THE KARST FROM GUILIN TO MAOLAN

Liu Zaihua
The Institute of Karst Geology, China

This part of excursion will take four days: the first two days for the trip from Guilin to Libo, which will pass through Lingui, Shoucheng, Siding, Rongshui, Luocheng, Yishan, and Jingchengjiang (Fig.1); the other two days for visiting Maolan Karst Forest Nature Preserve, which includes the Xiaoqikong Scenic Area, i.e, the middle-lower reach of Huanghou Underground Stream, and the Wangpaishan deep doline.

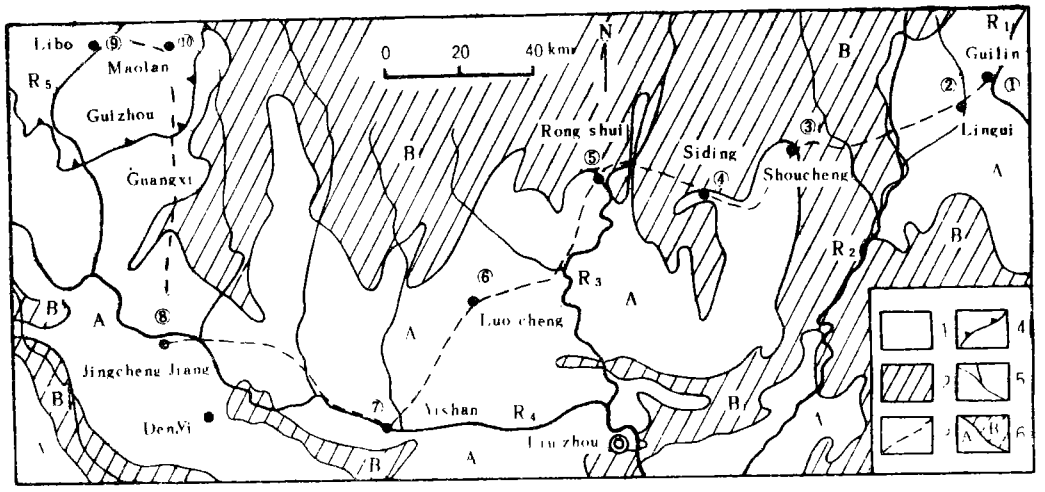

Fig.1 The Schematic geological map between Guilin, Guangxi, and Libo, Guizhou

R1--Lijiang R. R2--Luoqingjiang R. R3--Rongjiang R. R4--Longjiang R. R5--Dagouhe R. 1--U. Paleozoic Carbonate rock area 2--Non-soluble rock of L. Paleozoic 3--Highway 4--Boundary between provinces 5--River 6--Boundary between carbonate rock area and non-carbonate rock area

1. THE KARST FROM GUILIN TO LIBO

The highway between Guilin and Libo is mainly in karst area. On its northern side is the lower Paleozoic non-carbonate rocks, which comprised the basement of Caledonian Orogeny; whereas the Upper Paleozoic carbonate rocks underlie most part of the highway (Fig.1). From the Guangxi lowland (50-150 m asl in altitude) to the margin of Yunnan-Guizhou Plateau (900 m asl), the

following four points will be discussed:

(a) The relationship between the formation of peak forest landform in carbonate rock area and the allogenic water from non-carbonate rock area;

(b) The transition between peak forest and peak-cluster;

(c) The difference between deforested karst area and karst forest area;

(d) The karst collapse and water resources.

① Lingui: There are peak forests on Devonian limestone and round peaks on Carboniferous dolomite. The function of allogenic water on the development of peak forest will be clearly seen.

② From Shoucheng to Siding: There developed peak forest, in which there are many caves, and also there are a lot of outside cave stalactites.

③ Karst collapse in Siding Zinc-lead Mining Area: The area is 120 km to the southwest of Guilin City. The Zn-Pb ore deposit is

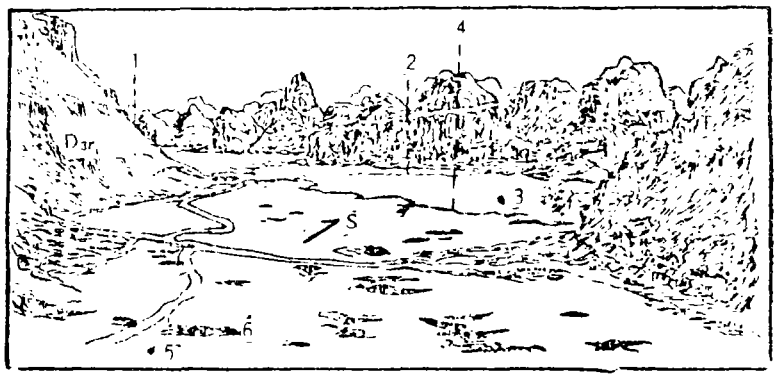

Fig.2 Sketch map of karst collapses in Siding Mining Area, Guangxi Province

1.New site for Siding Village 2.Rebuilt stream course 3. Old site of Siding Village 4. Original stream course 5. Mining area 6. Karst collapse

overlaid by well karstified upper Devonian limestone. Since the operation of the mine in 1960s, the karst collapses have continuously developed southward with the increase of discharge from mining tunnels(Fig.2): in 1963, the karst collapses distributed mainly in the vicinities of the mining area;from 1964 to 1965, 37 collapses and 25 fissures happened in old site of Siding Village when discharge increased to 2500 m^3/d, which forced the removal of the village; from 1970 to 1971, new collapses appeared along the Siding stream course when discharge increased to 3400 m^3/d.More than ten collapses with the diameter of 4-6 m and the depth of 9-10 m appeared on stream bed, which made water pour down to mining tunnel and threaten its safty. Finally, an artificial stream course was excavated to drain away surface flow.

④ Rongshui: There are peak forests on Devonian limestone, which have been strongly influenced by allogenic water.

⑤ Luocheng: This is a polje in middle Carboniferous dolomite, with round peaks in it. There are many irrigation wells in dolomite. The specific yield is generally more than 5 l/s, which indicates a more homogeneous karst development in granular dolomite. On the northern side of the polje, there are lower Carboniferous coal measures. Sulfate content in the ground water around mining area is higher in some places, as a result of pyrite oxidation.

⑥ Yishan: Longjiang fluvial plain was well developed, so did the peak forest plain because of the function of allogenic water, but transitionally to peak cluster westward. The water table in the karst depressions of the peak cluster region on both sides of Longjiang River is generally shallow. This situation is favourable for local people to utilize backwater in underground stream for irrigation. For example, the water in Denyi-Gandong underground Stream flows into Longjiang River with a minimum discharge of 0.14 m^3/s, but after the Longjiang River is clogged up by the Lalang Hydropower Station, there is a backwater in the underground course (Fig.3). Local people make full use of the phenomenon. A pump station was built on Denyi karst window with a capacity much more than the natural flow in the underground stream (up to 0.4 m^3/s), so as to increase the area of irrigation.

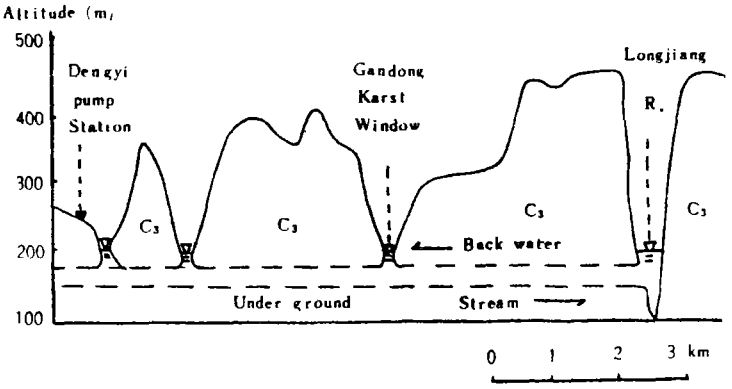

Fig.3 Profile showing the relationship between Dengyi-Gandong Underground Stream and Longjiang River
C_3--Upper Carboniferous limestone

7. Jingchengjiang: There are peak cluster depressions on both sides of Longjiang River, but further northward, you can see peak forest again. For example, in Mawei, the peak forest appears on plateau with altitude 750 m asl, which indicates the complex function of geology and hydrology, and the history of karst evolution.

2. MAOLAN KARST FOREST

The karst areas of south China were mostly covered by dense forest before the human history. This conclusion is based on the analysis about cave fossil flora and fauna data and the remnant forest. According to the detailed records on karst landscapes of Guangxi, Guizhou, Yunnan, and etc., by Xu Xiake (1587-1641), the well-known geographer and traveller in Ming Dynasty of China, as early as over 300 years ago, the forest on karst began to be destroyed. Up to now, they become almost extinct. So, for a long time, the theories about karst development, karst hydrogeological structure, the climate and soil in karst mountain areas, karst ecological environment, and etc. have mostly been based on the situation without forest. Evidently, it is difficult to make a reasonable conclusion. So, since Maolan karst forest was found in 1975, it has attracted great attention not only from botanical circles and the workers of environmental preservation but also karstological circles.

The most important value of Maolan karst forest is that it provides the

original natural background of karst forest, i.e, there still remains a original karst forest which grows on the karst peak cluster or karst peak forest. This is also the rare and unique karst forest in the areas with the same latitude.

Maolan, administrated by Libo County, is located in the boundary between Guizhou and Guangxi (Fig.4). It is in the mountainous area with bare carbonate

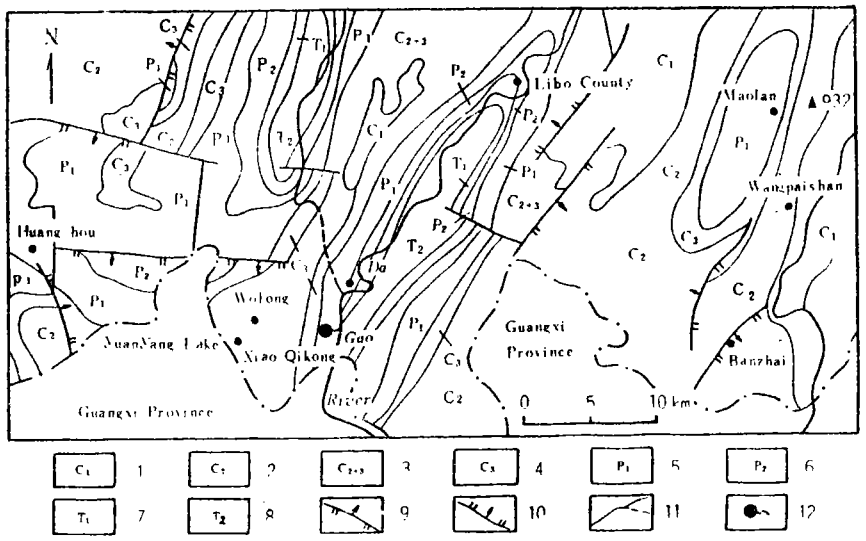

Fig.4 Geological map of Maolan and its vicinities, Libo, Guizhou

1.Lower Carboniferous limestone 2.Middle Carboniferous dolomite and limestone 3.Middle-Upper Carboniferous dolomite and limestone 4.Upper Carboniferous limestone 5.Lower Permian limestone intercalated with sandy shale 6.Upper Permian limestone intercalated with sandy shale 7.Lower Triassic sandy shale intercalated with limestone 8.Middle Triassic sandy shale intercalated with limestone 9.reverse fault 10. normal fault 11.surface river and its branching underground stream 12.outlet of Huanghou Underground Stream

rocks, on which unexpectedly grows a forest covering an area of over 200 km^2 (Fig.5). The forest cover rate is more than 90%, which is indeed rare in the country or even in the world.

Maolan karst forest area, 430-1078.6 m asl,and over 800 m asl in average, distributes in the north latitude between 25° 09′ and 25° 21′. It is in the subtropical humid monsoon climate , with annual mean precipitation 1752 mm, annual mean air temperature 15.3℃ and annual mean air humidity 83%.

Tectonically, there are a series of NE folding as the southwest part of Yangtze paramassif. Since Quaternary period, the area has become a karst peak cluster-peak forest mountainous area, as a result of continuous oscillating uplift and strong karstification. This led to the multi-level characteristics of karst depressions and caves.

The Maolan syncline at eastern part of the Nature Preserve composed of Carboniferous and Permian carbonate rocks, stretchs accross the area in the NNE orientation, and controls the outcrop and distribution of strata here. The dip angle of strata is generally 5 to 10 degrees. The karst forest preserved nowadays distributes mainly in Middle Carboniferous carbonate rocks (dolomite and limestone) in the southern part of the syncline.

The limestone and dolomite in the area are almost pure carbonate rocks. According to the chemical analysis, the content of CaO of all limestone is 52.59-54.33%, which is close to the theoretical content of CaO of calcite; the content of CaO and MgO for dolomite are 30.92-31.64% and 19.6 -21.89% respectively, which are also close to theoretical ones of CaO and MgO in

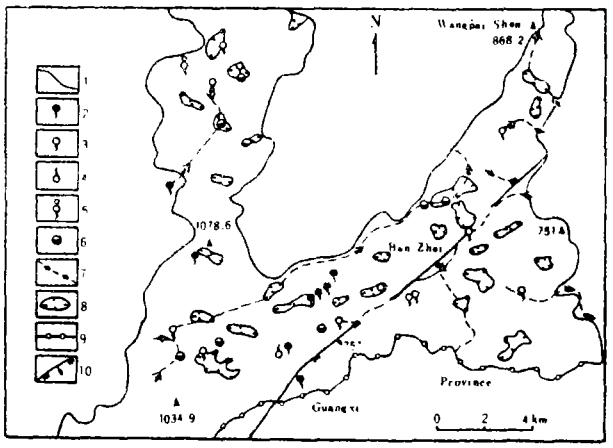

Fig.5 The distribution of karst depressions and some water points in Maolan Karst Forest Nature Preserve

1.boundary of the forest area 2.epikarst spring 3.descending spring from lower aeration zone 4.ascending spring from lower aeration zone 5.ebb and flow spring 6.karst blue hole 7.underground stream and its entrance and outlet 8.karst depression 9. provincial boundary 10.Banzhai normal fault

dolomite (30.4% and 21.7% respectively). So, in the carbonate rocks of the area, calcite and dolomite are about 97-99%, and insoluble oxides such as SiO_2, Al_2O_3, Fe_2O_3, which comprise the most important components of soil, are generally about 1%. Accordingly, it is impossible to have a continuous soil cover in this kind of karst peak-cluster mountainous area. The ratio of bed rock exposure in the area is over 70-80%, and the thin soil is seen only on the bottom of depression or valley, and as fillings in the grikes. The hydrochemical feature for ground waters are all characterized by HCO_3-Ca,Mg or HCO_3-Ca type

The area is in the slope zone from Yunnan-Guizhou plateau to Guangxi lowland, so the general trend of landform is high in the northwest, and low in the southeast. This is especially evident on both sides of Banzhai fault, with the peaks of 860-1010 m asl, and the bottoms of depression 670-800 m asl at its west; and 660-820 m asl for the peaks, 450-600 m asl for the bottoms of depression at its east. The relief between the peaks and depressions is from 150 to 300 m. The surface rivers here, all being recharged by underground stream, are not well developed, as a result of intensive karstification. The main karst features are sinkholes, depressions, underground streams, blind valleys, poljes, and etc. They distribute in an orientation of NE, NW or NNE, which indicates the structural control on the development of karst.

In the Maolan karst forest area, there is a unique double layer hydrogeological structure, i.e, the coexistance of upper aeration flow in the epikarst zone filled with dead branches and leaves, and the flow in the lower aeration zone (or saturation zone). The discharge of groundwater in the upper zone is low but stable; and that in the lower zone is great but with high amplitude of fluctuation. This kind of structure not only improves the situation for the recharge, flow and discharge of ground water, but also makes a good circle of precipitation, surface water and groundwater with remarkable regulation function in the hydrological system. It provides a favourable environment for forest to grow or even for human beings to live. Evidently, this is different from the general situation in stony karst area with frequent drought and waterlogging. The epikarst water in Maolan karst forest area which is different from that in stony karst area is the reflection of karst process under the influence of forest. The basic reason for this is the function of mechanical destruction by trees' roots, organic acid and large quantity of CO_2 from plant remains and humus. It promotes the development of epikarst fissures.

Because of the limitation of time, we will only visit Wangpaishan deep

doline karst forest, NE part of Maolan Nature Preserve (Fig.5 and Fig.6).

From Libo, up through Maolan, to Wangpaishan (Fig.4), the typical peak-cluster can be seen. Please pay attention to the difference between it and the peak forest of Guilin, Rongshui and Yishan.

① Vegetation at the deep doline karst forest: It will be introduced by the experts from the Maolan Nature Preserve.

② Epikarst spring in Wangpaishan peak-cluster depression: The spring, the point ② in Fig.6, locates in the half-slope of the depression, with permanant and stable flow. This indicates that the function of groundwater regulation by the epikarst zone is evident. The hydrochemistry of the spring is chracterized by low pH of 7, medium carbonate hardness of 9 German degree, with negative saturation index of calcite (-0.32). So the springwater is aggressive to limestone.

③ Muchao Underground Stream: It is about 30m beneath the depression bottom (Fig.6), with the discharge about 1 m^3/s in dry season. On the stream bed, there is sandy bars, containing many quartz grains.This indicates that the underground stream is recharged by allogenic water.

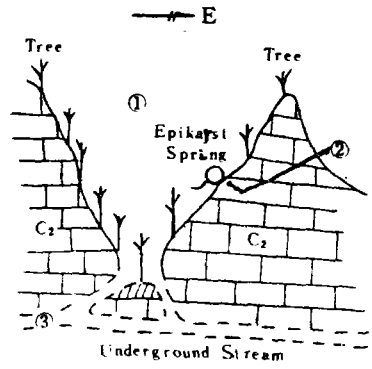

Fig.6 The sketch of Wangpaishan peak-cluster depression

In a word, we hope that the Maolan virgin karst forest will leave you the following impression and inspiration:

The function of spliting by plant roots is important in the development of karst. The mechanical destruction of rocks makes the increase of specific surface area for corrosion of carbonate rocks by water, so speeds the karst development. The above-mentioned function is stronger in the bottom of depression than in the peaks around. This is because that the humidity is higher in depression bottom, so plant is better developed.

Resulted from the variation of organic content in soil, i.e, from less than 12% in the neighboring nonforest area, through 19% on peaks, to over 30% in the bottom of depression, the corrosion induced by the organic material is greater in the bottom than in peaks, and greater in forest area

than in nonforest area.

Because of the variation of air humidity, i.e. from 83% in peaks to 94% in depressions, the karst in the latter is better developed as a result of higher humidity and more condense water under forest.

Seeing from the difference of precipitation, i.e. from 1320.5 mm in nonforest area to 1752.5 mm in forest area, the regulation of forest to climate is more favourable to karst development.

The hydrogeological characteristics of double-layer structure in forest area, i.e. epikarst zone and lower aeration zone underlying it mitigates the problem of drought and waterlogging in karst area.

The water detention of karst forest and its evenly seasonal allocation to the infiltration make stabler regime of surface water and ground water.

The cover of forest hinders the strong downwash on the slope, so mitigates soil erosion efficiently.

So, the original situation of karst process is evidently different from that of today. The data about the intensity of karst process obtained in the karst area nowadays in which forest has been destroyed may be much lower than before. It is not difficult to image that once forest is destroyed, the above-mentioned favourable hydrogeological environment will also be seriously changed, and the consequence must be drought and strong soil erosion, just as we have seen in nonforest karst area.

To sum up, because of its primitive, typical and unique character, Maolan karst forest area is not only a good place to study botany, but also the ideal site to get a better understanding on karst process and its history, tostudy hydrological effect of karst forest and to improve karst research.

3. HUANGHOU UNDERGROUND STREAM

Huanghou Underground Stream locates in the west part of Maolan karst forest area, seperated by Dagouhe River (Fig.4 and Fig.7). Its catchment area is 460 km^2. The strata is predominantly Carboniferous and Permian thick pure carbonate rocks. The structural features such as folds, faults are well developed. This provides favourable condition for the infiltration of water, the forming of karst depression and underground stream. In addition, long benificial climate (annual mean precipitation 1346 mm, and 16.8℃ for temperature) and dense vegetation in the area also provide the condition for karst development. Since Quaternary period, because of the differential uplift

between the northwest and the southeast, and strong cutdown of river, the great relief of 500-700 m between the water divide in anticline region and valley in syncline region has been formed. This also further speeds the circulation of ground water, and karst development.

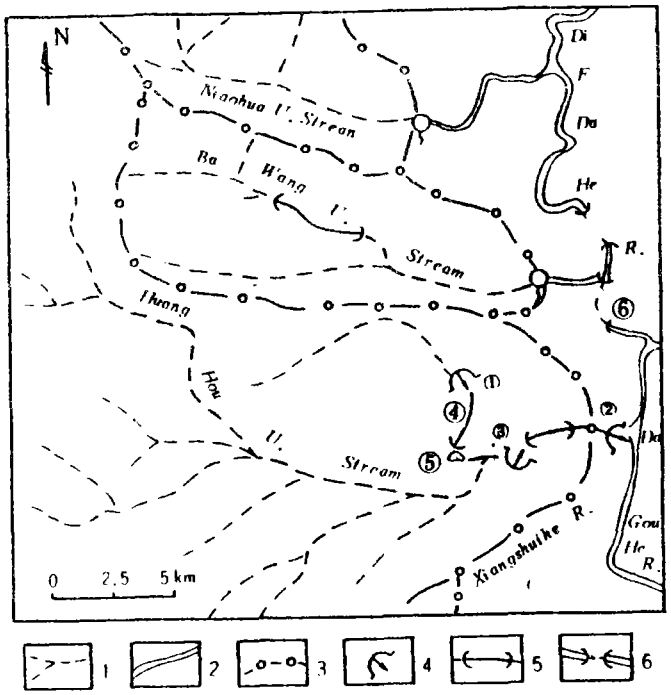

Fig.7 The distribution of Huanghou Underground Stream System
1. U. stream 2. surface river 3. boundary of catchment area for U. stream 4. outlet of U. stream 5. the window of U. stream 6. swallet stream of surface river ①--Wolong emergence ②--Xiaoqikong ③--Guibeishan karst forest ④--Yuanyang (Mandarin duck) Lake ⑤--Swallet and shaft ⑥--Daqikong natural bridge

① Wolong emergence and Cascade Hydropower Station Group (Fig.7 and Fig.8): 20 km away from the county town, it is the main electrical energy source for Libo County, . It depends on the water flow from the outlet of Huanghou Underground Stream, i.e, a low dam is built in front of the outlet at Wolong, to lead water (with discharge 1.5 m^3/s) to cascades of HE power stations. For example, the fourth station (point A in Fig.8) has a canal 1 km long to Xiaoqikong near Dagouhe River, to gain 34 m drop, with a capacity of 1000 kw.

The Huanghou Underground Stream has a flood discharge of 100 m^3/s, and minimum discharge about 1.5 m^3/s. In addition, the total drop between the uppermost outlet and Dagouhe River is about 300 m. So, the 4th HE Plant at

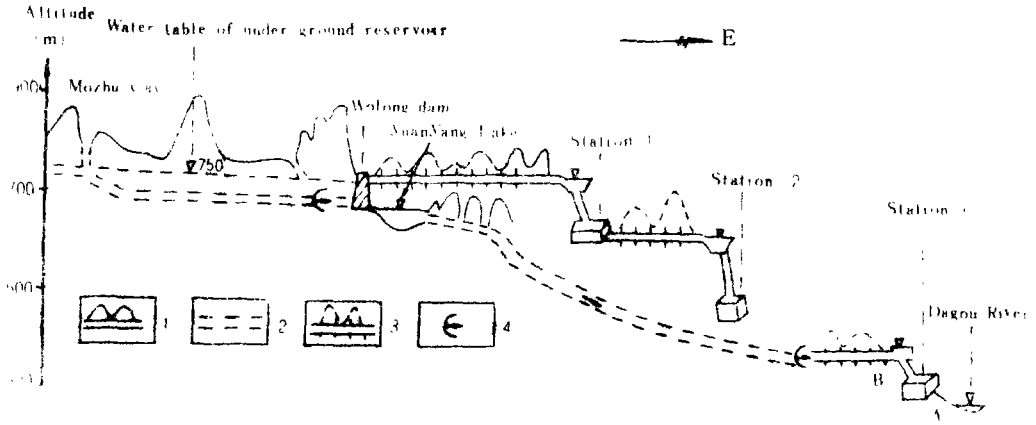

Fig.8 A Sketch showing the development of hydropower in the middle-lower reach of Huanghou Underground Stream
1. tunnel 2. underground stream 3. canal
4.upper, middle and lower outlets of Huanghou Underground Stream

Xiaoqikong makes use of only a very small part of hydropower of ground water. According to design, in order to make full use of the energy, four stations will be constructed. Up to now, besides Xiaoqikong 4th Station, the first station of 3000 kw has also been put into operation, and the second is being constructed. The drops are 80 m and 120 m respectively, and the operation flow are all 2 m^3/s. Fig.8 is a sketch map showing the development of hydropower.

② Tufa dams along the Xiangshuihe River (From A to B in Fig.8): Xiangshuihe River is actually a surface river from the lower outlet of Huanghou Underground Stream to Dagouhe River. Now, its discharge is usually very low because of the operation of Xiaoqikong 4th Hydropower Station. The main flow is led into a canal. There is a waterfall formed by the spillway on the canal as high as over 30 m beside Xiangshuihe River (point B in Fig.8). It is more interesting that there is a thick tufa cover (over 30 m high) on the waterfall. In a period about 20 years, the thickness of the tufa has reached

tens of centimeters, so the rate of deposition is very high. According to the measurement in-situ and calculation, it is found that the main reason for the tufa deposition are, on the one hand, that ground water has been supersaturated with calcite (with saturation index +0.45); on the other hand, because of strong stirring of water, CO_2 in water escapes rapidly, so led to the increase of pH-value (from 7.83 on the top of waterfall to 8.17 at the bottom) and saturation index for calcite (from +0.45 to +0.78 relevantly). Of course, there may be other reasons, for example, organism may also play an important role in the tufa deposition. It is considered that the photosynthesis of green plant (mainly bryophyte) growing on tufa absorbs a part of CO_2 from water, and some organisms fixing on the tufa absorbs calcite particles in water.

In addition to above-mentioned tufa, there are multi-cascade tufa dams on Xiangshuihe River bed. Their maximum thickness is more than 2 m. They began 2699 years B.P. (Carbon-14 Method) and are developing now. Almost all of them are formed at those part of the river bed with steep gradient. The formation mechanism of these river bed tufa is similar to that mentioned above.

③ Guibeishan karst forest (Fig.7): Karst forest is well-developed, and will be explained by expert from the Nature Preserve. The middle outlet of Huanghou Underground Stream can be seen. Feiyundong Cave hangs up the steep cliff, about 800 m asl in altitude, with less developed speleothem in it. It is a cave formed in vadose zone.

④ Yuanyang (Mandarin duck) Lake: It is a section of blind valley downstream from the upper outlet of Huanghou Underground Stream, 680 m asl in elevation, and developed in Qixia formation limestone of Lower Permian. The pH-value of lake water is 7.44, 8.6 German degree for carbonate hardness, and +0.14 for saturation index of calcite. These are the basic hydrochemical characteristics in the middle-lower reach of the underground stream.

⑤ Xiaoshuidong (sinkhole or shaft): From the Yuanyang Lake down the Huanghou Underground Stream System, a string of karst windows are well developed (Fig.9). The depth of water table in the shaftincreases gradually downstream from 10 m to more than 40 m. They indicate the general course of the underground stream.

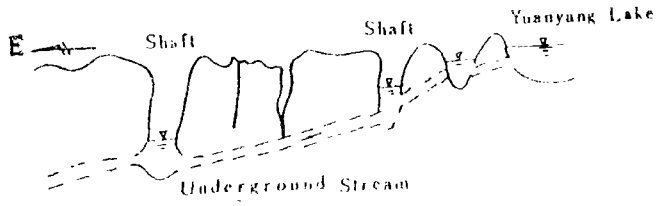

Fig.9 Relationship between Underground Stream and Shaft in the east of Yuanyang Lake

⑥ Daqikong natural bridge: 6 km to the north of Xiaoqikong, there is a reculee. It is actually the resurgence of the lost Diedahe River. Downstream from the reculee, a high natural bridge cross on the stream.