Ostracods and facies of the Early and Middle Frasnian at Devils Gate in Nevada: Relationship to the Alamo Event

JEAN-GEORGES CASIER, IVAN BERRA, EWA OLEMPSKA, CHARLES SANDBERG, and ALAIN PRÉAT

In order to document the Alamo Event and to investigate its influence on shallow-marine environments, we undertook a study of ostracods, conodonts, and analysis of the sedimentology of the lower member of the type Devils Gate Limestone. Six major carbonate microfacies (MF1–MF6) ranging from open-marine environments below storm wave base to pre-evaporitic supratidal lagoons were recognized. The sedimentological study detected no important sedimentological changes during the Alamo Event; only an influx of detrital material and lithoclasts indicate that an unusual event had occurred. Ostracods are generally rare or absent in the lower member of the Devils Gate Limestone, and only 2,000 carapaces, valves and fragments were extracted; from these some 26 taxa were identified. Two new species, *Voronina*? *eureka* and *Serenida dorsoplicata* are proposed. The ostracods belong to the Eifelian Mega-Assemblage and their distribution was influenced by strong salinity variations. Because of the rarity and low diversity of ostracods and conodonts in samples collected from the lower part of the lower member of the Devils Gate Limestone it is not adequate to demonstrate conclusively an extinction event close to the Alamo Event Bed. Nevertheless the greater abundance and diversity of ostracods above this bed seems to indicate that the Alamo Event did not result in significant extinction of ostracod taxa in this shallow water setting. The ostracod fauna present in the lower member of the Devils Gate Limestone suggests faunal exchanges between Nevada and the Russian Platform via the Western Canadian platform.

Key words: Ostracoda, conodonts, sedimentology, palaeoecology, Frasnian, Alamo Event, Pilot Basin, Nevada.

Jean-Georges Casier [casier@naturalsciences.be], Département de Paléontologie, Institut royal des Sciences naturelles de Belgique, 29, rue Vautier, B-1000, Bruxelles, Belgique;
Ewa Olempska [olempska@twarda.pan.pl], Instytut Paleobiologii PAN, ul. Twarda 51/55, PL-00-818 Warszawa, Poland;
Ivan Berra [iberra@ulb.ac.be] and Alain Préat [apreat@ulb.ac.be], Département des Sciences de la Terre et de l'Environnement, Université libre de Bruxelles CP 160, 50, Av. F.D. Roosevelt, B-1050, Bruxelles, Belgique;
Charles Sandberg, U.S. [sandberg@usgs.gov], Geological Survey, box 25046, Mail Stop 939, Federal Center, Denver, Colorado 80225, USA.

Introduction

The Alamo Event was responsible for deposition of a huge carbonate megabreccia, the Alamo Breccia, in the eastern Great Basin (southeastern Nevada). This breccia, dated as Early Frasnian and more precisely as within the *Palmatolepis punctata* conodont Zone (Sandberg and Warme 1993), is distributed in a semi-circular pattern. It covers an area of more than 100,000 km^2 and contains a rock volume as great as 1,000 km (Morrow et al. 1998; Warme 2004). The presence of a weak iridium anomaly (Warme and Sandberg 1995), shocked quartz (Leroux et al. 1995), carbonate spherules and tsunami deposits (Warme and Kuehner 1998) associated with this megabreccia have now proved that the Alamo Event was the result of a pelagic marine impact (Morrow et al. 2005). Because recent authors have reported a large number of other Late Devonian impacts globally, Sandberg et al. (2002) suggested that the Alamo Impact may have been part of a comet shower. Recently, Morrow and Sandberg (2006) reported that the Alamo Breccia Bed at Devils Gate yielded a comparable to slightly greater iridium anomaly than that reported elsewhere.

The identification of *Franklinella multicostata* Rabien, 1954 (Casier in Sandberg et al. 1997), in the Alamo Breccia Member exposed on the west slope of Tempiute Mountain, implies that the Alamo Event must be related to a marine hypoxic event. Other entomozoacean ostracod species belonging to the genus *Franklinella* have also been found in the *Pa. punctata* Zone in the southern border of the Dinant Basin in Belgium (stop VI-11 in Bultynck et al. 2001), and probably at the same level in the Algerian Sahara (Casier 1983). In reality, entomozoacean and (or) cypridinacean ostracods belong to the Myodocopid Mega-Assemblage, a proxy for anoxic events in the Devonian and Carboniferous (Casier 2004). Hypoxic events are frequently associated with periods of mass extinction, e.g., the Upper Kellwasser Event is related to the Late Frasnian mass extinction, one of the five largest known mass extinctions which was responsible for the disappearance of 70% of the ostracod fauna (Lethiers and Casier 1999; Casier and Lethiers 2001; Olempska 2002).

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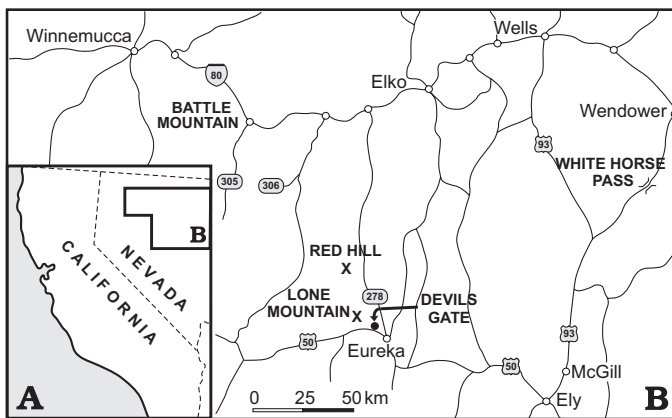http://app.pan.pl/acta51/app51-813.pdf

Fig. 1. Location of the Devils Gate section, Nevada (after Casier et al. 1996).

Nevertheless, at the present time, no abnormal disappearance of ostracods has been observed close to the Early Frasnian *Palmatolepis punctata* Zone in southern Belgium, the type region for definition of the Frasnian Stage. For example, 17 ostracod species out of 23 present at the base of the Frasnian and below the *Pa. punctata* Zone are recorded above this zone in this region (Casier 1979). However, in order to contribute to the knowledge of the Alamo Event and to appreciate its influence in Nevada, we undertook a study of ostracods from the lower part of the lower member of the Devils Gate Limestone, which included the Alamo Breccia Bed (Sandberg et al. 2003: fig. 5). Conodont zonation of this interval is revised herein by Sandberg on the basis of his new samples collected with Jared Morrow.

Institutional abbreviation.—IRScNB, Institut royal des sciences naturelles de Belgique.

Other abbreviation.—MF, microfacies.

The Devils Gate section

The Devils Gate section at Devils Gate Pass (GPS: N 39° 34'518; W 116°04'024) is located west of the Pilot Basin, along US Highway 50, 13 km west of the mining town of Eureka, in Eureka County, Nevada (Fig. 1). The lithology, sedimentology, and conodonts of the Devils Gate section, which exposes a continuous depositional sequence from the late *Mesotaxis falsiovalis* Zone (Early Frasnian) to the early *Pa. crepida* Zone (Early Famennian) have been studied by Merriam (1940), Sandberg and Poole (1977), Sandberg et al. (1988, 1989, 1997, 2003), Morrow and Sandberg (2003) and Morrow et al. (2005). The Devils Gate section is the type locality of the Devils Gate Limestone, and is one of the best North American reference sections for the Frasnian–Famennian boundary. According to Sandberg et al. (1997, 2003), the Alamo Event is recorded in this section by a 29-cm-thick bed of slightly sandy, graded, calcareous diamictite with

granule-size carbonate clasts, and, in the top 8–10 cm, with parallel laminations and tepee structures, more recently reinterpreted as dewatering structures (Morrow and Sandberg 2006).

Rock and facies analysis

(I. Berra and A. Préat)

For the sedimentological analysis, 164 samples representing a stratigraphic thickness of 325 m were collected in five sets at various places that were accessible on the outcrop (Fig. 2). Some complementary samples were picked up around the Alamo Breccia Bed reported by Sandberg et al. (1997, 2003). This paper deals with the lower 200 m of exposed section of the Devils Gate Limestone from the late *M. falsiovalis* conodont Zone through the early *Pa. hassi* Zone, as related herein by Sandberg from Sandberg et al. (2003). The samples were studied in thin sections using the textural criteria of Dunham (1962) and Embry and Klovan (1972). Six microfacies (MF1–MF6) were recognized by comparison with the sedimentological models of Wilson (1975), Flügel (1982), and Reading (1986). The described microfacies represent transition from distal quiet open-marine to the supratidal lagoon environment of a carbonate platform. This sequence is a preliminary petrographical approach and will be further detailed later.

MF1: Open-marine distal environment

Description.—Bioturbated silty mudstone and wackestone with whole shells of gastropods, valves of brachiopods, tentaculitids, and fragments of crinoids. Brachiopods and mollusks are predominant. Crinoids are rare, poorly preserved, well rounded and altered. The detrital silty fraction ranges between 0 and 5% by visual estimation.

Interpretation.—Brachiopods, crinoids and tentaculitids are good indicators of an open-marine environment. The low bioclast content and its good state of preservation suggest deposition in a quiet water, at some distance from the shoreface. Poorly preserved crinoids indicate possible transportation from shallower environments. The presence of an in place fauna and transported crinoids sets this facies in quiet open-marine water below the normal wave base.

MF2: Open-marine proximal environment

Description.—Deeply bioturbated packstone with fine-grained and well-sorted bioclasts forming a shell hash. Bioclasts are mainly composed of brachiopods and gastropods. Green algae (Paleosiphonocladales) are scarce and poorly preserved. Occasionally well-preserved *Umbella* and fragments of crinoids, trilobites, tabulate corals, and *Amphipora* are observed. Ostracods and foraminifers are also present. The bioturbations show concentric irregular swirlings leading to a mechanical sorting of bioclasts.
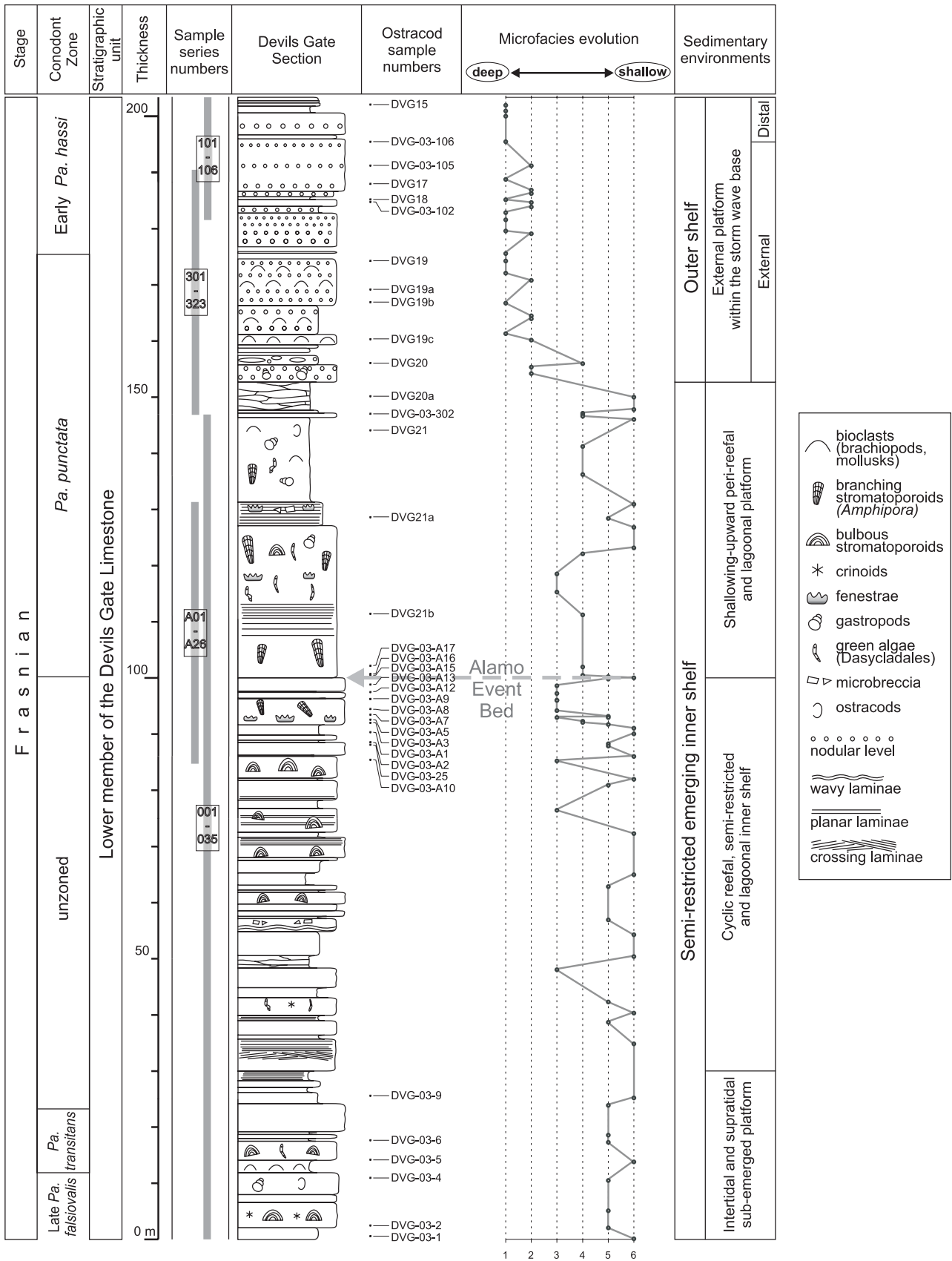
Fig. 2. Lithology of the lower member of the type Devils Gate Limestone showing positions of ostracod, conodont, and sedimentological samples. Ostracod samples numbered DVG are from Sandberg et al. (1988, 2003). Other columns indicate conodont zones revised herein by Sandberg, paleoenvironmental interpretation, and microfacies evolution. Abbreviation: *Pa.*, *Palmatolepis*.

Interpretation.—The presence of green algae is an indicator of proximity to the photic zone. The other fossils (brachiopods and gastropods) are typical of open-marine waters on a carbonate platform with strong littoral influence (*Umbella* and *Amphipora*). The whole set of mashed bioclasts have been intensively mixed through bioturbation activity. This type of deposit occurs in open-marine shallow neritic water environments below the wave base level (Wilson 1975).

MF3: High-energy shoal environment

Description.—Massive stromatoporoid floatstone and rudstone within a small microbrecciated, microbioclastic, and peloidal packstone or grainstone matrix. Bioclasts consist of calcispheres and well-sorted, rounded and altered green algae Paleosiphonocladales, echinodermal plates, and brachiopod valves. Peloids have different aspects but can be categorized into several groups. They can be uniform and well rounded or very irregular in shape and size. Some have a microbioclastic core. Microbreccias are small (around 250 μm), well rounded and consist of a calcisphaerid and microbioclastic mudstone. The packstone facies contains small dolomite rhombs (diameters from 25 to 100 μm).

Interpretation.—The peloids display different origins: faecal pellets, micritized grains and small rounded pieces of microbreccia. The bioclasts have undergone significant reworking as they are well sorted, rounded, and altered. Morover, micrite sedimentation is nearly absent. All these features might be explained by transportation and winnowing in agitated water. Stromatoporoids, on the other hand, are broken but not rounded, suggesting relatively short distance of transport (Da Silva and Boulvain 2002). This microfacies is interpreted as a biostromal shoal in agitated water.

MF4: Restricted-lagoon environment

Description.—Bioturbated, peloidal mudstone and wackestone with green algae (Paleosiphonocladales), ostracods, gastropods, *Calcisphaera*, and *Amphipora* floatstone. Green algae are numerous and varied. Peloids are poorly sorted and display sizes ranging from a few tens of microns to 0,5 mm, with angular to spherical shapes. They are encased by a thin microsparitic calcitic cement. *Amphipora* is well preserved and, along with green algae and ostracods, occurs in large numbers.

Interpretation.—The biota is typical of restricted lagoons and ponds with a low diversity but with a high abundance of endemic organisms (algae, ostracods or gastropods) (Reading 1986). Peloids were derived from slight local aggregation and dislocation of the muddy matrix. They are similar to those described by Wright (1983) in restricted subtidal deposits. *Amphipora* is usually found in back-reef environments and indicate very shallow subtidal water in restricted lagoons (Pohler 1998).

MF5: Intertidal-flat environment

Description.—Slightly oncoidised intraclastic, peloidal and bioclastic grainstone and floatstone. Intraclasts consist of peloidal mudstone and wackestone with calcispheres, green algae (Paleosiphonocladales), ostracods, and sponge spicules. They are surrounded by a thin isopachous equant calcite cement. The grains are subangular to rounded, poorly sorted, of low sphericity, and range from 500 μm to a few millimeters in longest dimension. Apart from intraclasts, bioclasts include ostracods and remains of green algae. Localy, brownish idiomorphic dolomite rhombs are present. Shrinkage cracks and geopetal cavities are common.

Interpretation.—Harwood (1988) interpreted circumgranular cement as a beach feature. Intraclasts found here are similar to the reworked lacustrine carbonates described by Platt (1989). The only noticeable difference from the former is the fauna, which is endemic in our facies suggesting a restricted-marine environment (sponges and ostracods). There is no evidence of pedogenic modification such as colour mottling or presence of rhizoids. Poor intraclast sorting might be related to storm or current activity in the intertidal zone (Khalifa 2005). Primary idiotopic dolomites, shrinkage cracks, and geopetal cavities indicate early diagenetic processes. This microfacies is interpreted as a reworked carbonate sediment in a protected tidal flat.

MF6: Intertidal and supratidal environments

Description.—Loferite or dismicrite and dolomitic laminar mudstone with fine-grained brownish idiotopic dolomite (crystals between 10 and 30 μm), rich in organic matter and with iron bacterial filaments. The sediment is sparsely laminar with vertical burrows. This dolomitic facies is interstratified at a millimeter to centimeter scale with undulating peloidal, cryptalgal loferite or dismicrite exhibiting regular, laminoid and domal fenestrae. The bioclastic content is sparse and consists of a few ostracods, algal remains, and calcispheres in a cryptalgal mudstone.

Interpretation.—Fischer (1964) considered the loferitic or dismicrite facies and the well-preserved pelletal texture in ancient limestones and dolostones as evidence of both supratidal deposition and early cementation. Thin horizontal laminations need restricted upper-intertidal to supratidal conditions to be preserved; otherwise burrowing organisms churn and homogenize the sediment (Shinn 1983). Because burrows are rare, the sedimentary structures are well preserved and the dolomite distribution pattern follows these structures. The poor faunal assortment of ostracods and algae suggests a restricted environment. Relicts of organic matter retained in the sediment indicate anoxic conditions at the sediment-water interface (Tissot and Welte 1984). The association of dolomites with fenestral cavities in cryptalgal mudstone and ostracods point to an intertidal to supratidal restricted environment.

Conodonts

(C. Sandberg)

Most of the sequence of the lower member of the Devils Gate Limestone depicted in Fig. 2 is assigned to the *Palmatolepis punctata* Zone, according to the zonal revision made herein. Unfortunately, the position of the boundary of this zone with the *Pa. transitans* Zone below is obscured by a stratigraphic interval that is unzoned because of the paucity or absence of conodont faunas, resulting from the shallowness of the carbonate platform. However, because of well-dated sequences elsewhere (Sandberg and Warme 1993; Sandberg et. al 1997), the Alamo Event is documented to occur near the middle of the *Pa. punctata* Zone. Hence, a large part of unzoned interval below the Alamo Event bed (Fig. 2) must belong to this zone.

The Devil Gate section is situated near the outer edge of a carbonate platform that during the *Pa. punctata* Zone extended in terms of the present-day latitude from central Colorado at least as far west as Lone Mountain and Red Hill (Fig. 1). Across this broad platform, conodont biofacies, named according to the adjectival ending for genera, display this seaward progression: pandorinellinid, icriodid, polygnathid, mesotaxid, and palmatolepid. Commonly, the conodont biofacies, which are based on genera composing 70% of the fauna, contain two laterally adjacent genera and are designated, with the deeper-water generic name first, as in these examples: polygnathid-icriodid or mesotaxid-polygnathid biofacies.

The basal part of the sequence depicted in Fig. 2 is dated as late *Pa. falsiovalis* Zone. The conodont fauna is dominated by *Icriodus subterminus,* as are most faunas of this age on the carbonate platform, and hence it is assigned to the icriodid biofacies. The next higher part of the sequence is dated as *Pa. transitans* Zone. The fauna is assigned to the pandorinellinid biofacies based on the presence of the morphotype of *Pandorinellina insita* with only two denticles in the anterior fin. The shallow icriodid biofacies and very shallow (10 m or less) pandorinellinid biofacies agree with the shallow-water interpretation based on microfacies analysis.

The overlying unzoned interval and lower part of the *Pa. punctata* Zone as high as sample conodont sample DVG20a (Fig. 2) is either nonproductive of conodonts or is represented by a polygnathid biofacies, characterized by sparse faunas containing <10 conodonts/kg. Conodont sample DVG20, however, although likewise sparsely productive contains a mixed biofacies comprising *Mehlina gradata*, *Icriodus symmetricus*, and fragmentary *Pelekysgnathus* sp., and *Polygnathus* sp. This change of conodont biofacies corresponds to the change from inner to outer shelf, based on microfacies analysis.

Beginning with conodont sample DVG19c and continuing through sample DVG15 at the top of the studied sequence (Fig. 2), the conodont biofacies undergo marked changes, some of which are at variance with the depth inter-

pretations by microfacies analysis. Sample DVG19c contains a mixed biofacies comprising: *Icriodus* sp. (68%), *Mesotaxis falsiovalis* (20%), *Polygnathus* spp. (6%), *Ozarkodina postera* (4%), and *Ancyrodella gigas* (2%). This is not necessarily a true icriodid biofacies because of the high percentage of *Mesotaxis* and the habitat of the two species of *Icriodus*: *I praealternatus* (62%) and *I. symmetricus* (6%). Sandberg et al. (1992) analyzed occurrences of individual species of *Icriodus* and found that *I. praealternatus* favored a neritic habitat but ranged into pelagic settings, whereas *I. symmetricus* was a neritic to pelagic species that live on the middle to outer shelf. Thus, their co-occurrence with *Mesotaxis*, which favored outer-shelf settings, is predictable. Hence, sample DVG19c definitely signals the beginning of a relative rise of sea level.

Conodont samples DVG19b and DVG19a (Fig. 2) are characterized by the icriodid-polygnathid biofacies, which signals a relative fall of sea level. This change is at slight variance with the depth interpretation by microfacies analysis. However, the interval from sample DVG19 to DVG19-1, collected in 2005 (and hence not shown in Fig. 2, but 4.3 m below DVG18) is characterized by abundant faunas (178–214 conodonts/kg). These faunas represent a nearly pure mesotaxid biofacies, composed of 92–95% *Mesotaxis*, with *M. johnsoni* as the overwhelmingly predominant species. Occurring with *M. johnsoni* are a few specimens of *Polygnathus timanicus* s.s. Neither species is known to range above the *Pa. punctata* Zone. This co-occurrence is the main reason for extending the upper limit of the *Pa. punctata* Zone much higher than in previous zonal schemes (e.g., Sandberg et al. 1997, 2003).

Besides DVG18 (Fig. 2), three intermediate conodont samples (not shown in Fig. 2) were collected in the 4.3-m interval above DVG19-1. Three of these four samples represent an unusual polygnathid-ancyrodellid biofacies, whereas one is a strictly polygnathid biofacies. This interval, which represents the start of the early *Palmatolepis hassi* Zone, demonstrates the beginning of a sea-level fall that is not reflected by the microfacies analysis (Fig. 2). The occurrence of *Ancyrodella gigas* in these samples, together with a few specimens of *Mesotaxis bogoslovskyi* and *M*. aff. *M. johnsoni*, is significant. In studying conodonts of the Lion mudmound at Frasnes, Belgium, Sandberg et al. (1992) found that *Ancyrodella* preferred a neritic setting and inhabited high-energy environments on the flank and landward side of the mudmound.

The highest part of the studied interval above DVG18 is dated as early *Pa. hassi* Zone, and the late *Pa. hassi* Zone begins just above the columnar section (Fig. 2). The five conodont samples collected in this interval are assigned to the polygnathid-icriodid biofacies, with abundances of *Polygnathus* decreasing upward from 70 to 40% and abundances of *Icriodus* increasing upward from 30 to 58%. Thus, the conodont biofacies signals a continuing relative fall of sea level that is not reflected by microfacies analysis.

Ostracods

(J.-G. Casier and E. Olempska)

Previous studies on ostracods at the Devils Gate section.— For the study of the Late Frasnian mass extinction (Sandberg et al. 1988) in the Devils Gate section, ostracods were extracted in the upper member of the Devils Gate Limestone, from the late *Palmatolepis rhenana* (Late Frasnian) to middle *Palmatolepis triangularis* (Early Famennian) zones. Casier and Lethiers (1997, 1998a, b) showed that extinction of ostracods was abrupt at the Frasnian–Famennian boundary: of the 70 ostracod species recognized in the Late Frasnian, only 16 survived the mass extinction. These studies have also demonstrated that the ostracod fauna recovered rapidly after this mass extinction. Fifty-nine species were recognized in the Early Famennian, 45 appeared for the first time, whereas 14 others were known from the Late Frasnian (= "Lazarus" species). Nearly all of these ostracods were fig-ured by Casier et al. (1996) and Casier and Lethiers (1997, 1998a, b).

Sixty-six ostracod species were extracted from 13 samples collected in the 6.5 m of massive limestone of the latest Frasnian *Pa. linguiformis* Zone, which is rich in corals and brachiopods and contains the last occurrences of *Iowatrypa* and *Tabulophyllum* (Casier and Lethiers 1998a) (Appendix 1).

In two other samples collected at the base of the 10 m sequence of shales, mudstones, and debris flows crossing the Frasnian–Famennian boundary, 24 silicified ostracod species were recorded (Casier and Lethiers 1998a) (Appendix 2).

Material and methods (Fig. 2, Table 1).—For our present study, 36 samples were collected from the lower member of the Devils Gate Limestone at the Devils Gate section, from the late *Mesotaxis falsiovalis* Zone through the early *Pa. hassi* Zone (see Fig. 2 for the locality of these samples numbered DVG from Sandberg et al. (1989, 2003), or numbered DVG-03-). Ostracods were extracted by the hot acetolysis method (Lethiers and Crasquin-Soleau 1988). Samples of

Table 1. Distribution of ostracods from the Late *Mesotaxis falsiovalis* Zone to the Early *Palmatolepis hassi* Zone at the Devils Gate section.

Devils Gate	03-4	03-6	03-A3	03-A12	03-A15	03-A17	21b	21a	21	03-302	20	19c	19b	19a	19	03-102	18	17	03-105	03-106	15
Voronina? eureka sp. nov.	•	•																			
Knoxiella? sp. A, aff. *rauseri*	•	•	?		•	•				•											
Bairdia sp. A		•																			
Westmontia? sp.		?																			
Acratia sp. D, aff. *paraschelonica*		•																			
Rozhdestvenskayites sp. A		•																			
Microcheilinella sp. A		•		?																	
Cytherellina sp . A		•						•	•	•											
Acratia sp. indet		?					•					•	•							•	
Platycopina indet.				•																	
Acratia sp. B			•					•	•	•	•		•	•	•			?	•		
Pachydomellidae? indet.					•																
Plagionephrodes cf. *medius*						•															•
Knoxiella sp. C, aff. *ornata*							•		•	•											
Knoxiella? *rauseri*							•	•	•	•		•	•	•							
Westmontia devilensis							?	•	•	•	•		•						?	•	
Acratia sp. A								•	•		•	•	•		•						
Knoxiella sp. B, aff. *ornata*									•												
Youngiella cf. *mica*									•			•	•	•	•		•		?		
Coelonella sp. A											•										
Bairdiacypris cf. *martinae*											•										
Acratia sp. C												•		•							
Bairdia sp.												•								•	
Cryptophyllus sp. A												•									
Elliptocyprites lorangeri												•						•			
Bairdia sp. B														•							
Serenida dorsoplicata sp. nov.															•	•					
Amphissites sp. A																				•	

approximatively 500 g each were crushed by a hydraulic press, and dried. About 100 g of each sample was attacked with 99.8% glacial acetic acid, at nearly 90°C, for four days at the rate of eight hours a day. The residue was sieved on 100 μm, 250 μm, and 1600 μm mesh screens. That part of the sample retained by the 1700 μm mesh screen was attacked by acid again and sieved on 250 μm and 1700 μm mesh screens only. About 2000 carapaces, valves and fragments of ostracods identifiable at any taxonomic level were thus extracted.

Ostracods are absent in the following 11 samples: DVG-03-1, DVG-03-2, DVG-03-5, DVG-03-9, DVG-03-25, DVG-03-A5, DVG-03-A7, DVG-03-A8, DVG-03-A10, DVG-03-A16, and DVG15. Ostracods are rare and unidentifiable in five other samples (DVG-03-A1, DVG-03-A2, DVG-03-A9, DVG-03-A13, and DVG20a), and they are only abundant in eight samples (DVG-03-4, DVG-03-6, DVG21a, DVG21, DVG-03-302, DVG20, DVG19b, and DVG19).

Review of identified ostracod taxa

(J.-G. Casier and E. Olempska)

Order Palaeocopida Henningsmoen, 1953
Suborder Palaeocopina Henningsmoen, 1953
Family Amphissitidae Knight, 1928
Genus *Amphissites* Girty, 1910

***Amphissites* sp. A** (Fig. 3A).—This species is represented by a single poorly preserved carapace in sample DVG-03-105. The ornamentation of the specimen is not preserved but its general shape resembles *Amphissites sandbergi* Casier and Lethiers, 1998a, a species relatively abundant in the *Palmatolepis linguiformis* Zone of the same section.

Family Youngiellidae Kellett, 1933
Genus *Youngiella* Jones and Kirkby, 1895

***Youngiella* cf. *mica* Rozhdestvenskaja, 1972** (Fig. 3B, C).—This species has been previously identified in the latest Frasnian *Pa. linguiformis* Zone (Casier and Lethiers 1998a) of the Devils Gate section. *Youngiella* cf. *mica* is the predominant species in sample DVG19c.

Family Aparchitidae Jones, 1901
Genus *Rozhdestvenskayites* Mc Gill, 1966

***Rozhdestvenskayites* sp. A** (Fig. 3D).—This finely reticulated species is the only one present in sample DVG-03-6 from the lower part of the Frasnian. The *Aparchites* sp. 64 figured by Braun (1967: pl. 3; no pl. 9) from the Great Slave Lake region (Canada), may belong to *R.* sp. A.

Suborder Platycopina Sars, 1866
Family Knoxitidae Egorov, 1950
Genus *Knoxiella* Egorov, 1950

***Knoxiella*? *rauseri* (Tschigova, 1977)** (Fig 3F, G).—This highly polymorphic and large species, first described from the Famennian of the Russian Platform, has been previously identified in the Late Frasnian and Early Famennian of the Devils Gate section (Casier et al. 1996, 1997). *K.*? *rauseri* is relatively abundant from sample DVG21b to sample DVG19.

***Knoxiella*? sp. A aff. *K. rauseri* (Tschigova, 1977)** (Fig. 3H).—This medium-sized species resembles some *K. rauseri* figured by Tschigova (1977). *K.*? sp. A is present in samples DVG-03-4, 03-6, 03-A15, 03-A17, and DVG-03-302.

***Knoxiella* sp. B aff. *K. ornata* Lethiers, 1981** (Fig. 3I).—This coarsely reticulated species is represented by a single carapace, probably of a juvenile, in sample DVG21.

***Knoxiella* sp. C aff. *K. ornata* Lethiers, 1981** (Fig. 3J).—This double-lobed and coarsely reticulated species is present in samples DVG21b, DVG21, and DVG-03-302.

Family Barychilinidae Ulrich, 1894
Genus *Coelonella* Stewart, 1936

***Coelonella* sp. A** (Fig. 3E).—This species is represented by a single poorly preserved specimen in sample DVG-03-20.

Genus *Serenida* Polenova, 1953
Serenida dorsoplicata sp. nov.
Fig. 3K, L, M.

Holotype: IRScNB n° b4504. Carapace. DVG-03-19. Fig. 3K$_1$, K$_2$. L = 0.73 mm; H = 0.48 mm; W = 0.30 mm.

Type horizon: Lower member of the Devils Gate Limestone. Near top of *Palmatolepis punctata* Zone.

Type locality: Devils Gate, close to Eureka in Nevada.

Derivation of the name: From the Latin *dorsum*—back and *plicatus*—folded. Referring to the slant dorsal fold.

Diagnosis.—*Serenida dorsoplicata* sp. nov. differs from other species of the genus in having a well-developed dorsum and a short dorsal fold directed forward, and forming an angle between 10 and 20° with the dorsal border.

Material.—12 carapaces, 12 valves and 15 fragments.

Description.—Medium-sized sub-elliptic *Serenida* with a nearly straight dorsal border except just posterior to the mid-length where it is slightly curved for a short distance. Ventral border regularly curved but slightly more posteriorly. Anterior border regularly rounded, and posterior border more curved dorsally than ventrally. Greatest length a little above mid-height, and greatest height at 4/7th of the length. Right valve larger than left valve and overreaching the left, especially ventrally, all along the margin. Ventral contour of left valve nearly straight, and posterior curvature of this valve more accentuated than on the right valve. Anterior and dorsal borders of left valve similar to the right one. Valves slightly depressed in the mid-dorsal sector. Short dorsal fold beginning along the dorsal border at 4/7th of the length, directed forward, and forming an angle between 10 and 20° with the dorsal border. In dorsal view, the hinge line is straight and depressed within a well-developed dorsum. The
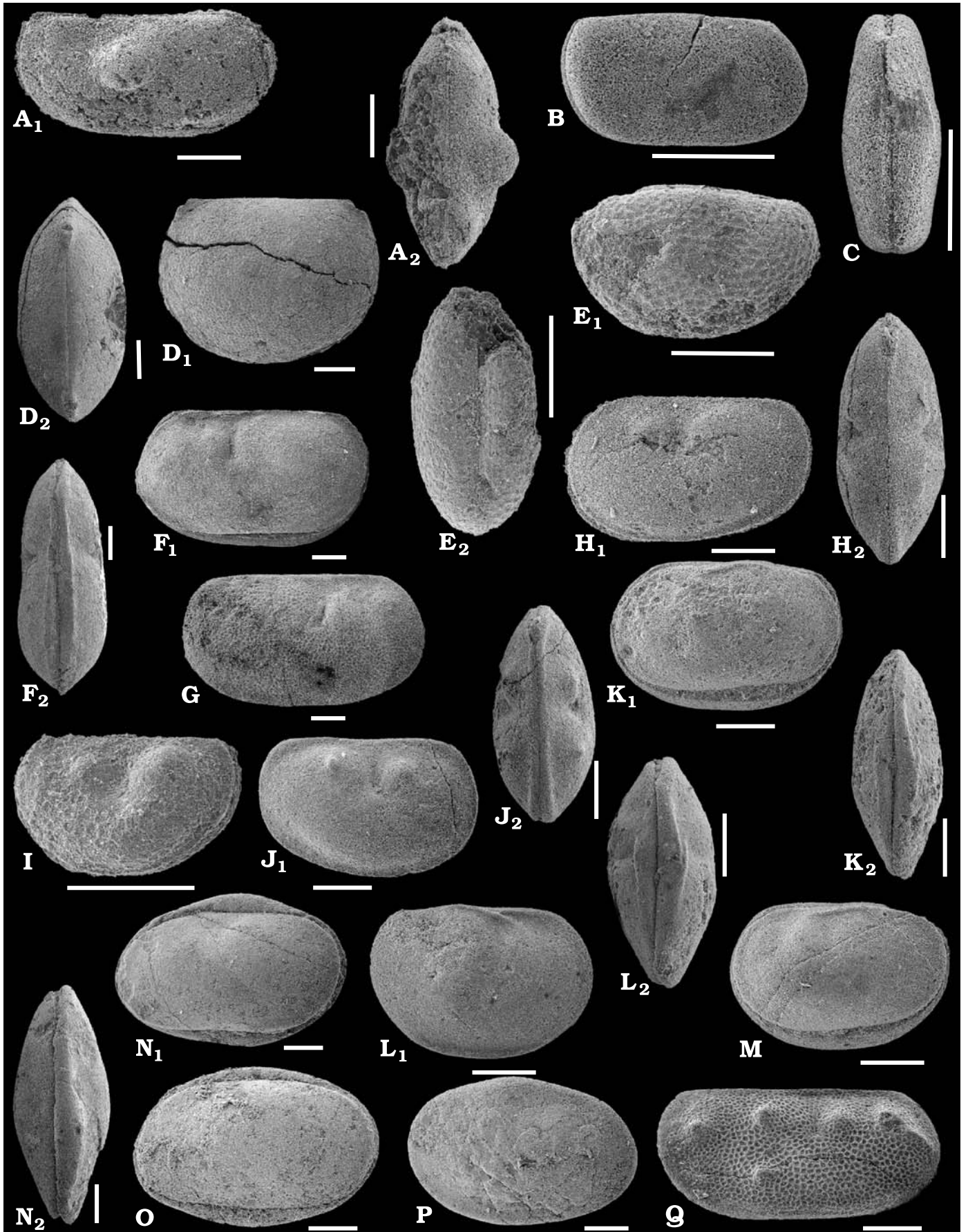
mid-length dorsal depressions are slightly visible in dorsal view on the two valves, which are flattened at mid-length and angular anteriorly and posteriorly. Greatest width at 3/5th of the greatest length. Surface of valves smooth.

Remarks.—*Serenida dorsoplicata.* sp. nov. is similar in lateral outline to *Serenida tenuisulcata* Rozhdestvenskaja, 1972, and *Serenida costulata* Rozhdestvenskaja, 1972, from the Upper Devonian of Baschkiria, however, the dorsal overreach is not as great in these two species, and they do not possess a dorsal fold. The carapace of *S. tenuisulcata* is also thicker. The Kloedenellid sp. 44 from the Great Slave Lake region (Canada), figured by Braun (1967: pl. 6), belongs probably to *S. dorsoplicata* sp. nov.

Family Cavellinidae Egorov, 1950
Genus *Voronina* Polenova, 1952

The validity of the genus *Voronina* Polenova, 1952, is controversial. According to Abushik (1990), this genus is a junior synonym of *Timanella* Egorov, 1950, whereas, according to Shaver (1961), *Voronina* is possibly an equivalent to *Cavellina* Coryell, 1928. We do not share these opinions because the lateral contour of the carapace of *Voronina voronensis* Polenova, 1952, the type species of the genus, differs from that of *Timanella* and *Cavellina*.

Voronina? *eureka* sp. nov.
Fig. 3N, O, P.

Holotype: IRScNB n° b4507. Carapace. DVG-03-4. Fig. $3N_1$, N_2. L = 1.10 mm; H = 0.75 mm; W = 0.44 mm.

Type horizon: Lower member of the Devils Gate Limestone. Late *Mesotaxis falsiovalis* Zone.

Type locality: Devils Gate, close to Eureka, Nevad.

Derivation of the name: Referring to the town Eureka, Nevada, close to the Devils Gate section.

Diagnosis.—*Voronina*? *eureka* sp. nov. differs from other species of the genus in having highly asymmetric valves and a thickening along the dorsal border of right valve.

Material.—71 carapaces, 6 valves, and about 175 fragments.

Description.—In left-lateral view, a medium-sized sub-elliptic *Voronina*. Curvature of the dorsal border maximum at mid-length, and of the ventral border, slightly behind the mid-length, however, both are regularly curved in young instars. Anterior border more curved ventrally, and anterior extremity slightly below mid-height. Posterior border regularly curved with extremity at mid-height. Greatest length at mid-height, and greatest height just behind mid-length. Right valve larger than left valve and overreaching the left all along the margin, especially dorsally and ventrally. Dorsal border of left valve nearly straight, ventral border occasionally very slightly concave, and anterior and posterior borders approximately parallel to the right valve. Right valve thickened along the dorsal border, fusiform in dorsal view with the extremity occasionally slightly pinched. Dorsal thickening of left valve very prominent. Greatest width at mid-length or slightly behind mid-length. Surface of valves smooth.

Remarks.—In lateral view *Voronina*? *eureka* sp. nov. is similar to *Voronina voronensis* Polenova, 1952, the type species for the genus. However, the dorsal view is quite different because the left valve of *V. voronensis* possesses a posterior thickening. *V. voronensis* is known from the Middle Devonian (Givetian) of Pachelma in Penza area, and also of the Tambov and Kaluga areas, all on the Russian Platform. *Voronina cornuta* Egorova, 1960a, *V. longula* Egorova, 1960a, *V. sulcata* Egorova, 1960a and *V.? remosa* Averjanov and Egorova, 1960 in Egorova (1960b) are Eifelian in age. *Voronina*? *eureka* sp. nov. is present only in two samples DVG-03-4 and DVD-03-6.

Uncertain family
Genus *Westmontia* Loranger, 1963

***Westmontia devilensis* Casier and Lethiers, 1997** (Figs. 3Q, 4A, B).—This highly polymorphic species, previously identified in the Late Frasnian and Early Famennian of the Devils Gate section (Casier and Lethiers 1996, 1997), displays five variably developed lobes, and a slightly to heavily reticulated ornamentation. *Westmontia devilensis* is a relatively abundant species from DVG21b upward. *Westmontia* sp. 257 *sensu* Braun (1967), from the Great Slave Lake region (Canada), and maybe also an instar described by Lethiers (1981) from the Root River, in the Northwestern Territories (Canada), belong to *W. devilensis*.

Platycopina indet. (Fig. 4C).—A finely ornamented but poorly preserved carapace from sample DVG-03-A12 is assigned to the Platycopina.

← Fig. 3. Ostracods from the Frasnian (late *Mesotaxis falsiovalis* to early *Palmatolepis hassi* zones) of the Devils Gate section, Nevada. **A**. *Amphissites* sp. A. Carapace in right lateral (A_1) and dorsal (A_2) views. Sample DVG-03-105. IRScNB n° b4494. **B**, **C**. *Youngiella* cf. *mica* Rozhdestvenskaja, 1972. **B**. Carapace in right lateral view. Sample DVG-03-21. IRScNB n° b4495. **C**. Carapace in dorsal view. Sample DVG-03-21. IRScNB n° b4496. **D**. *Rozhdestvenskayites* sp. A. Carapace in left lateral (D_1) and dorsal (D_2) views. Sample DVG-03-6. IRScNB n° b4497. **E**. *Coelonella* sp. A. Carapace in left lateral (E_1) and dorsal (E_2) views. Sample DVG20. IRScNB n° b4498. **F**, **G**. *Knoxiella*? *rauseri* (Tschigova, 1977). **F**. Carapace in left lateral (F_1) and dorsal (F_2) views. Sample DVG21. IRScNB n° b4499. **G**. Carapace in right lateral view. Sample DVG-03-302. IRScNB n° b4500. **H**. *Knoxiella*? sp. A aff. *K. rauseri* (Tschigova, 1977). Carapace in left lateral (H_1) and dorsal (H_2) views. Sample DVG-03-302. IRScNB n° b4501. **I**. *Knoxiella* sp. B aff. *K. ornata* Lethiers, 1981. Carapace in left lateral view. Sample DVG21. IRScNB n° b4502. **J**. *Knoxiella* sp. C aff. *K. ornata* Lethiers, 1981. Carapace in right lateral (J_1) and dorsal (J_2) views. Sample DVG-03-302. IRScNB n° b4503. **K**, **L**, **M**. *Serenida dorsoplicata* sp. nov. **K**. Holotype, carapace in left lateral (K_1) and dorsal (K_2) views. Sample DVG19. IRScNB n° b4504. **L**. Carapace in right lateral (L_1) and dorsal (L_2) views. Sample DVG19. IRScNB n° b4505. **M**. Carapace in left lateral view. Sample DVG19. IRScNB n° b4506. **N**, **O**, **P**. *Voronina*? *eureka* sp. nov. **N**. Holotype, carapace in left lateral (N_1) and dorsal (N_2) views. Sample DVG-03-4. IRScNB n° b4507. **O**. Carapace in left lateral view. Sample DVG-03-4. IRScNB n° b4508. **P**. Carapace in right lateral view. Sample DVG-03-4. IRScNB n° b4509. **Q**. *Westmontia devilensis* Casier and Lethiers, 1997. Right valve in lateral view. Sample DVG19b. IRScNB n° b4510. Scale bars 200 μm.
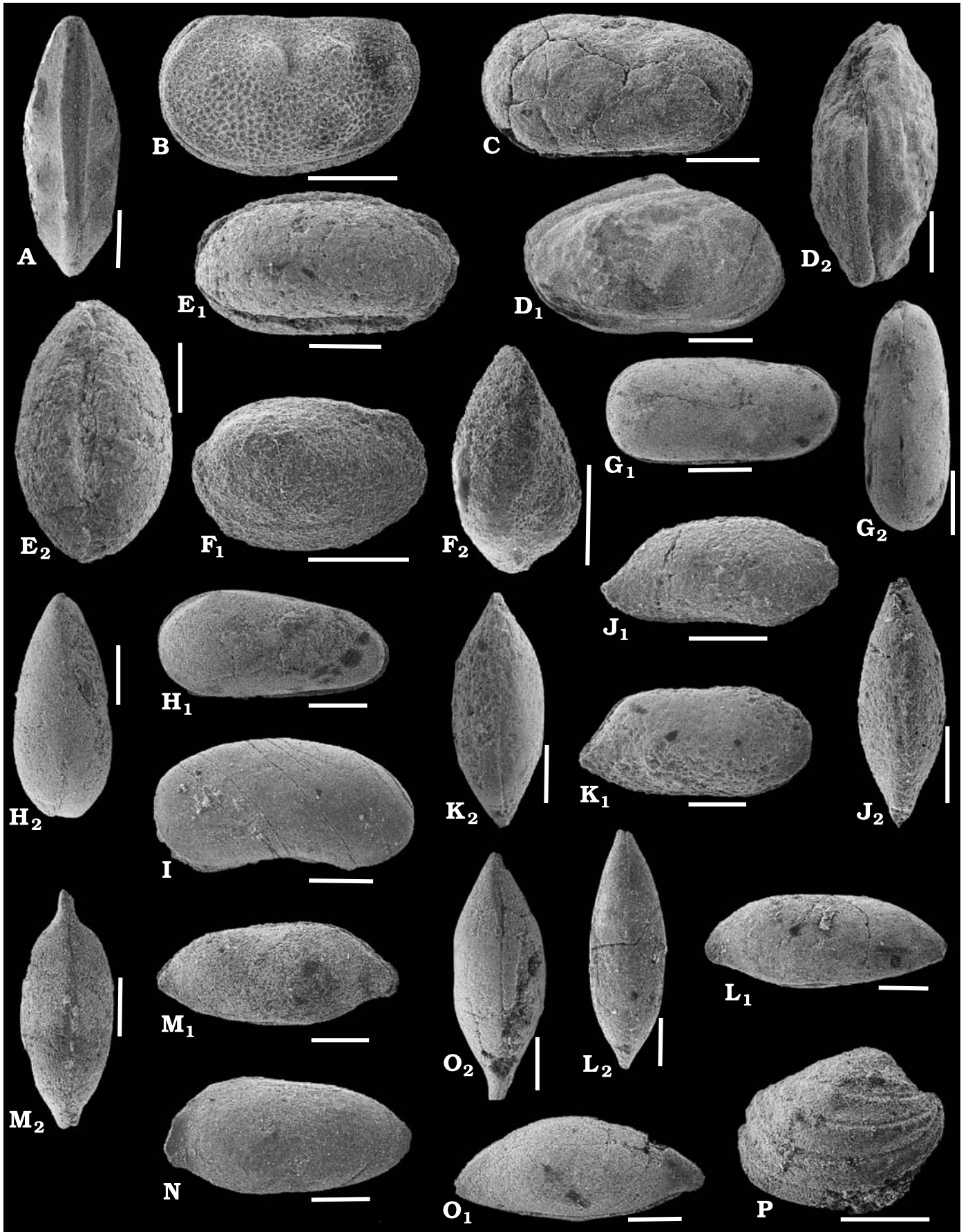
Order Podocopida Sars, 1866
Suborder Metacopina Sylvester-Bradley, 1961
Family Healdiidae Harlton, 1933
Genus *Cytherellina* Jones and Holl, 1869

Adamczak (1976: 341, 392) placed *Cytherellina* in Healdiidae, and was followed by Abushik (1990). However, the species belonging to the genus *Cytherellina* are morphologically similar to the representatives of *Poniklacella* Adamczak, 1976, and *Healdianella* Posner, 1951, so that phylogenetic relationships of these genera are unclear.

Cytherellina sp. A (Fig. 4H).—Several elongated carapaces are assigned to *Cytherellina*.

Family Ropolonellidae Coryell and Malkin, 1936
Genus *Plagionephrodes* Morey, 1935

Plagionephrodes cf. *medius* (Loranger, 1963) (Fig. 4D).— Two incomplete carapaces are regarded as close to *Plagionephrodes medius* described from northeastern Alberta (Canada) by Loranger (1963b) and figured later by Braun (1967: pl. 3) from the same region.

Suborder Podocopina Sars, 1866
Family Pachydomellidae Berdan and Sohn, 1961
Genus *Microcheilinella* Geis, 1933

Microcheilinella sp. A (Fig. 4E).—This species is present at the base of the Devils Gate Limestone in the Devils Gate section and is similar to *Microcheilinella* cf. *decora* Shi, 1964, described by Lethiers (1981) from the Alberta and the Northwest Territories (Canada).

Genus *Elliptocyprites* Swain, 1962

According to Becker (2000: 248), the genus *Elliptocyprites* may be assigned to the family Pachydomellidae.

Elliptocyprites lorangeri Lethiers, 1981 (Fig. 4G).—This species has been previously recognized from the Frasnian and Famennian of the Devils Gate section (Casier et al. 1996; Casier and Lethiers 1997) and from Alberta and Northwest Territories in Canada (Lethiers 1981).

Pachydomellidae? indet. (Fig. 4F).—A very poorly preserved thick carapace suggests membership in the Family Pachydomellidae.

Family Bairdiidae Sars, 1888
Genus *Bairdiacypris* Bradfield, 1935

Bairdiacypris cf. *martinae* Casier and Lethiers, 1997 (Fig. 4I).—A fragment of a left valve in sample DVG20 is similar to *B. martinae* described from the Late Frasnian and Early Famennian of the Devils Gate section (Casier and Lethiers 1997).

Genus *Bairdia* McCoy, 1844

Bairdia sp. A and sp. B.—A poorly preserved carapace (*Bairdia* sp. A) in sample DVG-03-6 (Fig. 4J), and another (Fig. 4K) in sample DVG19 belong to the genus *Bairdia* (*Bairdia* sp. B).

Family Acratiidae Gründel, 1962
Genus *Acratia* Delo, 1930

Acratia sp. A aff. sp. 42 *sensu* Braun (1967) (Fig. 4L).—We compare *Acratia* sp. A to *Acratia* sp. 42 figured by Braun (1967: pl. 3) from the Great Slave Lake region (Canada).

Acratia. sp. B aff. sp. 271 *sensu* Braun (1967) (Fig. 4M, N).—A second species of *Acratia* is close to the *Acratia* sp. 271 figured from northeastern Alberta (Canada) by Braun (1967: pl. 3). This species were previously recognized in the Late Frasnian of the Devils Gate section (Casier and Lethiers 1998a).

Acratia sp. C aff. 274 *sensu* Braun (1967) (Fig. 4O).—Some carapaces of *Acratia* may be close to *Acratia* sp. 274 figured from the Great Slave Lake region (Canada) by Braun (1967: pl. 4).

Acratia sp. D aff. *A. paraschelonica* Lethiers, 1974.— A poorly preserved carapace of Podocopina in the lower part of the Frasnian (sample DVG-03-6) presents some affinity with *Acratia parachelonica* Lethiers, 1974, from the Late Frasnian of Belgium.

← Fig. 4. Ostracods from the Frasnian (late *Mesotaxis falsiovalis* to early *Palmatolepis hassi* zones) of the Devils Gate Pass section, Nevada. **A, B**. *Westmontia devilensis* Casier and Lethiers, 1997. **A**. Carapace in dorsal view. Sample DVG21. IRScNB n° b4511. **B**. Carapace in left lateral view. Sample DVG20. IRScNB n° b4512. **C**. Platycopina indet. Carapace in left lateral view. Sample DVG-03-A12. IRScNB n° b4513. **D**. *Plagionephrodes* cf. *medius* (Loranger, 1963). Carapace in right lateral (D$_1$) and dorsal (D$_2$) views. Sample DVG-03-109. IRScNB n° b4514. **E**. *Microcheilinella* sp. A. Carapace in right lateral (E$_1$) and dorsal (E$_2$) views. Sample DVG-03-6. IRScNB n° b4515. **F**. Pachydomellidae? indet. Carapace in right lateral (F$_1$) and dorsal (F$_2$) views. Sample DVG-03-A15. IRScNB n° b4516. **G**. *Elliptocyprites lorangeri* Lethiers, 1981. Carapace in right lateral (G$_1$) and dorsal (G$_2$) views. Sample DVG19a. IRScNB n° b4517. **H**. *Cytherellina* sp. A Carapace in right lateral (H$_1$) and dorsal (H$_2$) views. Sample DVG21a. IRScNB n° b4518. **I**. *Bairdiacypris* cf. *martinae* Casier and Lethiers, 1997. Carapace in right lateral view. Sample DVG20. IRScNB n° b4519. **J**. *Bairdia* sp. A. Carapace in right lateral (J$_1$) and dorsal (J$_2$) views. Sample DVG-03-6. IRScNB n° b4520. **K**. *Bairdia* sp. B. Carapace in right lateral (K$_1$) and dorsal (K$_2$) views. Sample DVG19. IRScNB n° b4521. **L**. *Acratia* sp. A aff. sp. 42 *sensu* Braun (1967). Carapace in right lateral (L$_1$) and dorsal (L$_2$) views. Sample DVG21. IRScNB n° b4522. **M, N**. *Acratia* sp. B aff. sp. 271 *sensu* Braun (1967). **M**. Carapace in right lateral (M$_1$) and dorsal (M$_2$) views. Sample DVG-03-302. IRScNB n° b4523. **N**. Carapace in left lateral view. Sample DVG21. IRScNB n° b4524. **O**. *Acratia* sp. C aff. 274 *sensu* Braun (1967). Carapace in right lateral (O$_1$) and dorsal (O$_2$) views. Sample DVG19. IRScNB n° b4525. **P**. *Cryptophyllus* sp. A aff. sp. 11 *sensu* Braun (1967). Right valve in lateral view. Sample DVG19a. IRScNB n° b4526. Scale bars 200 μm.

Order Eridostraca Adamczak, 1976

Genus *Cryptophyllus* Levinson, 1951

***Cryptophyllus* sp. A aff. sp. 11** *sensu* **Braun (1967)** (Fig. 4P).—This species is represented by a single poorly preserved valve in sample DVG19a.

Palaeoecology of ostracods

(J.-G. Casier and E. Olempska)

Ostracods are generally rare or absent in the lower member of the Devils Gate Limestone (Table 1), unlike the large numbers present in the upper member investigated previously for the study of the Late Frasnian mass extinction (Casier et al. 1996; Casier and Lethiers 1997, 1998a, b). Ostracods of the Devils Gate section belong exclusively to the Eifelian Mega-Assemblage, a substitute for the "Eifelian ecotype" of Becker (in Bandel and Becker 1975), since the term "ecotype" has been improperly used in this case (Casier 2004; Casier et al. 2005). The Eifelian Mega-Assemblage, characterized by the presence of palaeocopid, platycopid, metacopid, podocopid, and more rarely of leperditicopid ostracods and Eridostraca, is indicative of shallow, and generally well-oxygenated environments. The relative proportions of these ostracod groups permit recognition of several assemblages from lagoonal environments to marine environments below storm wave base, which are controlled principally by the energy, the salinity, and the nature of the substrate. Neither ostracods indicative of poorly oxygenated environments (Myodocopid Mega-Assemblage) nor of deep and (or) cold environments (Thuringian Mega-Assemblage) have been observed until now in the Devils Gate section.

At the base of the lower member of the Devils Gate Limestone, and below the 29-cm thick Alamo Event Bed (Sandberg et al. 1997, 2003; Morrow and Sandberg 2006) ostracods are present in 30% of samples with a relative abundance of platycopids that are indicative of very shallow water conditions. Ostracods are abundant only in sample DVG-03-4 collected in the upper part of the late *Mesotaxis fasiovalis* Zone and in sample DVG-03-6 collected probably in the *Palmatolepis transitans* Zone. *Voronina*? *eureka* sp. nov. is virtually the sole species present in the first one. This mono-specificity is indicative of semi-restricted water conditions. Sample DVG-03-6, contains five species of podocopid, three of platycopid and one of palaeocopid ostracods; it is indicative of very shallow marine water conditions. The rarity of ostracods in all other samples indicates shallow semi-restricted water conditions; their absence may indicate very stressful lagoonal conditions. Similarly, conodonts are rare to absent in these beds. Close to the Alamo Event Bed, the rarity of ostracods is probably linked to the high energy of the environment as displayed by the sedimentological analysis.

In the upper part of the lower member of the Devils Gate Limestone, and above the 29-cm-thick Alamo Event Bed, ostracods are present in all the collected samples except for DVG20a. The platycopids, indicative of shallow environments, are relatively abundant and diversified except for sample DVG19. In this last sample, two species, *Serenida dorsoplicata* sp. nov. and *Youngiella* cf. *mica* Rozhdestvenskaja, 1972, dominate the ostracod fauna. However, the presence of several species of podocopid ostracods in all these samples is indicative of strong marine influence. The carbonate platform was always very shallow, becoming progressively more marine.

Conclusions

The lower member of the Devils Gate Limestone comprises six major carbonate microfacies (MF1–MF6) ranging from open-marine environments below the storm wave base level to pre-evaporitic supratidal lagoons. The general environment below the Alamo Event Bed consists of a very shallow carbonate-platform system. The pre-Alamo Event interval is composed of thin bedded cyclic subtidal-supratidal sequences showing a clear shallowing-upward evolution (from MF3–MF4 to MF5–MF6). The waters were oxygenated open marine at the base of the sequences with abundant stromatoporoids, brachiopods, and crinoids (MF3), and became semi-restricted to hypersaline at the top, with numerous *Calcisphaera*, ostracods and cryptalgal mats associated in loferites or dismicrites (MF5–MF6). The environment remained the same above the Alamo Event Bed although the thicker sequences and the less pronounced cyclicity. The Alamo Event affected a semi-restricted lagoon colonized by cryptalgal mats. The event brought into the lagoon coarse, well-rounded quartz grains (0.5 mm) and microbreccia of the same size that were derived from lagoonal settings. Consequently the facies analysis reveals that no important sedimentological changes occurred during the Alamo Event. The environment remained the same (a semi-restricted lagoon), and the input of detrital material and lithoclasts are the only sedimentological records indicating that an unusual event had occurred. A major change occurred later, during the latest part of the *Palmatolepis punctata* conodont Zone where deeper open marine-facies appear with cricoconarides, trilobites, corals, and brachiopods (MF1–MF2).

The ostracod fauna present in the lower member of the Devils Gate Limestone differs from the ostracod fauna discovered by Casier and Lethiers (1998) in the Frasnian part of the upper member of this formation. In the lower member, ostracods exhibit low species diversity and their distribution is greatly influenced by strong salinity variations. The ostracod fauna is generally indicative of very shallow semi-restricted water conditions, and the absence of ostracods in several samples may indicate short term lagoonal conditions. Conversely, in the Frasnian part of the upper member of the Devils Gate Limestone, the rich and more diversified ostracod fauna is always indicative of deeper open-marine environments (Casier and Lethiers 1998).

The rarity and low diversity of ostracods in samples collected from the lower part of the lower member of the Devils Gate Limestone are not to demonstrate whether or not an extinction event occurred close to the Alamo Event Bed. Nevertheless the greater abundance and diversity of ostracods above this bed seems to indicate the absence of extinction in this shallow setting. Ostracods in very shallow semi-restricted water conditions are certainly more adapted to support environmental changes and consequently are maybe less prone to extinction.

The ostracod fauna present in the lower member of the Devils Gate Limestone displays more affinities with faunas described from western Canada (Loranger 1963a, b; Braun 1967; Lethiers 1981) and to a lesser extent to faunas from Bashkiria (Rozhdestvenskaja 1972), than to those from western Europe and North Africa. The study of ostracods present across the Frasnian–Famennian boundary has shown extensive exchanges, with or without speciation, between Nevada and the Russian Platform via the Western Canadian platform (Casier and Lethiers 1998b). The absence of ostracod exchange between the Paleotethys and the Panthalassa may indicate that the collision of Laurussia and Gondwana (Avalon Terrane) along the Appalachian–Eovariscan belt was in progress.

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Appendix 1

Ostracod taxa, Devils Gate section, lower part of the *Palmatolepis linguiformis* Zone (samples a–k,1–2 in Casier and Lethiers 1998a: fig. 2).

Kozlowskiella lazarei Casier and Lethiers, 1998; *Amphissites sandbergi* Casier and Lethiers, 1998; *Villozona*? sp. A; *Scrobicula*? sp. A; *Aparchites* sp. A; *Saccelatia kakisaensis* Lethiers, 1981; "*Gravia*" sp. A; *Coryellina* sp. A; *Samarella*? sp. A; *S.*? sp. B; *Knoxiella*? *rauseri* (Tschigova, 1977); *K.* sp. A; *K.* sp. B; *Westmontia devilensis* Casier and Lethiers, 1998; *Youngiella* cf. *mica* Rozhdestvenskaja, 1972; *Eriella*? sp.; *Plagionephrodes* sp. 234 Braun 1968; *P.*? sp. A aff. ostracode indet. B *sensu* Duffield and Warshauer, 1981; *P.* sp. B aff. *P. albertensis* Loranger, 1954; *Sulcella* (*S.*) *ajensis* (Rozhdestvenskaja, 1972); *Cytherellina* sp. A; *Praepilatina* cf. *truncatiformis* (Zanina and Buschmina, 1968 in Buschmina 1968); *Bekena* sp. A aff. *B. aksakovaensis* Rozhdestvenskaja, 1972; *Elliptocyprites lorangeri* Lethiers, 1981; *Bairdiocypris* sp. A *sensu* Casier and Lethiers, 1998; *B.* sp. A; *Bairdiocypris* cf. *intrepida* Loranger, 1963; *Ampuloides* sp. indet.; *Decoranewsomites angelicus* Casier and Lethiers, 1998; *Micronewsomites natus* (Rozhdestvenskaja, 1972); *Microcheilinella* cf. *peculiaris* Rozhdestvenskaja and Netchaeva, 1972, in Rozhdestvenskaja (1972); *M.* sp. 93 Braun, 1968; *Acratia nevadaensis* Casier and Lethiers, 1998; *A. mayselae* Egorov, 1953; *A.* cf. *evlanensis* Egorov, 1953; *A.* sp. A aff. *A. silincula* Polenova, 1953; *A.* sp. A aff. *A. matura* (Loranger, 1963) *sensu* Braun, 1968; *A.* sp. B aff. *A. paraschelonica* Lethiers, 1974; *A.* sp. A aff. *A. pskovensis* Egorov, 1953; *Famenella*? sp. A; *Bairdia proximischimensis* Casier and Lethiers, 1998; *B. altodorsualis* Casier and Lethiers, 1998; *B. pintoensis* Casier and Lethiers, 1998; *B.* cf. *philippovae* Egorov, 1953; *B.* cf. *sokolovi* Egorov, 1953; *B.* sp. C aff. *B. multispinosa* Rozhdestvenskaja, 1972; *B. nalivkini* Egorov, 1953; *B.* cf. *fabaeformis* Polenova, 1953, *sensu* Lethiers (1981); *B.* sp. 14 Braun, 1968; *Bairdiacypris martinae* Casier and Lethiers, 1998; *B. anteroangulosa* Casier and Lethiers, 1998; *B. quarziana* (Egorov, 1953); *B.* sp. A aff. *B. zigulensis* (Polenova, 1953); *B.* cf. *irregularis* (Polenova, 1953); *B.* sp. indet.; *Monoceratina*? sp. A.

Appendix 2

Ostracod taxa, Devils Gate section, *Palmatolepis linguiformis* Zone (samples l–m in Casier and Lethiers 1998a: fig. 2).

Kozlowskiella lazarei Casier and Lethiers, 1998; *K.* sp. A Casier and Lethiers, 1998; *Milanovskya* sp. A aff. sp. 10 Braun, 1968; *Amphissites sandbergi* Casier and Lethiers, 1998; "*Gravia*" sp. A; *Coelonella*? sp. A Lethiers and Casier, 1996a; *Knoxiella*? *rauseri* (Tschigova, 1977); *Youngiella* cf. *mica* Rozhdestvenskaja, 1972; *Eriella*? sp.; *Healdianella*? sp. *sensu* Lethiers and Casier, 1996; *Praepilatina*? sp. indet.; *Microcheilinella* cf. *peculiaris* Rozhdestvenskaja and Netchaeva, 1972, in Rozhdestvenskaja (1972); *Acratia* aff. *A. gruendeli* Rozhdestvenskaja, 1972; *A. schelonica* Egorov, 1953; *A. nevadaensis* Casier and Lethiers, 1998; *Famenella* sp. B; *Bairdia proximischimensis* Casier and Lethiers, 1998; *B. altodorsualis* Casier and Lethiers, 1998; *B. pintoensis* Casier and Lethiers, 1998; *B.* cf. *kelleri* Egorov, 1953; *Bairdiacypris martinae* Casier and Lethiers, 1998; *B. quarziana* (Egorov, 1953); *B.* cf. sp. C *sensu* Lethiers, 1981; *B.* sp. indet.