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# A PRELIMINARY STUDY ON QUATERNARY GLACIAL LANDFORMS IN MT. MA' AN

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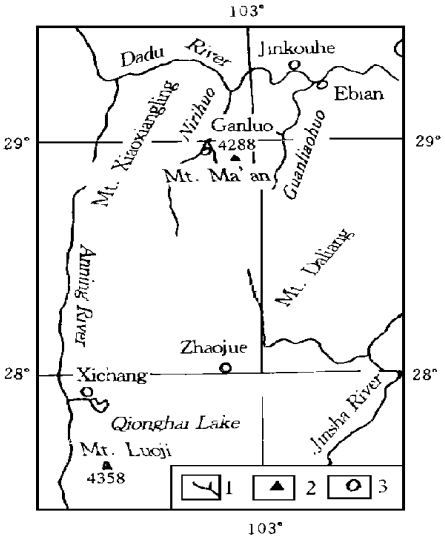
**ABSTRACT:** Mt. Ma' an (4288 m) s the h ghest mounta n n the south west edge of S chuan Bas n. It s s tuated to the south of the Dadu R ver. The geograph c coord nates are: 28° 58′ N, 102° 55′ E. There are s x peaks over 4000 m n elevat on. Many quaternary glac al landforms n th s mounta n have been d scovered. It' s a typ cal example of foss l glac al landform n the east Ch na. Its glac al stages are the last glac at on ($Q_3^3$) and the neoglac at on ($Q_4^3$). Mt. Ma' an and Mt. Luoj (4359 m) are s m lar n the foss l glac al landforms, but there are st ll some d fferences between them. For ex- ample, the rat o between the d rect d fference and the m nus d fference s d fferent.

**KEY WORDS:** southwest edge of S chuan Bas n, Mt. Ma' an, glac al landform, Quaternary glac er

Mt. Ma' an (saddle mounta n) w th an elevat on of 4288 m s s tuated between two south branches of the Dadu R ver' the Guanl ao and N r r vers, n the south- west edge of S chuan Bas n of Ch na. The geograph c coord nates are: 28° 58′, 102° 55′ E (F g. 1). Th s mounta n stretches n the d rect on of NNW, ts south part jo ns up w th the Mt. Dal ang wh ch stretches n the d rect on of NE. Geotecton cally, Mt. Ma' an l es to the north of the L angshan folded zone of the west Yangtze paraplatform. Th s folded zone s const tuted by many ant cl nes and synccl nes, wh ch are arranged alternat vely. Mt. Ma' an s s tuated on the northeast part of X ax ay da ant cl ne. The both slopes of the mounta n are 30° – 45°, almost symmetr cal of so th s mounta n s a hogback. The strata of ts structural slope s const tuted of basalt and shale of Upper Perm an se-

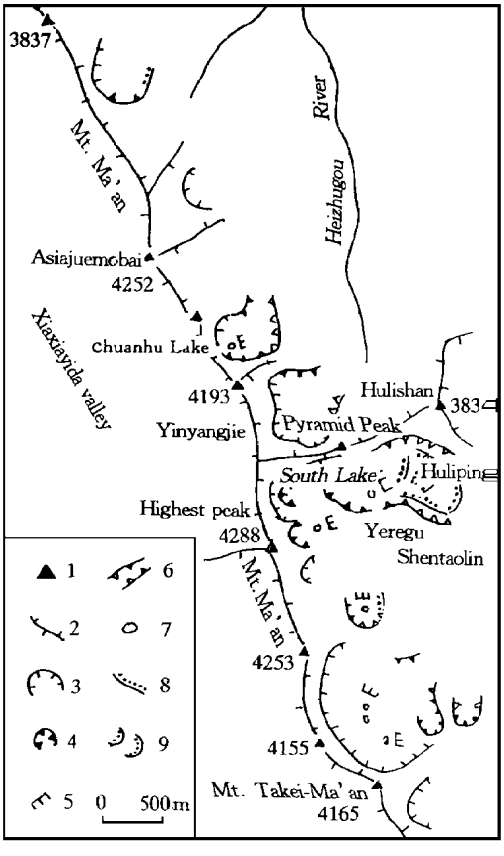



1. r ver 2. peak 3. c ty

F g. 1 Geograph c s tuat on of the Mt. Ma' an

r es and the sandstone, conglomerate, l mestone, etc. of M ddle-Lower T r ass c ser es. Most of the slopes near the r dge are prec p tous slopes( 35°– 55°) and cl ffs (> 55°), because the d p angles of strata near the r dge are 60°– 70°. We d scovered that there was the quaternary glac al landforms on the top of Mt. Ma'an, after we went there tw ce n 1994– 1995 for nves- t gat ng the natural env ronment of Mt. Ma'an. Th s s an mportant d scovery of foss l glac al landforms to the east of 102°E of Ch na(Zhou *et al*., 1988)

## I. THE DISTRIBUTION OF QUATERNARY GLACIAL LANDFORMS IN MT. MA'AN




1. horn 2. kn fe-edge crest 3. z rkustal
4. c rque 5. cross-wall 6. U- valley
7. lakelet 8. lateral mora ne 9. end mora ne
F g. 2 D str but on of Quaternary glac al vest ges n Mt. Ma'an

There are many peaks n the area of Mt. Ma'an, among wh ch seventeen peaks are over 3500 m n elevat on and s x peaks of them are over 4000 m, such as Ax ajuemoba (4252 m), Mt. Take–Ma'an( 4165 m) and the h ghest peak (4288 m), etc. The foss l glac al landforms are most d str buted on the east part of the peaks w th an elevat on of 4000 m. The d str but ng area of glac er' s rema ns from Waj r (3907 m) n the north to Mt. Take–Ma'an n the south s 12 km long and about 1– 2 km w de. Horns, kn fe-edge crests, c rques, U-valleys, lateral mora nes, term nal mora nes and rock glac ers, block f elds of the per glac al landforms, are ex- tens vely d str buted n th s area, espec ally from Ax ajuemoba to Mt. Take–Ma'an(F g. 2).

The c rques, clearly-outl ned and well-kept are d str buted on the south part of Ax ajuemoba (3930 m), the east part of the h ghest peak (3740 m, 4030 m), the east part of 4253 m peak (3940 m), the north part and the east part of Mt. Ma'an (4010 m, 3930 m), etc.. Some c rques floors were depressed, f ll w th water to become lakelets, among wh ch two b gger lakelets are Chuanhu (boat lake) and South Lake. Chuanhu l es n the southern c rque of Ax- ajuemoba. South Lake, l es n the lowest step c rque n the eastern part of the h ghest peak, now has become marsh. The c rque threshold (115 m h gh) n front of the South Lake s cut by a stream, fall ng down 70 m to the outs de of the c rque threshold, form ng falls w th many steps.

There are five glacial trough valleys, which are distributed on the southeast part of Axiajuemoba, the east part of 4193 m peak, the east part of the highest peak, and the east part of 4253 m peak. The largest one of them is in the Hulping trough valley on the east slope of the highest peak. The top of the trough valley is a spacious firn basin(0.62 $km^2$) of South Lake cirque. The trough valley stretches in the direction of southeast 700 m long, about 200–300 m wide with high lateral moraines ridges on both sides. The lateral moraine in the northeast is 80–100 m high; and that in southwest is 80–120 m high. There are four-step end moraines in this trough valley, the lowest step is at 3610 m a.s.l., its inside is 10 m high, and a small marsh with a diameter of about 30 cm is behind the end moraine, the second step is 200 m from the lowest step; the third is 110 m from the second step; and the fourth, at 3650 m a.s.l., is the highest step, 90 m away from the third step.

The moraines in the trough valley almost consist of rock block, breccia and debris of basalt. The biggest boulder is 5–6 m in long diameter.

The most outstanding per glacial landforms of Mt. Ma'an is the Shentaolin rock glacier. It lies in the south of Hulping U-valley, extending 700 m long, 400 m wide, 3550–3700 m a.s.l.. Its floor consist of rock blocks of basalt with 30–50 cm in diameter, covered with the over-ripen fir forest and thick moss. The springs under the floor stones are murmuring. The vertical section slope of the rock glacier is about 13°, but less than 12° at the lower part and 17° at the upper part. The top of the upper part is named Yerengu(3680 m). There are many rock blocks with a diameter of 5–6 m, falling down from a cirque threshold.

## II. THE CHARACTERISTICS OF FOSSIL GLACIAL LANDFORMS IN MT. MA'AN

### 1. The Fossil Glacial Landforms Forming in the Last Glaciation and Neoglaciation

The extant distinct fossil glacial landforms of Mt. Ma'an was formed by the glacial movement of last glaciation ($Q_3^3$) and neoglaciation ($Q_4^3$). In the last glaciation, the glacial tongue extended downwards to the place of 3500–3600 m a.s.l. nowadays, and the bottom of the lowest cirque was as high as the place of 3740 m a.s.l. nowadays. It indicates that the height of the snow line in the glacial stage was at 3740 m a.s.l., which was higher than the line of Mt. Taba(3650 m), but lower than that of Mt. Luoj (3860 m). During the neoglaciation, the glacial scope reduced greatly, and the fossil glacial landforms only lay in the part close to the ridge. In this stage, the bottom of the lowest cirque was 3930 m a.s.l., meanwhile the snow line was lower than that of Mt. Louj (4050 m) too (Shi *et al.*, 1989). The glaciers were cirque glaciers and hanging glaciers, and horns and knife-edge were also products of glaciation in this glacial stage. The height difference of the above-mentioned old snow lines mainly came from the difference of latitude and precipitation. The latitude of Mt. Ma'an is 1.5° northerly to the Mt. Luoj, and the former admits more warm and humid airflow coming from southeastern than the latter (the annual rainfall of Mt. Ma'an is about 1900 mm, the Mt. Luoj only

about 1100 mm nowadays), so the marine nature of former glacier was stronger than the latter, meanwhile snow line of Mt. Ma'an was lower than Mt. Luoji.

## 2. The Hulping's Fossil Glacial Landforms with Outstanding Typicality

The Hulping's glacier was well developed in the last glaciation, and the fossil glacial landforms were very typical(Fig. 3). The circque shape of South Lake that offers service to the Hulping glacier looks like an armchair. The back wall is steep with an angle of about 54°, the planar close degree is 250°. The $F$ value [$F = a/(2c)$] of exponential of this circque's level is 2.19, within the $F$ value of 1.7–5 of the general typical circque. The specific value between depth and width of the Hulping's U-valley are 0.25–0.35, which is also within the specific values 0.24–0.45 of the general U-valley. In addition, the cross section of this U-valley accords with the parabolic equation $y = ax^b$. The $a$ and $b$ values in the northwest slope are 0.6 and 1.48; 0.5 and 1.53 in the southwest slope. The $b$ values are near 2, typical $b$ value of U-valley (Svensson, 1957). The specific value AAR between the accumulation area and the whole area of this glacier is 0.68, which is near the average AAR (0.67) of the Alps' glaciers nowadays.

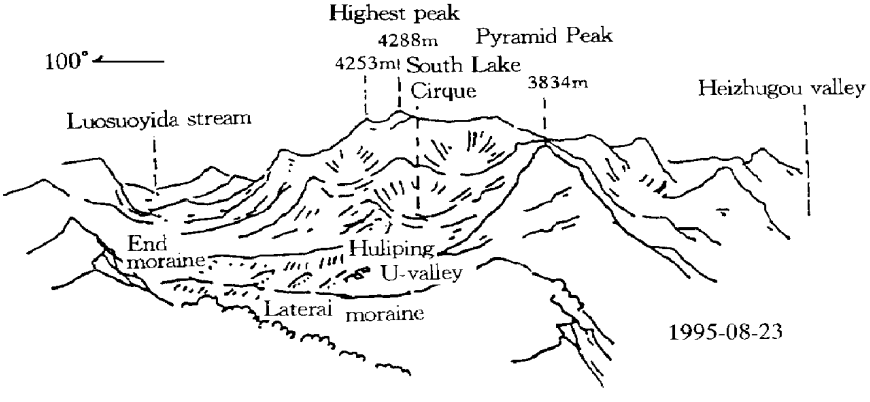



Fig. 3 A view of fossil glacial landforms in Hulping at the top of Hulshan (3834 m)

## 3. The Comparison of Fossil Glacial Landforms Between Mt. Ma'an and Mt. Luoji

The elevation of Mt. Ma'an (4288 m) is quite close to that of Mt. Luoji (4359 m). The difference in longitude between them is just about 0.6°, that in latitude only 1.5°. Hence, they are similar in the fossil glacial landforms. For example, the elevations of the snow lines are close; the intervals of the end moraines in last glaciation are similar, too. But there are still some differences between them, which are the ratio between the direct difference (the altitude difference from the snow line to the mountain top) and the minus difference (the altitude difference from the snow line to the lowest part of glaciation) of Mt. Ma'an in the last glaciation is

4:1. The ratio between the direct difference and the minus difference of Helongtan in Mt. Luoji in the last glaciation is 5:3, and the second glacial from the last is even 2:3(Shi *et al.*, 1989). They all deviate from the average ratio of 2:1 between the direct and the minus difference of the present glaciers in the west China(LIGG, 1988). Some scholars thought the reason why Mt. Luoji deviate from the average is that its top had been denuded, hence reduced the direct difference (Cui, 1989). However Mt. Ma'an next to Mt. Luoji had been denuded more seriously but it was not reduced. On the contrary, the direct difference increased. The correct reason should lie in the landforms of both mountains. The top of Mt. Luoji is like a steam bread in shape, with the glacier on its head like an ice-cap. Hence an inevitable result must be the ratio going down. But Mt. Ma'an was a hogback. The slopes of its top was very precipitous, so its slopes were not easy to be piled up with the ice and snow, the ratio must increase.

## 4. The Fossil Glacial Landforms Concentrating on the East Slope of This Mountain

The fossil glacial landforms of Mt. Ma'an are concentratedly distributed on the east slope of its ridge. The reasons of this appearance are not only related with the southeast airflow, but also with the landform, the local climate and the other general circulation. The eastern part of Mt. Ma'an area is named Hezhugou enclosed by high mountain ranges to form a big bag. The warm and humid airflow from the east is closed in it, forming the particular local climate. The climate of Mt. Ma'an east slope is characterized by high moisture, more rainfall, more rainy days, less sunny days, etc.. But the climate in the west slope is drier because of influence of the westerly and the climate in dry season and most seasons. The ridge of Mt. Ma'an is named Yinyangjie (the dividing line between cloudy day and sunny day). The east valley of the ridge is full of clouds and fog, while the west of ridge is sunny day. The general circulation in the last glaciation was similar with that nowadays. This climatic state was advantageous to glacier development, because the strong westerly blew the snow from the west slope to the depression of the east slope, promoting the development of the glaciers on the east slope of Mt. Ma'an.

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