Late Pleistocene Limnic Ostracods and Their Environmental Significance in the Tengger Desert, Northwestern China*

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Seven ostracod species, namely Limnocthera inopinata, Darwinula stevensoni, Candona neglecta, Cypriella torosa, Ilyocypris gibba, Cyclocypris serena and Nocypridopsis sp., have been i-

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identified from Duantouliang section in the Tengger Desert, Northwest China. *L. inocythere in-opinata* and *D. inula stevensoni* are the dominant species. Four ostracod assemblages have been identified in the light of ostracod abundance, diversity and percentage. Based upon ostracod ecology, chronological data, depositional features and associated pollen, four main environmental stages are observed for the time interval 42 000 - 23 000 a. B. P., representing a period of generally warm and humid climate, interrupted by several phases of slightly declining temperature. The ostracod fauna indicates a fresh-mesohaline environment, which apparently persisted over the entire sedimentation period without any desiccation phases.

### Introduction

The Tengger Desert situated in Northwest China, covering an area of 36 700km², is the fourth largest desert in China, with more than 400 lakes, large or small, residing in the desert (Zhang *et al.*, 1983). These lakes, which have reacted sensitively to rainfall changes triggered by East Asian monsoons and westerly-induced cyclones, are the terminal sites of endorheic drainage systems of northwestern China. In order to analyze paleoenvironmental changes, this report presents results on late Pleistocene limnic ostracods from Duantouliang section, situated in the northwestern part of the Tengger Desert.

The Tengger Desert extends from western Inner Mongolia to northwestern Gansu province. The desert is bounded on the south by the Qilian Mountains, on the west by the Yabulai Mountain, on the east by the Helan Mountain. Elevations in most part of the area are about 1 000 - 1 500m. The dry denuded low mountains and hills of Precambrian and Paleozoic metamorphic and crystalline rocks, with altitudes from 100m to 250m, break up the area into many large or small endorheic basins. The desert are mainly composed of active or semi-active dunes. There are a lot of lakes in it. The Shiyang River, which rises in the Qilian Mountains, with elevation of 4 900m, flows into the desert and becomes the main source of the drainage system of the area. The mean annual temperature and precipitation of the area are > 10°C and 50 - 100mm respectively, and the rainfall is concentrated from July to September. The strong wind has blown throughout the year, and the strong wind and more sand have formed the climatic features of the area. The vegetation, consisting of grass and shrubs, is mainly concentrated in basins, plains, and between dunes where the groundwater level is at the surface. A rare rainfall appears in spring and rare snowfall in winter. Spring rain type, short-day plants are almost completely lacking, while summer rain type, annum growth desert herb is comparatively lush in the flora of the area (Ma *et al.*, in press).

### Description of Duantouliang Section

Duantouliang section (39°40'N, 103°55'E), with the altitude about 1 266m, is situated in the northwestern Tengger Desert, also in the alluvial basins in front of the Yabulai mountain, and at the end of the western tributary of the Shiyang River. The section is described as follows in order of down to up (Ma *et al.*, in press):
Ostracod Assemblages

Seven ostracod species, namely *L. inocythere inopinata*, *Daninula stevensoni*, *Candona neglecta*, *Cyperis torosa*, *Ilyocypris gibba*, *Cyclocypis rissera*, and *N. eocyridopsis* sp., have been identified from 20 samples of Duantouliang section. It is clear that the fauna diversity is low. *L. inocythere inopinata* and *Daninula stevensoni* predominate in the assemblage. Ostracods of the section can be divided into four assemblages based upon species abundance and diversity (Fig. 1, Fig. 2) as follows:

**Assemblage 1** (370-320 cm)

There are four species, namely *L. inocythere inopinata* (0-81% percentage in one sample), *Candona neglecta* (0-9%), *Cyperis torosa* (0-5%), *N. eocyridopsis* sp. (0-5%), in the assemblage. The species abundance is rather low, and the amount of *L. inocythere inopinata* which predominate in the assemblage is only 35 valves/10 g. No one ostracoda has been found in sample 1 (370-360 cm depth).

**Assemblage 2** (320-220 cm)

*Daninula stevensoni* first occurs in the assemblage, while the content of this species is low. Still the assemblage is predominated by *L. inocythere inopinata* as in assemblage 1. Four species, namely *L. inocythere inopinata* (82-99%), *Daninula stevensoni* (1-12%), *Candona neglecta* (0-7%), *Cyperis torosa* (0-2%) have been identified.

**Assemblage 3** (220-198 cm)

The percentage of *Daninula stevensoni*, ranging from 32% to 43%, distinctly increases in the assemblage, while the percentage of *L. inocythere inopinata*, ranging from 54% to 63%, decreases. Species composition is the same as in assemblage 2, and the other two species are respectively *Candona neglecta* (3-5%) and *Cyperis torosa* (0-2%).

**Assemblage 4** (198-60 cm)

*Ilyocypris gibba* and *Cyclocypis rissera* first occur in the assemblage. Six species, namely...
Fig. 1 Ostracoda percentage diagram of Duantouliang Section

Fig. 2 Ostracoda abundance diagram of Duantouliang Section
L in nocy there inopinata (33- 77%), D aw inula stevensoni (19- 59%), Candona neglecta (1 - 14%), Cyprides torosa (0- 3%), I cy ocyp ris gibba (0- 1%), Cyclocypris serena (0- 0 3%) have been identified. Two subassemblies are identified in the assemblage as follows:

**Subassemblage 4a** (198- 174cm)

Three samples have been analyzed, while the percentage of D aw inula stevensoni is over 50% in two samples. There are five species in the subassembly, respectively L in nocy there inopinata (33- 72%), D aw inula stevensoni (26- 59%), Candona neglecta (1- 6%), I cy ocyp ris gibba (0- 07- 0 3%), Cyprides torosa (0 07- 2%).

**Subassemblage 4b** (174- 60cm)

In comparison with subassemblage 4a, the mean percentage of D aw inula stevensoni decreases. Cyclocypris serena first occurs in the subassemblage. There are six species, respectively L in nocy there inopinata (45- 77%), D aw inula stevensoni (19- 38%), Candona neglecta (1- 14%), Cyprides torosa (0- 3%), I cy ocyp ris gibba (0- 0 1%), Cyclocypris serena (0- 0 3%), in the subassemblage.

**Paleoenvironmental Analysis**

Ostracods are important microfauna in limnic environment. Plentiful palaeoenvironmental information can be gained from their species composition, quantity, structural features and chemical composition. They can be used as good indicators of temperature and salinity.

Ostracods from Duantouliang Section in Tengger Desert are predominated by L in nocy there inopinata and D aw inula stevensoni. In the lakes of Qaidam Basin, northwestern China, majority of living species of L in nocy there dwell on muddy substrates and fossil species of Tertiary are often found in the strata rich in carbonates, and they thrive well in oligomesohaline water (Exploration and Development Research Institute et al., 1988). L in nocy there inopinata is the dominant species in modern Qinghai Lake in northwestern Tibet, where the salinity ranges from 12% to 13% (Huang, 1984a). In the Eifel highlands between Trier and Bonn (Germany), living L in nocy there inopinata occurs in mesotrophic-eutrophic lakes Holmaar and Schalkemehrner Marr (Scharf, 1993). The species of D aw inula are commonly considered as one kind of ostracods most often found in freshwater (Exploration and Development Research Institute et al., 1988). Occasionally they are also encountered in oligomesohaline water (Van Morkhoven, 1963). Tertiary D aw inula species from Qaidam Basin are mainly yielded in comparatively low salinity strata, and no one has been found yet in comparatively high salinity, dull color mudstone strata (Exploration and Development Research Institute et al., 1988). Huang (1984b) described D aw inula stevensoni yielded in fine sand of Pliocene Qugou formation in Gonghe Basin, Qinghai province of China. Living D aw inula stevensoni has been identified in puddles around Qinghai Lake, while the abundance is rather low (Huang, 1984a). Sars (1928) described this species moved slowly on muddy substrate 2 fathoms deep under water surface at Vensjø in Moss of Norway.

Some other species of the study section, such as Candona neglecta, Cyprides torosa, also
provide some environmental information. Living species belong to Candonia mainly live in various fresh water, and some species are encountered in oligomeshaline water (Van Morkhoven, 1963). In Qaidam Basin, living Candonia species are comparatively wide in distribution and rich in quantity in fresh-oligohaline water, no living Candonia species has been found yet in the water with salinity over 2% , and Candonia neglecta is the dominant species in the common species of the area (Exploration and Development Research Institute et al , 1988). Living Candonia neglecta thrives best in the clear and cool freshwater or alkaline lakes with water temperatures 5°C - 8°C and luxuriant flora (Li et al , 1991). In Lake Mondsee, Austria, Candonia neglecta is an ubiquitous species living in all types of habitats, from astatic to deep lake and from saline to freshwater (Danielopol et al , 1993). Cyp rideis is a common worldwide genus since Miocene and prefers to live under salinity comparatively high. It is also an euryhaline and eurythermal genus, such as, the tubercles not developed form of Cyp rideis torosa are adapted to temperatures of 0°C - 30°C and salinities of oligohaline - 120g/l (Exploration and Development Research Institute et al , 1988). Cyp rideis torosa can live in the 0- 30m depth water (Exploration and Development Research Institute et al , 1988). In China, living Cyp rideis torosa only distribute in western Qinghai and Xinjiang provinces where sulphate or chloride predominates in chemical composition of water, while it is lack in eastern China where the water chemical composition is predominated by carbonates (Zhao, 1993). The tubercles not developed form of Cyp rideis torosa, mainly living in river or pond around lake, is the only species of Cyp rideis found in Recent water of Qaidam Basin, and the percentages in assemblages range from 0.2% to 5.3% (Exploration and Development Research Institute et al , 1988). Ilyocypris is commonly found in various fresh water and a few species, such as Ilyocypris gibba in oligohaline water. The genus prefers to live under temperature of 10.5°C - 20°C. Although Ilyocypris often scatters in ponds or swamp s , it tends to be used as an indicator of fluid water bearing hydrobio and algae. Living Ilyocypris gibba has been observed from Qaidam Basin, while the abundance is rather low (Exploration and Development Research Institute et al , 1988). It has been recorded that Ilyocypris gibba live mainly in persistent or temporary fluid water with plants and algae in it and water temperature ranges from 4°C to 19.5°C (Li et al,. 1991, 1994). The results on ostracods from surface deposits of fifteen recent lakes in Tibet indicate that Ilyocypris gibba only appears in lake Yangzhuoyong Co, and the main environmental elements are water temperature 15°C (in August), pH 9.18, salinity 1.781g/l, greyish yellow substrata respectively (Huang et al , 1985, Yang et al , 1982).

Zhao (1993) presents the results on the salinities of 48 living species on the Northern Hemisphere, in which the salinity of Limnothrix inopinata is 0.5 - 10.69 - 25‰, Danaw inula stevensoni< 0.5 - 15‰, Candonia neglecta 0.5 - 15.7‰, Cyp rideis torosa 0.4 - 150‰, Cyclocypris serena 0.714‰.

Based upon ostracod ecological materials above, consulting chronological data, deposits and pollen, it is inferred that four main environmental stages are indicated as follows:

**Stage 1** (42 000 - 38 000 B. P.)

The deposits consist of two parts, the lower part gravel and the upper part silty clay. Tex-
ture and structure indicate that it is lake sand with local pebble input (Pachur et al., 1995). Ostracods are found in silty clay. The abundance of ostracoda is low and L inocythere inopinata predominates. Ostracoda indicates oligo-mesohaline lake. It is remarkable that the values of L inocythere inopinata are all female. Recent studies in Europe have shown that this species reproduces only parthenogenetically and is an indicator of summer water temperatures > 8.6°C (Pachur et al., 1995). It may be inferred that the climatic condition of this period is temperate; this coincides the evidence presented from pollen (Ma et al., in press). Pollen also provide the evidence of moist condition.

Stage 2 (38 000- 31 000 a B. P.)

The occurrence of the common freshwater species *Danw inula stevensoni* reflects that the area of the lake is larger than in stage 1, corresponding to the results inferred from pollen (Ma et al., in press); this may be set off by increased surface runoff caused by decreased evaporation, and pollen indicates moist climatic condition. Still ostracods are dominated by L inocythere inopinata. Ostracod assemblage indicates oligohaline-mesohaline water environment. The deposit, being characteristic of rich carbonates, interdigitating with silty sand, is largely lacustrine sediment with dominant local input (Pachur et al., 1995).

During 36 000- 34 000 a B. P., the abundance of ostracods is comparatively high and the male L inocythere inopinata occurs; this may be caused by rich carbonates as a result of increased salinity.

Stage 3 (31 000- 30 000 a B. P.)

The percentage of *Danw inula stevensoni* in assemblages increases and the content of this species is only second to L inocythere inopinata. And *Danw inula stevensoni* predominates as well as L inocythere inopinata. It is inferred that the lake is larger than that in stage 2 at the same time, ostracod carapaces become large, it seems to imply decreased temperature. Pollen presents evidence of wet and cooling and temperate climatic condition (Ma et al., in press).

Stage 4 (30 000- 23 000 a B. P.)

The occurrence of tubercles-bearing *I byocyp ris gibba* seems to indicate comparatively temperate climatic conditions and less salinity water body, while the content of the species is rather low. The lake water may be oligohaline. Stage 4 is established in two steps:

Stage 4a (30 000- 28 000 a B. P.)

The percentage of *Danw inula stevensoni* in two samples of analyzed three samples is over 50%; this indicates rising water levels and the lake is larger than stage 3. Still comparatively large ostracod carapaces implies a cooling. Low evaporation rate or increased snow fall may be the cause of rising water lever during cooling stage. The lake is freshwater.

Stage 4b (28 000- 23 000 a B. P.)

Although the abundances are changeable, the percentages of species are comparatively...
stable; this suggests less environmental variety. Smaller ostracod carapaces compatible
with stage 4a imply comparatively warm water. The occurrence of Cyclocypris serena
indicates oligohaline water Decreased percentage of Daniculina stevensoni reflects a falling
in the water level, this may be caused by increased evaporation rate compatible with stage 4a.

It is worth mentioning that L inocythere inopinata and Cyprideis torosa are all without
well-developed the tubercles A number of species, mainly of genera belonging to the
Cytherideinae (such as Cyprideis, Cytheridea, Cytherissa) develop typical phenotypic hollow
tubercles on lateral surface of their valves when moving to environments of less salinity
(Van Morkhoven, 1963). The form of L inocythere inopinata without well-developed tubercles
mainly lives in brackish water (Yang, 1986). It is inferred that during 42 000 - 23
000a B. P. the water body of palaeolake was comparatively stable and no considerable in-
crease in salinity occurred.

In summary, the period 42 000 - 23 000 years ago represented a generally temperate
time, interrupted by several phases of slightly declining temperature. The ostracod fauna
indicates a fresh-mesohaline lake, which apparently persisted over the entire sedimentation
period without any desiccation phases.

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Plate Explanation

All specimens are deposited in Nanjing Institute of Geology and Palaeontology, Academia Sinica

Plate I

1- 3 L inocythere insipinata Baird, 1843
1 external view of female left valve. × 60, Cat No. 128203
2 external view of female left valve. × 60, Cat No. 128204
3 external view of female right valve, × 60, Cat No. 128205
4. 5 D amo inula stevensoni Brady & Robertson, 1870
4 external view of left valve. × 60, Cat No. 128206
5 external view of right valve, × 60, Cat No. 128207
6. 7 C andona neglecta Sars, 1887
6 external view of right valve, × 50, Cat No. 128208
7 external view of right valve, × 50, Cat No. 128209
8- 10 C yprideis torosa Jones, 1850
8 hinge features of female left valve. × 250, Cat No. 12820a
9 internal view of male left valve, × 60, Cat No. 12820b
10 external view of male right valve, × 60, Cat No. 128211
11 C yclopyris serena Koch, 1837
11 right lateral view of a carapace. × 60, Cat No. 128212
12, 13 H ycyp ris gibba Ramdohr, 1808
12 external view of right valve, × 50, Cat No. 128213
13 external view of left valve. × 50, Cat No. 128214
14, 15 N eocyp ris sp.
14 internal view of left valve. × 50, Cat No. 128215a
15 details of muscle scars. × 300, Cat No. 128215b