IAH 21st Congress
KARST HYDROGEOLOGY AND KARST ENVIRONMENT PROTECTION
10-15 October 1988 GUILIN.CHINA

KARST IN TIBET

M. M. Sweeting, University of Oxford

Bao Haosheng and Zhang Dian, Nanjing University

ABSTRACT

The Karst in Tibet is discussed in three regional zones - Southern Tibet, the Lhasa area, and the Northern Tibet plateau. All three regions are areas of high altitude peri-glacial pinnacle Karst. Calcareous and clastic sediments associated with the Karst are extremely rare but some specimens have been collected and are being analysed. The potential for palaeoclimatic reconstruction is discussed. It is unlikely that any relic tropical or sub-tropical landforms remain. The Karst on the Tibet plateau is regarded as a separate type of high altitude Karst.

a) Introduction

Carbonate rocks of various ages are distributed widely in Tibet. These rocks are all at high altitudes - over 3000 m. There is no Karst in Tibet at a low altitude. The Karsts are therefore comparable to similar high altitude Karsts of the Alps in Europe and of the Rocky Mountains in North America. In this paper the regional differentiation of Karst landforms in Tibet will be considered, together with a short discussion on the extent to which these landforms can be used for the palaeoclimatic reconstruction of the Tibetan area. The Karsts of Tibet will be examined in three regions - Southern Tibet, the Lhasa area and the Northern Tibetan Plateau.

b) Southern Tibet

Limestones of various ages from the Ordovician to the Eocene occur in the overthrust masses which run E - W along the northern Himalayan foothills South of the Yarlung Zambo Valley. Because of the strongly folded and fractured nature of these limestones, outcrops are rarely extensive and are isolated by cross faulting. Limestones frequently occur in the ridges over 5000 m., the alluvial plains between being about 4000 m. One of the largest exposures is near New Dingri, where Eocene limestones occur in an E. - W. trending

ridge at over 5000 m. The rocks have been thrust from the South. The region is relatively dry and the present average annual rainfall is about 200-300mm

Limestones in the Dingri area form the uppermost cliffs in the thrust masses which rest on non-Karstic beds below, often shales. The contact between the limestones and the non-Karstic beds is frequently marked by a spring-line with occasional shallow caves - 1 - 2 m. deep. Because of the intense frost weathering at this altitude, almost all the lower slopes and much of the upper slopes are covered with frost weathered debris fans; the spring line and caves at the contact zone of the limestone and non-limestone beds are therefore quite often obscured by the peri-glacial debris fans. It is possible that many of the buried small caves are older than the fans.

The limestones forming the ridges are dissected into small frost weathered pinnacles, probably controlled by joints and faults. The pinnacles are about 20 - 25m. high and give the sky-line of the ridges a serrated appearance; we have called these pinnacled ridges, cockscomb Karst. Between the pinnacles are frost shattered and debris fans. Fallen blocks of limestone detached by frost from the cliff-face occur on the fans below. There is some evidence of present day solution in the form of rain-pits, rillen Karren on the sides of the pinnacles and caused by rain or snow.

Where the E. - W. ridges are cut by N. - S. cross faulting, there are deeper gorges in which modern rival and fluvial action is important and where larger fans debouch onto the plain below. In these gorges, springs and caves tend to occur. One cave at 5000 m. has been explored by Zhang Dian; its dimensions are length 40 m., width, 30 m. and height 20 m. Such a cave may be a fragment of a larger phreatic cave formed by glacial meltwater, and later truncated by glacial erosion. No sediments have been found in the cave but the walls of this and other caves in the area are covered with condensation deposits, about 1 cm. thick. The condensation deposits resemble "cave pop-corn", which is seen on the walls of caves in the arid S.W. of the U.S.A. and are indicative of a drying out phase of climate. It is hoped to be able to date such deposits by 14 C or uranium series.

Snow and ice are found in small cirque-like hollows on the ridges. Meltwater from these snow and ice masses is important in the formation of solution features, particularly in summer. The characteristics of this meltwater in July was as follows:- Temperature 3°C, pH. 8.3, Sp. conductivity, 80 . Deposition of calcium carbonate takes place at the foot of the fans and limestone blocks are cemented into breccia by tufaceous deposits; such cementation is taking place at the present time, but some might be fossil and indicative of both former wetter and warmer periods.

The Dingri Karst is characteristic of a fairly dry high mountain Karst and resembles the Crow's Nest mountain Karst of the Rocky Mountains - though it is much drier and more peri-glacial.

Many of the solutional features owe their origin to melt-waters; during the extensions of the ice during the Quaternary, caves would be truncated by ice erosion. Meltwater solutional features are rapidly destroyed in the present peri-glacial climate.

c) The Lhasa Area

In the Lhasa area, there are many small limestone outcrops, particularly of Jurassic limestones. The rocks are much thrusted and faulted, with much fault breccia and slickensiding W. of Lhasa, the outcrops are at 3,700 - 3,800 m. in height. The climate of the area is warmer than that of Dingri, being about -2.3°C in January and as high as +15°C in July; the rainfall is higher than in S. Tibet, about 445

The style of the Lhasa Karst is also peri-glacial pinnacle Karst. Each outcrop is dissected by frost and snow ravines into steep-sided pinnacles; the pinnacles are generally wider and higher than those in S. Tibet - up to 50 m. high and 20 - 30 m. wide at the base and becoming quite narrow (1 - 2 m.) at the top. As a result of the somewhat milder climate and lower altitude rather less rock is covered by peri-glacial frost debris than in S. Tibet. And because more rock is exposed finely chiselled Karren and other solution features and small caves are more numerous. However, most caves are very short and the longest cave found in the Lhasa area is only about 150 m. long. Many of the outcrops have been quarried which has made investigations easier.

S.W. of Lhasa a quarried face has intersected a small epiphreatic cave about 50 m. long. The cave is in a thrust mass, in dripping limestone beds (40^{o} - 45^{o}), and opens out in the middle of the quarried cliff, about 10 m. above the level of the plain. The cave extends to the plain level where there was water and where the pH was 8.1 and conductivity 150 . Flowstone deposits occur on the floor of the cave; some of these were collected and are now being dated by uranium series. Flowstone deposits are also associated with the slickensided bedding-planes and in addition some breccias and fissure deposits have been collected. Scalloping caused by actively flowing waters (possibly old cave waters) occur on inclinal thrust planes; the scallops indicate a pattern of water flow different from what would be expected today, and they may thus be older than the thrusting. The relationships of the caves and former water flow to the tectonics can only be resolved by more detailed investigations, and supported by absolute dating of the deposits.

other areas West of Lhasa are similar. Breccias cemented by tufa, travertine are commonly found at cave entrances. It is possible that these cemented breccias were formed in two different climatic phases; the limestones breaking up by frost into fragments in colder and dry phases and the cementation taking place in rather wetter and warmer phases.

d) The Northern Tibet Plateau

The Tibet plateau occupies most of Northern Tibet and lies North of the Nyainqentanglha Mt.. It is believed to have three levels, at heights of 5200 m., 4700 - 4800 m., and 4500 m. Its average rainfall is again about 400 mm. per year. At 4500 m, the hottest months are 4 - 10°C (maximum 25°C), and the coldest months are -15°C to -10°C, (minimum -40°C).

The Tibetan plateau is therefore an example of a peri-glacial frost-riven plateau, with very little rainfall or snowfall. The whole landscape is covered with frost debris flows which bury the rock outcrops almost entirely. Rock outcrops are therefore relatively restricted, both vertically and horizontally. Limestones of Jurassic and Cretaceous age outcrop in East - West trending bands; these were examined particularly in the neighbourhoods of Ando and Namo Lake. The limestone outcrops consist of pinnacles of bare rock delimited by frost shutes along joints and fractures. The pinnacles are generally smaller than those in the Lhasa area - the result of a much greater cover of peri-glacial debris. On the pinnacles solutional features are relatively few. Thin peaty deposits cover the debris fans and some rock outcrops; limestones beneath these show some solution as a result of biogenic CO_2. Solutionally enlarged joints and bedding planes form small caves - only a few metres deep and wide. Such caves contain very few deposits, either clastic or calcareous; however, some cave earths and their flowstones have been collected. Condensation deposits are found on the cave walls; no true stalagmites or stalactites were found. Some of the caves which penetrate right through the pinnacles, may be fragments of former truncated epiphreatic caves. Frost deposits obscure most of the cave entrances. This type of Karst is well illustrated in the area N. and E. of Ando and we propose to call it the Tibetan Karst type.

Two lakes in the S.E. part of the Tibet plateau, Nam Co and Nag Co, are associated with limestone outcrops. There are small caves related to old lake shore lines which have been formed by wave abrasion, assisted by aeolian action - the caves are not essentially of solutional origin.

Tufa deposits on the Tibet plateau are uncommon, but there is one particularly widespread deposit, N. East of Amdo which is at

least 50 m. thick. The deposit fills a good part of the N. side of the Sangu river valley - and it diverts the river to the S. side of the valley. About 1 km. is exposed along the highway and the tufa beds dip at about 10° - 15° south to the river. The deposit is made up of several varieties of tufa. Near to the river, water upwells through the tufa in deep Karst springs rather like blue holes. The water in these springs has a temperature of 10° - 12°C, a pH of 6.4 and a conductivity of 0-1370. The springs contain much algal life - which is probably the reason for the calcium carbonate deposition. It is not known if the springs originate from surface water or from deep underground sources.

The progressive decrease in PCO_2 in both the atmosphere and in the soil with ascending altitude is shown in figures 1 and 2. The conductivity of the waters reflects this change, fig. 3; the pH of the waters also appear to change with altitude, fig. 4, - the reasons for this we are unable to explain.

e) Conclusions

Until the cave earths, flowstones and other deposits have been examined it is not possible to say what potential the Tibetan Karsts have for climatic and palaeokarstic reconstruction. Karstic sediments, both clastic and calcareous, are so rare in Tibet that the preliminary conclusion is that there is relatively little potential, except perhaps in the Lhasa area,. In the Lhasa area there are distinct phases of breccia formation and tufa/flowstone formation, which may reflect colder and warmer climatic phases in the late Quaternary and the Holocene. In Southern Tibet, the Karstic landforms, particularly the caves, may be related to variations in ice and meltwater, i.e. to cold and less cold fluctuations. On the Tibetan plateau, the effects of the all-pervading peri-glacial climate has obliterated almost every vestige of landforms originating under any other climate. It is possible that by careful searching in caves, some pre- peri-glacial sediments may be found - but they will be very difficult to find. The authors therefore conclude that there are no relic Tertiary or even early Quaternary Karsts in Tibet. If the Karsts did originate at lower levels under warmer, sub-tropical conditions, then all traces of such an origin have been obliterated by the severe climatic conditions both during the later part of the Quaternary and of today.

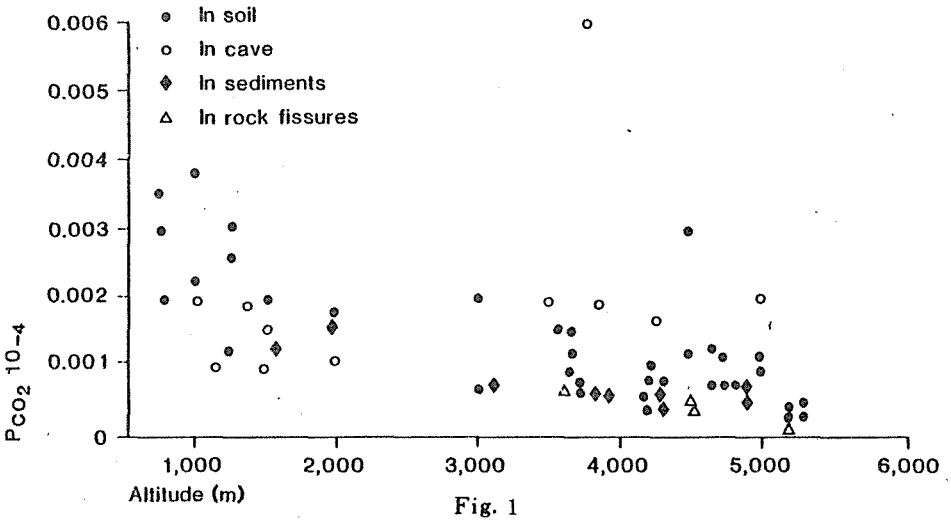

Fig. 1

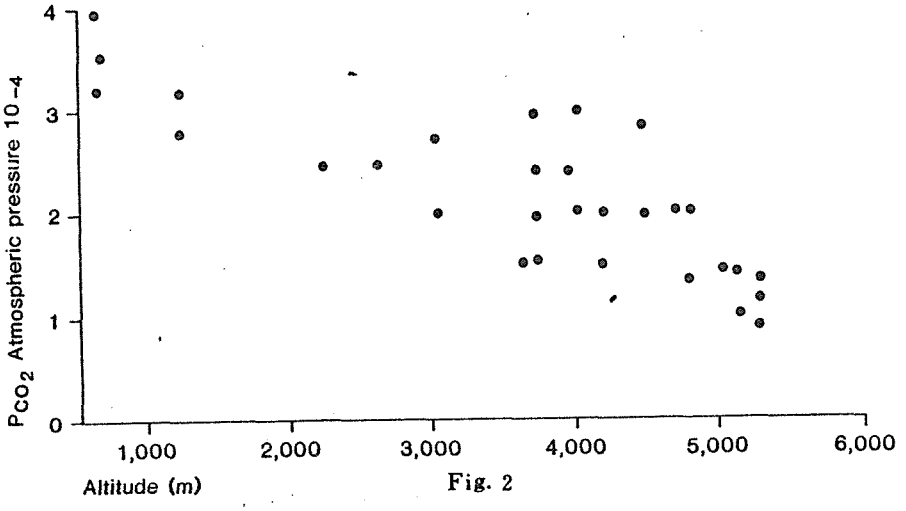

Fig. 2

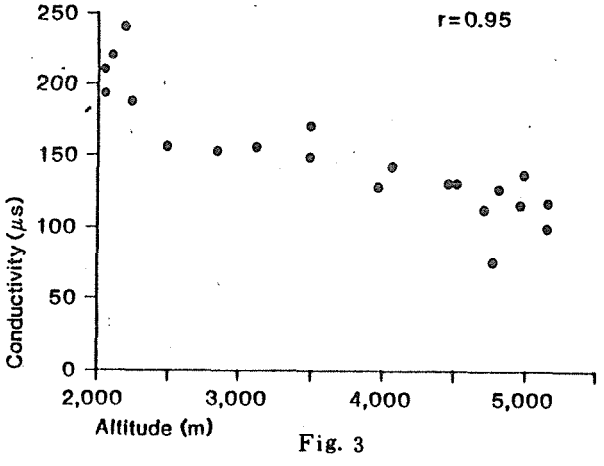

Fig. 3

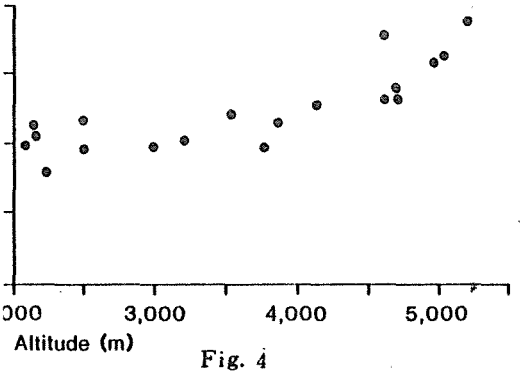

Fig. 4