

Middle Pleistocene Ostracoda from a large freshwater lake in the presently dry Qaidam Basin (NW China)

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ABSTRACT – Ostracods of Middle Pleistocene age were recovered from an escarpment at the northeastern margin of the large Qarhan playa surface in the Qaidam Basin (NW China). The Middle Pleistocene age of the sampled Quan Ji section was determined by means of Optically Stimulated Luminescence (OSL) dating of seven sediment samples. Among the 31 ostracod taxa identified in total, only *Eucypris gyirongensis*, *Leucocythere dorsotuberosa* and *Prionocypris gansenensis* seem to be restricted to high-altitude sites in Central Asia whereas most taxa are known from a number of European and Siberian (Palaeoartic) or even Holarctic sites. Laterally widespread sediments and the ostracods from the Quan Ji section suggest the formation of a large freshwater to oligohaline lake of at least several metres in depth in the Qaidam Basin, which is presently dry apart from a few shallow salt lakes. *J. Micropalaeontol.* 25(1): 57–64, April 2006.

KEYWORDS: *Ostracoda, Qaidam Basin, NW China, palaeolake, Middle Pleistocene*

INTRODUCTION

The Qaidam Basin at the northern margin of the Tibetan Plateau is a large intermontane basin, covering approximately 100 000 km² between 36° and 39° N latitude and 90° and 98° E longitude. Owing to the low annual precipitation (38 mm a⁻¹ in Golmud; Domrös & Peng, 1988, Fig. 1), the basin represents a desert characterized by a typical Yardang topography of wind-shaped hills of lacustrine or playa sediments, and large playa lakes. Shallow salt lakes cover the lowermost depressions in the centre of the basin at 2675 m elevation above sea-level (asl) or in somewhat higher positions, whereas the peaks of the surrounding mountain ranges exceed 5000 m asl (W. Yang *et al.*, 1995). Thick sequences of lacustrine sediments were investigated by means of numerous petroleum exploration drill holes and are exposed as low hilly remnants of rapid deflation. While these lake deposits were concurrently attributed to a former large inland lake by Chen & Bowler (1986) and Hövermann & Süßenberger (1986), the size and timing of the inland lake formation has been the subject of controversy (Chen & Bowler, 1986; Hövermann & Süßenberger, 1986; Hövermann *et al.*, 1992). Ancient shoreline deposits about 120 m above the depression centre were attributed to Early or Middle Pleistocene age by Chen & Bowler (1986), whereas similar deposits about 270 m above the lowermost part of the basin were regarded as Late Quaternary remnants of a large lake by Hövermann & Süßenberger (1986), although an absolute age determination was not conducted. Ostracod shells served as a main proxy for palaeoenvironmental inferences and stratigraphical correlation but, in contrast to Pre-Quaternary Cenozoic ostracods (Exploration, 1988), Quaternary ostracod shells have been, if at all, poorly illustrated in publications so far. To overcome this insufficient state of shell documentation and to contribute to the discussion on the timing of the large inland lake formation, the

authors studied the exposed Quan Ji section at the northeastern margin of the large Qarhan playa in the lowermost region of the basin (Fig. 1).

MATERIAL AND METHODS

An escarpment displaying thick sequences of fine-grained silty sediments with intercalations of aeolian and fluvial sands is exposed in the northeast of the Qarhan playa, one of the world's largest playa surfaces, covering 5856 km² (Zheng *et al.*, 1989). About 10 km to the north of the escarpment, a foothill range of the Qilian Mountains (Amunike Mountains) rises c. 1000 m above the flat playa surface. Sediments of the escarpment are laterally continuous over the exposed distance of c. 2 km and dip c. 1.5° towards the SSE, i.e. away from Amunike Mountains. Sediment samples from a sequence of 50 m thickness (36° 58' 27.6" N, 96° 15' 33.3" E, 2734 m asl) were collected and washed through 0.098 mm and 1 mm meshes for ostracod analysis. In addition, five samples of fine-grained, well-sorted sand regarded as wind-blown sand, as well as two samples of probably fluvial origin, were collected for Optically Stimulated Luminescence (OSL) dating. Optical dating is the only method with which the absolute ages of sediment burial can be determined. Natural occurring sedimentary minerals such as quartz and feldspar are generally used for dating. The applicable age range for optical dating is usually restricted by saturation of the quartz OSL signal and stability of the feldspar Infrared Stimulated Luminescence (IRSL) signal. Depending on the environmental dose rate and saturation behaviour of the quartz, a successful OSL application is limited to approximately 100 ka. The IRSL signal of feldspar usually saturates at higher doses and can hence be used to date much older deposits but is often affected by anomalous fading (see, for example, Wintle, 1973; Aitken, 1985), which leads to underestimation of the burial age.

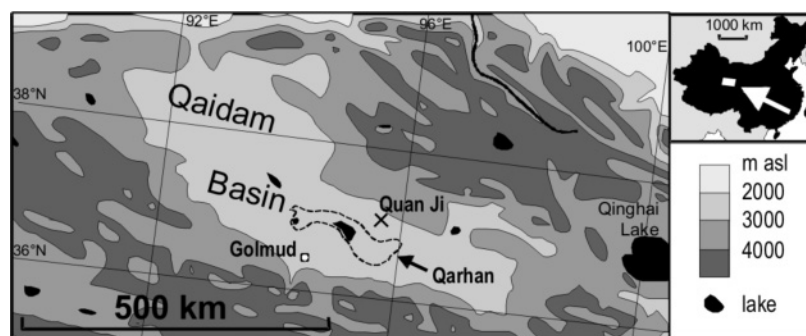


Fig. 1. Map showing the location of the sampled Quan Ji section in the northeast of the large Qarhan playa surface, indicated by the broken line.

For this study, equivalent dose determinations of sand-size potassium feldspar and quartz were carried out on a standard Risø TL/OSL reader (Bøtter-Jensen *et al.*, 2002) using the single aliquot regeneration (SAR) protocol (Murray & Wintle, 2000; Wallinga *et al.*, 2000). A 200 s IR stimulation was applied to feldspars and IRSL detection used a blue transmitting filter pack (Schott BG39, Corning 7-59 and Schott GG 400) for the measurements. The dating approach on quartz using the SAR protocol with blue light stimulation and UV detection failed due to large scatter and saturation effects. Fading experiments were carried out on two feldspar samples over a period of three months. Forty-one days after irradiation, the samples lost 9–6% of their initial IRSL signal and 3–0.5% within the following 56 days.

Dose rates were determined by neutron activation analysis. Internal potassium contents of $9 \pm 1\%$ and an alpha efficiency of 0.2 ± 0.02 was assumed (Mejdahl & Christiansen, 1994). The sampled sequence mainly comprises lacustrine sediments (see below) but with regard to the escarpment morphology and the present-day conditions, a water content of $10 \pm 5\%$ ($15 \pm 5\%$ for the lowermost sample) was adopted for age calculation.

AGE ASSIGNMENT

IRSL dating studies on seven samples from the 50 m thick sequence yielded ages between 110 ± 17 ka and 144 ± 13 ka for the upper 40 m of sediments and 176 ± 17 ka for the lowermost fluvial sand. The results obtained for the upper six samples are not in stratigraphic order and all cover the same age range within standard deviation. Associated equivalent doses range from 318 ± 44 Gy to 437 ± 21 Gy and dose rates show a wide variation in the section. They vary from 2.3 ± 0.2 Gy ka⁻¹ to 3.1 ± 0.2 Gy ka⁻¹. The highest equivalent dose was obtained for the lowermost sample from the fluvial sand.

Obtained IRSL ages for the feldspar fraction seem to imply a Late Pleistocene burial age sometime between Marine Isotope Stage (MIS) 5c and 5e for the upper 40 m of sediments but, with regard to the fading rate of 0.5–3%, these ages represent minimum ages and probably underestimate the true deposition time interval significantly. Thus, a Middle Pleistocene age is very likely for the formation of the sampled sediment sequence and can be further specified to a late Middle Pleistocene age (MIS 7 or 6) taking the presence of *Candona candida* shells into account, which are considered to have appeared in the Qaidam Basin not earlier than *c.* 210 ka bp (Yang *et al.*, 1997).

OSTRACOD ASSEMBLAGES

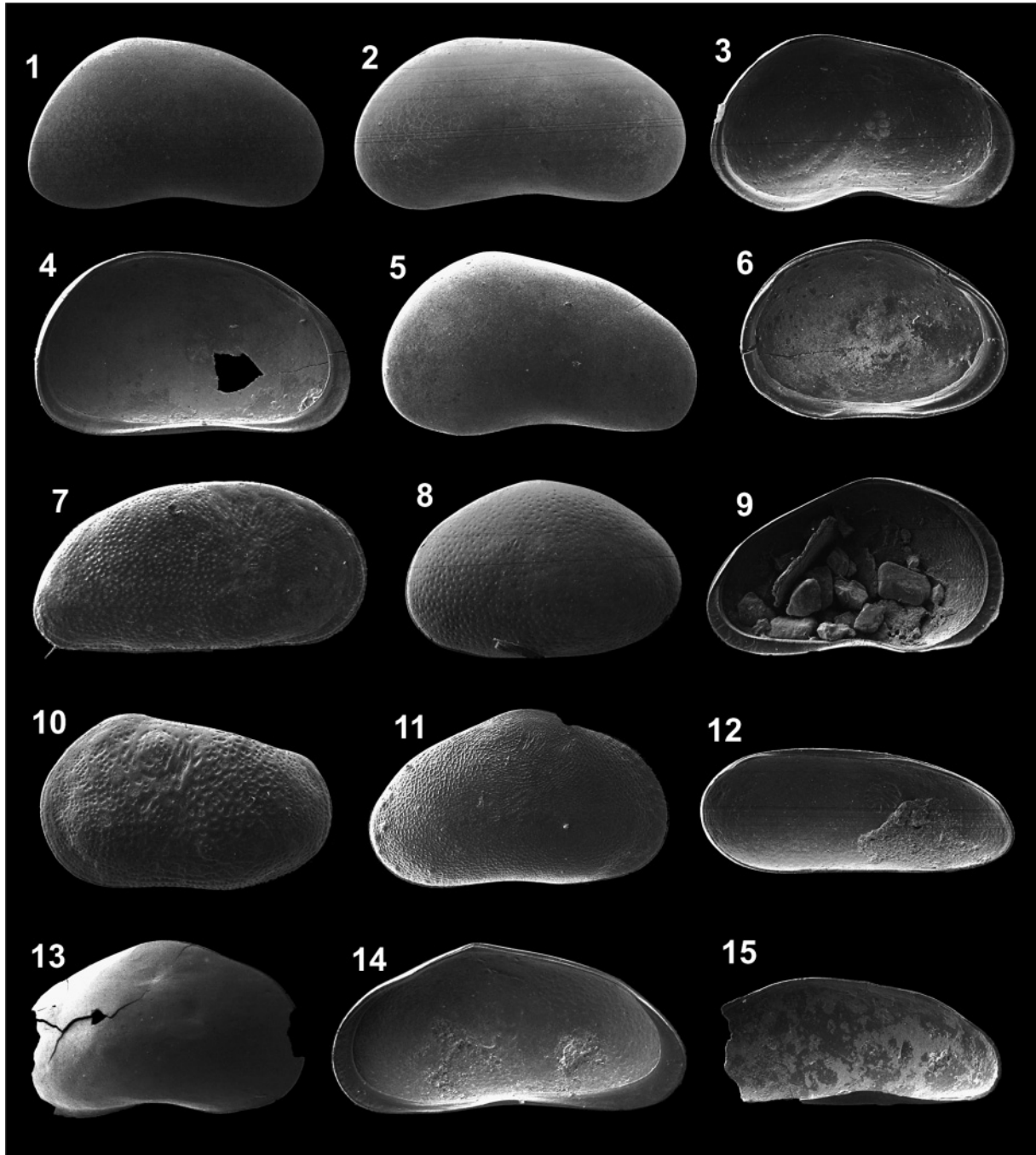
In total, 31 ostracod taxa were recorded from the Quan Ji section (Pls 1–3). According to literature on Quaternary Ostracoda from the Qaidam Basin (Huang, 1964; Chen *et al.*, 1990; Wang & Shen, 1993; Sun *et al.*, 1995; F. Yang *et al.*, 1995, 1997; Liu *et al.*, 1998) and from the neighbouring Qinghai Lake basin (Yang, 1988, Yang *et al.*, 2002; Zhang *et al.*, 1994), half of these taxa were recorded previously from deposits in the region (Table 1).

Eucypris gyrongensis, *Leucocythere dorsotuberosa* and *Prionocypris gansenensis* are the only three species from Quan Ji which do not have a Palaeoartic distribution and which are probably restricted to high-altitude sites of Central Asia. Most other taxa are known from numerous sites of northern Asia and Europe, although some species, such as the cold stenothermal or oligothermophilic *Candona weltneri*, were not recorded from a position as far in the south as the Qaidam Basin until now (Meisch, 2000; and refs therein).

The shells of *Paralimnocythere psammophila* from Quan Ji represent the oldest specimens recorded so far. Until now, Recent and sub-Recent specimens of *P. psammophila* were recorded from Germany, France, Spain, the Ukraine (see refs in Meisch, 2000) and Scotland (Smith & Horne, 2004). According to the record of sub-Recent specimens from the Qilian Mountains (China; Mischke *et al.*, 2003) and the current study, *P. psammophila* occurs at least at the northern margin of the Tibetan Plateau since the Middle Pleistocene.

Three taxa of *Ilyocypris* could be identified due to the existence and number of tubercles and the appearance of so-called inner marginal ripplelets of the left valve which are believed to be species-specific characters (Van Harten, 1979; Janz, 1994; Pl. 2). Existing or missing tubercles cannot be used for shell identification alone. Meisch (2000) reported on forms with and without tubercles for *Ilyocypris decipiens* and *I. gibba*, and Yang *et al.* (2002) have shown that there are all transitional stages between noded and unnoded shells of *Ilyocypris gibba* and *I. echinata*. Marginal ripplelets in the posteroventral area of the inner lamella of the left valve were used by Van Harten (1979) for the first time as a shell characteristic to enable the distinction between different taxa of *Ilyocypris*.

The specimens here with tubercles from Quan Ji were identified as *Ilyocypris bradyi* and *I. decipiens* which may be distinguished by the different pattern of the marginal ripplelets (Pl. 2). In *I. bradyi*, few marginal ripplelets with an adjoining inner

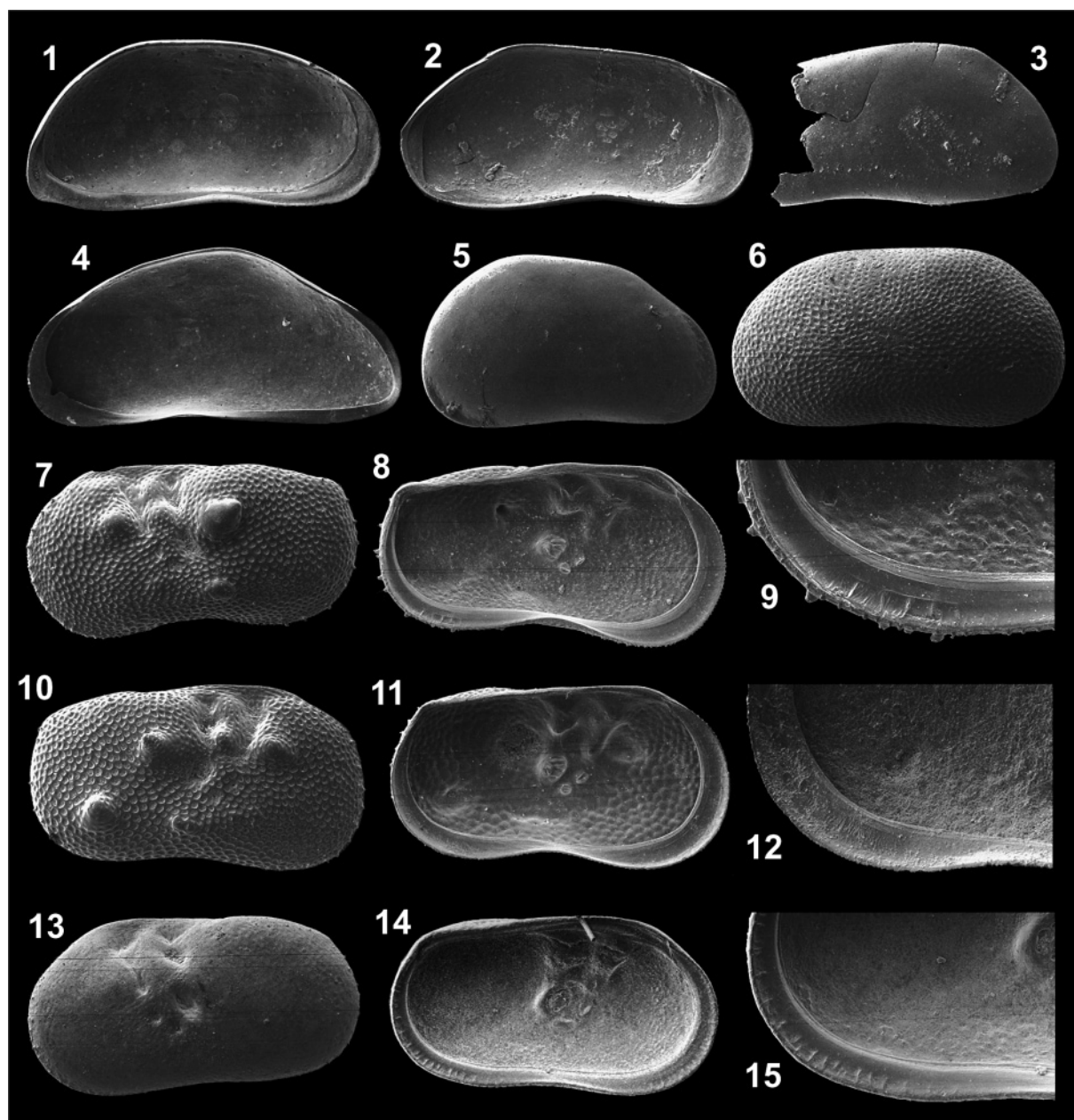


Explanation of Plate 1.

fig. 1. *Candona candida*, RV ext., length 1060 μm (SMII8). **figs 2, 3.** *Candona neglecta*: **2,** ♀RV ext., length 1100 μm (SMII22); **3,** ♂LV int., length 1110 μm (SMIII31). **figs 4, 5.** *Candona weltneri*: **4,** ♀LV int., length 1120 μm (SMII10); **5,** ♂RV ext., length 1120 μm (SMI26). **fig. 6.** *Cyclocypris ovum*, LV int., length 530 μm (SMI6). **fig. 7.** *Cyprideis torosa*, ♂RV ext., length 954 μm (SMII2). **fig. 8.** *Cypridopsis vidua*, LV ext., length 740 μm (SMIII27). **fig. 9.** *Cypris pubera*, juvenile, LV int., length 1740 μm (SMIII30). **fig. 10.** *Cytherissa lacustris*, juvenile, LV ext., length 758 μm (SMIII29). **fig. 11.** *Eucypris dulcifons*, juvenile, RV ext., length 813 μm (SMI3). **fig. 12.** *Darwinula stevensoni*, LV int., length 710 μm (SMIII25). **fig. 13.** *Eucypris mareotica*, RV ext., length 847 μm (SMI4). **fig. 14.** *Eucypris gyrongensis*, juvenile, RV int., length 742 μm (SMI30). **fig. 15.** *Dolerocypris* sp., RV int., length 465 μm (SMI29). Specimens housed in the Interdisciplinary Centre for Ecosystem Dynamics in Central Asia of the Freie Universitaet Berlin, Germany.

list above are typically located relatively near the outer valve margin, whereas a band of numerous inconspicuous small ripples may be found on left valves of *I. decipiens* (Van Harten,

1979; Janz, 1994). The smooth-shelled specimens from the current study of the recently described *Ilyocypris sebeiensis* show a number of distinct marginal ripples without an adjoining

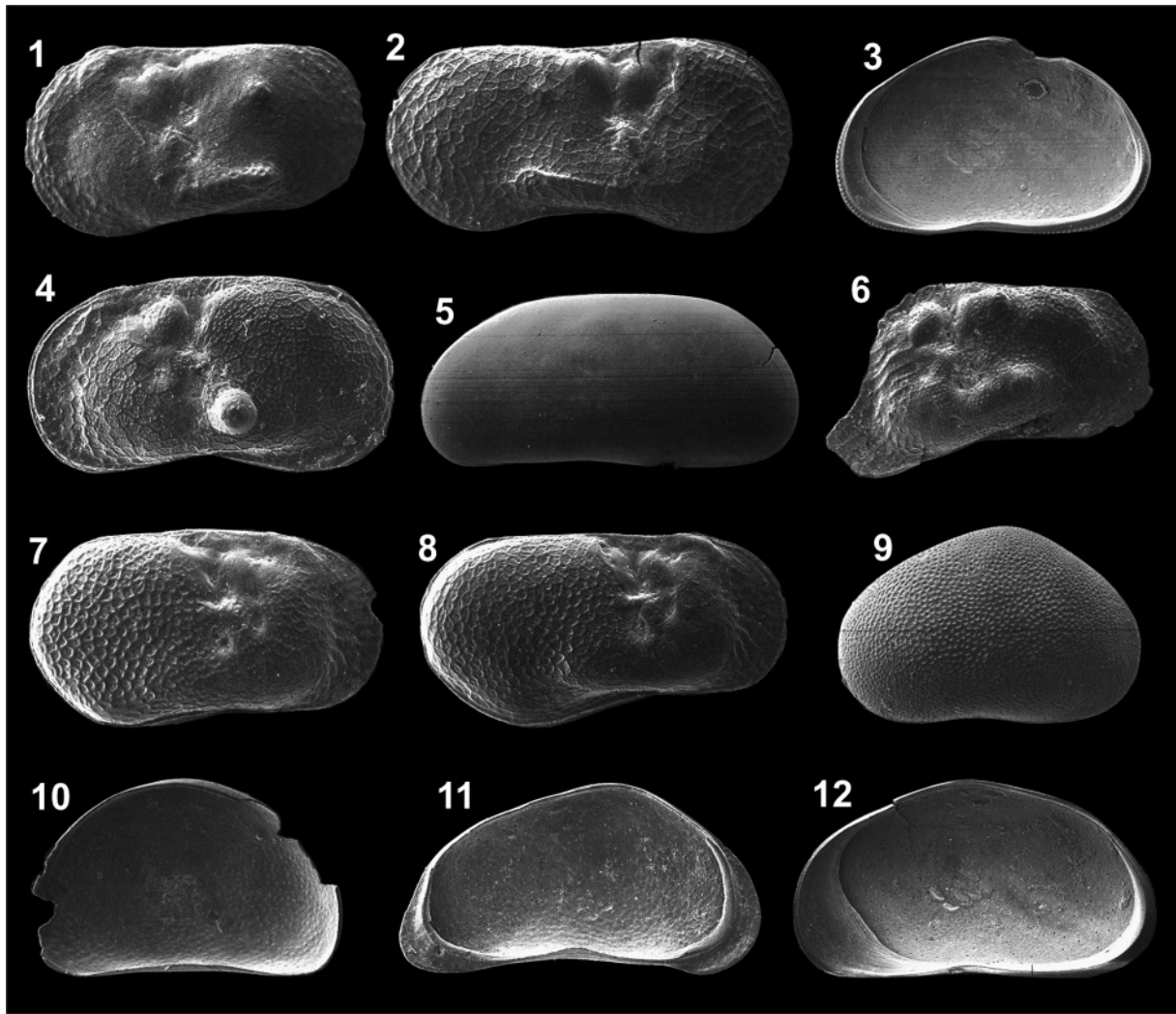


Explanation of Plate 2.

fig. 1. *Fabaeformiscandona caudata*, LV int., length 1140 μm (SMIII26). **fig. 2.** *Fabaeformiscandona fabaeformis*, LV int., length 1040 μm (SMI28). **fig. 3.** *Fabaeformiscandona* sp., LV ext., length 1240 μm (SMI19). **fig. 4.** *Fabaeformiscandona hyalina*, RV int., length 1140 μm (SMI2). **fig. 5.** *Pseudocandona compressa*, RV ext., length 942 μm (SMII3). **fig. 6.** *Pseudocandona compressa*(?), juvenile, pitted surface, LV ext., length 620 μm (SMIII32). **figs 7–9.** *Ilyocypris bradyi*, LV: **7**, ext., length 1030 μm (SMIII13); **8**, int., length 1040 μm (SMIII17); **9**, marginal ripples, enlargement of posteroventral area of specimen of fig. 8, width of cutting 346 μm . **figs 10–12.** *Ilyocypris decipiens*: **10**, RV ext., length 835 μm (SMIII15); **11**, LV int., length 811 μm (SMIII14); **12**, LV int., marginal ripples in posteroventral area, width of cutting 352 μm (SMIII14). **figs 13–15.** *Ilyocypris sebeiensis*, LV: **13**, ext., length 860 μm (SMIII23); **14**, int., length 787 μm (SMIII22); **15**, marginal ripples, enlargement of posteroventral area of specimen of fig. 14, width of cutting 396 μm . Specimens housed in the Interdisciplinary Centre for Ecosystem Dynamics in Central Asia of the Freie Universitaet Berlin, Germany.

inner list (Yang *et al.*, 2004; Pl. 2). The specific pattern of marginal ripples may be used to distinguish shells of *Ilyocypris sebeiensis* from those of the similarly smooth-shelled taxa *I. getica* and *I. inermis* which have either inconspicuous marginal ripples (*I. getica*) or which lack marginal ripples at all (*I. inermis*; Janz, 1994; Meisch, 2000).

The shells of *Limnocytherina* cf. *sanctipatricii* from the Qaidam Basin differ in shape from shells of European sites by a slightly more expanded posterior part of female and male shells. Thus, dorsal and ventral margins of female shells are not approximately parallel as is typical for *L. sanctipatricii* but the ventral margin is diverging posteriorly from the dorsal margin



Explanation of Plate 3.

figs 1, 2. *Leucocythere dorsotuberosa*: 1, ♀LV ext., length 788 µm (SMI32); 2, ♂RV ext., length 752 µm (SMI33). **fig. 3.** *Heterocypris salina*, RV int., length 1190 µm (SMII24). **fig. 4.** *Limnocythere inopinata*, ♀LV ext., length 600 µm (SMI16). **fig. 5.** *Herpetocypris chevreuxi*, LV ext., length 2200 µm (SMII21). **fig. 6.** *Paralimnocythere psammophila*, LV ext., length 563 µm (SMI11). **figs 7, 8.** *Limnocytherina* cf. *sanctipatricii*: 7, ♀RV ext., length 713 µm (SMI22); 8, ♂RV ext., length 733 µm (SMI23). **fig. 9.** *Sarscypridopsis aculeata*, RV ext., length 683 µm (SMIII24). **fig. 10.** *Potamocypris* cf. *arcuata*, RV int., length 637 µm (SMI11). **fig. 11.** *Potamocypris smaragdina*, LV int., length 674 µm (SMI7). **fig. 12.** *Prionocypris gansensis*, RV int., length 1300 µm (SMI21). Specimens housed in the Interdisciplinary Centre for Ecosystem Dynamics in Central Asia of the Freie Universitaet Berlin, Germany.

(pers. comm. D. J. Horne). Living specimens from the Qaidam Basin should be collected for a firm identification of *L.* cf. *sanctipatricii* shells.

Identification to species level was not possible for *Fabaeformiscandona* sp. due to the sole occurrence or preservation of early juvenile stages and few fragments of adult shells (Pl. 2), and for a single large fragment of *Dolerocypris* sp. (Pl. 1).

In addition to microfossils, a catfish-like skeleton (Siluridae; T. Klose, pers. comm.) was found embedded in a cross-stratified sand layer in the middle of the section.

INFERENCES AND DISCUSSION

The taxa recovered from the Quan Ji section are regarded as indicating fresh to oligohaline conditions. Of all 27 taxa with known salinity ranges, 15 are considered to thrive in fresh or

oligohaline (salinity <5‰) water bodies (Table 1). A further six taxa have been recorded from mesohaline conditions (5–18‰) also. Two species may inhabit euhaline conditions (30–40‰), while three species even tolerate hypersaline (>40‰) waters. However, all taxa are known from oligohaline water bodies as well (Table 1).

Cytherissa lacustris, *Limnocytherina* cf. *sanctipatricii*, *Fabaeformiscandona caudata* and, to a lesser degree, *Candona neglecta* (e.g. Danielopol *et al.*, 1993) are regarded as characteristic of the profundal zone of a deep lake, whereas most other taxa hint towards shallower lake conditions (data compilation in Meisch, 2000). In addition, the high number of taxa points towards a relatively shallow lake of several metres depth only, rather than a permanently deep lake. However, the recorded ostracods, the fine silty sediments and the laterally continuous bedding of

| Taxa | Salinity (g l ⁻¹) | Source of salinity data | First record from region |
|--|--|--|---------------------------------|
| <i>Candona candida</i> (O. F. Müller, 1776) | 0.1–5.8 | Meisch (2000) | Yang (1988) |
| <i>Candona neglecta</i> Sars, 1887 | 0–20 | Meisch (2000) | Huang (1964) |
| <i>Candona welineri</i> Hartwig, 1899 | 0–5 | Hiller (1972) | — |
| <i>Cyclocypris ovum</i> (Jurine, 1820) | 0–6.4 | Meisch (2000) | — |
| <i>Cyprideis torosa</i> (Jones, 1850) | 0–150 | Mazzini <i>et al.</i> (1999) | Huang (1964) ^a |
| <i>Cypridopsis vidua</i> (O. F. Müller, 1776) | 0–10.5 | Hiller (1972); Neale (1988); Curry (1999) | Yang (1988) |
| <i>Cypris pubera</i> O. F. Müller, 1776 | 0.6–4.2 | De Deckker (1981) | — |
| <i>Cytherissa lacustris</i> (Sars, 1863) | 0.5–1.5 | Meisch (2000) | Sun <i>et al.</i> (1995) |
| <i>Darwinula stevensoni</i> (Brady & Norman, 1870) | 0.5–15 | Meisch (2000) | Exploration (1988) |
| <i>Dolerocypris</i> sp. | — | — | — |
| <i>Eucypris dulcifons</i> Diebel & Pietrzeniuk, 1969 | probably freshwater <i>sensu lato</i> | Diebel & Pietrzeniuk (1975) | — |
| <i>Eucypris gyrongensis</i> Huang, 1982 | 0–5 | Yang (1988) | Yang (1988) |
| <i>Eucypris mareotica</i> (Fischer, 1855) | 3–325 | Williams (1991); Li <i>et al.</i> (1997) | Huang (1964) ^b |
| <i>Fabaeformiscandona caudata</i> (Kaufmann, 1900) | 0.5 | Meisch (2000) | Yang (1988) ^c |
| <i>Fabaeformiscandona fabaeformis</i> (Fischer 1854) | 0–8.1 | Meisch (2000) | — |
| <i>Fabaeformiscandona hyalina</i> (Brady & Robertson, 1870) | 0–5 | Meisch (2000) | — |
| <i>Fabaeformiscandona</i> sp. | — | — | — |
| <i>Herpetocypris chevreauxi</i> Sars, 1896 | 0–4 | Meisch (2000) | — |
| <i>Heterocypris salina</i> (Brady, 1868) | 0.4–74 | Hammer (1986); Neale (1988) | Exploration (1988) ^d |
| <i>Ilyocypris bradyi</i> Sars, 1890 | 0.3–4.5 | Anadon <i>et al.</i> (1994); Meisch (2000) | Wang & Shen (1993) |
| <i>Ilyocypris decipiens</i> Masi, 1905 | 0–2.2 | Meisch (2000) | — |
| <i>Ilyocypris sebeiensis</i> Yang & Sun, 2004 | — | — | Yang <i>et al.</i> (2004) |
| <i>Leucocythere dorsotuberosa</i> Huang 1984 | — | — | Huang (1984) |
| <i>Limnocytherina</i> cf. <i>sancipatricii</i> (Brady & Robertson, 1869) | 0–40 | Yang (1988) | Huang (1964) ^e |
| <i>Limnocytherina</i> sp. | 0–3 | Meisch (2000) | Huang (1964) |
| <i>Paralimnocythere psammophila</i> (Fjössner, 1965) | probably freshwater <i>sensu lato</i> | Meisch (2000) | — |
| <i>Potamocypris arcuata</i> (Sars, 1903) | probably freshwater <i>sensu stricto</i> | Meisch (2000) | — |
| <i>Potamocypris smaragdina</i> (Vávra, 1891) | 0.1–4.2 | Meisch (2000) | — |
| <i>Prionocypris gansuensis</i> Huang 1964 | 0.5–5 | Yang (1988) | Yang (1988) |
| <i>Pseudocandona compressa</i> (Koch, 1838) | 0.5–8 | Meisch (2000) | Huang (1964) |
| <i>Sarscypridopsis aculeata</i> (Costa, 1847) | 0.4–33 | Hammer (1986); Neale (1988) | Yang (1988) ^f |

Salinity ranges were reported from European sites mainly and reference for the first record of a species from the Qaidam Basin or the neighbouring Qinghai Lake basin in the east is given. The elevation of the latter is more or less comparable to the Qaidam Basin with the surface of Qinghai lake at about 3200 m asl (Fig. 1).

^a as *Cyprideis littoralis* (synonymous with *Cyprideis torosa*)

^b as *Eucypris inflata* (synonymous with *Eucypris mareotica*)

^c as *Candona caudata* (species newly assigned to *Fabaeformiscandona*)

^d as *Cyprinotus* (*Heterocypris*) *salinus*, probably synonymous with *L. inopinata*

^e identified as *Limnocythere dubiosa*, probably synonymous with *L. inopinata*

^f as *Candona compressa* (species newly assigned to *Pseudocandona*)

^g as *Cypridopsis aculeata* (species newly assigned to *Sarscypridopsis*)

Table 1. Ostracod taxa recorded from Quan Ji section in the Qaidam Basin.

almost horizontal sediment units over a distance of at least 2 km are evidence for a former large freshwater or oligohaline lake in the eastern Qaidam Basin, possibly characterized by more saline lagoons and/or temporary stages of increased salinity levels. The catfish-like skeleton (Siluridae) from Quan Ji section further points to the former existence of a perennial water body of low salinity. In contrast to the depositional environment during the large lake period, contemporary sediment accumulation in the study area is controlled by halite formation in shallow hypersaline playa lakes at sites lower than the sampled escarpment (Schubel & Lowenstein, 1997) or by locally restricted sporadic heavy precipitation events triggering flash floods and sand and gravel transport from the near Amunike Mountain range as well as by aeolian sand deposition at sites above (observation by the authors).

The inference of a Middle Pleistocene large lake in the Qaidam Basin arose from an initial study based on detailed taxonomical analysis of micro-organisms from a thick sequence of predominantly lake sediments. A large inland lake in the Qaidam Basin was inferred earlier from remnants of shoreline deposits and its relation to the present-day topography. Chen & Bowler (1986) postulated a large inland lake, covering c. 59 000 km² or half the size of the Qaidam Basin, based on shoreline relicts at about 2800 m asl (i.e. 125 m above the present-day Qarhan playa). Although no dating results were available, Chen & Bowler (1986) suggested an Early to Middle Pleistocene formation of a large lake considering the age of underlying strata.

Higher elevated shoreline deposits, at about 2950 m asl, were described by Hövermann & Süßenberger (1986) and Hövermann *et al.* (1992). A 300 m deep freshwater lake of huge size (70 000 km²) was suggested and attributed to ¹⁴C-dated clastic sediments in wells in the central part of the basin (Hövermann & Süßenberger, 1986; Hövermann *et al.*, 1992). Radiocarbon ages of these sediments ranged between 32 and 24 ¹⁴C ka bp, in contradiction to those of halite deposits from similar wells, suggesting that hot and dry conditions prevailed since 32 ¹⁴C ka bp (Huang & Chen, 1990) or even earlier between 50 and 30 ¹⁴C ka bp (Zhang *et al.*, 1995). Halite deposits can be found below c. 2700 m asl, pointing towards very shallow conditions during the salt-forming stage of the lake (Chen & Bowler, 1986). Contrary to the findings of Hövermann & Süßenberger (1986) and Hövermann *et al.* (1992), remnants of shoreline deposits at 2704 m asl (i.e. about 250 m lower than those reported by Hövermann *et al.* (1992)) yielded radiocarbon ages between 39 and 29 ¹⁴C ka bp and were regarded as indicating a much smaller and shallower but still large freshwater or slightly saline lake in the late MIS 3 (Chen & Bowler, 1986).

The large lake inferred from the ostracods of the Middle Pleistocene Quan Ji section may correspond with the Early to Middle Pleistocene large inland lake suggested by Chen & Bowler (1986). However, scanty existing data do not provide a sound basis either for a correlation of the Quan Ji sediments with shoreline deposits, or for depth and area inferences of the large Middle Pleistocene lake. In general, former lake extent inferences based on the present-day topography must be regarded as very speculative until there is more detailed knowledge on the spatial and temporal pattern of sediment accumulation in the Qaidam Basin. The tectonic activity of this region

at the northern margin of the Tibetan Plateau (e.g. Van der Woerd *et al.*, 2000), as well as the strong deflation of the easily erodible basin infill, complicate inferences of the former lake extent.

CONCLUSIONS

A sediment sequence of 50 m thickness in the eastern Qaidam Basin yielded very well-preserved ostracod shells of Middle Pleistocene age. According to the lateral extent of fine-grained lake sediments and the Recent ecological requirements of the 31 ostracod taxa recovered from the section, a large freshwater lake of at least several metres depth existed in the Middle Pleistocene in the Qaidam Basin. Inferred primarily fresh to oligohaline conditions of the lake are in marked contrast to the pronounced aridity in the region today. Further studies are needed to evaluate the evolution and size of the former lake.

ACKNOWLEDGEMENTS

Funding was provided by the Deutsche Forschungsgemeinschaft (DFG) and the Deutscher Akademischer Austauschdienst (DAAD). The authors wish to thank David J. Horne and an anonymous reviewer for their thorough reviews and John Gregory for many helpful comments.

Manuscript received 4 February 2005

Manuscript accepted 21 September 2005

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