

EVOLUTION OF MOUNTAIN LAKES OF CENTRAL ASIA IN LATE QUATERNARY

D. V. Sevastyanov, G. N. Berdovskaya, A. A. Liiva

(*Institute of Limnology, Leningrad*) (*Institute of Zoology and Botany, Tartu*)

The Tien Shan and the Pamir mountain lakes and their history have been studied to a considerably lesser extent than the lakes on plains. In the past years new data have been obtained on the present state of high-mountain (alpine) lakes and on the palaeography and palaeolimnology of the mountain regions of Central Asia.

The authors have investigated the basins of the great lakes in the Tien Shan and the Pamirs. The geomorphology of lake depressions, the distribution and composition of glacier and lacustrine sediments have been studied, the spore-and-pollen analyses of lacustrine sediments have been carried out and the ^{14}C dating of buried plant remnants performed. This has given the possibility of establishing the main evolution stages of mountain lakes and of reconstructing the palaeogeographical conditions of the high-mountain regions of Central Asia in the Late Quaternary period.

The lakes under investigation are situated at different altitudes but they all exist under conditions of insufficient humidity. According to the results obtained by us, the lakes of the Tien Shan, viz. Lake Issyk Kul (with absolute height of 1607 m a. s. l.), Sonkul (3016 m), Chatyrkul (3530 m), the lakes of the pamirs, viz. lake Karakul (3915 m), Rangkul (3785 m), Shorkul (3778 m) and some others have more than once experienced transgression and regression. The changes in the state of mountain lakes were mainly caused by the variations in moisture, glaciation of lake basins and variations in runoff and discharge. The plant communities in high-mountain lake basins changed in accordance with the alterations in climate.

The lacustrine sediments and terraces of the late Pleistocene have been investigated in the basins of Lake Chatyrkul in the Tien Shan and Lake Karakul in the Pamirs. It has been ascertained that 22-17 thousand years ago they were drainage freshwater basins and their

area exceeded the contemporary one 2-3 times.

The spore-and-pollen spectra of lacustrine sediments, which have the radiocarbonic age of 20220 ± 500 /TA-733/, 18720 ± 150 /TA-1681/ and 17200 ± 500 /TA-1680/, correspond to the domination of dry steppe vegetation in the lake depressions. Besides, a considerable amount of long-transported pollen of trees and shrubs (*Picea schrenkiana*, *Cedrus deodara*, *Pinus* sp., *Betula* sp.) is found in the spectra. This is probably connected with larger areals and higher timber-line in the Tien Shan and the pamirs during the referred period. The climate of those times was warmer and more humid than it is now at the same altitudes (Никонов, Пахомов, Шумова, 1979; Севастьянов, Бердовская, Лийва, 1986).

In the end of the Late pleistocene, 16-11 thousand years ago, the glaciation reached its maximum in the mountains of Central Asia. It was accompanied by continual increase in aridity and decrease of glaciers and meltwater. In conditions of cold arid climate the high-mountain lakes dried up and disappeared. Glaciers descended into lake depressions. Glacial deposits mantled completely or partially the Late-glacial lacustrine deposits in Lake Chatykul and Karakul depressions and dammed up Lake Sonkul.

The frequency of spore-and-pollen from high-mountain lacustrine sediments of that period is very low. The microfossils have preserved badly, they contain mainly xerophyte pollen (*Ephedra* spp., Chenopodiaceae, *Artemisia* spp.), some long-transported pollen grains of trees and shrubs can be distinguished. This is explained by the remarkable descent of the timber-line in the mountains and the appearance of high-mountain cold desert communities in lake depressions.

On lower altitudes, i.e. in the depression of Lake Issyk Kul, the steppe-desert and dry steppe vegetation dominated. Considerable regression of lake level started.

The climate of that period in high mountains may be characterized as cold and extremely arid (Серебрянный И Др., 1980; Озеро Иссык-Куль И тенденции..., 1986).

In the Early Holocene the glaciers started to retreat. In depressions the alpine regime was restored. The increase in meltwater brought about the transgression of lakes and accumulation of coarse deposits on their bottom. According to our calculations, the sedimentation rate was 2.0-2.5 mm per year 10-8 thousand years ago. The water-level in Lake Chatyrkul was 12 m higher than it is at present and the area

of the lake was 3 times larger. At the same time the water-level in Lake Sonkul dropped down as a result of the destruction of glacier dams and the lake waters penetrated into the South-East. In the spore-and-pollen spectra of those times the share of mesophytic communities and that of *Artemisia* pollen increased with respect to *Chenopodiaceae* and the contribution of long-transported pollen of *Picea schrenkiana* was remarkable. The above evidence shows a general rise in temperature and improvement of humidity conditions in the highmountain regions (Озера Тянь-Шаня..., 1980).

The period of Middle Holocene (8000-4000 years ago) was conspicuous due to variations in climate. At the beginning of the period the climate became remarkably arid. Probably at the same time the area of the lakes decreased. About 6000 years ago the climatic amelioration took place with respective changes in the landscapes of the Tien Shan and the Pamirs. In the basins of Lake Chatyrkul, Sonkul and Karakul the glaciers decreased. At that time the content of organic matter and calcium carbonates increased in bottom sediments. At the beginning of the Middle Holocene the CaCO_3 content in lacustrine sediments was 28-41 per cent, reaching its maximum (54.7 per cent) in younger layers which accumulated approximately 5500 years ago. This was followed by a decrease in calcareous compounds up to 30 per cent about 4500 years ago and up to 17-19 per cent about 3000 years ago. The organic matter content in the sediments of Lake Chatyrkul has also been studied. It reached its maximum (31 per cent) about 5000 years ago. The average calculated sedimentation rate in the lakes in the Middle Holocene is the following: about 1.1 mm per year in Lake Chatyrkul, 0.7-0.8 mm per year in Lake Sonkul and 0.9-1.2 mm per year in Lake Rangkul (Севастьянов и др., 1986).

On the spore-and-pollen diagram (Fig. 1) the spectra III and II of pollen zones illustrate the middle Holocene in the depression of Lake Chatyrkul. In the composition of zone III high content of *Ephedra* spp. pollen (More than 20 per cent) and that of *Chenopodiaceae* (about 20 per cent) has been identified with complete lack of the pollen of mesophytic communities. Pollen of trees (*Picea schrenkiana*, *Pinus*, *Betula*) has a sporadic curve, among shrub pollen *Nitraria* is worth mentioning.

The pollen zone II corresponds to the period of 6000-5000 years ago and coincides with the Holocene climatic optimum. The spore-and-pollen spectra reveal a sharp decrease in *Ephedra* pollen, increase in

Artemisia pollen and the appearance of mesophyte pollen, represented by the genera Ranunculaceae, Liliaceae, Caryophyllaceae, Polygonaceae, Leguminosae, Rosaceae, Cruciferae, Geraniaceae, Umbelliferae, Labiatae and Composite.

The spectra reveal the existence of the pollen of aquatic and littoral plants, such as *Sparganium* sp., *Potamogeton* sp., and *Typha* sp. The long-transported pollen content of the trees is the same as it is in zone III, however, shrub pollen, viz. that of *Lonicera* sp., *Nitraria sibirica*, *Hippophaë rhamnoides* and *Tamarix*, is also represented. This refers to a possible extension of areal of shrubs in the river valleys and on foothills.

The diminuation of glaciers and increase in the humidity of mountain regions caused the water-level rise in high-Mountain lakes. The aquatic and littoral species (*Vaucheria* sp., *Charales*) began to flourish in the shallow parts of lake Chatyrkul, Sonkul and Rangkul.

The data given above permit us conclude that in the Middle Holocene the climate of lake depressions of the Inner Tien Shan and the East Pamir was relatively warm and humid.

Noticeable changes in climatic conditions took place 4000—3500 years ago in the high-mountain regions of Central Asia. The spore-and-pollen spectra of the sediments of the Chatyrkul depression reveal the growth of the percentage of xerophyte pollen content (Fig. 1, pollen zone I), such as that of *Ephedra* spp. and Chenopodiaceae. Among the latter *Eurotia ceratoides*, *Atriplex oblongifolia*, *Kalidium caspicum* and *Kochia prostrata* have been specified.

During the past 3000 years the development of climatic conditions in the regions of the Tien Shan and the Pamirs was characterized by the desiccation of the climate, diminuation of the sedimentation rate in lakes and lowering of lake level. In the vegetation of mountain depressions of the Tien Shan, high-mountain steppes and steppe-deserts started to prevail. In the Pamirs the vegetation became more xerophytic, approaching to the present state (Алешинская и др., 1985).

The spore-and-pollen diagram (Fig. 2) presents the data on Lake Sonkul sediments, formed during the Late Holocene. In lacustrine sediments the organic matter content is decreasing as compared with the deposits formed during the climatic optimum. There are also several changes in the grain-size composition (K) and sorting (H_2), which took place about 2000 years ago. This was possibly connected with the activity of glaciers on the catchment of Lake Sonkul.

1500 years ago the climate became more arid and this brought about the regression of the lakes investigated. This process has continued up to now. In the sediments of Lake Sonkul, dated 1540-70/TA-944/, molluscs *Radix lagotis* (Schram), *Odhneripisidion stewarti* Preston and *Valvata cristata* (Müller) have been found, which are characteristic of well-warmed small water-bodies (Минутников и др., 1980).

The spore-and-pollen spectra of that period are characterized by the increase in the percentage of the xerophyte (*Ephedra*) pollen, whereas the *Artemisia* pollen has a tendency to decrease. Dry steppe communities began to dominate in the Sonkul depression, those of steppedeserts and deserts in the West Pamir lake depressions.

According to historical and archaeological evidence the 14th-16th centuries A. D. stood out as a period of warm and dry conditions in the Tien Shan. At that time a regression and drying of lake depressions took place in Lake Sonkul and Issyk Kul (Озера Тянь-Шаня..., 1980).

In the 17th-18th centuries A. D. a transgression was observed in the lakes of the Tien Shan and the Pamirs. It was caused by the increasing humidity, by cooling and by the activities of the glaciers. At that time Lake Chatyrkul level was 4 m higher than it is at present, that of Lake Sonkul was 2 m and of Lake Issyk Kul 12 m higher than it is now (Озеро Иссык-Куль и тенденции..., 1986).

At present Lake Chatyrkul, Sonkul and Issyk Kul in the Tien Shan and Lake Rangkul, Shorkul and Sasykkul in the Pamirs are in the regression phase. However, several high-mountain lakes with sufficient feeding from glaciers show signs of transgression, e.g. Lake Karakul, Sarezhskeye and Yashilkul in the Pamirs.

Hence, the evolution of high-mountain lakes in the Late Quaternary in Central Asia has proceeded under the influence of complicated climatic fluctuations. Cold and dry conditions were accompanied by the decrease in ablation, meltwater discharge and regression of lakes. Warm and humid conditions in high mountains brought about the retreat of glaciers, strengthening of meltwater discharge, intensive accumulation of lacustrine sediments and transgression of lakes.

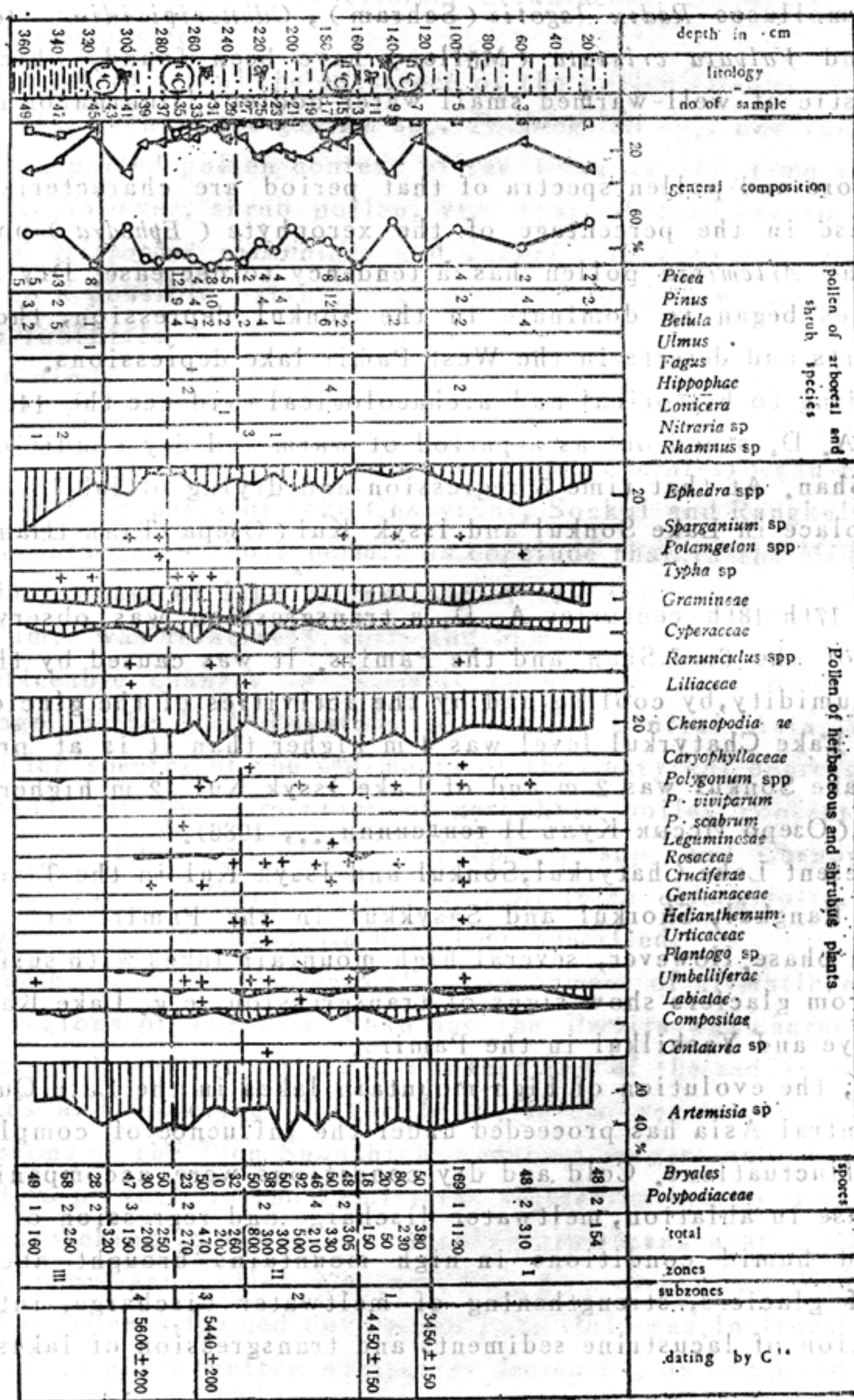


Fig. 1 Spore-and-pollen diagram of zone I, Lake Chatyrkul, the Tien Shan
1. AP; 2. NAP; 3. Spores; 4. Single pollen; 5. Remnants of buried water plants;
6. Sandy loam; 7. Loam; 8. Sand; 9. Clay

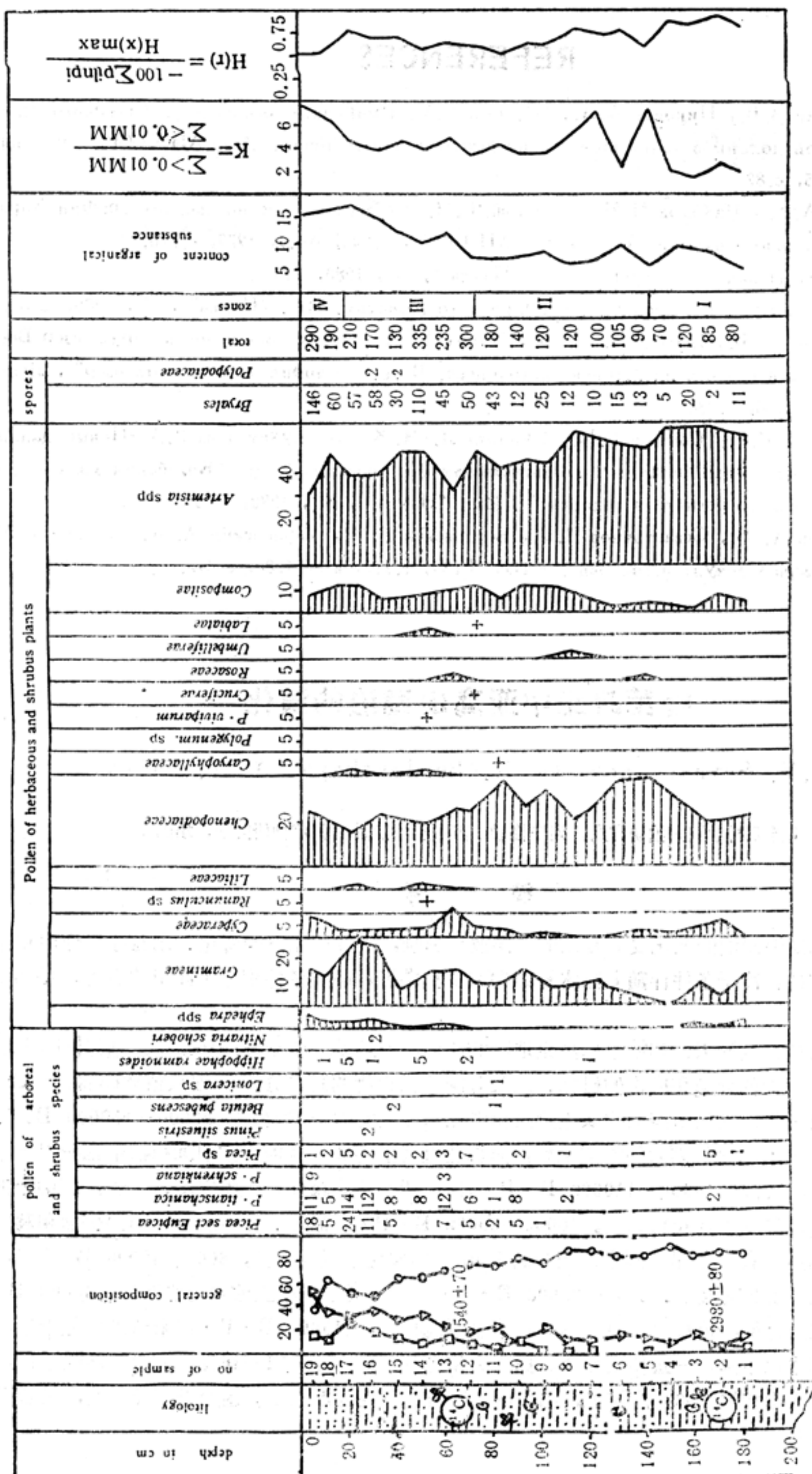


Fig. 2 Spore-and-pollen diagram of zone I, Lake Sonkul, the Tien Shan

For conventional signs see Fig. 1.

REFERENCES

- [1] Алешинская З.В., Никонов А.А., Шумова Г.М. - Природные особенности Северного Пахира и Алайской долины в конце позднего плейстоцена и в голоцене. - Изв. АН СССР, сер. геогр., No.2, 1985, с.87.
- [2] Никонов А.А., Пахомов М.М., Шумова Г.М. - Новые данные по палеогеографии Каракульской котловины на Памире. Доклады АН СССР, т.244, No.1, 1979, с.170.
- [3] Озера Тянь-Шаня и их история Изд. "Наука", Л., 1980, 232 с.
- [4] Озеро Иссык-Куль и тенденции его природного развития. Изд. "Наука", Л., 1986, 256 с.
- [5] Севастьянов Д. В., Бердовская Г. Н., Лийва А. А. - Новые данные по истории озер Восточного Памира в позднем плейстоцене и голоцене. В кн. "История современных озер", Ленинградталин, 1986, с.234.
- [6] Серебрянный Л.Р., Пшенин Г.Н., Пуннинг Я.-М. К., Халмухамедова Р.А. - Новые данные о развитии ландшафтов Ферганы в позднечетвертичное время. - В кн. "Колебания увлажненности Аралокаспийского региона в голоцене". Изд. "Наука", М., 1980, с.214.
- [7] Щитников А. В., Севастьянов Д.В., Бердовская Г.Н., Тарновский А. А. - Палеогеография бассейна озера Сонкуль в голоцене. - Изв. ВГО, т.112, в.6, 1980, с.497.

晚第四纪中亚高山湖泊的演化

D.V. Sevastyanov, G. N. Berdovskaya, A. A. Liiva

(苏联科学院湖泊研究所, 列宁格勒; 苏联科学院动物和植物研究所, 塔图)

摘 要

中亚晚第四纪高山湖泊的演化受到复杂的气候波动影响, 主要由水汽的变化、湖盆冰川作用和径流与流量的变化而引起的。冷干条件伴随着融水补给的减少和湖退; 暖湿条件引起了冰川的后退, 增加了融水补给, 引起湖进。

分布于不同海拔高度的天山和帕米尔高原地区的湖泊, 普遍处于较干旱的环境中。通过对湖盆地貌学、冰川和湖泊沉积物的分布和成份的研究、以及对湖泊沉积物的孢粉分析和埋藏植物碎屑的¹⁴C年代测定, 可以重建晚更新世以来高山湖泊的演化阶段和中亚高山区的古地理环境。22000—17000a B.P., 天山查特爾庫爾湖和帕米尔喀拉湖为外流淡水湖, 面积超过目前的2—3倍。湖泊沉积物中孢粉以干草原植被为主, 反映气候较暖湿。16000—11000a B.P., 冰川活动达到极盛, 气候寒冷、干燥, 湖泊干涸、消失。孢粉频率低, 以旱生植物花粉为主。10000—8000a B.P., 温度、湿度提高, 中湿植物和藜属相对藜科增加, 开始湖进。查特爾庫爾湖水位较今高12m, 面积超过现今3倍; 8000—4000a B.P., 天山和东帕米尔的湖盆气候相对暖湿。4000—3500a B.P., 气候变干, 旱生植物花粉增加。3000a B.P.以来以气候干旱化为特征, 植被以高山干草原和草原-荒漠为主。1500a B.P.以来气候更趋干旱, 干旱植物花粉增加, 湖水位下降, 一直持续至今。据历史和考古资料, 公元14—16世纪天山气候暖干化, 发生湖退; 17—18世纪天山和帕米尔湿度增加, 出现湖进。目前该地区湖水位普遍处于下降时期, 仅若干冰融水补给湖泊有湖进的迹象。