified in 1987 by the International Union of Geological Sciences (IUGS) [House *et al.,* 2000]. The section is located on the Puech de la Suque hill (fig. 1), 1.1 km southeast of St. Lazaire-de-Ladarez, and 15 km southwest of Bédarieux (Hérault) (GPS: N 42°58'474; E 2°37'875). The section is more precisely located about 50 m east-northeast from the hill top at 358 m. The Middle/Upper Devonian boundary stratotype has been

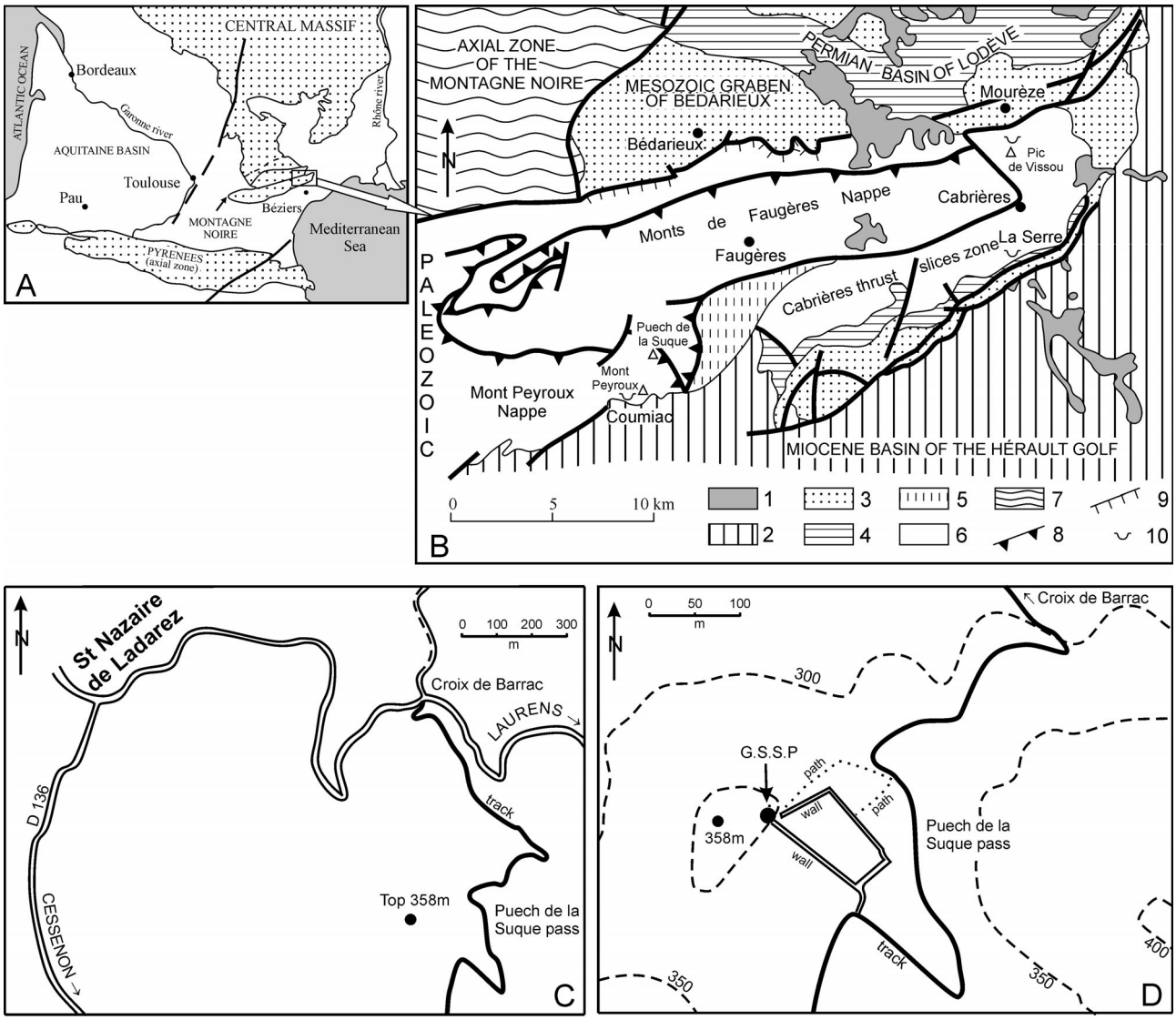


FIG. 1. – Locality map of the Puech de la Suque Middle / Upper Devonian GSSP. A. Map of southern France; B. Location of the Puech de la Suque on a structural map of the eastern Montagne Noire (southern slope); C. Localisation of the Puech de la Suque pass; D. Localisation of the GSSP. Legend: 1. Basalt; 2. Tertiary; 3. Mesozoic; 4. Permian-Stephanian; 5. Autochthonous Visean (?); 6. Paleozoic nappes (Ordovician to Visean); 7. Axial zone (micaschists, gneiss, migmatites, granites); 8. Base of Paleozoic nappes; 9. Pyrenean thrust; 10. Quarry (fig. 1B after the 1/50,000 geological map of France; figs. 1C,D after Klapper *et al.* [1987]).

FIG. 1. – *Localisation du stratotype de la limite Dévonien moyen / Dévonien supérieur au Puech de la Suque*. A. *Carte de la partie sud de la France*; B. *Situation du Puech de la Suque sur un schéma structural de la Montagne Noire (versant sud)*; C. *Situation du col du Puech de la Suque*; D. *Situation du GSSP. Légende : 1. Basalte ;* 2. *Tertiaire ;* 3. *Mésozoïque ;* 4. *Permien-Stéphanien ;* 5. *Viséen autochtone (?) ;* 6. *Nappes paléozoïques (Ordovicien à Viséen) ;* 7. *Zone axiale (micaschistes, gneiss, migmatites et granites) ;* 8. *Base des nappes paléozoïques ;* 9. *Chevauchement pyrénéen ;* 10. *Carrière* (fig. 1B : *d'après la carte géologique de la France au 1/50 000 ;* fig. 1C, D : *d'après Klapper et al., [1987]).*

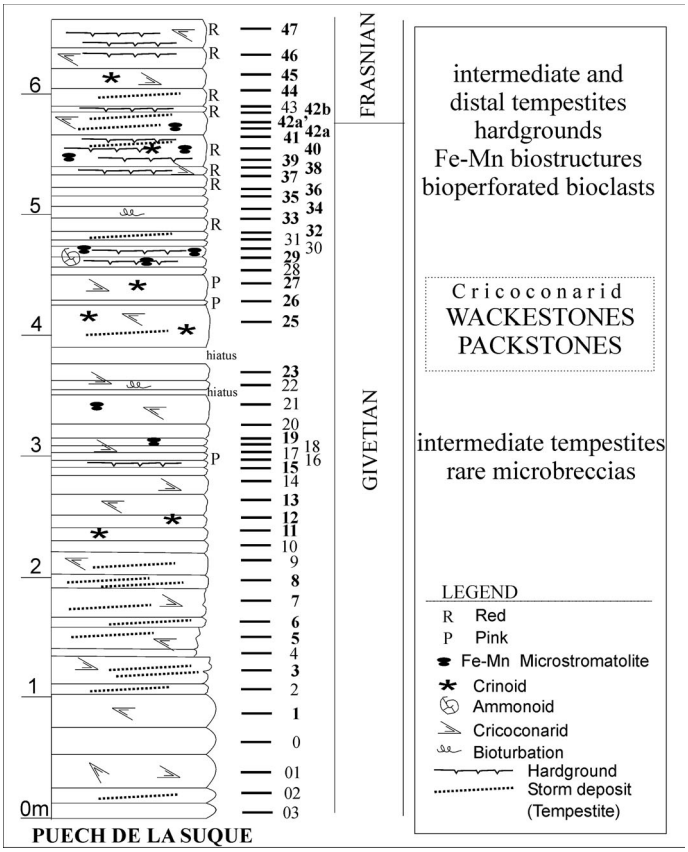


FIG. 2. – Lithological column of the Puech de la Suque Middle / Upper Devonian GSSP. Numbering of beds after Klapper *et al.* [1987] except below bed numbered 35. Position of sedimentological and ostracods (in wet) samples. The series consist of grey limestones except a few ones, which are red (see 'R' on the log) or pink (see 'P' on the log).
FIG. 2. – *Colonne lithologique du stratotype de la limite Dévonien moyen / Dévonien supérieur au Puech de la Suque. Numérotation d'après Klapper* et al. *[1987] excepté sous le banc 35. Localisation des échantillons recueillis pour l'analyse sédimentologique et en gras, pour l'étude des ostracodes. La série est composée de calcaires gris, parfois rouges (indiqués par 'R' dans le log) ou roses (indiqués par 'P' dans le log).*

described among others by Feist and Klapper [1985], Feist *et al.* [1985], House *et al.* [1985], Klapper [1985], Klapper *et al.* [1987] and House *et al.* [2000].

The rock sequence containing the Middle/Upper Devonian boundary stratotype is overturned and the GSSP has been fixed at the base of bed 42a' containing the first occurrence of the conodont species *Ancyrodella rotundiloba*. We have retained the numbering of beds used by Klapper *et al.* [1987] for the figure 2, except below the bed numbered 35.

ROCK AND FACIES ANALYSIS

The sequence studied across more than 6 meters consists of thin-bedded fine-grained homogeneous limestones (fig. 2). In the field, it displays a few crinoids in the lower part of the section, and millimetric reddish hardgrounds in the upper part. No shaly intercalations are observed and the stratification is regular. Forty-seven samples were collected (fig. 2) for petrographical study in order to constrain the palaeoenvironment. Microfacies consist mainly of wackestones and packstones rich in cricoconarids (pl. I, figs. 4-8; pl. II, fig. 2) with subordinate bioclasts (crinoids: pl. I, fig. 8; pelecypods: pl. I, figs 5-7; ostracods: pl.I, fig. 1-3 and pl. II, fig. 6; trilobites: pl. II, figs 2 and 3; rare brachiopods: pl. II, fig. 6; gastropods and sponge spicules). A single ammonoid fragment was observed. Bioclasts are episodically abundant and constitute thin laminar packstone layers (< 2 mm) rich in pelecypods and cricoconarids displaying a slightly oblique stratification (pl. I, fig. 6), commonly with an erosive boundary. Thicker laminations with cross-bedding and weak grading were observed exceptionally. These laminations contain irregular peloids and subrounded inframillimetric microbreccias (pl. II, figs 4 and 5), these latter consisting of cricoconarid wackestones and packstones of the same type as those described here. The bioturbation is discrete and in most cases has preserved the original laminations (in the laminar packstones). An important feature of the microfacies is the abundance of bioperforations and corrosions with partial dissolution of bioclasts (mainly pelecypods, brachiopods, trilobites and crinoids (pl. I, fig. 8; pl. II, figs 1-3 and 6). The bioclasts are encrusted by Fe-Mn biofilms and irregular thin crusts, ferruginous microstromatolites and blisters (pl. II, figs 6-8). These ferruginous bioconstructions are preferentially associated with hardgrounds in the reddish facies. In this case the further corrosion of hardgrounds and their surrounding micritic matrix lead to the formations of 'blebs' [Mamet and Préat, 2003], which are mixed in the sediment. A fine-grained calcite microspar is regularly observed.

The great abundance of the cricoconarids points to a hemipelagic environment partly affected by distal storms, as suggested by the thin bioclastic levels. These laminar bioclastic packstones are similar to the intermediate and distal storm deposits (tempestites) of Aigner [1985], which contain mixed bioclasts of several communities (mainly pelecypods, ostracods and cricoconarids). They form sharp-based skeletal layers ranging in thickness from a few hundred of microns, exceptionally to a few millimetres (pl. I, figs 1 and 6) displaying fining-upward sequences without wave-ripples. The thicker ones consist of parallel laminae, often slightly inclined, with minor discordances, erosive bases and weak grading. A striking aspect in these skeletal layers is the presence of well-preserved articulated, double-valved ostracods or pelecypods (pl. I, figs 2 and 6). This strongly suggests rapid winnowing and immediate redeposition during an instantaneous event than rather slow accumulation. Numerous skeletal layers are only partly preserved as they were destroyed by bioturbation (pl. I, fig. 7). The general environment was very calm, except during the storms, and the sedimentation rate was very low permitting the condensation of the series [Préat *et al.,* 2006]. As a result, various Fe-Mn biostructures developed near the sediment-water interface in the matrix or around and inside the corroded bioclasts [Mamet and Préat, 2006].

By comparison with recent environments, the depositional setting was located near the storm wave base, *i.e.* 150-300 m deep [McLane, 1995], in the upper part of the profile where intermediate and distal storm deposits are abundant and associated with numerous hardgrounds highlighting an important condensation of the sequence. The extreme base of the section (sample PSGF02 not studied for ostracods) records slightly shallower environments (100-150 m?) as intermediate tempestites (storm deposits) contain small-sized subrounded microbreccias.

OSTRACODS

Sampling and extraction of ostracods

Thirty-six samples weighting about 500 g each were collected for ostracods in the Puech de la Suque section (fig. 2). Ostracods were extracted by the hot acetolysis method [Lethiers and Crasquin-Soleau, 1988]. Samples were crushed with a hydraulic press and dried. Then, about 200 g of each sample was processed with glacial acetic acid 99.8%, at a temperature close to 90°C, for four days at the rate of seven hours a day. The residue was sieved with 100 µm, 250 µm and 1600 µm mesh sieves. The part of the sample retained by the 1600 µm mesh sieve was attacked twice more.

About 1040 carapaces, valves and fragments of ostracods were extracted from the section, of which 590 were from the upper Givetian. Only 5 samples (PSGF12, 15, 23, 25 and 34) are barren of ostracods, and all ostracods present in sample PSGF6 are indeterminable.

List of identified ostracod taxa (pl. III, IV)

Suborder Palaeocopina: *Amphissites* sp. *A*, aff. *tener omphalotus* BECKER, 1964; *Buregia?* sp. indet.; Hollinellidae indet.; *Parabolbinella* sp. *A*.

Suborder Metacopina: *Marginohealdia* sp. A; *Thlipsohealdia?* sp. A, aff. *gustalapiedra* BECKER, 1989; *Jenningsina lethiersi* BECKER, 1971; *Polyzygia?* sp. indet.

Suborder Podocopina: *Healdianella* sp. A, aff. *alba* (LETHIERS, 1971); *H? longissima* (KUMMEROW, 1953); *H?* sp. B, aff. *longissima* (KUMMEROW, 1953); *H?* sp. C; *H?* sp. D; *Bairdiocypris* sp. A, aff. *symmetrica* (KUMMEROW, 1953); *B.* sp. B; *B.* sp. C; *B.* sp. indet.; *Rectoplacera* sp. A; *Tubulibairdia* sp. A, aff. *clava* (KEGEL, 1922); *T?* sp. indet.; *Decoranewsomites* nov. sp. A; *Micronewsomites* sp. A, aff. *natus* (ROZHDESTVENSKAJA, 1972); *M.* sp. indet.; *Microcheilinella* sp. A; *M.* sp. B; *Spinomicrocheilinella* sp. A; *Acratia* sp. A, aff. *gassanovae* EGOROV, 1953; *A.* sp. B, aff. *paraschelonica* LETHIERS, 1974; *Acratia* sp. indet.; *Bairdia* sp. A, aff. *retrorsa* POLENOVA, 1953; *B.* sp. B., aff. *retrorsa* POLENOVA, 1953; *B.* sp. C; *Bairdiacypris* sp. A; *B.* sp. B. Order Eridostraca: *Cryptophyllus* sp. A.

DISCUSSION

Almost all ostracod species extracted close to the Givetian/Frasnian boundary in the Puech de la Suque section are identified in open nomenclature. This is partly because of their poor preservation. Broken valves and carapaces are abundant in some samples (PSGF1, 5, 8 and 11). More generally these ostracods are difficult to determine at the specific level because the majority is constituted of young instars of podocopids. The specific distinctive features are generally not clearly visible on these small specimens.

The distribution of ostracods across the Givetian / Frasnian boundary in the Puech de la Suque stratotype section is reported on table I. The ostracod fauna belongs to the Eifelian mega-assemblage, a substitute for the "Eifelian ecotype" of Becker [*in* Bandel and Becker, 1975] because the term "ecotype" has been improperly used in this case [Casier, 2004; Casier *et al.,* 2005]. The Eifelian mega-assemblage is characterised by the presence of palaeocopid, platycopid, metacopid, podocopid, and rarely of

PLATE I – Pl. I

The thin sections are deposited in the Department of Earth Sciences and Environment of the University of Brussels. *Les lames minces sont déposées au Département des Sciences de la Terre et de l'Environnement de l'Université de Bruxelles.*

FIG. 1. – Thin ostracod-cricoconarid packstone layer (thickness < 1 mm, distal storm deposit, see text) in a wackestone. The layer displays a well-defined oblique stratification. The matrix is slightly recrystallised in a fine grained calcite microspar. Sample PSGF01. ulb nº 9531. Givetian. Scale bar = 390 µm.

FIG. 1. – *Niveau d'épaisseur inframillimétrique constitué d'un packstone à ostracodes et cricoconarides (tempestite distale, voir texte) dans un wackestone. Les bioclastes soulignent une stratification oblique. La matrice est légèrement recristallisée en un fin microspar calcitique. Echantillon PSGF01. ulb nº 9531. Givétien. La barre d'échelle est de 390 µm.*

Figs. 2, 3 – Thin ostracod-cricoconarid packstone layer (storm deposit, fig. 2, see text) in a wackestone (upper part of the fig. 2 and fig. 3). Ostracods are present as well as disarticulate valves or carapaces (fig. 2) and can present spiny forms (fig. 3). The matrix is slightly recrystallised in a fine-grained calcite microspar and contains small tufts of pyrite (fig. 3). Sample PSGF30. ulb nº 9556 and 9588 respectively. Givetian. Scale bar respectively 390 and 155 µm.

Figs. 2, 3. – *Niveau de packstone à ostracodes et cricoconarides (tempestite, fig. 2, voir texte) dans un wackestone (partie supérieure de la fig. 2 et fig. 3). Les ostracodes se présentent sous forme de carapaces ou de valves (fig. 2) et peuvent présenter des formes épineuses (fig. 3). La matrice est légèrement recristallisée en un fin microspar calcitique et contient de petits buissons de pyrite (fig. 3). Echantillon PSGF30. ulb respectivement nº 9556 et 9588. Givétien. La barre d'échelle est respectivement de 390 et 155 µm.*

FIG. 4. – Cricoconarid wackestone slightly bioturbated and recrystallised (left lower part). Sample PSGF1. ulb nº 9539. Givetian. Scale bar = 950 µm.

FIG. 4. – *Wackestone légèrement bioturbé et recristallisé (en bas à gauche) à cricoconarides abondants. Echantillon PSGF1. ulb nº 9539. Givétien. La barre d'échelle est de 950 µm.*

FIG. 5. – Cricoconarid packstone with a pelecypod shell and an altered crinoid. Bioclasts constitute a thin laminae with slight oblique stratification in a homogenous wackestone. Sample PSGF5. ulb nº 9548. Givetian. Scale bar = 390 µm.

FIG. 5. – *Packstone à cricoconarides avec une coquille de lamellibranche et un bioclaste de crinoïde altéré. Ces bioclastes constituent une lamine à faible stratification oblique dans un wackestone homogène. Echantillon PSGF5. ulb nº 9548. Givétien. La barre d'échelle est de 390 µm.*

FIG. 6. – Thin pelecypod-cricoconarid-ostracod packstone lens with oblique stratification in a cricoconarid wackestone. A strongly altered and corroded (bioperforations) pelecypod shell is present on the left corner of the picture. Sample PSGF44. ulb nº 9638. Frasnian. Scale bar = 950 µm.

FIG. 6. – *Lentille bioclastique (packstone à lamellibranches-cricoconarides-ostracodes) en stratification oblique dans un wackestone à cricoconarides. Dans le coin gauche de la photo, présence d'un bioclaste de lamellibranche fortement altéré et corrodé (bioperforations). Echantillon PSGF44. ulb nº 9638. Frasnien. La barre d'échelle est de 950 µm.*

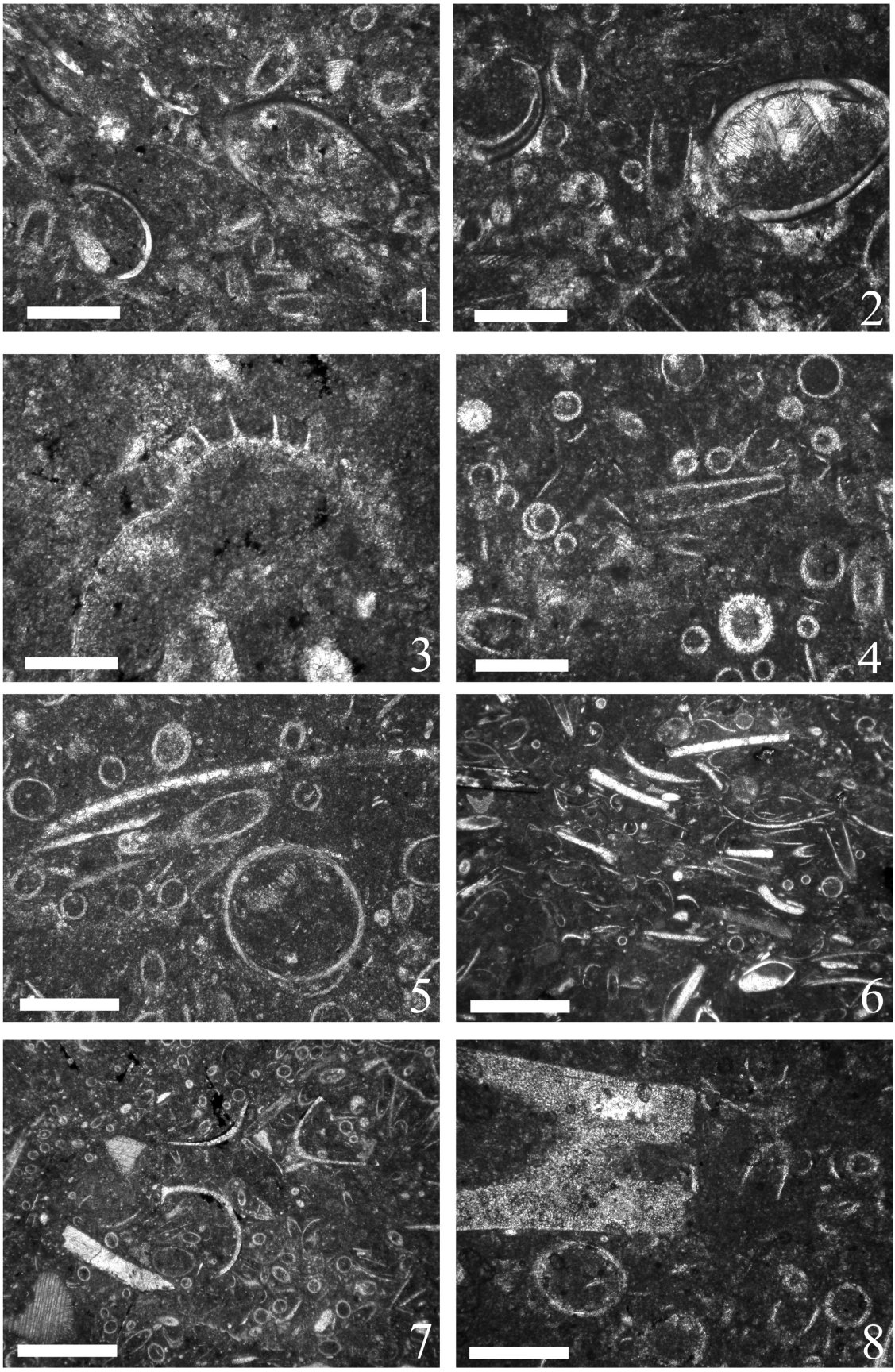
FIG. 7. – Thin pelecypod-crinoid-cricoconarid packstone layer in a cricoconarid wackestone. Small pyrite tufts growing in the matrix or on the bioclasts. Sample PSGF27. ulb nº 9599. Givetian. Scale bar = 390 µm.

FIG. 7. – *Mince niveau de packstone à lamellibranches-crinoïdes-cricoconarides dans un wackestone à cricoconarides. Petits buissons de pyrite dans la matrice ou sur les bioclastes. Echantillon PSGF27. ulb nº 9599. Givétien. La barre d'échelle est de 390 µm.*

FIG. 8. – Cricoconarid wackestone with a partly dissolved pitted crinoid. Sample PSGF29. ulb nº 9536. Givetian. Scale bar = 950 µm.

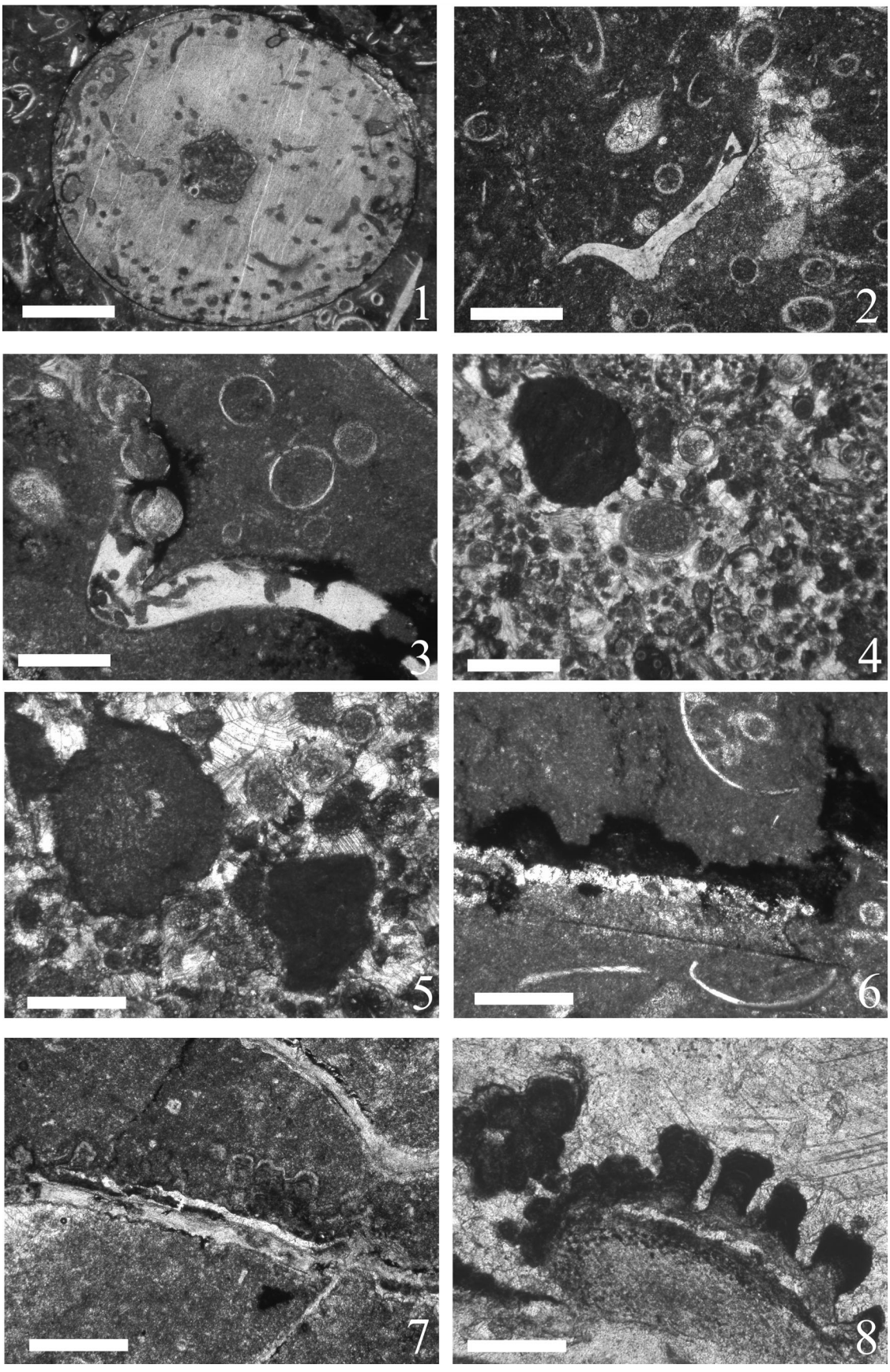
FIG. 8. – Wackestone à cricoconarides avec un bioclaste de crinoïde partiellement dissout ('picottis ou 'pitting'). Echantillon PSGF29. ulb nº 9536. Givétien. La barre d'échelle est de 950 µm.

leperditicopid ostracods and Eridostraca. That mega-assemblage is indicative of shallow and generally well-oxygenated environments. Within the Eifelian mega-assemblage, the relative proportion of these ostracod groups permits recognition of several assemblages from lagoonal to marine environments located below the storm wave base. The



distribution of the ostracod fauna in the Eifelian mega-assemblage is controlled principally by the energy, salinity, oxygenation and type of substrate.

In the Puech de la Suque section, the ostracod fauna is principally composed of podocopid ostracods indicative of well-oxygenated shallow environments. However, ostracods



are generally represented by instars indicating unequivocally that they have been transported during storms to deeper settings. The presence of broken valves and carapaces in some samples (PSGF1, 5, 8 and 11) is probably also related to storms. We conclude that nearly all the beds close to the Givetian/Frasnian boundary in the stratotype have been affected by storm activity. Moreover the facies analysis arrived at the same conclusion.

The increase of the diversity of ostracod species in the upper part of the Givetian is probably related to a relative regressive trend of the sea-level as storm deposits are less distal. In fact we can assume that the diversity in storm deposits is inversely proportional to the length of transport. Moreover shallower environments below air-weather wave base are richer and diversified in ostracods. A first important change in the ostracod fauna occurred in two steps close to the Givetian / Frasnian boundary. Five species disappeared between beds 42a and 42a', at the Givetian / Frasnian boundary, and three others between beds 42a' and 42b. The disappearance of these ostracod species is probably linked to the Frasnes Event caused by a rapid sea-level rise. In the base of the Frasnian (samples 42b to 46) the diversity is again very low due probably to more distal conditions.

A second change in the ostracod fauna occurred in bed 47. In that bed ostracods are more abundant and diversified and they probably occur *in situ.* Five genera and eight ostracod species, of which three belong to the Thlipsuracea, are recorded for the first time. The assemblage in this bed is indicative of a calm marine environment below the storm wave level [= Assemblage III of Casier, 1987; see also Casier *et al.,* 1995].

CONCLUSIONS

The sequence across the Givetian/Frasnian boundary in the stratotype section consists principally of storm deposits. In fact, carapaces of ostracods are generally dislocated and the majority of specimens is constituted of young instars. Consequently nearly all the ostracod species are described in open nomenclature. The ostracod study documents a regression in the late Givetian followed by a sea-level rise at the start of the Frasnian. This change may explain the disappearance of several species close to the Givetian / Frasnian boundary. Only the ostracod fauna found in the upper part of the section seems to be *in situ.* That fauna indicates an environment below the storm wave base. In the Dinant Synclinorium, the type region for the definition of the Frasnian Stage, the ostracod study and the sedimentological analysis also display a sea-level rise close to the Givetian/Frasnian boundary.

The sedimentological analysis confirms that the section is constituted principally of storm deposits and reveals in addition the presence of numerous hardgrounds. The choice of the section for a GSSP is consequently questionable. The problem is the same for all the GSSP fixed in the Montagne Noire area. Ziegler and Sandberg [1996] pointed out the serious sedimentologic and conodont biostratigraphic mistakes arising from selection of not only the basal Frasnian GSSP, but also the basal Famennian and basal Carboniferous GSSP's in this area. The Frasnian/Famennian boundary stratotype section is highly condensed and contains numerous hardgrounds, and the GSSP event has been fixed at the top of a hard-ground. The conodont faunas, in fact, suggest an unconformity or a depositional hiatus at this position [Ziegler and Sandberg, *ibid.*]. The study of ostracods and the sedimentology indicated also that the La Serre section is far from being an ideal stratotype for the Devonian/Carboniferous boundary [Paproth *et al.*, 1991] since most of the fossils are reworked and mixed [Ziegler and Sandberg, 1996; Casier *et al.,* 2002].

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Plate II – Pl. II

FIG. 1. – Strongly bioperforated crinoidal ossicle in a bioclastic (mainly cricoconarids and pelecypods, see right lower corner) wackestone. A relatively thick and continuous ferruginous biofilm encrusts the outer part of the ossicle. Sample PSGF37. ulb nº 9617. Givetian. Scale bar = 950 µm.

FIG. 1. – *Ossicule crinoïdique fortement bioperforé dans un wackestone à cricoconarides et lamellibranches (coin inférieur droit). Un biofilm assez épais et continu s'est développé sur la partie externe de l'ossicule. Echantillon PSGF37. ulb nº 9617. Givétien. La barre d'échelle est de 950 µm.*

FIG. 2. – Slightly recrystallized (calcite microspar) bioclastic wackestone. Bioclasts consist of cricoconarids, crinoids, pelecypods associated with a bioperforated trilobite (centre of the picture). Sample PSGF27. ulb nº 9603. Givetian. Scale bar = 390 µm.

FIG. 2. – *Wackestone bioclastique légèrement recristallisé (microspar calcitique). Les bioclastes consistent en cricoconarides, crinoïdes et lamellibranches. Un fragment bioperforé de trilobite est présent au centre de la photo. Echantillon PSGF27. ulb nº 9603. Givétien. La barre d'échelle est de 390 µm.*

FIG. 3. – Bioclastic wackestone with cricoconarids, pelecypods (right upper corner) and a trilobite section through the cephalon. The trilobite is heavily bioperforated and encrusted by pyritic tufts. These tufts can fill the former bioperforation (right part of the bioclast). Sample PSGF29. ulb nº 9628. Givetian. Scale bar = 390 µm.

FIG. 3. – *Wackestone bioclastique avec cricoconarides, lamellibranches (coin droit supérieur) et une section passant par le céphalon d'un trilobite. Ce dernier est fortement bioperforé et incrusté de buissons de pyrite qui remplissent les perforations (partie droite du bioclaste). Echantillon PSGF29. ulb nº 9628. Givétien. La barre d'échelle est de 390 µm.*

Figs. 4, 5. – Laminar bioclastic peloidal packstone and grainstone displaying oblique stratifications. Bioclasts consists of cricoconarids and ostracods mixed with subroundred microbreccias of cricoconarid wackestones (fig. 5). Calcite drusic cementation in the grainstone layers and slight microsparitic recrystallisation in the packstone layers. Sample PSGF02. ulb nº 9607 and 9608 respectively. Givetian. Scale bar respectively 950 and 390 µm.

Figs 4, 5. – *Packstone et grainstone laminaires à péloïdes et bioclastes disposés en stratifications obliques. Les bioclastes consistent en cricoconarides et ostracodes. Ils sont mélangés à des microbrèches subarrondies de wackestones à cricoconarides (fig. 5). La cimentation est drusique dans les niveaux de grainstones et une légère recristallisation microsparitique s'observe dans les niveaux de packstones. Echantillon PSGF02. ulb respectivement nº 9607 et 9608. Givétien. La barre d'échelle est respectivement de 950 et 390 µm.*

Figs 6-8. – Bioclastic wackestone with some solution cavities (fig. 8). Bioclasts are heavily corroded and encrusted (pelcypod, fig. 6) or coated by Fe-Mn columnar microstromatolites (brachiopods, fig. 7 and crinoid, fig. 8). Disarticulated ostracod carapaces are observed as well as a few circoconarids (fig. 6). Sample PSGF30. ulb nº 9527, 9607 and 9667 respectively. Givetian. Scale bar respectively 390, 155, and 390 µm.

Figs. 6-8. – *Wackestone bioclastique avec cavité de dissolution (fig. 8). Les bioclastes sont fortement corrodés et encroûtés (lamellibranche, fig. 6) ou colonisés par des microstromatolithes Fe-Mn (brachiopodes, fig. 7 et crinoïde, fig. 8). Des carapaces désarticulées d'ostracodes et quelques cricoconarides (fig. 6) sont également présentes. Echantillon PSGF30. ulb respectivement nº 9527, 9607 and 9667. Givétien. La barre d'échelle est respectivement 390, 155 et 390 µm.*

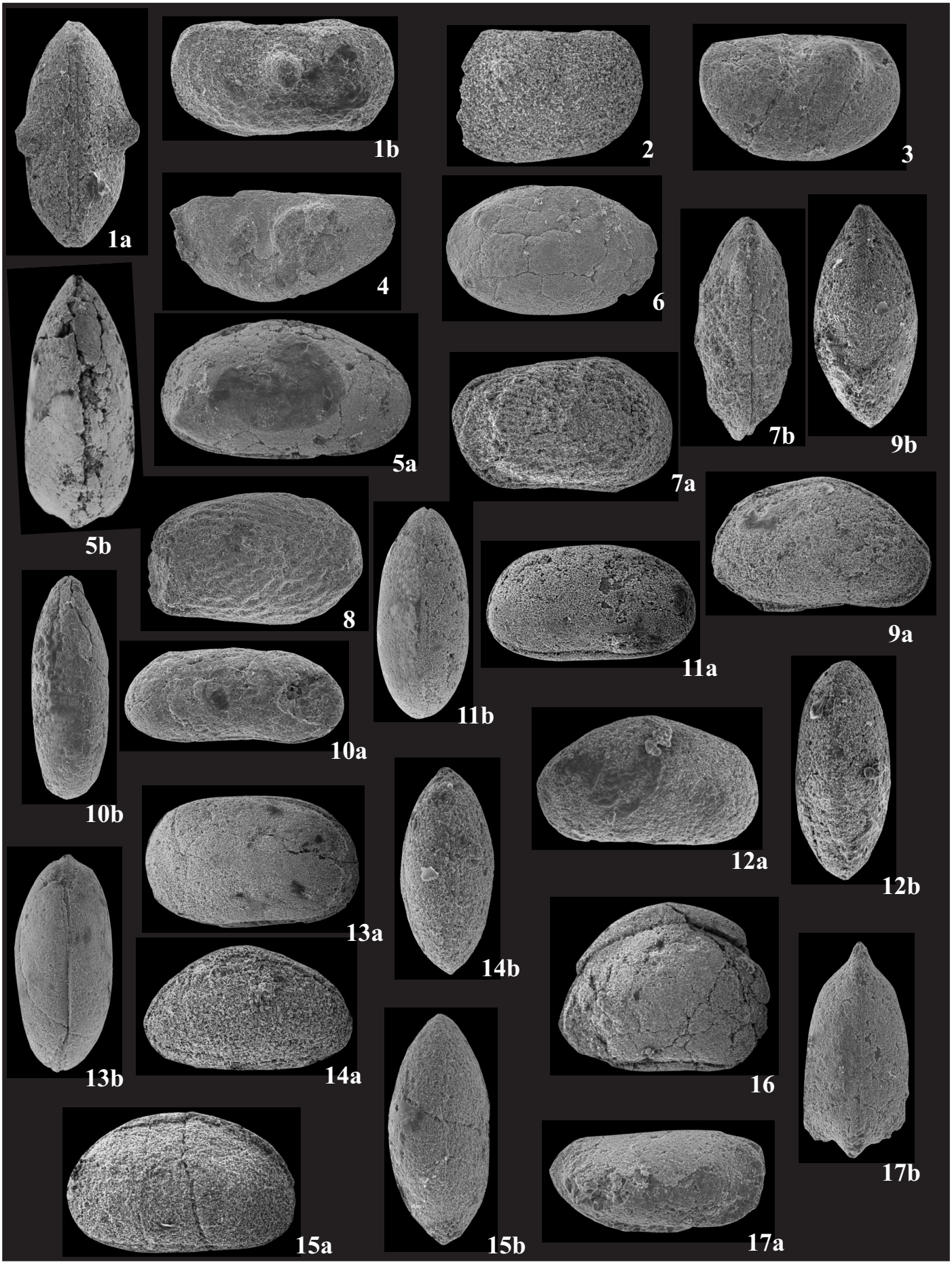
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TABLE. I. – Distribution of ostracods through the Middle/Upper Devonian transition in the Puech de la Suque GSSP.
TABL. I. – Distribution des ostracodes de part et d'autre de la limite Dévonien moyen/Dévonien supérieur dans le stratotype du Puech de la Suque.

PUECH DE LA SUQUE	GIVETIAN																				FRASNIAN					
	1	3	5	7	8	11	13	19	26	27	29	32	33	35	36	37	38	39	40	41	42	42	42	44	45	46	47
Tubulibairdia sp. A, aff. *clava*	*		*	?	*	*	*	*		?	?	*					?										
Healdianella? longissima		*									*	*				*	*	*	*	*	*						
Microcheilinella sp. A				*					*		*	*	*		*			*	*	*	*						
Decoranewsomites nov. sp. A									*			*															
Bairdia sp. A., aff. *retrorsa*											?	*	*	*	?	*	*										
Micronewsomites sp. A, aff. *natus*											*			?		*		*	*		*						
Amphissites sp. A, aff. *tener omphalotus*											?	?				*	*	*	*	*	*	*					
Buregia? sp. indet.												*															
Bairdiacypris sp. A												*		*					*	*		*					
Acratia sp. A, aff. *gassanovae*															*	*	*	*	*	*	*						
Rectoplacera sp. A																	*										
Parabolbinella sp. A																		*									
Healdianella? sp. C																		*									
Bairdiocypris sp. C																		*				*					
Healdianella sp. A, aff. *alba*																		*	*		*						*
Spinomicrocheilinella sp. A																			*	*							
Marginohealdia sp. A																			*		*						
Bairdia sp. B., aff. *retrorsa*																					*						
Microcheilinella sp. B																					*						*
Bairdiocypris sp. B																						*					
Bairdiacypris sp. B																						*					*
Bairdiocypris sp. indet.																							*				
Acratia sp. B, aff. *paraschelonica*																							?	*			*
Bairdiocypris sp. A., aff. *symmetrica*																									*		
Healdianella? sp. B, aff. *longissima*																									*		*
Tubulibairdia? sp. indet.																									*	*	*
Acratia sp. indet.																										*	
Jenningsina lethiersi																											*
Thlipsohealdia sp. A, aff. *gustalapiedra*																											*
Healdianella? sp. D																											*
Bairdia sp. C																											*
Cryptophyllus sp. A																											*
Hollinellidae indet.																											*
Micronewsomites? sp. indet.																											*
Polyzygia? sp. indet.																											*

PLATE III – Planche III

The figured specimens are deposited in the collections of the Department of Palaeontology (section Micropalaeontology) of the Royal Belgian Institute of natural Sciences (IRScNB).

Les spécimens figurés sont déposés dans les collections du Département de Paléontologie de l'Institut royal des Sciences naturelles de Belgique (IRScNB).

FIG. 1a,b. – *Amphissites* sp. *A*, aff. *tener omphalotus* BECKER, 1964. PSGF42A. Givetian – *Givétien*. IRScNB n° b4652. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x105.

FIG. 2. – *Buregia ?* sp. indet. PSGF32. Givetian – *Givétien*. IRScNB n° b4653. Left lateral view of a broken valve – *Vue latérale gauche d'une valve brisée.* x95.

FIG. 3. – Hollinellidae indet. PSGF47. Frasnian – *Frasnien*. IRScNB n° b4654. Left valve – *Valve gauche*. x130.

FIG. 4. – *Parabolbinella* sp. A. PSGF 39. Givetian – *Givétien*. IRScNB n° b4655. Poorly preserved left valve – *Valve gauche mal conservée*. x45.

FIG. 5a,b. – *Marginohealdia* sp. A. PSGF42A. Givetian – *Givétien*. IRScNB n° b4656. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x80.

FIG. 6. – *Thlipsohealdia ?* sp. A, aff. *gustalapiedra* BECKER, 1989. PSGF47. Frasnian – *Frasnien*. IRScNB n° b4657. Right lateral view of a carapace – *Carapace en vue latérale droite*. x45.

FIG. 7a,b. – *Jenningsina lethiersi* BECKER, 1971. PSGF47. Frasnian – *Frasnien*. IRScNB n° b4658. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x70.

FIG. 8. – *Jenningsina lethiersi* BECKER, 1971. PSGF47. Frasnian – Frasnien. IRScNB n° b4659. Right lateral view of a carapace – *Carapace en vue latérale droite*. x65.

FIG. 9a,b. – *Healdianella* sp. A, aff. *alba* (LETHIERS, 1971). PSGF47. Frasnian – Frasnien. IRScNB n° b4660. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x115.

FIG. 10a,b. – *Healdianella ? longissima* (KUMMEROW, 1953). PSGF29. Givetian – Givétien. IRScNB n° b4661. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x90.

FIG. 11a,b. – *Healdianella ?* sp. B, aff. *longissima* (KUMMEROW, 1953). Frasnian – Frasnien. PSGF47. IRScNB n° b4662. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x115.

FIG. 12a,b. – *Healdianella ?* sp. C. PSGF39. Givetian – *Givétien*. IRScNB n° b4663. Carapace. a. Left lateral view – *Vue latérale gauche*. b. Dorsal view – *Vue dorsale*. x140.

FIG. 13a,b. – *Healdianella ?* sp. D. PSGF47. Frasnian – *Frasnien*. IRScNB n° b4664. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x70.

FIG. 14a,b. – *Bairdiocypris* sp. A, aff. *symmetrica* (KUMMEROW, 1953). PSGF45. Frasnian – Frasnien. IRScNB n° b4665. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x90.

FIG. 15a,b. – *Bairdiocypris* sp. B. PSGF42A'. Frasnian – *Frasnien*. IRScNB n° b4666. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x75.

FIG. 16. – *Bairdiocypris* sp. C. PSGF42A'. Frasnian – *Frasnien*. IRScNB n° b4667. Right lateral view of a broken carapace – valve – *Vue latérale droite d'une valve brisée*. x70.

FIG. 17a,b. – *Rectoplacera* sp. A. PSGF38. Givetian – Givétien. IRScNB n° b4668. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x90.

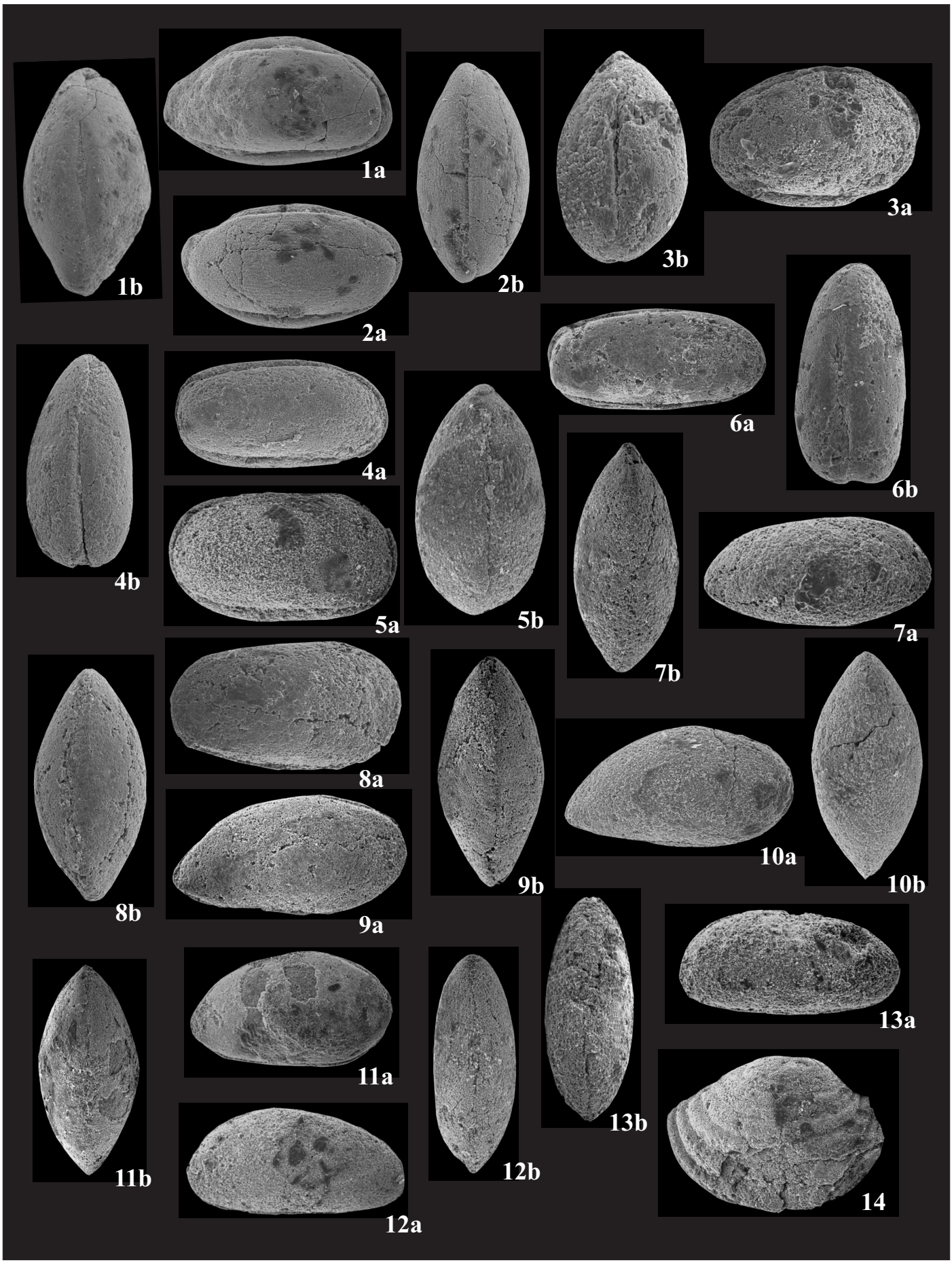
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PLATE IV – Pl. IV

FIG. 1a,b. – *Tubulibairdia* sp. A, aff. *clava* (KEGEL, 1922). PSGF19. Givetian – *Givétien*. IRScNB nº b4669. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x35.

FIG. 2a,b. – *Decoranewsomites* nov. sp. A. PSGF26. Givetian – *Givétien*. IRScNB nº b4670. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x65.

FIG. 3a,b. – *Micronewsomites* sp. A, aff. *natus* (ROZHDESTVENSKAJA, 1972). PSGF40. Frasnian – Frasnien. IRScNB nº b4671. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x145.

FIG. 4a,b. – *Microcheilinella* sp. A. PSGF42A. Givetian – *Givétien*. IRScNB nº b4672. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x85.

FIG. 5a,b. – *Microcheilinella* sp. B. PSGF47. Frasnian – *Frasnien*. IRScNB nº b4673. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x115.

FIG. 6a,b. – *Spinomicrocheilinella* sp. A. PSGF40. Givetian – *Givétien*. IRScNB nº b4674. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x140.

FIG. 7a,b. – *Acratia* sp. A, aff. *gassanovae* EGOROV, 1953. PSGF38. Givetian – *Givétien*. IRScNB nº b4675. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x90.

FIG. 8a,b. – *Acratia* sp. *B*, aff. *paraschelonica* LETHIERS, 1974. PSGF47. IRScNB nº b4676. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x135.

FIG. 9a,b. – *Bairdia* sp. A, aff. *retrorsa* POLENOVA, 1953. PSGF32. Givetian – Givétien. IRScNB nº b4677. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x110.

FIG. 10a,b. – *Bairdia* sp. B, aff. *retrorsa* POLENOVA, 1953. PSGF42A. Givetian – *Givétien*. IRScNB nº b4678. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x110.

FIG. 11a,b. – *Bairdia* sp. C. PSGF47. Frasnian – *Frasnien*. IRScNB nº b4679. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x85.

FIG. 12a,b. – *Bairdiacypris* sp. A. PSGF41. Givetian – *Givétien*. IRScNB nº b4680. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x80.

FIG. 13a,b. – *Bairdiacypris* sp. B. PSGF47. Frasnian – *Frasnien*. IRScNB nº b4681. Carapace. a. Right lateral view – *Vue latérale droite*. b. Dorsal view – *Vue dorsale*. x95.

FIG. 14. – *Cryptophyllus* sp. A. PSGF47. Frasnian – *Frasnien*. IRScNB nº b4682. Broken valve. *Valve brisée.* x70.

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