

Late Permian (Changsingian) ostracods of the Bellerophon Formation at Seis (Siusi) (Dolomites, Italy)

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ABSTRACT – Ostracod assemblages of the Upper Permian Bellerophon Formation at Seis near Bozen (South Tyrol, Italy) have been studied with respect to their taxonomy and palaeoecology. The investigations were concentrated on the Late Changsingian Casera Razzo Member which yielded five ostracod assemblages including more than twenty-four species. Twelve of these species are described herein and four species are new, including two species with strong affinity to taxa appearing in the Early Triassic. The lithofacies characteristics and low species diversity are suggestive of a protected shallow lagoonal environment with salinity fluctuations due to freshwater influx. Only four species are recorded from Late Permian localities outside of the Dolomites. This is due to the restricted environmental conditions which inhibited the immigration of more taxa from open shelf environments. *J. Micropalaeontol.* 31(1): 73–87, February 2012.

KEYWORDS: *Ostracods, Late Permian, palaeoecology, palaeosalinity, Bellerophon Formation, Dolomites*

INTRODUCTION

During the last decade ostracods from the Upper Permian and Lower Triassic have been reported from several sections in various parts of the world (e.g. Crasquin-Soleau *et al.*, 1999; 2004; 2005; Crasquin-Soleau & Kershaw, 2005; Crasquin *et al.*, 2010a, b). Due to these studies the patterns of extinction and recovery of ostracods during the Permian/Triassic biotic crisis is understood much better now than it was a few years ago. Although the Bellerophon Formation had been the subject of intensive palaeontological research on various fossil groups, particularly with respect to the forminifera, there was very little known about the ostracods of this formation. Ostracods from the Bellerophon Formation were documented for the first time by Pasini (1981). The first detailed analysis of Late Permian and Early Triassic age ostracods from the uppermost part of the Bellerophon Formation and the lowermost Triassic part of the Werfen Formation was published by Crasquin *et al.* (2008). In the present study ostracods from a stratigraphically lower part of the Bellerophon Formation are described. Besides the species documented herein, there occur a number of other ostracod species which are not included here because of poor preservation and insufficient material. This suggests that the Bellerophon Formation may yield a greater number of hitherto unknown species.

STRATIGRAPHY AND FACIES

The Bellerophon Formation is an Upper Permian succession of fossiliferous limestones, dolomites, siltstones, sandstones, shales and evaporites indicative of shallow-marine, lagoonal and marginal-marine environments. It is distributed in the southern Alps from the Etschtal (western Dolomites) in the west to the Karawanken Mountains in the east. Evaporitic and dolomitic sediments which constitute the lower part of the formation are traditionally called the ‘Fiemazza Facies’. Dark-grey fossiliferous carbonates, deposited in shallow-marine and lagoonal environments of a broad and gently eastward-tilted carbonate ramp (Bosellini & Hardie, 1973; Noé, 1987) occur in the upper part of the formation and are known as the ‘Badiota Facies’ (Accordi, 1957). According to subsequent research (Farabegoli *et al.*, 1986; 2007) the upper Bellerophon Formation is subdivided into three lithostratigraphical

units: the Casera Razzo Member, ‘Ostracod unit’ and Bulla Member. The exact biostratigraphical age of these units has always been a matter of discussion due to the extreme scarcity of conodonts and absence of ammonoids. At present the upper part of the Bellerophon Formation is dated by means of palynomorphs and a few conodonts that suggest a late Changsingian age (Pittau, 2001; Farabegoli *et al.*, 2007).

The ostracods described here were recovered from an outcrop of the Casera Razzo Member in a gorge along the Weissenbach River (Rio Bianco) south of Seis (Siusi) (Fig. 1). The section consists of dark-grey fossiliferous wacke- and packstones (‘Badiota facies’) intercalated with marls, siltstones and fine-grained sandstones. According to Farabegoli *et al.* (2007) its thickness increases greatly from 12 m in the western Dolomites to more than 150 m in the Carnic Alps. In contrast to these data the Casera Razzo Member at Seis shows a total thickness of only 9 m. At this outcrop the member consists of two lithostratigraphical units (parasequences 1 and 2) reflecting minor sea-level fluctuations (Fig. 2).

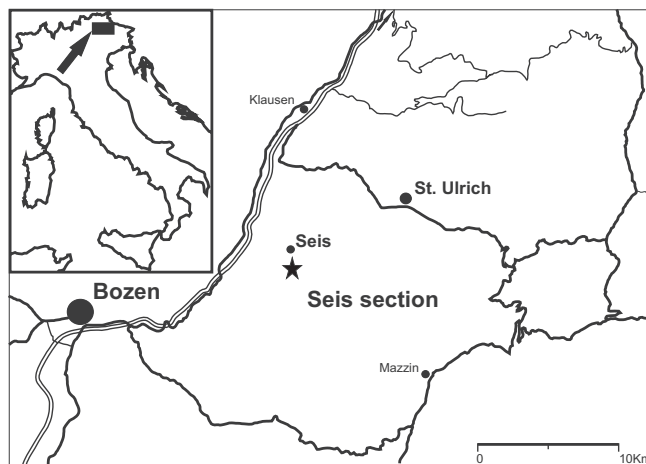


Fig. 1. Location of Seis section.

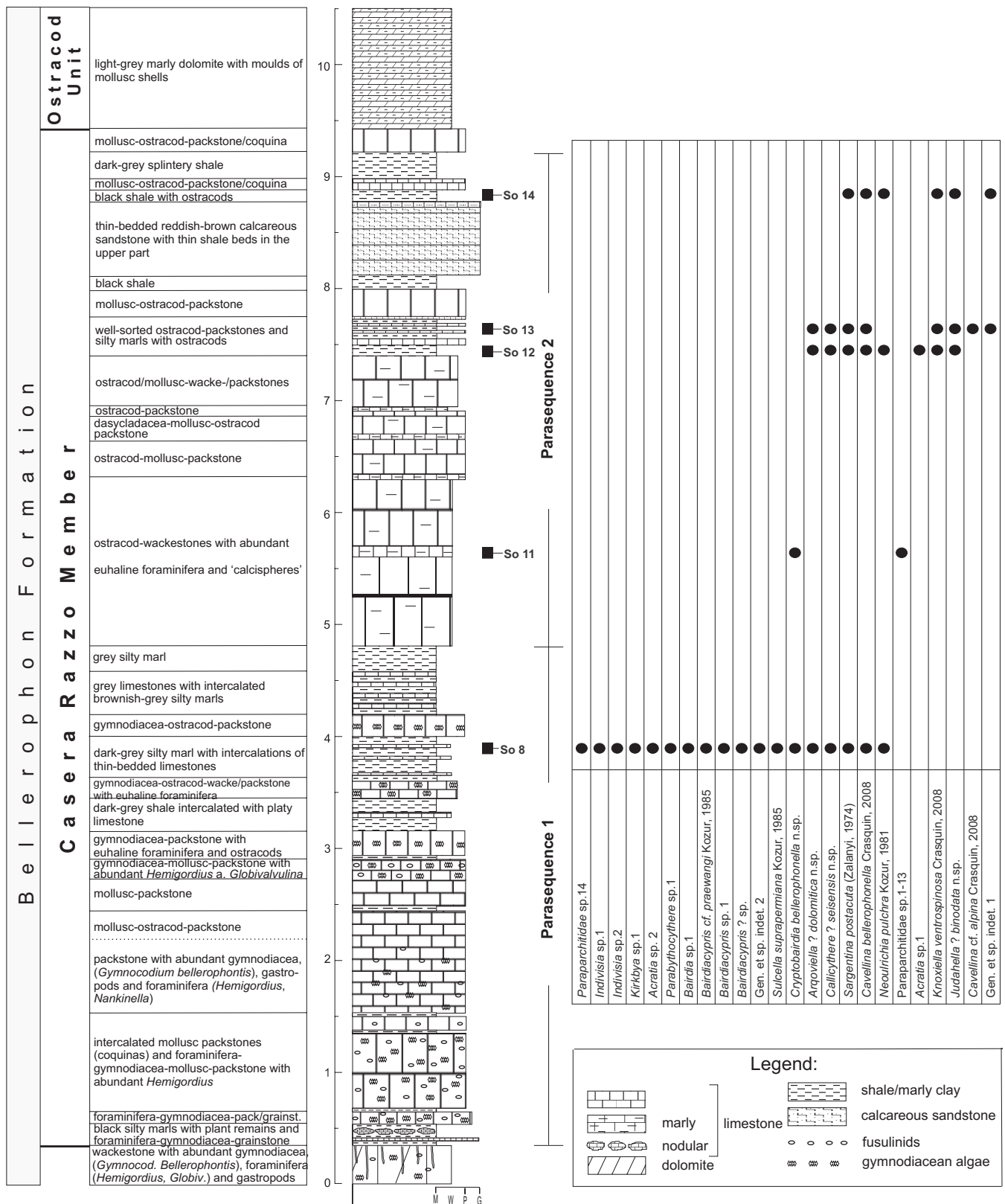


Fig. 2. Stratigraphy, facies and ostracods of the upper Bellerophon Formation (Casera Razzo Member) at Seis section.

Both units start with thick-bedded to massive packstones and wackestones rich in euryhaline and euhaline foraminifera (*Hemigordius*, *Nankinella*, *Globivalvulina* amongst others) and calcareous algae (*Gymnocodium bellerophonensis*, dasycladacean algae). In the upper part of the parasequences the shallow-marine carbonates with euhaline foraminifera are followed upsection by packstones and coquinas of monotypic fossil assemblages (molluscs, ostracods, gymmodiacean algae) intercalated with dark-grey and black shales and marls, indicative of restricted conditions. The shales contain abundant microconchids (*Microconchus*) which are known as eurytopic organisms (Vinn, 2010). Abundant fragments of coalified wood and other plant remains in the upper parts of parasequences 1 and 2 suggest freshwater influx and periods of hypohaline conditions which are also indicated by the disappearance of euhaline foraminifera. Increased input of terrestrial organic matter in the upper parts of parasequences 1 and 2 is also reflected by a ^{13}C -enriched organic carbon isotope signature because Permian wood shows higher carbon isotope values than coeval marine organic matter (Siegert *et al.*, 2011). It is, therefore, supposed that the benthic communities were strongly controlled by salinity variations. Environmental perturbations due to oxygen deficiency seem unlikely because lamination or framboidal pyrite does not occur. Most of the ostracods described herein were recovered from the shales (samples 8, 12, 13, 14) in the upper parts of parasequences 1 and 2. The ostracods of sample 11 are from a marly limestone horizon intercalated in thick-bedded fossiliferous wackestones of the lower parasequence 2. This assemblage consists almost exclusively of Paraparchitidae, representing at least 13 species which are documented on Plate 1. These species are not described here and left under open nomenclature due to strong recrystallization and deformation of the carapaces and valves. The palaeoenvironments and palaeoecology of the ostracod assemblages from different sections of the upper Bellerophon Formation are currently being studied. Preliminary results of this analysis are presented below.

PALAEOECOLOGICAL AND PALAEOBIOGEOGRAPHICAL ASPECTS

General remarks on ostracod taphonomy

Autochthonous and allochthonous ostracod assemblages can be differentiated by means of population age structure analysis (Whatley, 1983a, b; 1988; Boomer *et al.*, 2003). The latter authors pointed out that autochthonous low- to moderate-energy assemblages are characterized by the presence of adults and abundant instars of at least four moult stages, while allochthonous high-energy assemblages include only adult specimens and the largest instars. This method is, however, only practicable with well-preserved material because the valves and carapaces of juveniles are usually more easily destroyed during burial and diagenesis than the thicker-shelled adults specimens.

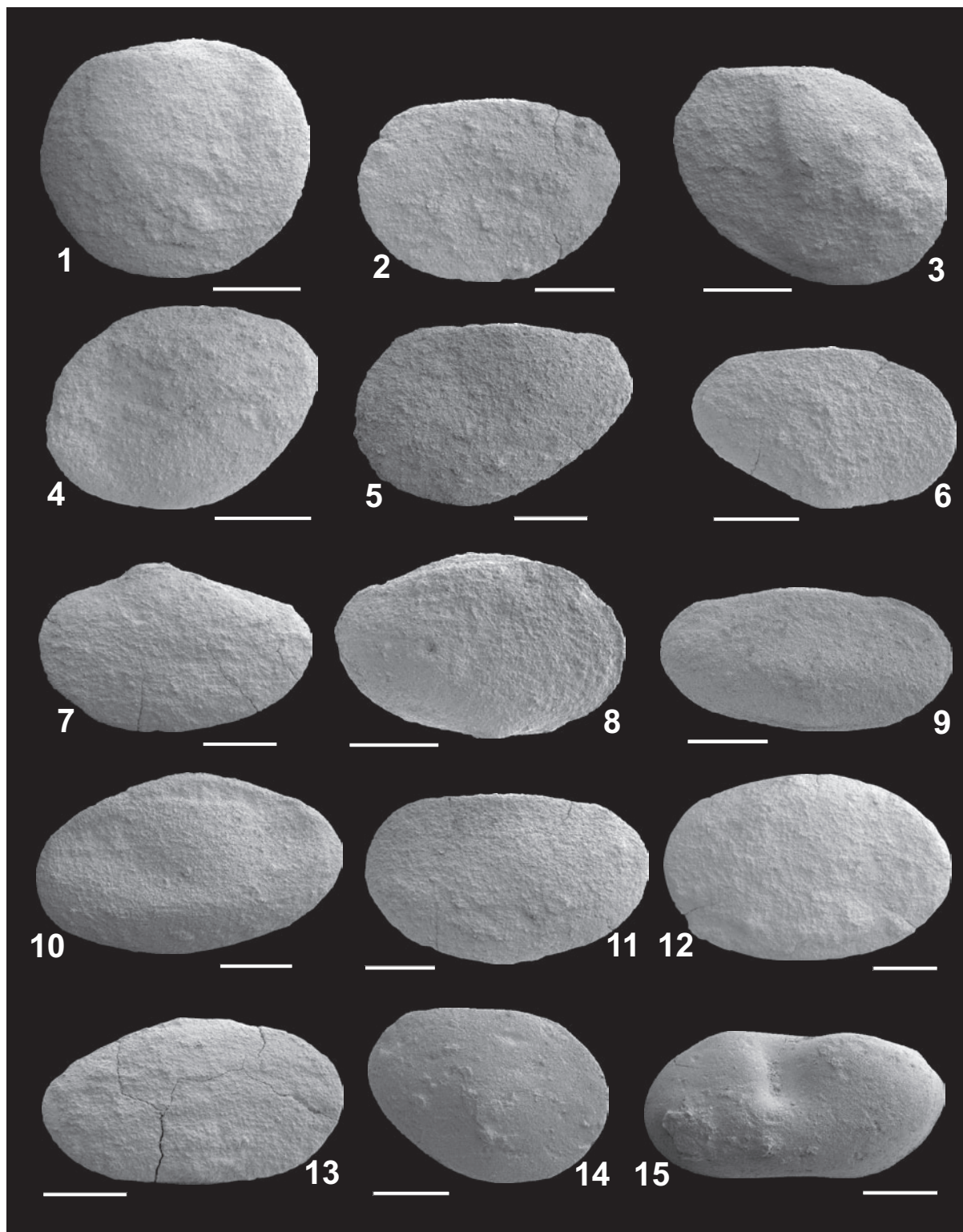
An additional tool for the differentiation of autochthonous and allochthonous ostracod assemblages, which can also be used for poorly preserved material, is the valve/carapace ratio (v/c ratio). The v/c ratio of fossil ostracod assemblages is controlled by the intensity and duration of various pre- and post-burial processes. The most important factors include pre-burial bacterial decomposition of organic matter, activity of scavengers and mechanical disarticulation during transport. But post-burial processes, such as bioturbation, post-burial bacterial activity and early diagenetic

lithification, may also play an important role in disarticulation. The significance of these post-burial disarticulation processes has, however, not yet been studied. Kilenyi (1971a, b) reported that different ostracod taxa of Recent assemblages show very different resistance to disarticulation processes. Whatley (1988) pointed out that these differences are probably due to different strengths of hinge structures, overlap and even different physiological post-mortem processes (relaxation or contraction of the adductor muscle). As noted by Boomer *et al.* (2003), the mode of life (infaunal, epifaunal) may also considerably control the ostracod disarticulation rate of fossil ostracod assemblages. It is, therefore, recommended to compare only v/c ratios of single species or closely related taxa with a similar mode of life.

It is generally suggested that pre-burial biotic and abiotic processes are most important for the ostracod disarticulation and that the relative abundance of valves and carapaces in ostracod assemblages is controlled primarily by burial rate and water turbulence. A positive correlation between sedimentary rate and abundance of carapaces has been outlined by Oertli (1971). The v/c ratio may, therefore, yield important information about depositional conditions. Boomer *et al.* (2003) pointed out that low-energy autochthonous ostracod assemblages ('low-energy thanatocoenosis') are usually characterized by a relative high abundance of carapaces, while high-energy allochthonous assemblages ('high-energy taphocoenosis') show generally a predominance of valves. Detailed quantitative data of the range of v/c ratios in different depositional environments are, however, not available in the literature.

Taphonomy of the ostracods from Seis

The present ostracod assemblages have not been analysed with respect to their population age structure because of fragmentation and dissolution, particularly in samples 8 and 14. The assemblages of samples 8, 12 and 13 (Fig. 3) are, however, suggested to be more or less autochthonous because they include a significant proportion of smaller instars. Furthermore, the species of these assemblages show a relatively high percentage of carapaces (average v/c: 0.46 to 1.16). The v/c ratio of *Cavellina bellerophonella* Crasquin, 2008 ranges between 0.65 (sample 12) and 1.02 (sample 13). *Callicythere? seisisensis* n. sp. and *Arqoviella? dolomitica* n. sp. are almost exclusively represented by carapaces. Assemblages 8 and 12 include abundant shells of encrusting organisms (microconchids) which may reflect a relatively low sedimentation rate. In contrast to assemblages 8, 12 and 13 the ostracods of sample 14 are almost exclusively represented by single valves (v/c of *Cavellina bellerophonella* Crasquin, 2008: 33.3) which suggests that this assemblage has been post-mortally transported. Most of the shells (more than 90%) are broken, which points to high water turbulence, probably due to a storm event. Such a storm event is recorded in the overlying mollusc/ostracod coquina (Fig. 2). Assemblage 14 shows no indications of a low burial rate, such as encrustation, bioerosion or reworking. Since the taxonomic composition of assemblage 14 is almost identical to assemblages 12 and 13 and the relative abundance is also similar, there was probably no transport over long distances and mixing of taxa from different environments. Long-distance transport would probably have separated the species due to different hydrodynamic properties of their valves. The present composition of the ostracod assemblages is thus regarded as indicative of the palaeoenvironmental conditions. A time-averaging of ostracod populations cannot be excluded,



Explanation of Plate 1.

figs 1–14. Paraparchitidae gen. et sp. indet. (sp. 1–13: sample 11): **1**, sp. 1, carapace, lateral view, S11-1, 6; **2**, sp. 2, left valve, S11-2, 4; **3**, sp. 3, carapace, right lateral view, S11-3, 15; **4**, sp. 4, carapace, left lateral view, S11-2, 9; **5**, sp. 5, carapace, left lateral view, S11-2, 11; **6**, sp. 6, right valve, S11-2, 7; **7**, sp. 7, left valve, S11-3, 9; **8**, sp. 8, carapace, right lateral view, S11-1, 1; **9**, sp. 9, carapace, right lateral view, S11-2, 9; **10**, sp. 10, carapace, left lateral view, S11-4, 10; **11**, sp. 11, left valve, S11-1, 12; **12**, sp. 12, carapace, left lateral view, S11-4, 2; **13**, sp. 13, right valve, S11-3, 12; **14**, sp. 14, right valve, sample 8, S8-23. **fig. 15.** *Sargentina postacuta* (Zalányi, 1974), left valve, sample 12, S12/11-4, 45. Scale bar: figs 1–13, 400 µm; figs 14, 15, 200 µm.

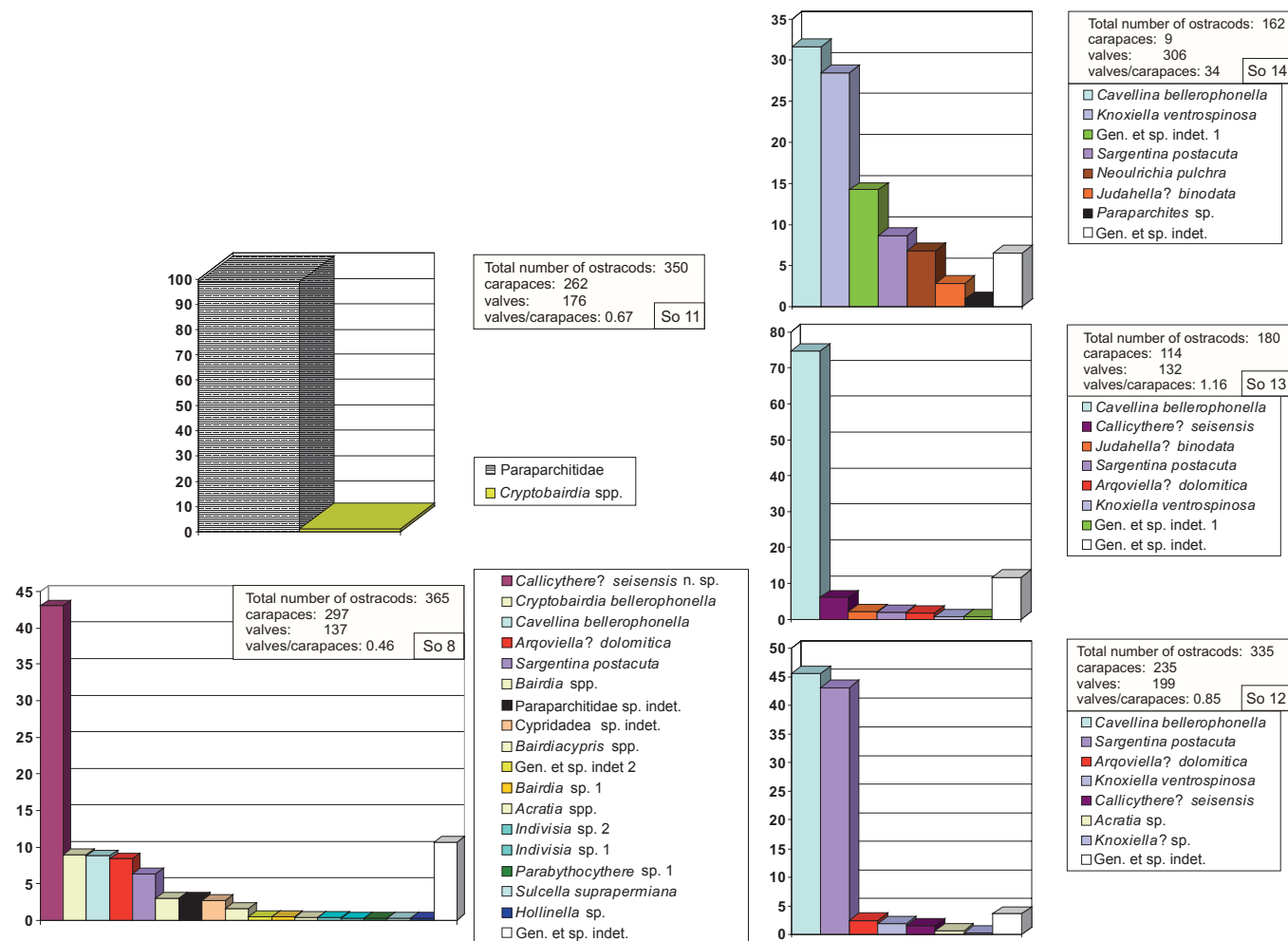


Fig. 3. Relative abundance (%) of species in the ostracod assemblages (valves are counted as 0.5 specimen; species which represent less than 0.2% are not listed).

however, which means that the composition of the assemblages may reflect average palaeoecological conditions of a longer period.

Palaeoenvironment and palaeobiogeography

Although the lithofacies characteristics of the Casera Razzo Member at Seis section described above suggest a restricted palaeoenvironment with freshwater influx and, hence, salinity fluctuations in the upper part of the two parasequences, the ostracod taxa extracted from these intervals do not include taxa which are clearly indicative of strong brackish to freshwater conditions, such as *Darwinula* or *Carbonita*. Preliminary results of a quantitative analysis (Fig. 3) suggest that only minor salinity fluctuations occurred. The assemblage of sample 8 shows a relatively high species diversity (18 species) and a significant percentage of Bairdioidea, which may be interpreted, therefore, as a normal marine fauna. The strong dominance of *Callicythere? seisisensis* n. sp. indicates, however, that the environment was not constantly normal marine but periods of unfavourable conditions occurred. Compared to sample 8 the assemblages of samples 12, 13 and 14 show a relatively low species diversity (6–8 species) and are

dominated by one or two species (*Cavellina bellerophonella* Crasquin, 2008, *Sargentina postacuta* (Zalanyi, 1974), *Knoxiella ventrospinosa* Crasquin, 2008, *Callicythere? seisisensis* n. sp.), which may reflect a greater environmental instability. This interpretation is corroborated by the occurrence of *C. bellerophonella*, *S. postacuta*, *K. ventrospinosa* and *C.? seisisensis* in the overlying ‘Ostracod unit’ (Crasquin *et al.*, 2008), which was certainly deposited in a marginal marine (peritidal) environment, characterized by dolomitic mud-/wackestones with mudcracks and root traces. Crasquin *et al.* (2008) concluded from the high dominance of *C. bellerophonella* and *S. postacuta* that these species were eurytopic taxa with a greater tolerance to adverse environmental conditions (salinity variations, oxygen deficiency). Since the lithofacies characteristics of the Casera Razzo Member are not indicative of periods with anoxic conditions it seems, therefore, most likely that the ecological stress was actually due to salinity fluctuations. This interpretation is also supported by the fact that several Kloedenelloid genera, such as *Cavellina* and *Knoxiella*, include species which were particularly abundant in marginal-marine palaeoenvironments of the Late Palaeozoic and are thus

interpreted as marine euryhaline taxa (Williams *et al.*, 2006; Bennett, 2008). The ostracod assemblages of the Casera Razzo Member differ significantly from the assemblages of the overlying Bulla Member (Crasquin *et al.*, 2008). The latter unit shows a much higher taxonomic diversity due to the transgressive character of this unit which is also reflected by the high diversity of foraminifera, brachiopods and algae (Farabegoli *et al.*, 2007).

The ostracod assemblage of sample 11 is totally different from the other assemblages because it consists almost exclusively (more than 95%) of different species of the Paraparchitidae (Fig. 3). The species are relatively large, thick-shelled, without spines and mostly (60%) preserved as carapaces (Pl. 1). The rest of the fauna is represented by poorly preserved specimens of *Cryptobairdia bellerophonella* n. sp. The palaeoecology of the Paraparchitidae has been extensively studied in the Late Devonian and Carboniferous of Belgium and surrounding areas (Bless, 1983; Bless *et al.*, 1987; Becker & Bless, 1990). According to their results the Paraparchitidae include many euryhaline taxa and their environmental distribution was largely controlled by physical factors. Large Paraparchitidae without spines are the most common ostracods in the eulitoral zone. Considering the presence of only a few Bairdioidea in the present material it seems most likely that the assemblage of sample 11 was deposited in a nearshore environment which was transitional between the turbulent eulitoral and the shallow sublittoral zone. Smaller instars are very rare which points to a relatively high water turbulence and post-mortem transportation of the smaller specimens. Since the assemblage includes a high percentage of carapaces an autochthonous deposition in combination with rapid burial seems probable and it may thus be interpreted as a 'high-energy thanatocoenosis' (*sensu* Boomer *et al.*, 2003).

The 24 species recorded from the Casera Razzo Member include only four species (or 17%) which are also known from, or related to species of other localities outside of the Dolomites. These are: *Bairdicypris* cf. *praewangi* Kozur, 1985; *Sulcella suprapermiana* Kozur, 1985; *Sargentina postacuta* (Zalanyi, 1974) and *Neoulrichia pulchra* Kozur, 1981. These four species reflect palaeobiogeographical links to the Late Permian of Hungary (Bükk Mountains) (Kozur, 1985a, b). But only one of the present species (*Sulcella suprapermiana* Kozur, 1985) is recorded from the Upper Permian of Serbia (Crasquin *et al.*, 2010b). The 'endemic' faunal character can be explained by the instability of environmental conditions in the Casera Razzo Member, which inhibited the immigration of faunal elements from the open-marine areas of the Tethys. This conclusion is supported by the much higher percentage (33%) of immigrant species in the assemblages of the transgressive Bulla Member (Crasquin *et al.*, 2008).

MATERIAL

The holotypes and paratypes are housed at the Institute of Geology and Palaeontology at Innsbruck University under the number Me 2010.

SYSTEMATIC DESCRIPTIONS

The following abbreviations are used: L, length; H, height; W, width. 'Dimensions' include the maximum and minimum values of length, height and width of the present specimens.

Class **Ostracoda** Latreille, 1802
Order **Palaeocopida** Henningsmoen, 1953
Superfamily **Kirkbyoidea** Ulrich & Bassler, 1906
Family **Kirkbyidae** Ulrich & Bassler, 1906
Genus *Kirkbya* Jones, 1859

Kirkbya sp. 1
(Pl. 2, fig. 4)

?2008 *Kirkbya* cf. *buekkensis* Kozur, 1985: Crasquin *et al.*, pl. 1, fig. 18.

Material. 2 carapaces.

Stratigraphic and geographical range. Upper Bellerophon Fm., Casera Razzo Member (sample 8), late Changsingian, Seis (Siusi) section, South Tyrol, Italy. ?Upper Bellerophon Formation, Bulla Member, late Changsingian, Pufels (Bulla) section, South Tyrol, Italy (Crasquin *et al.*, 2008).

Remarks. The specimens probably represent a new species but it is left in open nomenclature because of insufficient material. In lateral view the species shows an elongate subrectangular carapace outline with a straight ventral margin. The posterior part of the dorsal margin is slightly inclined towards the posterior end. In dorsal view the carapace is very weakly convex and not inflated laterally. Parallel to the anterior, ventral and posterior margin run two narrow and shallow ribs. These marginal ribs converge at the anterior and posterior cardinal angles into a narrow and shallow dorsal rib. The lateral surface shows an irregular reticulation and, in the central part, very weakly developed longitudinal ribs which are slightly inclined towards the anterior margin. The kirkbyan pit is small and shallow.

The present material may belong to the same species as *Kirkbya* cf. *buekkensis* Kozur, 1985 in Crasquin *et al.* (2008). The latter species was, however, not described in the text and documented by only one incomplete carapace. *Kirkbya* sp. 1 differs from the other species of *Kirkbya* in the type of ornamentation, very narrow and low marginal ribs and narrow carapace outline in dorsal view.

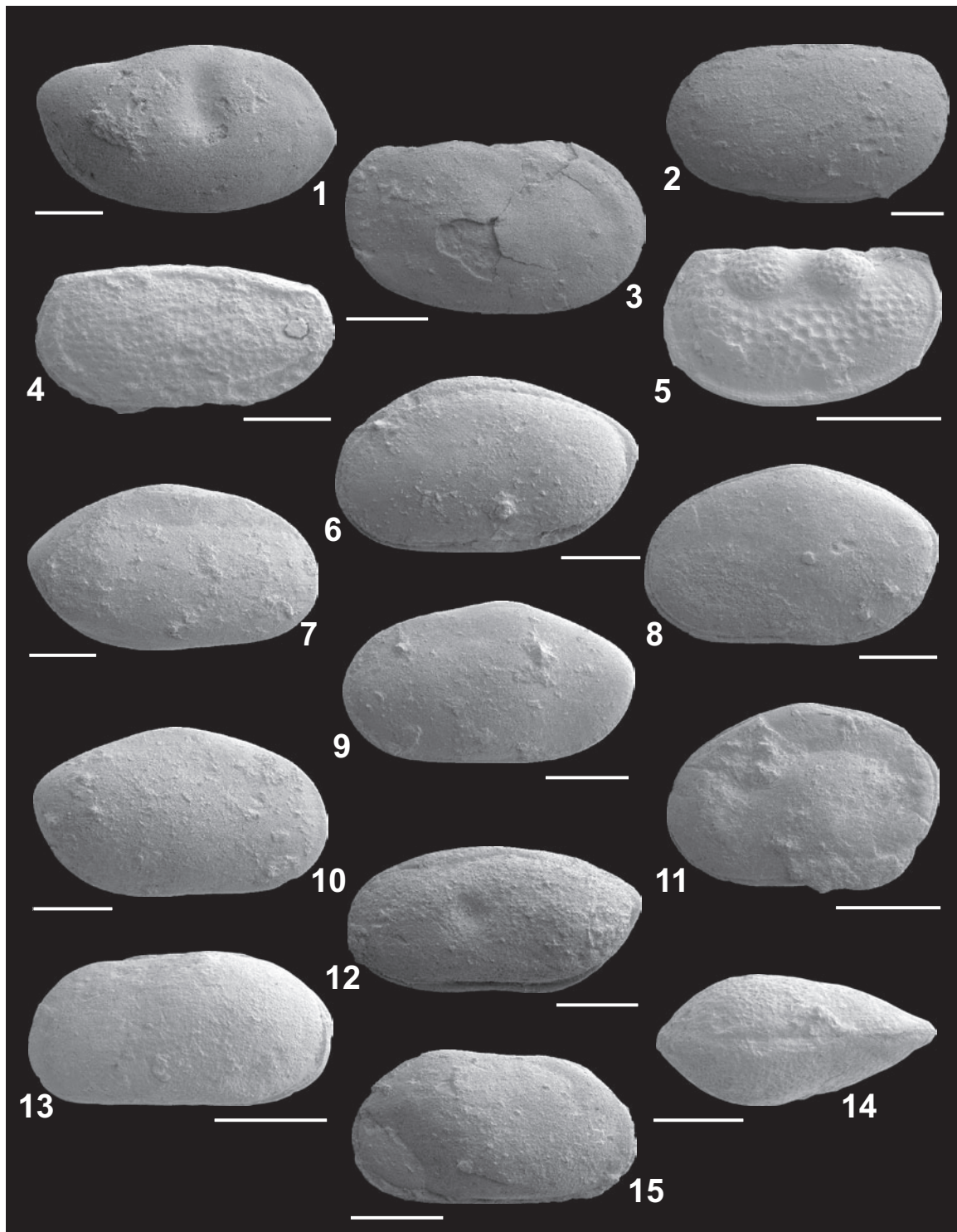
Order **Podocopida** Müller, 1894
Suborder **Platycopina** Sars, 1866
Superfamily **Kloedenelloidea** Ulrich & Basler, 1908
Family **Cavellinidae** Egorov, 1950
Genus *Cavellina* Coryell, 1928

Cavellina bellerophonella Crasquin, 2008
(Pl. 2, figs 6–10)

2008 *Cavellina bellerophonella* Crasquin n. sp.: Crasquin *et al.*, 2008, p. 254, pl. 6, figs 3–7.

Material. More than 233 carapaces and 279 valves.

Stratigraphic and geographical range. Upper Bellerophon Formation, 'Ostracod unit', late Changsingian, Pufels (Bulla) section, South Tyrol, Italy (Crasquin *et al.*, 2008). Upper Bellerophon Formation, Casera Razzo Member (samples 8, 12, 13, 14), late Changsingian, Seis (Siusi) section, South Tyrol, Italy.



Explanation of Plate 2.

fig. 1. *Sargentina postacuta* (Zalányi, 1974), right valve, sample 12, S12/11-4, 46. **fig. 2.** *Indivisia* sp. 1, carapace, left lateral view, sample 8, S8-35. **fig. 3.** *Indivisia* sp. 2, right valve, sample 8, S8-37. **fig. 4.** *Kirkbya* sp. 1, carapace, left lateral view, sample 8, S8-34. **fig. 5.** *Neoulrichia pulchra* Kozur, 1981, left valve, sample 14, S14/11-5, 22. **figs 6–10.** *Cavellina bellerophonella* Crasquin, 2008: **6**, female carapace, left lateral view, sample 12, S12/11-4, 16; **7**, female right valve, sample 12, S12/11-4, 17; **8**, male carapace, left lateral view, sample 13, S13/11-4, 20; **9**, male left valve, sample 12, S12/11-4, 13; **10**, female right valve, sample 12, S12/11-4, 14. **fig. 11.** *Cavellina* cf. *alpina*, Crasquin, 2008, carapace, left lateral view, sample 13, S13/11-5, 6. **fig. 12.** *Sulcella suprapermiana* Kozur, 1985, male carapace, left lateral view, sample 8, S8-14. **figs 13–15.** *Callicythere? seisensis* n. sp.: **13**, holotype, female carapace, left lateral view, sample 13, S13/11-5, 26; **14**, female carapace, dorsal view, sample 13, S13/11-5, 25; **15**, female carapace, right lateral view, sample 8, S8/11-5, 29. Scale bar 200 µm.

Remarks. The female specimens differ from the males in the posterior swelling of the carapace and in the shape of the dorsal border. Both valves of the male carapaces show an angulation of the dorsal border at or just behind mid-length. In the females the dorsal border of the left valve is evenly convex or gently angled at mid-length and the right valve does not show an angulation at the dorsal border. The posterior margin is angled at or just above mid-height; this angulation is particularly distinct in the right valve.

The present specimens show a higher maximum carapace size (0.94 mm) and a slightly higher maximum height/length ratio (0.64) than those specimens of *Cavellina bellerophonella* which were recorded from the 'Ostracod unit' of the Pufels section (Crasquin-Soleau *et al.*, 2008). These minor differences are regarded as intraspecific variability. *C. bellerophonella* is suggested to be a descendant of *Cavellina visnoyensis* Kozur, 1985 from the Middle Permian of Hungary (Kozur, 1985a) which differs in the higher length/height ratio and occurrence of a shallow subdorsal carapace depression on the left valve.

Family Indivisiidae Egorov, 1954
Genus *Indivisia* Zaspelova, 1953

Indivisia sp. 1
(Pl. 2, fig. 2)

Material. 1 carapace.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (sample 8), late Changsingian, Seis (Siusi) section, South Tyrol, Italy.

Remarks. A characteristic feature of the present specimen is the subovate outline of the carapace in lateral view with an obtuse posterior cardinal angle and a rounded anterodorsal margin. The anterior margin is symmetrical and more narrowly rounded than the posterior margin which is slightly flattened in the posteroventral part. The ventral margin is slightly convex and the maximum height is located in the posterior portion of the carapace, just behind the middle. There is no median sulcus and no ornamentation on the lateral surface. With regard to the carapace shape *Indivisia* sp. 1 is comparable to *Indivisia symmetrica* Kozur, 1985 but can be distinguished from that species by the much greater carapace size and the asymmetrically rounded posterior margin. *Indivisia* cf. *symmetrica* Kozur in Crasquin *et al.* (2010b) is also much smaller and shows a flattened posterior and asymmetrical anterior margin. Compared to *Indivisia pelikani* Kozur, 1985 the present specimen differs clearly in the subovate lateral outline, particularly the different shape of the anterior and posterior margins. The species which was documented as '*Indivisia symmetrica* Kozur, 1985' in Crasquin *et al.* (2010a) is more similar to the present specimen but also of much smaller size. Another comparable species is the Lower Permian *Indivisia nuzhencevi* Kotchetkova, 1972 (in Kotchetkova & Gusseva, 1972). It is particularly similar in lateral view but, in contrast to the latter species, *Indivisia* sp. 1 has a more obtuse posterior cardinal angle and its dorsal margin is not incised.

Indivisia sp. 2
(Pl. 2, fig. 3)

Material. 3 valves.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (sample 8), late Changsingian, Seis (Siusi) section, South Tyrol, Italy.

Remarks. This species shows a distinct posterior cardinal angle, a gently convex ventral margin with the greatest height located before the middle. The anterior margin is strongly convex and almost symmetrically rounded while the posterior margin shows a much more asymmetrical convexity. It is most similar to *Indivisia pelikani* Kozur, 1985 from which *Indivisia* sp. 2 can be distinguished by the gently convex ventral margin. Another important difference is the oblique posterior margin of *I. pelikani* Kozur, 1985.

Suborder Podocopina Sars, 1866
Superfamily Bairdioidea Sars, 1888
Family Bairdiidae Sars, 1888
Genus *Bairdia* M'Coy, 1844

Bairdia sp. 1
(Pl. 4, figs 4–5)

Material. 4 left valves, 1 right valve.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (sample 8), late Changsingian, Seis (Siusi) section, South Tyrol, Italy.

Remarks. *Bairdia* sp. 1 is characterized by a distinct angulation of the left dorsal margin and its bipartition into a gently inclined anterior part and a more strongly inclined posterior part. The left posterior margin is very narrowly rounded. In lateral outline the present species is reminiscent of *Truncobairdia beaglensis* Jones, 1970 from the Lower Triassic of Western Australia but the present species lacks the truncation of the posterior end and the right valve is different in lateral outline. *Bairdia* sp. 1 differs from the other species of *Bairdia* in the conspicuous lateral outline of the left valve and is, therefore, regarded as a new species. It is left in open nomenclature due to insufficient material.

Genus *Cryptobairdia* Sohn, 1960

Cryptobairdia bellerophonella n. sp.
(Pl. 4, figs 6–9)

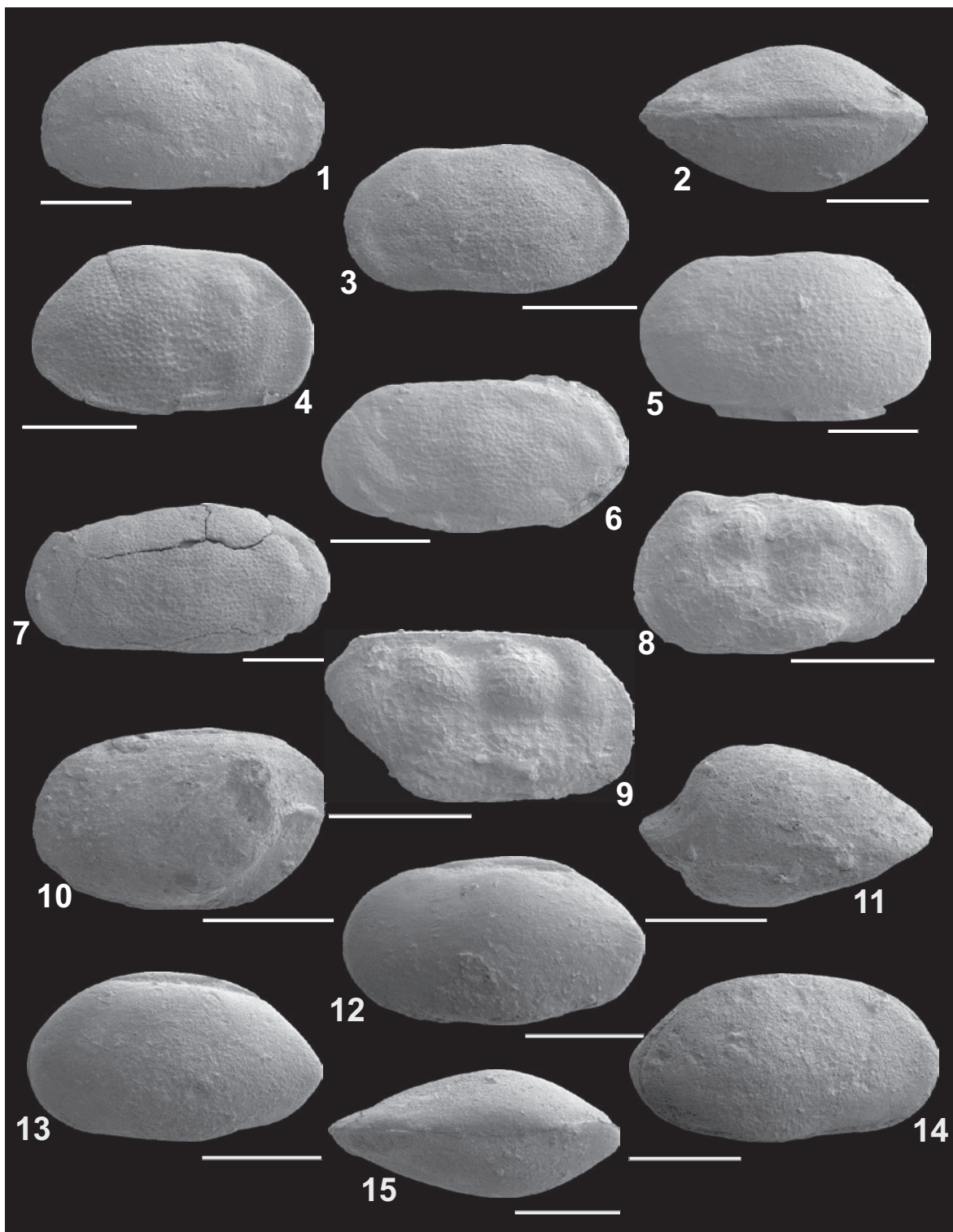
Derivation of name. From its occurrence in the Bellerophon Formation.

Diagnosis. A species of *Cryptobairdia* with an angulation of the left anterior margin just below mid-height and a left posterior margin which is weakly angled at two-fifths of carapace height. The smaller right valve shows almost symmetrically rounded anterior and posterior margins.

Holotype. S8-8; carapace, Plate 4, fig. 9.

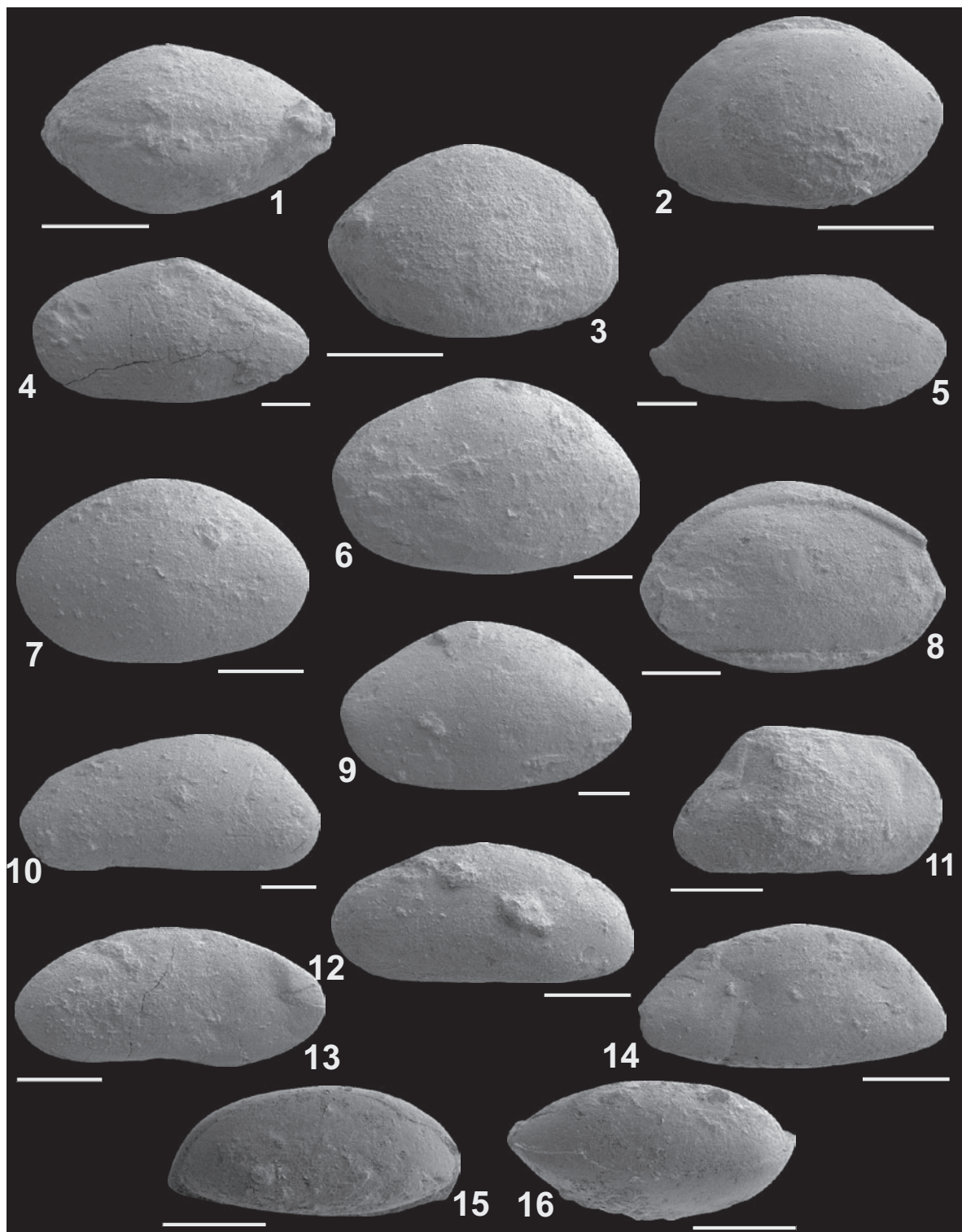
Material. 5 carapaces and 5 valves of adult specimens; 15 carapaces and 21 valves of juvenile specimens.

Type locality and horizon. Seiser Klamm (Gola di Siusi), 1 km south of the village Seis, South Tyrol (Dolomites), Italy; dark-grey



Explanation of Plate 3.

figs 1–2. *Callicythere? seisensis* n. sp., sample 8: **1**, male carapace, right lateral view, S8/11-5, 27; **2**, male carapace, dorsal view, S8/11-5, 30. **figs 3–7.** Gen. et sp. indet. 1, sample 14: **3**, female?, left valve, S14/11-4, 28; **4**, female?, right valve, S14/11-4, 29; **5**, female?, left valve, S14/11-4, 31; **6**, male?, right valve, S14/11-4, 32; **7**, male?, left valve, S14/11-4, 36. **figs 8–9.** *Judahella? binodata* n. sp.: **8**, holotype, left valve, sample 13, S13/11-4, 42; **9**, right valve, sample 14, S14/11-4, 40. **figs 10–11.** *Parabythocythere* sp. 1: **10**, carapace, left lateral view, sample 8, S8-39; **11**, carapace, dorsal view, sample 8, S8-39. **figs 12–15.** *Argoviella? dolomitica* n. sp.: **12**, male carapace, left lateral view, sample 12, S12/11-4, 23; **13**, holotype, male carapace, left lateral view, sample 8, S8/11-5, 32; **14**, male carapace, right lateral view, sample 12, S12/11-4, 22; **15**, male carapace, dorsal view, sample 8, S8-1. Scale bar 200 µm.



Explanation of Plate 4.

figs 1–3. *Arqoviella? dolomitica* n. sp.: **1**, female carapace, dorsal view, sample 8, S8-3; **2**, female carapace, left lateral view, sample 8, S8-4; **3**, female carapace, right lateral view, sample 8, S8-5. **figs 4–5.** *Bairdia* sp. 1, sample 8: **4**, left valve, S8-11; **5**, right valve, S8-12. **figs 6–9.** *Cryptobairdia bellerophonella* n. sp., sample 8: **6**, left valve, S8-10; **7**, juvenile carapace, left lateral view, S8-6; **8**, juvenile carapace, right lateral view, S8-9; **9**, holotype, carapace, left lateral view, S8-8. **fig. 10.** *Bairdiacypris* cf. *praewangi* Kozur, 1985, left valve, sample 8, S8-13. **fig. 11.** Gen. et sp. indet. 2, carapace, right lateral view, sample 8, S8-28. **fig. 12.** *Bairdiacypris* sp. 1, carapace, left lateral view, sample 8, S8-21. **fig. 13.** *Bairdiacypris?* sp., right valve, sample 8, S8-26. **fig. 14.** *Acratia* sp. 2, left valve, sample 8, S8-19. **figs 15–16.** *Acratia* sp. 1, sample 12, S12/11-5, **1**: **15**, carapace, right lateral view; **16**, carapace, dorsal view. Scale bar 200 μ m.

Late Permian ostracods of the Bellerophon Formation, Seis, Italy

silty shale (sample 8), 0.8 m below a 2.7 m thick unit of thick-bedded to massive micritic limestone, upper Bellerophon Formation, Casera Razzo Member.

Age. Late Changsingian.

Description. In lateral view the carapace displays a moderately convex dorsal margin with a more or less flattened anterodorsal part on the left valve. The anterior margin of the left valve is more or less distinctly angled just below mid-height and gradually merges into the straight or gently convex ventral margin. Some juvenile specimens show a symmetrically rounded left anterior margin without any angulation. The posterior margin of the left valve is narrowly rounded or angled at two-fifths of carapace height with a gently convex posterodorsal part. Anterior and posterior margins of the right valve are narrowly rounded and almost symmetrical to each other. The dorsal margin of the right valve consists of a straight median part which is slightly inclined towards the posterior end and distinctly inclined anterodorsal and posterodorsal parts. At the ventral margin of the right valve occurs a distinct median concavity. In dorsal view the carapace shows a narrow outline, with the greatest width located at or just behind mid-length and tapering anterior and posterior extremities.

Dimensions (mm). Left valve: L 1.06/H 0.62; L 1.18/H 0.69; carapace (holotype) L 1.20/H 0.70; L 1.04/H 0.62/W 0.40.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (sample 8 and 11), late Changsingian, Seis (Siusi) section, South Tyrol, Italy.

Remarks. *Cryptobairdia bellerophonella* is comparable to *Cryptobairdia maddocksii* Kozur, 1985 but, in contrast to the latter species, *C. bellerophonella* shows a more or less distinct angulation of the anterior margin and the right valve lacks antero- and posterodorsal concavities. Another similar species is *Bairdia beedei* Ulrich & Bassler, 1906 but the present material differs from *B. beedei* in the almost symmetrically rounded posterior margin of the right valve.

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

Acratia sp. 1
(Pl. 4, figs 15–16)

?1978 *Acratia zhongyingensis* Wang: 295, pl. 4, figs 5–6.

?2002 *Acratia zhongyingensis* Wang: Shi & Chen, pp. 82–83, pl. 20, figs 25–26.

2008 '*Acratia zhongyingensis* Wang 1978': Crasquin *et al.*, p. 250, pl. 5, figs 10–12.

Material. 1 carapace.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (sample 12), late Changsingian, Seis (Siusi) section, South Tyrol, Italy. Upper Bellerophon Formation, 'Ostracod unit', lower Tesero Member ('Tesero Oolite'), late Changsingian, Pufels (Bulla) section, South Tyrol, Italy (Crasquin *et al.*, 2008). ?Late Permian of Western Guizhou

Province (Wang, 1978) and Zhejiang Province (Shi & Chen, 2002), China.

Remarks. The species is characterized by a gently convex dorsal margin, strongly convex antero- and posterodorsal margins, a sharply pointed posterior end and a narrowly rounded anterior margin. The ventral margin is slightly upturned anteriorly. In dorsal view the carapace displays a symmetrically convex outline with the greatest width located at mid-length. The overlap of the left valve over the right valve is most strong at the anterodorsal margin. The present species corresponds in carapace outline and overlap structure to the species which was recorded as '*Acratia zhongyingensis* Wang, 1978' in Crasquin *et al.* (2008) from the Upper Permian and Lower Triassic of the Dolomites (Bulla section). According to the original documentation in Wang (1978), *A. zhongyingensis* has a more convex dorsal margin and a laterally compressed anterior end. It seems, therefore, questionable if the present species is conspecific with the species from China. *Acratia* sp. 1 corresponds to *Acratia* n. sp. 3 in Crasquin *et al.* (1999) in the lateral carapace outline but the latter species lacks the strong anterodorsal overlap of the left valve. It differs from *Acratia post-hungarica* Kozur, 1985 in the less convex dorsal margin and the less strongly tapering anterior end.

Superfamily **Cytheroidea** Baird, 1850
Family **Cytheruridae** Sars, 1925
Genus *Judahella* Sohn, 1968

Judahella? binodata n. sp.
(Pl. 3, figs 8–9)

?1970 *Judahella?* sp.: Sohn, p. 202, pl. 1, figs 26, 27.

Derivation of name. Referring to the occurrence of two prominent nodes on the subdorsal part of the lateral surface.

Diagnosis. The most conspicuous feature of the present species is the occurrence of two subequal nodes in the subdorsal part of the lateral surface and an elongate and tumid ventrolateral node. The lateral surface is covered by a delicate reticulation.

Holotype. S13/11-4, 42; left valve, Plate 3, fig. 8.

Material. 2 carapaces, 15 valves.

Type locality and horizon. Seiser Klamm (Gola di Siusi), 1 km south of the village Seis (Siusi), South Tyrol (Dolomites), Italy; dark-grey silty shale (sample 13), 0.25 m above a 2.7 m thick unit of thick-bedded to massive micritic limestone, upper Bellerophon Formation, Casera Razzo Member.

Age. Late Changsingian.

Description. *Judahella? binodata* n. sp. has a subrectangular outline in lateral view with a straight dorsal margin, which is inclined towards the posterior, a straight ventral margin, a broadly and almost symmetrically rounded anterior margin and a more narrowly rounded posterior margin. The posterior margin of the right valve is pointed above mid-height. The carapace is laterally

compressed at the anterior and posterior marginal zones. On the lateral surface occur two prominent subdorsal nodes which are separated by a distinct subcentral sulcus extending from the dorsal margin in vertical direction below mid-height. Another short subvertical sulcus is located in the anterodorsal part of the lateral surface. It separates the anterior node from a more or less distinct anterodorsal lobe extending from the anterior cardinal angle to mid-height. A third more or less distinct node is situated under the anterodorsal node, just below mid-height. In the middle part of the ventrolateral surface occurs a short and elongate node which forms a blunt wing-like extension. The lateral surface, except the compressed marginal zones, is covered by a delicate reticulate ornamentation.

Dimensions (mm): Valve: L 0.41/H 0.23; L 0.44/H 0.24; carapace: L 0.41/H 0.25.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (samples 12, 13, 14), late Changsingian, South Tyrol, Italy. ?Mianwali Formation, Mittiwali Member, Lower Triassic (Griesbachian), Salt Range, Pakistan (Sohn, 1970).

Remarks. The species is considered to be closely related to *Judahella* because of the similar shape of the carapace, occurrence of prominent subdorsal nodes and reticulate ornamentation. There are, however, some features which suggest that the *Judahella?* sp. 1 may represent a closely related genus. The present specimens do not show an eye node and they bear only two subdorsal nodes. The low number of specimens, poor preservation and inaccessibility of internal features, however, preclude an exact systematic assignment. A species which shows some affinity to the present material is *Judahella?* sp. from the Lower Triassic (Griesbachian) of Pakistan (Sohn, 1970), but in contrast to the present species the specimen figured by Sohn lacks an anteroventral node and shows a delicate longitudinal ridge on the lateral surface.

Family **Bythocytheridae** Sars, 1928
Genus *Parabythocythere* Kozur, 1981

Parabythocythere sp. 1
(Pl. 3, figs 10–11)

Material. 1 carapace

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (sample 8), late Changsingian, Seis (Siusi) section, South Tyrol, Italy.

Remarks. The present specimen probably represents a new species but is left under open nomenclature because of insufficient material. It differs from the other known species of *Parabythocythere* in the shape of the carapace. It is squat in lateral view, strongly convex in dorsal view and shows a broadly rounded posterior margin. The maximum height is located in the posterior part at about two-fifths of carapace length. Posteriorly there is a very broad laterally compressed marginal zone. The specimen is poorly preserved and does not display any surface ornamentation.

?Family **Cytheressinellidae** Kashevarova, 1958
Genus *Arqoviella* Gerry & Honigstein, 1987

Arqoviella? *dolomitica* n. sp.
(Pl. 3, figs 12–15; Pl. 4, figs 1–3)

?2008 *Arqoviella* sp. 1: Crasquin *et al.*, pl. 6, figs 17, 18, 19.

Derivation of name. From its occurrence in the Dolomites.

Diagnosis. A species characterized by a sharp angulation of the posterior margin, strong ventrolateral carapace inflation and reverse dorsal overlap structure: The right valve distinctly overlaps the left valve at the dorsal margin.

Holotype. S8/11-5, 32; carapace (Form A), Plate 3, fig. 13.

Material. Form A: 15 carapaces, 1 valve; Form B: 19 carapaces, 1 valve.

Type locality and horizon. Seiser Klamm (Gola di Siusi), 1 km south of the village Seis, South Tyrol (Dolomites), Italy; dark-grey silty shale (sample 8), 0.8 m below a 2.7 m thick unit of thick-bedded to massive micritic limestone, upper Bellerophon Formation, Casera Razzo Member.

Age. Late Changsingian.

Description. The present specimens have a subovate outline in lateral view and do not show any ornamentation. A characteristic feature of the species is the distinct angulation of the posterior margin of the left valve at mid-height or just below mid-height which strongly overlaps the narrowly rounded right posterior margin. Another typical feature of the species is the reverse overlap at the dorsal margin. The right valve strongly overlaps the left valve at the dorsal margin; at the anterodorsal, posterodorsal, anterior and ventral margins the left valve slightly overlaps the right valve. In dorsal view the carapace shows maximum inflation in the posterior part at two-fifths of carapace length. The species displays a moderate to strong ventrolateral carapace inflation which slightly overreaches the ventral margin. Due to this inflation the carapace outline is subtriangular in frontal view. Internal features are not accessible. The material includes relatively slender specimens (Form A) and shorter, more inflated specimens (Form B). It seems very probable that Form A and Form B represent male and female carapaces.

Form A (presumed male): These specimens are relatively slender in lateral carapace outline with a moderately convex dorsal margin. The anterior margin of both valves is almost symmetrically rounded and only slightly flattened anterodorsally. In dorsal view the carapace is lens-shaped and shows a moderate ventrolateral carapace inflation (Pl. 3, figs 12–15).

Form B (presumed female): These specimens have a short carapace which is strongly convex dorsally and laterally more inflated than Form A (Pl. 4, figs 1–3). In contrast to Form A the anterior margin is clearly asymmetrically rounded with a maximum of curvature at one-third of carapace height.

Dimensions (mm): Form A (male carapace?) – holotype: L 0.49/H 0.29; L 0.54/H 0.34/W 0.29; L 0.56/H 0.33/W 0.28; L

0.59/H 0.34/W 0.27. Form B (female carapace?): L 0.45/H 0.35/W 0.30; L 0.50/H 0.40/W 0.31; L 0.50/H 0.36/W 0.34; L 0.54/H 0.36/W 0.32.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (samples 8, 12, 13), late Changsingian, Seis (Siusi) section, South Tyrol, Italy. ?Upper Bellerophon Formation, 'Ostracod unit', Bulla Member, late Changsingian, Pufels (Bulla) section, South Tyrol, Italy (Crasquin *et al.*, 2008).

Remarks. The exact systematic position of the present species is unknown because the hinge structure and other internal features are not accessible. With regard to carapace outline, it shows affinities to *Pulviella* but differs from the latter genus by the alternating overlap structure and absence of ornamentation at the ventral surface. The assignment to *Arqoviella* is based on similarities in the shape and overlap structure of the carapace but this interpretation is questionable because all presently known species of *Arqoviella* show a more or less strong reticulate ornamentation of the lateral surface. *Arqoviella?* sp. 1 which was recorded from the Upper Permian of the Dolomites (Crasquin *et al.*, 2008) coincides in carapace outline with some specimens of the present species (Form B) but *Arqoviella?* sp. 1 was not described in the text and the figures do not allow a detailed comparison with the present material.

?Genus *Callicythere* Wei, 1981

Callicythere? *seisensis* n. sp.
(Pl. 2, figs 13–15; Pl. 3, figs 1–2)

2008 *Callicythere mazurensis* (Styk, 1972): Crasquin *et al.*, p. 254, pl. 5, figs 20–21.

Derivation of name. From its occurrence near the village of Seis (Siusi).

Diagnosis. The species is characterized by a smooth carapace with subovate outline in lateral view, reverse overlap structure at the dorsal margin and greatest height located at the posterior cardinal angle at one-quarter of carapace length. The curvature of the anterior and posterior margins is clearly asymmetrical.

Holotype. S13/11-5, 26; female carapace, Plate 2, fig. 13.

Material. 167 carapaces, 12 valves.

Type locality and horizon. Seiser Klamm (Gola di Siusi), 1 km south of the village of Seis (Siusi), South Tyrol (Dolomites), Italy; dark-grey silty shale (sample 13), 0.25 m above a 2.7 m thick unit of thick-bedded to massive micritic limestone, upper Bellerophon Formation, Casera Razzo Member.

Age. Late Changsingian.

Description. The species has a subovate carapace outline in lateral view with broadly rounded anterior and posterior margins. The left valve overlaps the right valve slightly at the anterior, posterior and ventral margins and the right valve overlaps the left

valve more clearly along the dorsal margin. The anterior and posterior margins are broadly rounded but the curvature is flattened above mid-height particularly at the posterior margin. The transition of the dorsal margin into the anterior and posterior margins is rounded. The ventrolateral parts of the carapace slightly overreach the ventral margin in lateral view and the ventral surface is slightly flattened. There is no ventrolateral carapace inflation so that the carapace outline in frontal view is almost symmetrically convex with the greatest width located at mid-height or just below mid-height. In the subdorsal area, just in front of the middle of the lateral surface, there is a shallow and broad carapace depression. In dorsal view the maximum lateral carapace width is located just behind mid-length or at one-third to two-fifths of carapace length. Some specimens show a lateral compression at the anterior marginal zone. The present specimens do not show any surface ornamentation. Internal features are not accessible because the material includes almost exclusively closed carapaces.

It seems probable that *C.?* *seisensis* shows sexual dimorphism: Most of the specimens are swollen posteriorly and are regarded as females. The maximum lateral carapace width of these specimens is located at one-third to two-fifths of carapace length and the anterior portion of the carapace is tapered towards the anterior end. In lateral view the dorsal margin is slightly inclined towards the anterior end and the maximum height occurs in the posterior part at one-quarter of carapace length. A few specimens, which probably represent the males, lack the posterior swelling and show an almost symmetrical carapace outline in dorsal view with the maximum width located at mid-length or just behind mid-length. The dorsal margin of these specimens is parallel to the ventral margin.

Dimensions (mm): Female carapace – holotype: L 0.50/H 0.25; L 0.56/H 0.34; L 0.58/H 0.36/W 0.32; L 0.60/H 0.36/W:0.32. Male carapace: L 0.52/H 0.32/W 0.29; L 0.56/H 0.31/W 0.29; L 0.60/H 0.36.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (samples 8, 12, 13), late Changsingian, Seis (Siusi) section, South Tyrol, Italy. ?Upper Bellerophon Formation, 'Ostracod unit', late Changsingian, Pufels (Bulla) section, South Tyrol, Italy (Crasquin *et al.*, 2008).

Remarks. With regard to carapace outline and overlap structure the present species shows affinity to *Callicythere*. But according to the original diagnosis of *Callicythere* in Wei (1981) the maximum height of this genus occurs in the anterior portion of the carapace, not in the posterior portion and it is also of distinctly smaller size. The anterior margin of *Callicythere* is symmetrically rounded. In dorsal view the carapace of *Callicythere* is more strongly and symmetrically convex and not tapering towards the anterior and posterior ends. Another similar genus is *Lutkevichinella*. In contrast to the latter genus the maximum height of the present species is situated in the posterior part of the carapace. Furthermore, the sharp central sulcus (S1) and the anterodorsal sulcus (S2) seen in *Lutkevichinella* are missing. The present species is also larger than most representatives of *Lutkevichinella*. It seems possible that the present species represents an early precursor of *Callicythere* or *Lutkevichinella*. The exact systematic position can, however, only be determined if internal features are accessible.

C.? seimensis can be distinguished from the Middle Triassic species *Lutkevichinella minima* Starozhilova, 1968 by its greater carapace size and absence of ornamentation. The lower Triassic species *Lutkevichinella archangelskyi* Schleifer, 1973 also shows affinity to the present material in carapace shape but the present species differs by the inclination of the dorsal margin, the overlap of the left valve around the complete free margin and the reverse overlap at the dorsal margin.

The present specimens are assumed to be conspecific with material from the uppermost Permian of the Dolomites (Bulla section) (Crasquin *et al.*, 2008) determined as '*Callicythere mazurensis* (Styk, 1972)'. *Callicythere mazurensis sensu* Styk (1972) shows a symmetrically rounded anterior margin and the anterior margin of *C.? seimensis* is clearly asymmetrical in the anterodorsal portion. In dorsal view the carapace of *C. mazurensis* is not inflated posteriorly and does not show sexual dimorphism. Styk (1972) also reports a small sulcus in the central part and a short ridge along the ventral margin, which do not occur on *C.? seimensis*.

Family unknown
Gen. et sp. indet. 1
(Pl. 3, figs 3–7)

Material. 4 carapace, 41 valves.

Stratigraphic and geographical range. Upper Bellerophon Formation, Casera Razzo Member (samples 13, 14), late Changsingian, Seis (Siusi) section, South Tyrol, Italy.

Remarks. The present species is characterized by a fine irregular reticulate ornamentation of the lateral surface. The size of the reticulation meshes is greatest in the central part of the lateral surface and decreases towards the peripheral parts. In lateral view the species is subrectangular and comprises specimens with a relatively slender outline and specimens with a stouter outline. This variability in lateral outline may be due to sexual dimorphism but this suggestion cannot be proved because of poor preservation. The species shows some affinity to the Rhaetian genus *Rhombocythere* with regard to the type of ornamentation and outline in lateral view. In contrast to this genus the present specimens do not have a flattened venter and no carina on the ventral and dorsal margins. A comparison of internal features is not possible because these are not accessible for the present species. Other similar species are not reported in literature on Permian and Triassic ostracods and the present species may thus represent a new genus.

CONCLUSIONS

The Late Permian (Changsingian) Casera Razzo Member of the Bellerophon Formation at Seis (Dolomites) yielded low diversity ostracod assemblages which are dominated by *Cavellina bellerophonella* Crasquin, 2008, *Sargentina postacuta* (Zalanyi, 1974), *Knixiella ventrospinosa* Crasquin, 2008 and *Callicythere? seimensis* n. sp. They inhabited a protected inner lagoonal environment which was characterized by minor sea-level changes and salinity fluctuations. A monotypic assemblage of large and thick-shelled representatives of Paraparchitidae is indicative of a more turbulent eulittoral palaeoenvironment which was probably located in the external part of the lagoon. The low number of species common with Late

Permian ostracod assemblages of other localities is a result of the environmental instability which inhibited the immigration of species from the open-marine Tethyan realm. *Callicythere? seimensis* n. sp. and *Argoviella? dolomitica* n. sp. show some affinity to the genera *Lutkevichinella* and *Pulviella*, respectively, which appear in the Early Triassic. *C.? seimensis* n. sp. and *A.? dolomitica* n. sp. may thus represent early precursors of these Triassic taxa.

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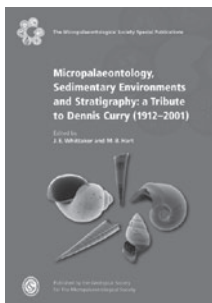
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