

the Third Chinese Conference on Permafrost:

# EXPANDS RESEARCH ON FROZEN GROUND



by Troy L. Péwé

**W**ITH 22 PERCENT of its country underlain by permafrost and an additional 68 percent subject to seasonal freezing, China continues to expand its research in science and engineering of frozen ground.

Glaciology and Geocryology (the largest institution dealing with these subjects in China) and the Heilongjiang Provincial Scientific Research Institute of Water Conservancy. The conference covered many

the U.S., 2 from Canada, and 5 from Japan. The 218 abstracts of 121 oral presentations revealed important advances since the second conference held in 1981.

Permafrost in China can be divided into two broad categories: permafrost in high latitudes and permafrost in high altitudes (alpine permafrost). The permafrost region in northeast China is part of the southernmost zone of the Eurasian continental high-latitude permafrost area. It lies in the discontinuous zone as shown on the international permafrost map of the northern hemisphere (Fig. 1). The southern limit of discontinuous permafrost is between 46°36' and 49°24' N latitude in northeast China (Fig. 2). The southern permafrost border used here is 450 km north of Harbin (after Lu et al.<sup>2</sup>) and is slightly farther north than the border given by Cui and Xie.<sup>3</sup> Most permafrost in China is alpine and lies in the west, mainly in the mountains and in the Tibet Plateau, which has more than 70 percent of the permafrost of China<sup>4</sup> (Fig. 2).

Temperature has long been used in the classification of permafrost zones and is critical in the evaluation of permafrost for engineering needs. A -5°C mean annual ground temperature has traditionally been used to distinguish between continuous and discontinuous permafrost zones. It is customary to refer to the temperature of permafrost as that which occurs at the level of zero amplitude, that is, the depth at which significant variation between winter and summer ground temperatures is no longer present. This depth ranges be-

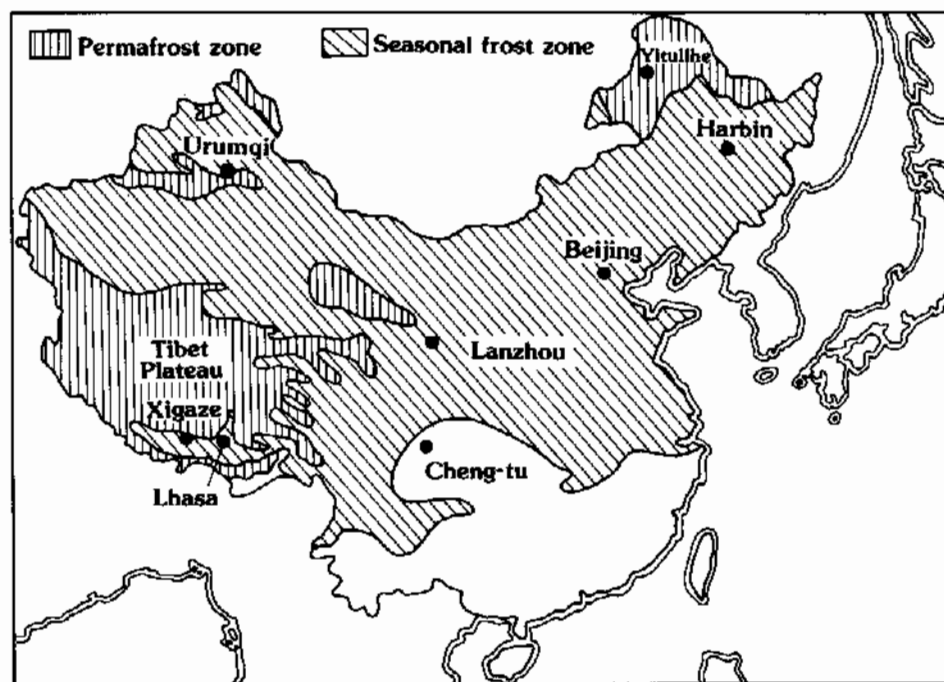


Figure 2. Generalized distribution of permafrost and seasonally frozen ground in China. (From Lanzhou Institute of Glaciology and Geocryology.)

The Third National Chinese Conference on Permafrost was held in Harbin, Heilongjiang Province, in northeast China, 19-24 August 1986. Organizers for the conference were the Lanzhou Institute of

aspects of seasonally and perennially frozen ground in six days of presentations and local field trips. In addition to the 156 delegates from about 20 Chinese institutions, there were 3 invited foreign guests from

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tween 10 and 25 m. The temperature of permafrost in northeast China ranges from slightly colder than 0°C to -4.2°C recorded at Mangui near the China-USSR border. Permafrost temperatures on the Qinghai-Xizang (Tibet) Plateau in southwest China may be -12°C at a 6000-m elevation.<sup>4</sup>

In the late Pleistocene, permafrost in northeast China was more widespread, thicker, and colder than it is today. With the worldwide lowering of temperature and the withdrawal of the Yellow Sea, a colder climate permitted the southern border of permafrost to move about 10 degrees of latitude farther south than today.<sup>2</sup> Cui and Xie<sup>3</sup> indicate that the southern border was even slightly farther south.

#### THE CONFERENCE: OPENING SESSION

The Permafrost Conference was opened by Zhou Xingwu, director of the Heilongjiang Provincial Scientific Research Institute of Water Conservancy. Greetings were extended first by Professor Shi Yafeng, senior permafrost scientist of China and honorary director of the Lanzhou Institute of Glaciology and Geocryology, and also by Wang Lianzheng, vice-governor of Heilongjiang Province, the most northern province in China, of which Harbin is the capital. Remarks by the vice-governor included reference to the great economic importance of the study of frozen ground to the province. Shi noted that one of the conference goals was to select the best papers for the Fifth International Conference on Permafrost to be held in Norway in 1988; in addition, it was a great honor for China to be selected as host for the Sixth International Conference on Permafrost in 1993.

A book of selected abstracts in English was presented to the foreign participants (available from the Institute of Glaciology and Geocryology, Lanzhou, China). After a group photograph, the formal presentation of papers began. The conference was divided into four subject areas: general and regional geocryology (about 60 abstracts); physical, thermal, and mechanical properties in freezing and thawing of soils (70 abstracts); design and construction in cold regions (80 abstracts); and instrument and testing techniques (24 abstracts).

#### Engineering Considerations

The largest share of presentations were papers considering construction and physical, chemical, and thermal properties of frozen ground in cold regions. Subjects

considered ranged from groundwater problems, including icings (aufeis), through deep embankment studies to insulation problems. Discussion of frozen ground problems in connection with railway construction and maintenance were well represented. By far the majority of papers in these sections dealt with some aspect of frost heaving. In fact, the two main conference themes appeared to be (1) the various aspects of theoretical and practi-

cal interpretation of frost heaving and (2) periglacial phenomena.

Although the impact of frost heaving and correction techniques on conventional structures such as highways, railways, and bridges (including piles) were considered, most research appeared to be connected with the damage by frost action on irrigation structures such as canal walls, sluice gates, and diversion structures used in most agricultural areas of northeast



Figure 3. Load frames to measure frost heaving in loam. Field station of the Low Temperature Construction Science Research Institute of Heilongjiang Province, 30 km west of Harbin, China, August 21, 1986. (T. L. Péwé photo no. PK 28,153.)



Figure 4. Field installation to measure frost heave on piles and footings. Field station of the Heilongjiang Provincial Scientific Research Institute of Water Conservancy, 19 km west of Harbin, China, July 19, 1984. (T. L. Péwé photo no. 4807.)

China. These irrigation-related problems are not common elsewhere in the world, since irrigation is used mostly in nonpermafrost regions.

It was reported that in Heilongjiang Province alone, frost heaving has damaged more than half of the thousands of kilometers of concrete-lined canals and ditches with diversion structures used in irrigation. Since 1949 most of the concrete structures have been rebuilt three or more times, and in one area, canals have been rebuilt three times in the last ten years. In addition to hearing papers describing this problem and examining field-station experiments (Figs. 3 and 4), participants were shown two color films of the disastrous results of frost heaving on irrigation structures. The vertical pressures on the structures and the lateral pressures on canal walls are more than the structures can accommodate. Various methods are vigorously being undertaken to solve frost heaving problems of irrigation structures but with only limited success. These methods include trying to improve soil drainage, adding lime or salt to the soil, strengthening the structures, and insulating the soil from cold air by natural or artificial cover. Foamed polystyrene appears to have some success, but only on test sites, and it is not available for the thousands of kilometers of canals.

#### *Regional Distribution of Permafrost and Periglacial Phenomena*

Although the general distribution of modern permafrost in China has been outlined for some time, the details are still emerging. It was interesting to have confirmed a 1985 newspaper account that was a first report of permafrost in central China, on a mountain top near Lanzhou. At an elevation of 3650 m, an excavation for construction material exposed 12 m of ground ice, ranging from clear to milky, in veins up to 10 cm wide, within bedrock fractures 3 to 8 m beneath the surface. Tritium and  $O^{18}/O^{16}$  tests on the ice revealed that it was formed when the mean annual air temperature was  $-4.5^{\circ}\text{C}$ ; this is  $2.3^{\circ}\text{C}$  colder than temperatures today on the mountain top. The permafrost is interpreted to be no more than 3000 years old. It is too marginal in temperature to have survived the mid-Holocene warm period. Total thickness of permafrost on the mountain is unknown.

For the first time in a Chinese national permafrost conference, there was a paper on frozen ground phenomena in Antarctica.<sup>5</sup> Xie reported permafrost up to 50

m thick and many periglacial features at the new (1984) year-round Chinese field station (Changcheng or Great Wall) on King George Island just off the northern tip of the Antarctic Peninsula in the sub-antarctic.

#### *Ice Wedges*

Two discussions among Li Qu-Xiu and associates, engineers for the Qiqihar Branch of the Harbin Railway Administration, and Péwé and Kreig of the U.S. provided additional information concerning what appears to date to be the only excavated, photographed, and reported ice wedge in permafrost in China. During the July 1984 visit of the U.S. Permafrost Delegation to northeast China we were shown a black and white photograph (labeled geologic cross section No. 5) of the upper part of a flat-topped foliated ice wedge about 1 m wide discovered at Yitulihe in northeast China; this photograph is reproduced in Brown.<sup>6</sup> Li sent Péwé a photograph (Fig. 5) of a different wedge in October 1984. Because of the rarity of ice wedges in China, their importance in considerations of past and present climatic reconstruction, and especially because of the importance of knowing the existence and distribution of ice wedges for engineering construction on ice-rich terrain, Péwé communicated several times in 1984-85 with Chinese engineers, and the Harbin meetings were arranged. New information is presented here.

Contrary to the earlier report,<sup>6</sup> the one ice wedge was not found in an excavation for the permafrost observatory building, but four or five ice wedges were encountered in the winter of 1982-83 in a 100-m-long water-supply pipeline trench in Yitulihe extending southward from the railway to residence buildings. Additional ice wedges were found in a residence building excavation near the end of the pipeline. The construction was rapidly completed and evidently no photographs were taken.

In January 1984 special trenches 15 m long were dug next to the aforementioned pipeline for the express purpose of exposing and photographing ice wedges. This was for a report to be presented by Jia Minghao, director, Yitulihe Branch, Frozen Ground Observatory Station, at a permafrost meeting in Lanzhou in the spring of 1984. At least two ice wedges were exposed and photographed. The papers presented were not published.

From the above information we now know that inactive flat-topped ice wedges occur about 1 m below the surface in the northern part of northeast China in discontinuous permafrost. They may be late Pleistocene in age because they occur in alluvium on the first terrace of the Yituli River.

#### *Periglacial Phenomena*

One of the major sections of the conference was devoted to a discussion of periglacial phenomena—past and present.



Figure 5. Flat-topped 1-m-wide ice wedge in discontinuous permafrost exposed in a trench in alluvium on the first terrace of the Yituli River in Yitulihe, China, January 1984 (labeled "Geologic cross section No. 1"). (Photo courtesy of Li Qu-Xiu, Qiqihar Branch of the Harbin Railway Administration.)

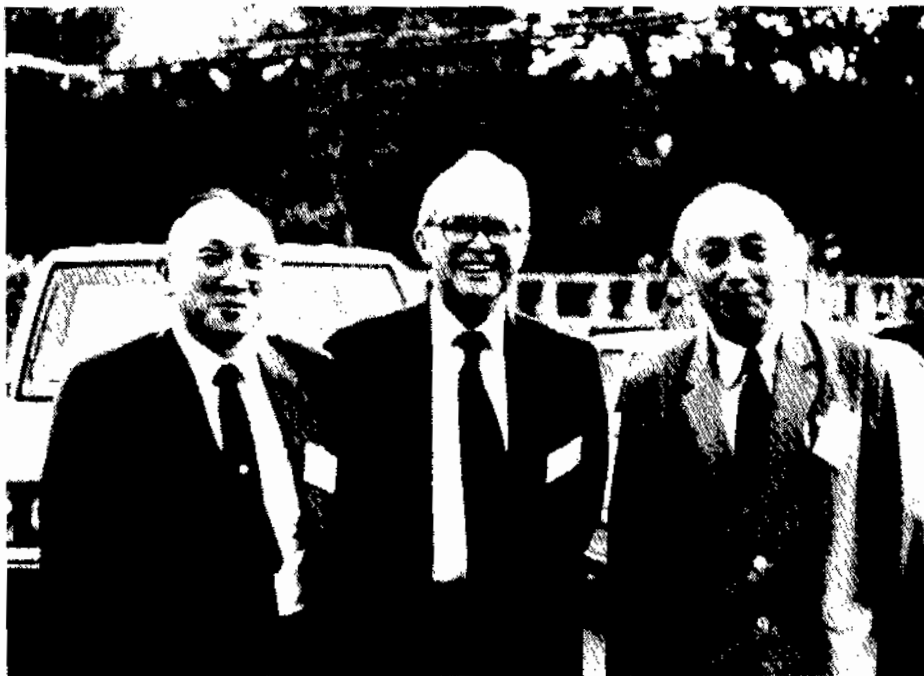


Figure 6. Officials of the International Permafrost Association at Harbin, China, August 20, 1986. Left to right: Professor Seiti Kinoshita, chairman, Japanese adhering body; Professor Troy L. Péwé, first vice-president, IPA; Professor Shi Yafeng, chairman, Chinese adhering body. (T. L. Péwé photo no. PK 28,149.)

Periglacial features and processes are active in regions of rigorous climate. Such features as ice wedges, sand wedges, pingos, lobate rock glaciers, and cryoplanation terraces occur only where permafrost is present—the true periglacial environment.<sup>7,8</sup> Features such as involutions, solifluction deposits, and sorted patterned ground also form in cold areas, but they do not necessarily indicate the presence of permafrost or of a true periglacial climate.

Presentations at the conference indicated that confusion still exists over terminology and identification of actual features, i.e., annual frost blisters were also termed pingos. Most scientists in China who are interested in periglacial features have not had the opportunity to examine active features in other parts of the world. Maps of past periglacial environments of China have been based on permafrost phenomena, including the distribution of plants and animals.

Yet, considerable progress has been made in this area. Good dating of geologic sections by carbon-14 and thermoluminescence have yielded ages for colder environments, even if not for permafrost environments. Some researchers are now returning from the Arctic and Antarctic with valuable experience to refine the study of active and inactive periglacial features in China.

#### Field Trips

Two official engineering field trips were conducted to frozen ground test stations near Harbin. The group first visited the field station of the Low Temperature Construction Science Research Institute of Heilongjiang Province about 30 km west of Harbin. The station was established in 1978 and is devoted mainly to the study of frost heaving. One of the major experimental projects involves test plots to register frost heaving in loam (from retransported loess) of various thicknesses (1, 1½, 2, and 3 m) above the natural water table (Fig. 3).

The other field station visited is of the Heilongjiang Provincial Scientific Research Institute of Water Conservancy, 19 km west of Harbin. It was established in 1979 to study frost-heave forces on various foundation elements (Fig. 4). The station was also visited in 1984 by the U.S. Permafrost Delegation and is described in Brown.<sup>6</sup>

Two valuable nonscheduled field trips were also made to historic loess exposures in Harbin.<sup>9</sup> These sections exhibit retransported loess up to 1 million years old and are classic sites for Pleistocene vertebrate collections.

#### International Permafrost Association

The conference provided an ideal place to recognize the newly founded (1983) In-

ternational Permafrost Association (IPA) and the fact that China was one of the original four founding countries, along with the USA, the USSR, and Canada. The author, as first vice-president of the organization, spoke briefly about the IPA in the opening and closing sessions and also was allotted a formal time to describe the status of the IPA and comment on the 14 adhering countries. The author met in special session with the Chinese adhering body to the IPA to discuss the fifth (1988) and sixth (1993) conferences. Professor Shi Yafeng (Fig. 6) is chairman of that body and Cheng Xiaobai is secretary. Also present at the conference were Professor S. Kinoshita, chairman of the adhering body of Japan, and Dr. M. Fukuda, secretary.

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