XIV IAEG Congress 2023 Field Trip

Field Trip #2: Co-seismic landslides and Major Engineering Projects Site Selection

26-27 September 2023 – 2 FULL DAYS WITH ACOMMONDATION
Departure on 26/09 at 8:00 - return to Chengdu on 27/09 at approx. 18:00

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Topic:Two engineering masterpieces (Yakang Bridge and Luding hydropower station), one ancient iron chain bridge (Luding chain bridge is a famous red tourist attraction), two large-scale landslides induced by historical earthquakes (Wuzhisuo landslide and Mogangliang landslide) and one famous ancient town built on glacial water (glacier) deposit will be introduced.

General description:

Luding County is located in the southeastern part of the Garze Tibetan Autonomous Prefecture in Sichuan Province, China. It is situated in the transitional zone between the Qinghai-Tibet Plateau and the Sichuan Basin, bordered by Tianquan County and Yingjing County to the east, Kangding County and Jiulong County to the west, and Shifang County to the south. The Dadu River runs through the county from north to south, making it a necessary passage for traveling between Tibet and Sichuan. Luding County is 236.2km from Chengdu City and 49km from Kangding County, with an altitude of 1321m.

Luding County is located on the eastern edge of the Qinghai-Tibet Plateau and is the most deeply entrenched gorge area in the western Sichuan high mountain and plateau region. The landscape includes low and middle mountain gorge to high and extremely high mountain areas.

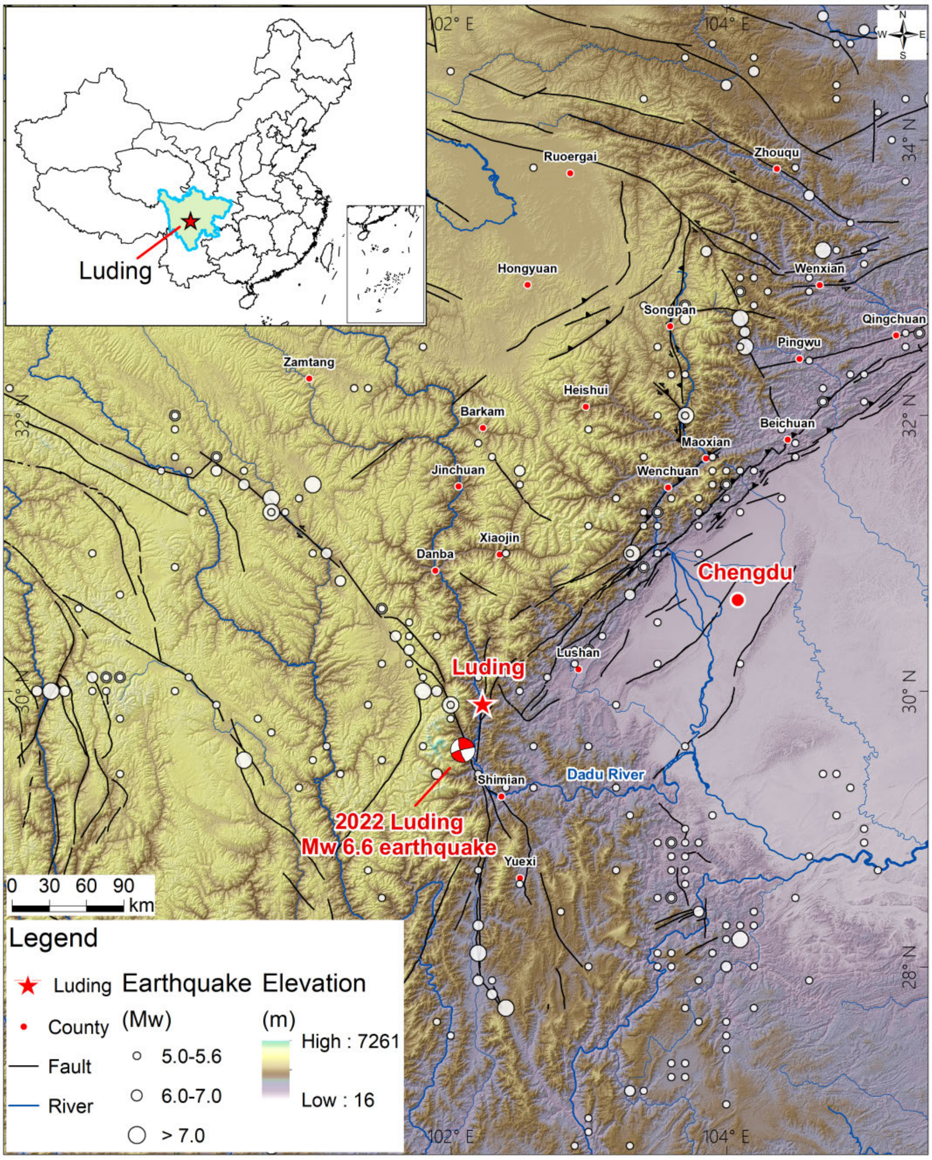


Fig. 1　Luding County

1. The field trip route

The two-day field trip route is illustrated in Figs. 2&3.

Fig. 2　DAY1 Route Map

Fig. 3 DAY2 Route Map

2. Yakang Bridge

✧ Background Information

The Luding-Ya'an Bridge (Figs. 1&2) is a mega-span steel truss cable-stayed bridge that crosses the Dadu River Valley on the Ya'an-Kangding Expressway, and is known as the "No.1 Bridge in Sichuan and Tibet". Located in Zali Village, Luqiao Town, Luding County, the bridge is a key project and landmark building on the Ya'an-Kangding Expressway of State Route G4218 and has significant importance for the development of the Sichuan and Tibet regions.

Fig. 1 Overview of Yakang Bridge

Fig. 2 On the side of Yakang Bridge

The bridge project consists of two approach bridges and the main bridge (Figs. 3&4). The main bridge is a 1,100m single-span suspension bridge, with a steel truss girder and a deck system composed of the steel-concrete composite structure. The main cables are made of 91 strands of prefabricated parallel wire ropes with a standard tensile strength of 1,860MPa and a 1/9 sag-to-span ratio. An articulated energy dissipation central clamp is installed at the mid-span. The anchorage system on the Ya'an side adopts tunnel anchors while that on the Kangding side uses gravity anchors. Both bridge towers are of portal frame type, with reinforced concrete columns, corrugated steel web plate composite beams, and group pile foundation. The two approach bridges are both continuous cast-in-place box beam bridges with a span of 34m (30m), and the total length of the bridge is 1,411.0m.

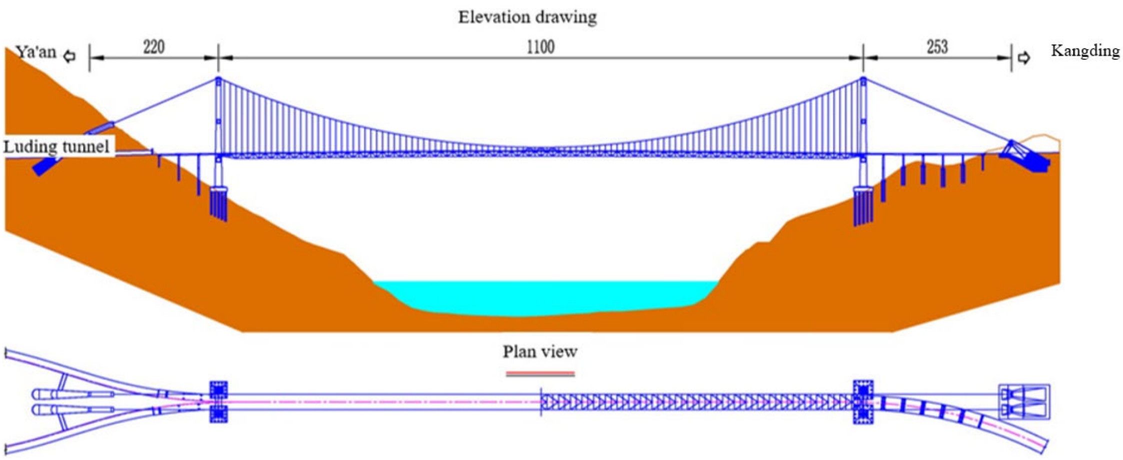


Fig. 3 Design and Elevation of Yakang Bridge

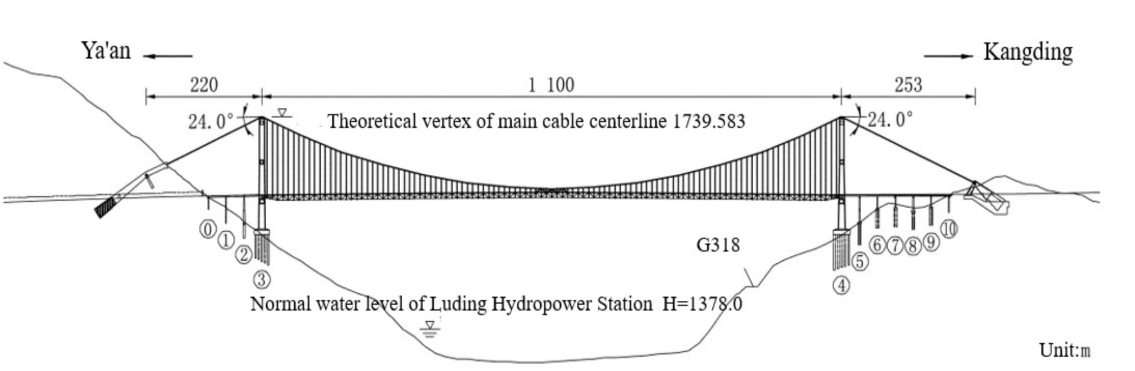


Fig. 4 Elevation of Yakang Bridge(TaoQY et al, 2018)

In high-intensity and deep-cut gorge areas, the stability of the slopes on both sides of the bridge location is a key factor in controlling the selection of the bridge location. In the preliminary design phase, three bridge locations were initially proposed for comparative study: Shangba, Zhongba, and Zali. However, the slopes on both sides of the Shangba and Zhongba bridge locations are high, and the stability under seismic action is poor. Based on a comprehensive index method derived from the experience of the Wenchuan earthquake, the Zali bridge location was ultimately selected.

✧ **Engineering Geological Condition**

Terrain and Topography: The bridge is located in a U-shaped high mountain canyon region, with steep slopes on both sides, generally with a gradient of over 35°.

Geological formation and lithology: The exposed strata consist of the Middle Pleistocene alluvial layer and the Quaternary landslide deposit layer. The bedrock is exposed as the Precambrian granite diorite with developed structural planes. The dominant structural planes strike northwest and dip northeast at an angle of 60°-70°.

Geological Structure: The bridge site is located in the intersecting and complex part of the three major fault zones (the Xianshuihe Fault, the Longmenshan Fault, and the Anninghe Fault). The near-field of the bridge site is about 22 km west of the active Xianshuihe Fault, and the east bank of the bridge site is located within the Luding ductile shear zone with an earthquake intensity of VIII degrees. The stability of the slope is controlled by strong earthquakes.

✧ **Brief Introduction to the Bridge Foundation on Both Sides**

The left bank is located on the concave slope formed by the U-shaped bend of the Dadu River, with a slope height of about 400m. A tunnel-type anchor is used, and the maximum height of the slope above the pier and anchor hole is still more than 200m. The long-term stability of the slope and the problem of debris flow hazards on the local slope surface of high altitude are prominent.

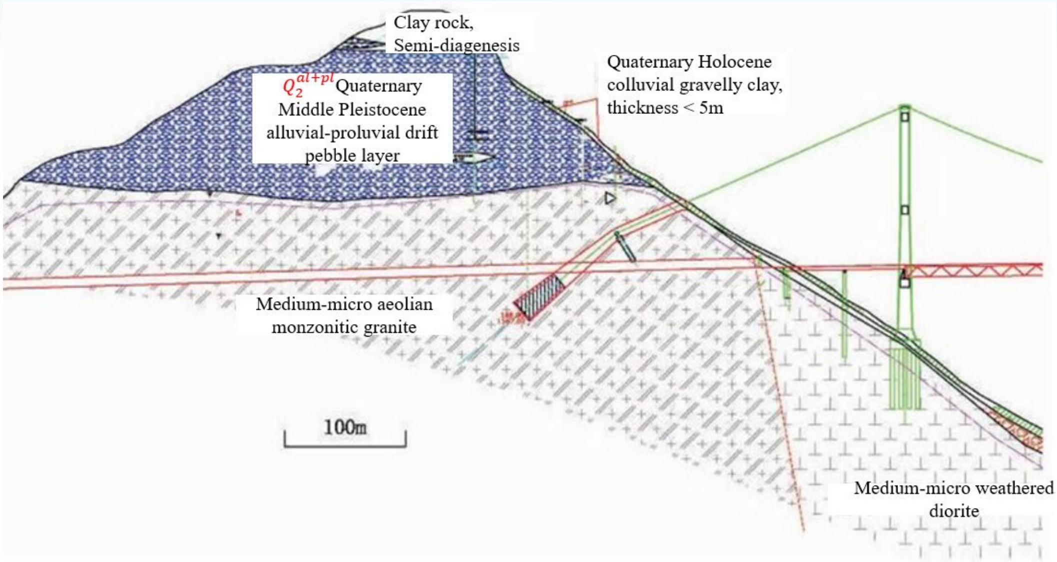
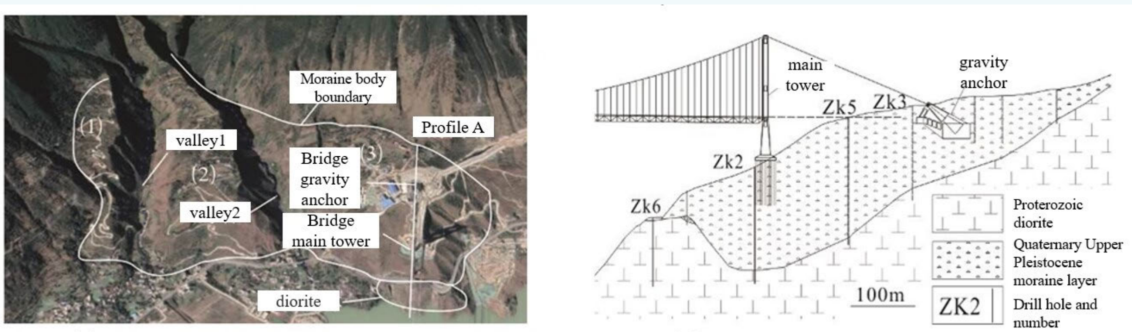


Fig. 4 Typical Engineering Geological Profile on the Left Bank（ChengQ, 2014）

Fig. 5 After the completion of construction on the left bank

The foundation of the main pier and gravity anchor on the right bank are located within a thick layer of glacial till. The thick layer of glacial till is used as the bearing layer, and there is no domestic or international engineering precedent for this. After excavation, a soil foundation pit and slope with a maximum depth of approximately 82m were formed, which poses significant potential risks.



(a) Moraine image (Google Earth screenshot) (b) Typical engineering geological profile

Fig. 6 Distribution characteristics of moraine soil layer (a) and the typical geological profile on the right bank (b)

Construction of the Deep Foundation Pit for the Gravity Anchor on the Kangding Bank, as shown in Fig. 8

Fig. 8 Construction of the Deep Foundation Pit for the Gravity Anchor

✧ **Implications for Engineering**

The Yakang Bridge has made many innovations in the field of geological and geotechnical engineering, including:

1. Developed a risk assessment method for geological hazards on both sides of the Yakang Bridge, which provides strong support for bridge location and design optimization in the canyon mountain area.

2. Addressed the challenge of using reinforced concrete bridge towers for kilometer-long suspension bridges in high-intensity earthquake zones by introducing two innovative technologies, waveform steel web beam, and hinged energy-dissipating central latch, to form a new type of suspension bridge seismic system. This expands the application of reinforced concrete bridge towers and saves investment compared with steel bridge towers.

3. Developed a comprehensive aerodynamic measure with central grooving and central stabilization plate to improve the wind stability of the bridge. Also, introduced a new layout of connecting the bridge and tunnel to skillfully handle the complex relationship between the bridge anchorage and the tunnel at the bridgehead, which makes it a demonstration project for constructing a mega-span bridge under extremely complex conditions.

4. Successfully solved the long-term stability and high-altitude long-run slope geological hazard chain problem of the left bank slope by developing a low-disturbance slope protection combined with blocking and drainage technology.

5. Adopted different construction methods based on the differences in slope bedrock lithology.

The left bank adopted the method of using the suspension bridge anchorage to bear the enormous main cable tension of the suspension bridge, which is the first longest tunnel anchor excavated in fractured rock masses in the world. The right bank slope is composed of a huge layer of ice-cemented gravel, and the excavation of an 80m-deep foundation pit is far beyond the domestic engineering scale under similar geological conditions.

In addition to the above, the completion of the Yakang Bridge also has cultural and economic effects. The bridge shortens the distance between Ya'an and Kangding, improves transportation convenience, and further promotes the formation of the Sichuan-Tibet economic belt. It also provides a new platform and opportunities for the inheritance and exchange of minority cultures on both sides, further promoting the development of local tourism and the economic take-off of the area.

✧ **References**

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3. Luding Hydropower Station

✧ **Background Information**

The Luding Hydropower Station (Figs. 1&2) is located in Luding County, Sichuan Province, China, approximately 2.5km from the county seat. The basic seismic intensity of the site is VIII, with a peak ground acceleration of 0.3g. The installed capacity of the Luding Hydropower Station is 920MW, with a normal reservoir water level of 1,378.00m and a total storage capacity of 219.5 million m^3. The dam of the Luding Hydropower Station is a rockfill dam with a crest width of approximately 12m, a maximum height of 84m, and a clay core wall for seepage control. The top width of the core wall is 4m, and the upstream and downstream slopes of the core wall and dam body are 1:0.25. The maximum bottom width is 45.00m, and an anti-filtration layer and transition layer are set between the core wall and the dam body.

Fig. 1 Luding Hydropower Station

Fig. 2 Luding Hydropower Station

The main structures of the hydropower station include the dam, spillway, and power plant, among which the spillway tunnels are arranged on both the left and right banks and the power plant is located on the right bank of the riverbed in the spillway system.

Engineering Geological Condition

Terrain and landform: The river section of the reservoir area is characterized by a deeply cut V-shaped valley terrain. The elevation of the dam crest is 1,380m. The left bank generally has a slope of 45°-55°, locally reaching 60°-70°. The right bank has well-developed alluvial terraces, and the dam site area has experienced strong uplift since the Quaternary period. The river has undergone rapid downcutting, leaving many traces of glacial activity.

Geological formation and lithology: The rock mass of the dam foundation is the Precambrian Kangding Complex, with main lithologies of diorite, granite, and granodiorite. The rock mass has undergone intense weathering and unloading, and has poor physical and mechanical properties. The overburden thickness of the dam foundation reaches 148.6m, with strong permeability.

Geological structure: The dam site is located at the junction of the northern end of the Sichuan-Yunnan structural zone in the south-north direction and the Longmen Mountain fault zone in the northeast direction, the Xianshui River fault zone in the northwest direction, and the Jin Tang arcuate structural zone. The geological structures are complex. Among them, the Xianshui River fault zone has strong seismicity and has experienced several strong earthquakes of magnitude 7 or above in history, such as the 73/4 magnitude earthquake in Luding in 1786. The interval between strong earthquake recurrences is roughly between 400 to 500 years.

Implications for Engineering

Luding Hydropower Station, an important component of China's fifth largest hydropower base (the Daduhe Hydropower Base), plays a significant role in the rational development and utilization of the Daduhe River's water energy resources, meeting the growing demands of the power grids, and transforming resource advantages into economic advantages. On September 5, 2022, a strong earthquake with a magnitude of 6.8 occurred in Luding, Sichuan. The investigation after the earthquake showed that the Luding Hydropower Station was operating normally, and its dam site selection, dam body design, and earthquake-resistant design have good engineering demonstration value.

1. The Luding Hydropower Station is located near the Luding Fault, with high seismic intensity in the area. The dam site selection has fully considered avoiding the nearby active fault zone, but the safety risks of the dam site have not been completely eliminated. Therefore, a rubble-mound dam was selected for the dam body, which is relatively flexible and lightweight, and can effectively cushion the impact of vibration, thus reducing the damage of strong earthquakes to the dam.

2. In addition to the successful selection of the dam type, the Luding Hydropower Station also adopted various seismic-resistant structures in the dam design, such as flexible geogrids and concrete seismic-resistant frame structures. Furthermore, the hydropower station also has comprehensive functions such as flood control and water regulation, playing a significant role in maintaining downstream water ecological balance.

Reference

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4. Luding Chain Bridge

✧ Background Information

The Luding Chain Bridge (Figs. 1&2), which was initially constructed in 1705 and completed in 1706, holds the world record for the longest ancient suspension bridge span, being the first bridge in human history to span over 100 meters. Emperor Kangxi named the bridge "Luding" after the words "Lu Shui" (meaning "Lu River") and "Ping Ding" (meaning "peaceful settlement"), and personally wrote the characters on the bridge, which led to the naming of Luding County. The bridge gained worldwide fame due to the Battle of Luding Bridge during the Chinese Red Army's Long March.

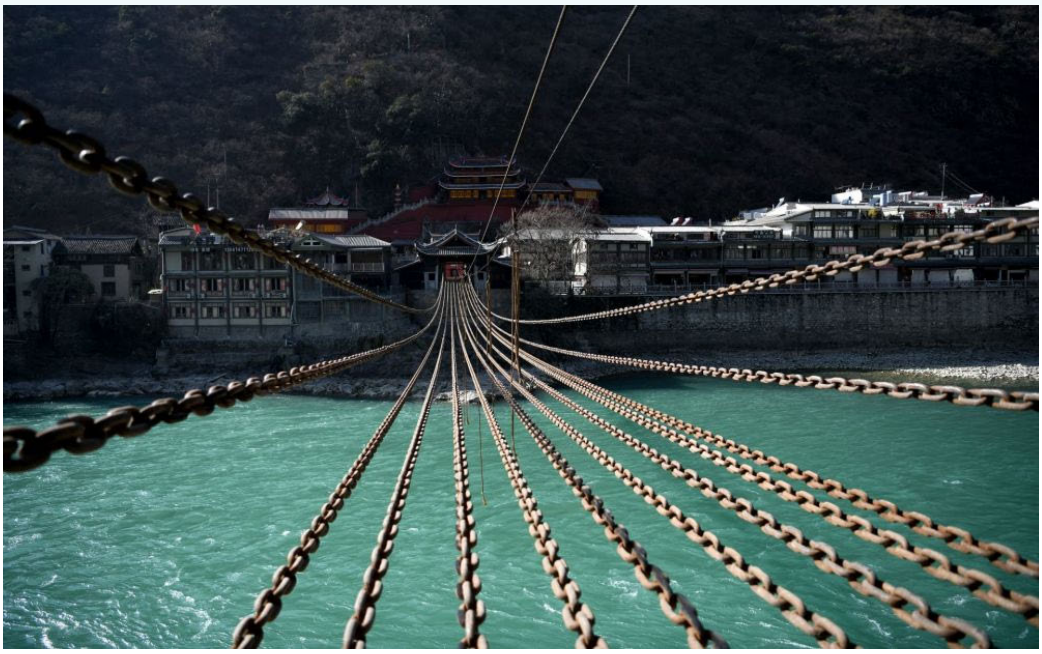

Fig. 1 Luding Chain Bridge

The Luding Bridge is a unique hanging iron chain bridge with wooden castle-like structures on either end. It consists of three main components: the bridge deck, bridge piers, and bridge pavilions. The total length of the bridge is 103.67 meters, with a width of 3 meters and 13 lock chains. Each side of the bridge has two iron chains for the railings, and the bridge deck has nine iron chains. Each iron chain is made up of 862 to 997 interlocking iron rings, for a total of 12,164 rings. The two bridge piers on either end are 20 meters high, with the east end of the bridge being 14.5 meters high and the west end being 5.2 meters high. The total weight of the bridge's iron components is over 40 tons, with the weight of the iron chains being 21 tons, averaging 1.6 tons per chain. A total of 20 tons of iron were used for one horizontal "lying dragon" pile and seven vertical "ground dragon" piles. Each wooden plank is 3 meters long and 0.1 meters wide, with the main walkway in the middle of the bridge being 0.75 meters wide and the auxiliary walkway at the railing being 0.2 meters wide.

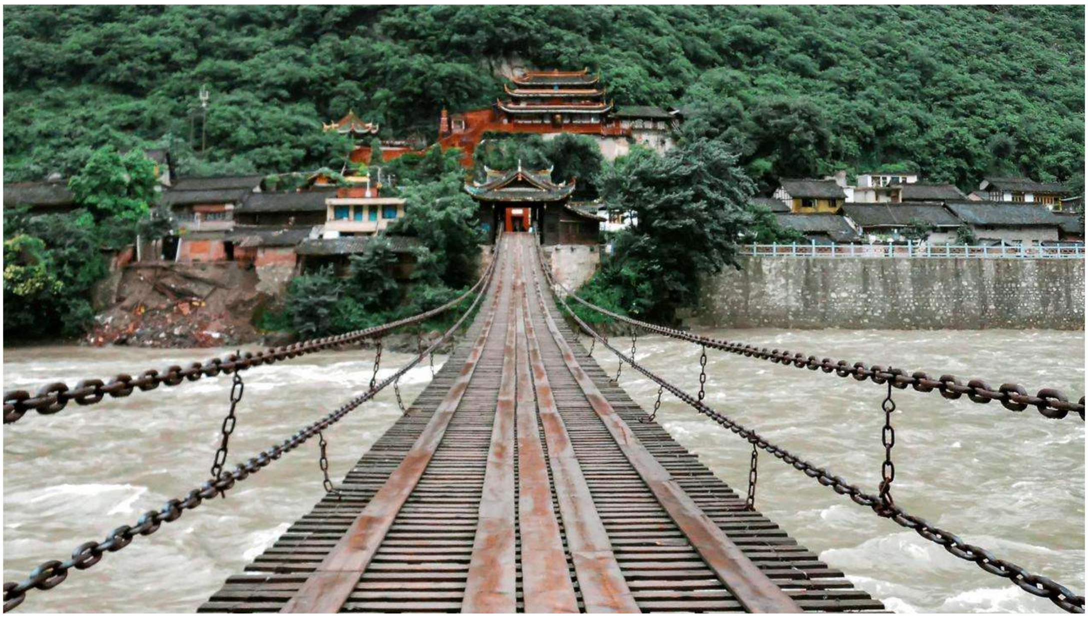

Fig. 2 Luding Chain Bridge

✧ **The Spirit of "Fei Duo Luding Bridge"**

The Battle of Luding Bridge (Fig. 3) was a significant campaign during the Chinese Red Army's Long March. In 1935, facing relentless pursuit from the Kuomintang forces and under a life-or-death situation, Mao Zedong, Zhu De, and other Red Army leaders made the decision to seize Luding Bridge.

On the evening of May 24, 1935, the main force of the First Red Army was ordered to forcefully cross the Dadu River in the Anshun field south of the river. A 22-member Red Army assault team bravely crossed the Dadu River, defeated an enemy battalion, and occupied the northern bank ferry crossing. Subsequently, the Red Army crossed the first major snow-covered mountain, the Jiajin Mountain, and successfully met with the Fourth Red Army.

The 22 brave warriors who participated in the "Fei Duo Luding Bridge" campaign fearlessly advanced through a hail of bullets, exhibiting selfless dedication, and achieved victory in the battle, thwarting Chiang Kai-shek's attempt to annihilate the Red Army south of the Dadu River.

The capture of Luding Bridge by the Red Army was accomplished through excellent battlefield command and close cooperation among various units, relying on the fearless spirit of daring sacrifice.

The spirit of "Fei Duo Luding Bridge" represents the invaluable spiritual wealth of the Communist Party of China during the Long March, guided by the scientific principles of Marxism.

Fig. 3 The red army quickly captured the "Luding Bridge"

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5. Wuzhisuo landslide

✧ **Basic general situation**

The landslide area is located at the intersection of northeast-southwest faults in Longmen Mountain.Wuzhisuo landslide is an ancient high slope earthquake landslide.The front edge elevation of the landslide is 1220 m, and the rear edge elevation is 1810 m.The landslide platform is clear, and the shape of the landslide area is like an armchair. The leading edge is cut by the Dadu River, leaving a 60 ~ 70 ° steep slope.The landslide is 1400 m long along the Dadu River, with an average width of

1300 m, an area of 1.12 km^2, an average thickness of 200 m, and a landslide volume of 3.64×10^8 m^3. It is a large landslide.The main sliding direction is 290 °.According to thermoluminescence dating, the landslide was formed 2.0×10^4 years ago.

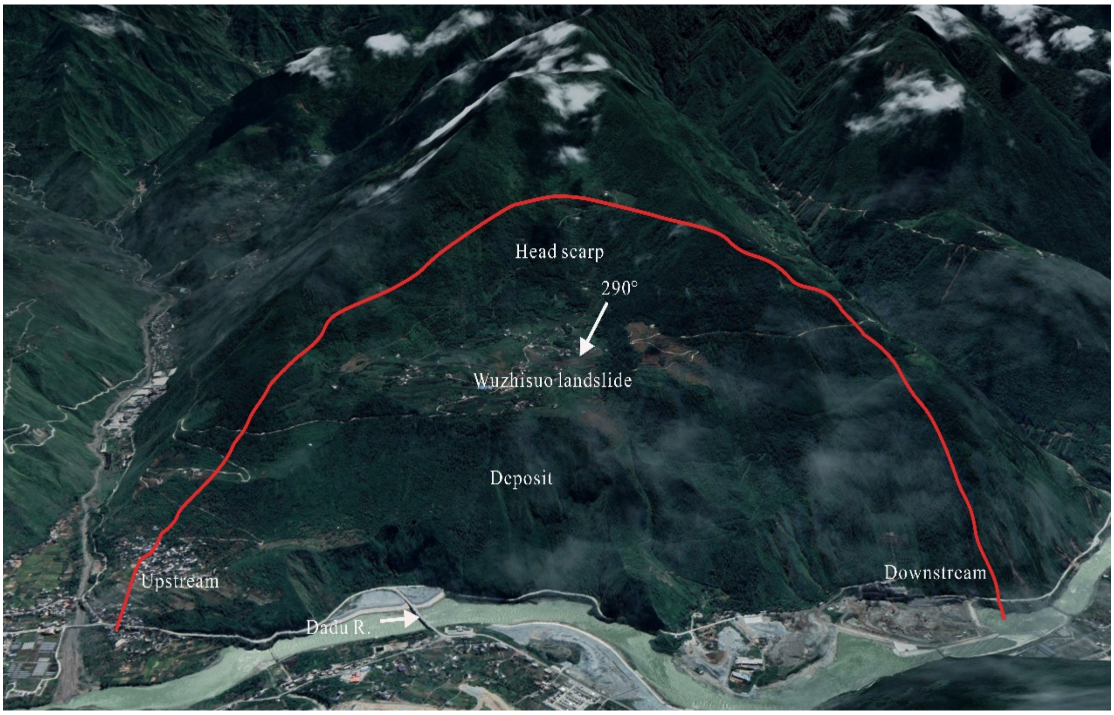

Fig.1 Accumulation platform characteristics of Wuzhisuo landslide

✧ **Engineering geological condition**

The landslide area is located in the convergence of the NE–SW trending Longmenshan fracture(e,f,g in Fig.2), NW–SE trending Xianshuihe, fracture (b, c in Fig.2) and N–S trending Daduhe fracture (h, i in Fig.2). This area is one of the most seismically active areas in China. Six faults are involved in the zone. The regional tectonic stability is controlled primarily by the active Xianshuihe fracture. The Moxi fault strikes generally in N30º-40ºW, dips to SW with the dip angle of 60º–80º. There are valleys and hot springs developed along the fault. The earthquakes were frequent in the history (Fig.2). A series of earthquakes happened along the Xianshuihe fracture, the seismic intensity is high, recorded highest historic intensity is VIII-X. The regional geostress reach to 20-25 MPa.

Dadu River flows by the landslide toe from north to south. It is a wide bottom valley and the slopes on the two banks are with 30~50º angle. There are two EW-trending deep cutting branches in the left bank, Dazhai valley in the upsteam and Wuzhisuo valley in the downstream, they cut the Wuzhisuo slope a triangle shape. The bedrock of the Wuzhisuo landslide area is composed of Proterozoic diorite and granite. Due to the east-west tectonic compression and fault activity, the bedrock structural planes are well developed. There is a large alluvial fan on the opposite bank (Fig.3), which pushes the Dadu River to bend eastward.

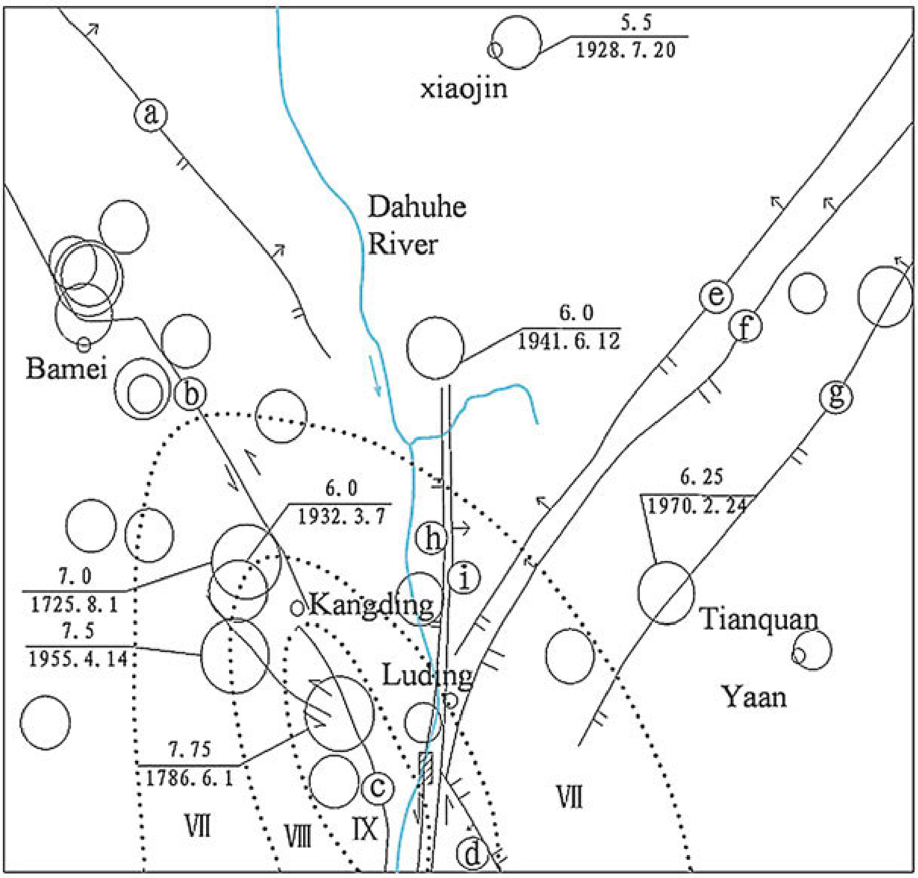

Fig.2 The regional seismic-structure diagramt

a Yuke fault; b Xianshuihe fault; c Moxi fault;d Jinping fault; e Gengda-Longdong fault; f Yanjing-Wulong fault; g Dachuan-Shuangshi fault;h Guadagou fault,i Changchang fault; The rectangle with shadow: thelandslide region

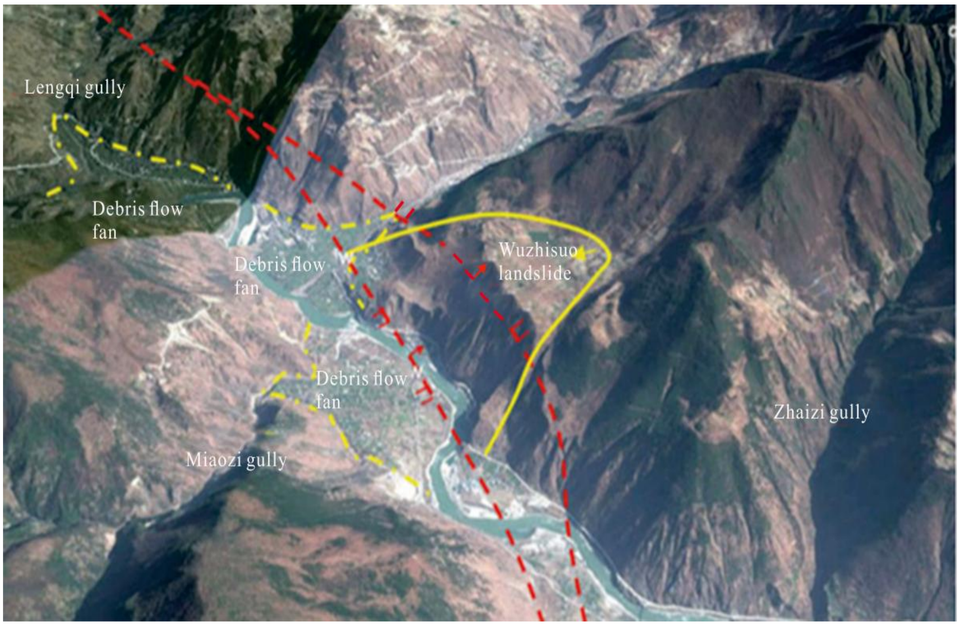

Fig.3 Geological setting of Wuzhisuo landslide

Fig.4 The huge blocks in the landslide accumulation

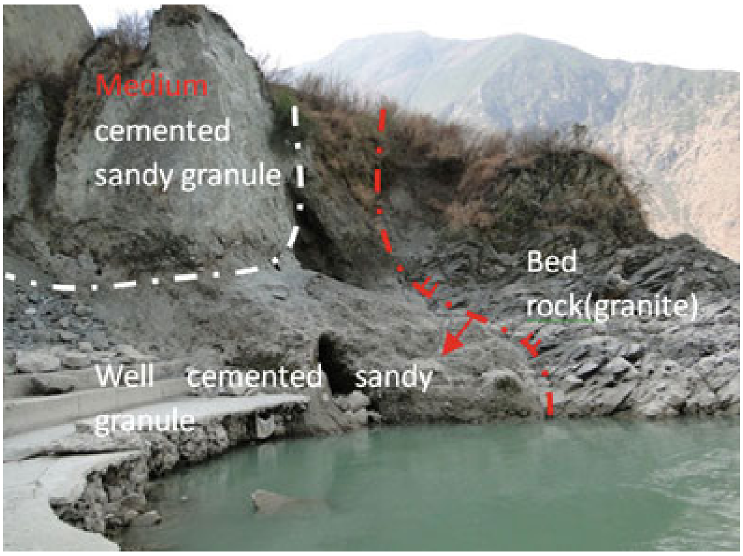

Fig.5 Medium cemented and well cemented sandy granule in the accumulation

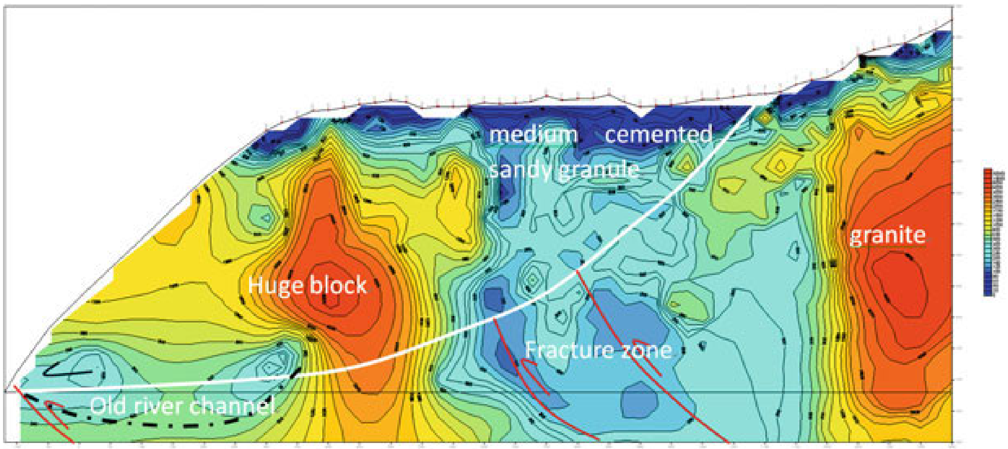

Fig.6 The geophysical prospecting interpretation (the white line represents the slip surface)

✧ Evolution process of ancient landslide

The evolution of the Wuzhisuo landslide mainly has four stages :the Wuzhisuo high slope with strong unloading is triggered by historical strong earthquakes, forming a large-scale landslide and blocking the Dadu River ;The Dadu River is filled with thick sediments, and the formed barrier dam is about 200 meters high and exists along both banks.The dam breaks along the right bank, cuts the slope and forms a new river channel ;Dadu River fault thrusts the landslide accumulation body ;The tributary debris flow happened and pushed the River channel bending earthward, the front was eroded and the landslide remains with steep front slope present. At present, the remains are generally stable, but the front is potentially unstable.Under the induction of certain factors (earthquake, heavy rainfall, slope excavation), landslides may still resurrect, blocking the Dadu River again, causing huge geological disasters.

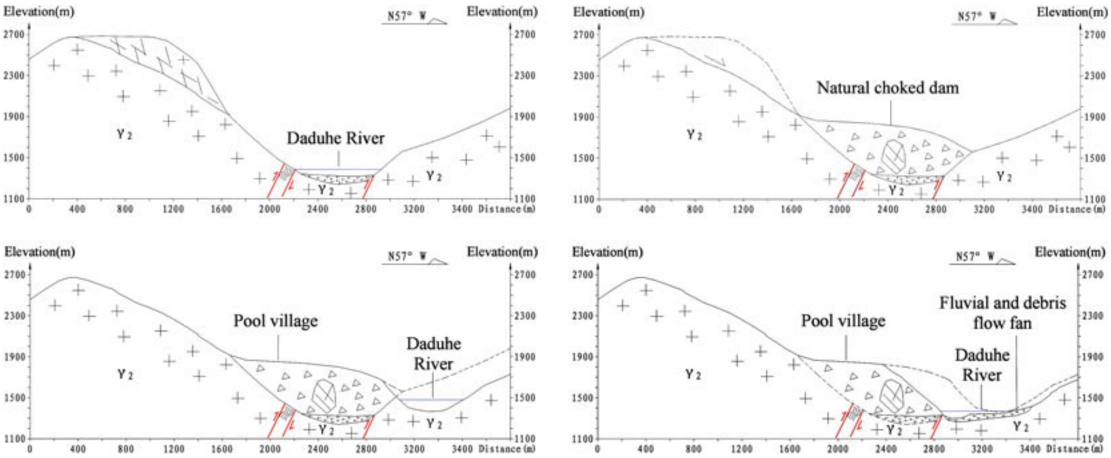

Fig.7 The evolution of the landslide

✧ Reference

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6. The Mogangling landslide（1786）

✧ Background

The Mogangling (MGL) landslide is located in the right bank of Dadu River and close to the mouth of Moxi River, it also near the Jinguang Village, Detuo Township, Luding County, Sichuan Province, China. This landslide was triggered by the Moxi Ms7.8 earthquake occurred in 1786, which blocked the Dadu River ~9 days until the dam-break. The size of the residual landslide deposit is ~450 m×1000 m (length×width) (Figure 1), with a volume about 4500×104 m3, and the sliding direction is N75ºE. The elevations are ~1850 m in the back edge of the landslide source region, and 1110 m in the toe of the slope, respectively. It is worthy to note that there is a landslide platform with a dip angle of 5º ~ 10º located in the elevation between 1360 m and 1400 m.

Fig 1 Characteristics of accumulation platform of Mogangling landslide

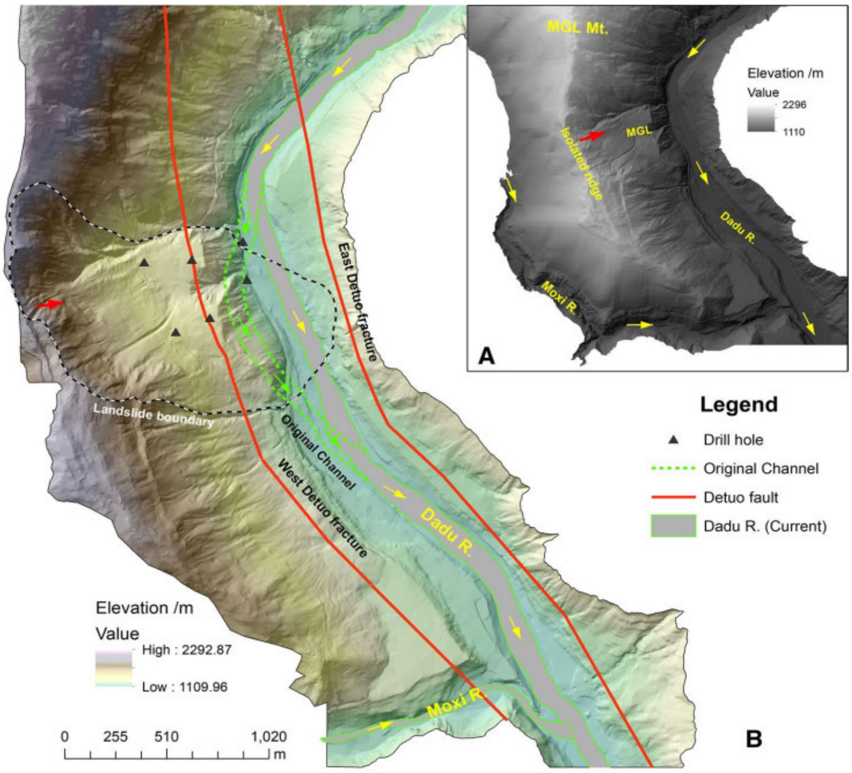

Fig.2 Characteristics of Mogangling Mountain and Dadu River.
A) Topographic features MGL mountain, B) Dadu River diversion and position of Detuo fault

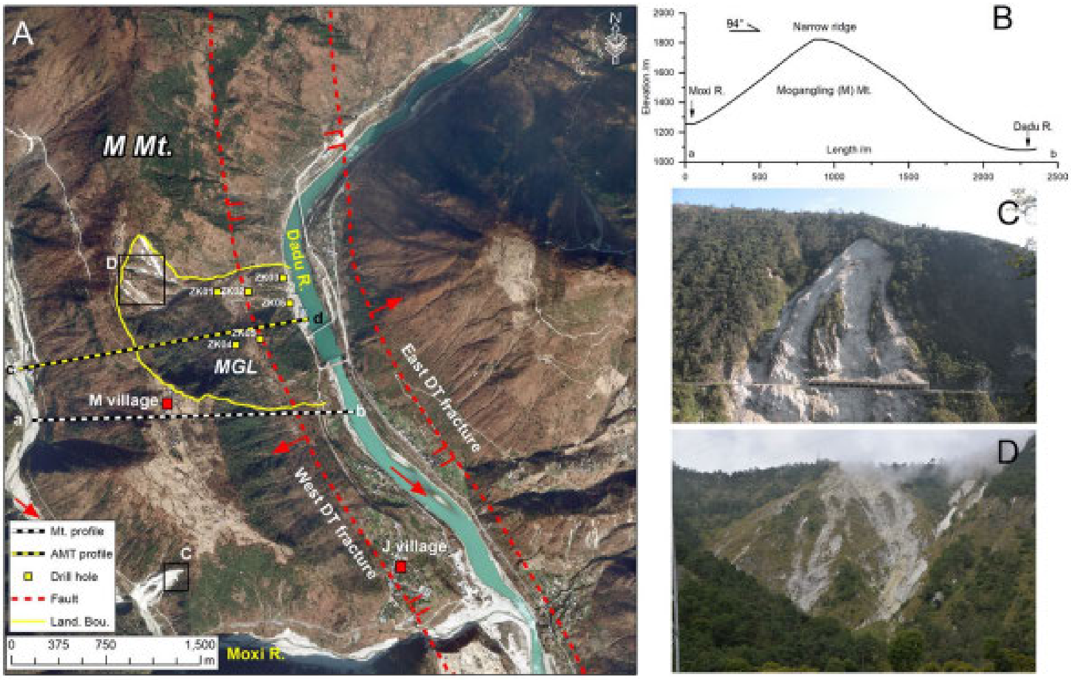

Fig.3 Typical characteristics of M (Mogangling) mountain.
A) Satellite image of Mogangling landslide, B) Profile of Mogangling mountain, C-D) field photographs of fractured rock at C point and D point. Geophysical prospecting profile (C-D) is shown in Fig.8. The satellite image is download from the software of Google earth.

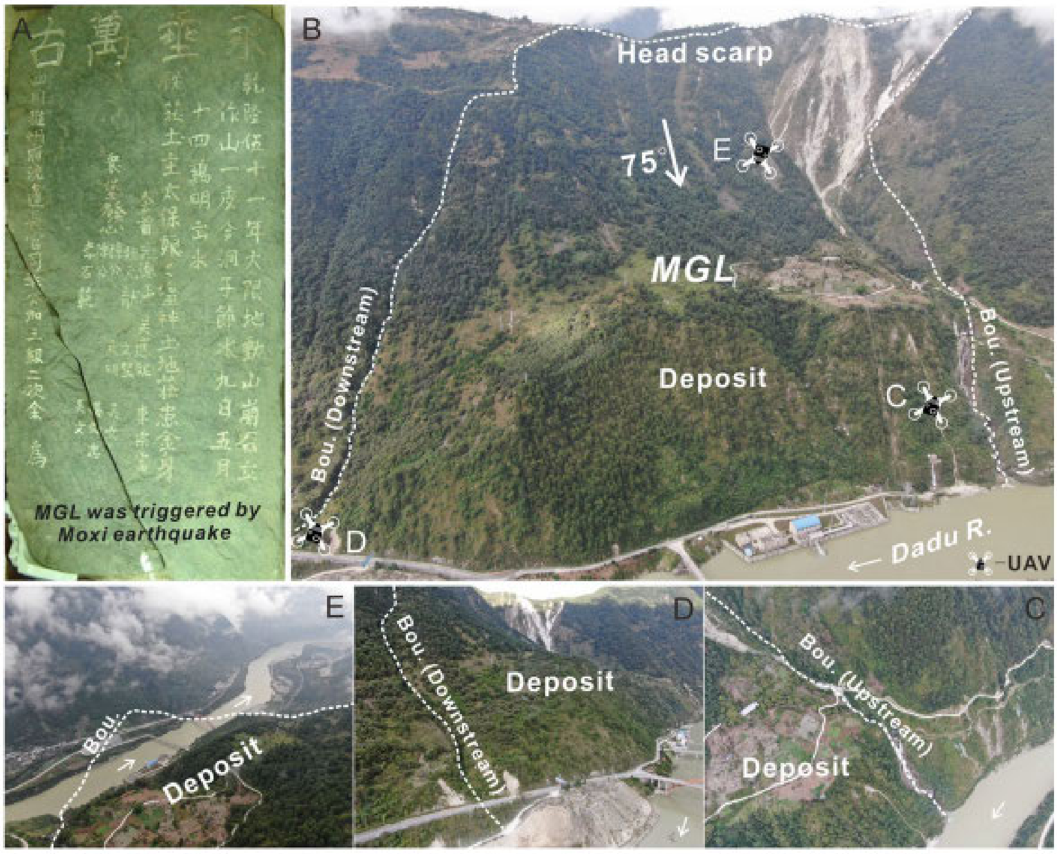

Fig.4 Overall UAV images of MGL
A) Moxi carthquake-triggered MGL recorded by ancient stele, B) Overall UAV images of MGL, C) Upstream boundary, D) Downstream boundary, E) Front edge of MGL

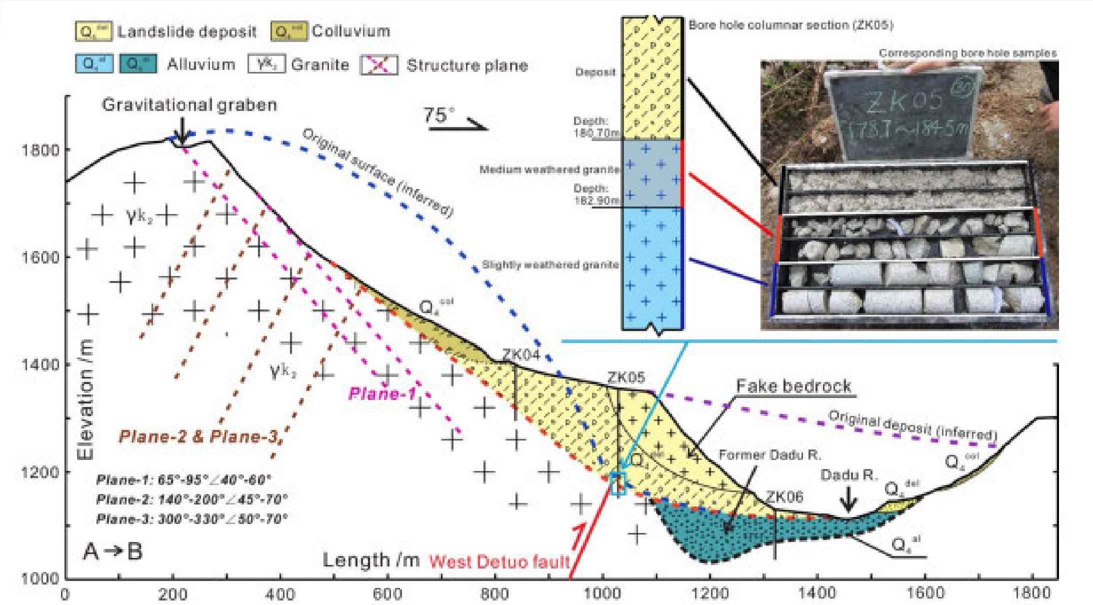

Fig.5 Cross-section of the Mogangling landslide.

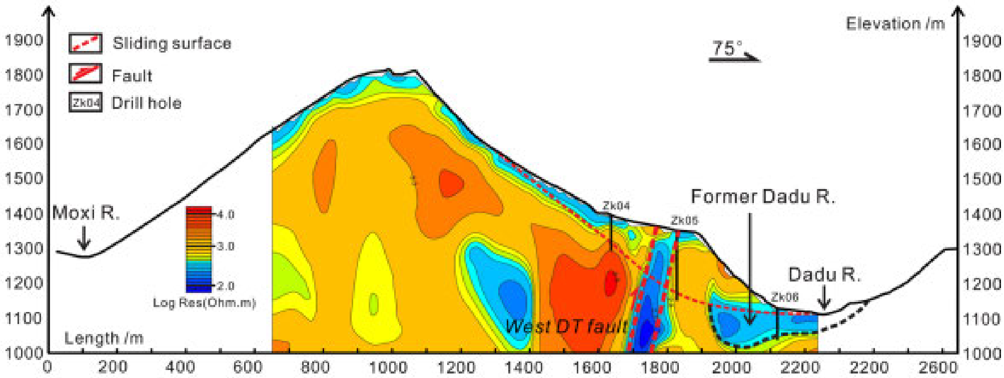

Fig.6 Geophysical prospecting profile(AMT method) of Mogangling landslide

✧ Engineering Geological Conditions

The Mogangling landslide is located in the southeastern of Tibetan Plateau, where the medium mountain landform with a deep valley are widely distributed. The regional terrain shows that the northwest is higher than the southeast, and 5 planation surface and VI fluvial terraces were developed in this area, and the local highest point with elevation of ~3420m, is located in the Mogangling.

The bedrock of Mogangling landslide is Jinningian plagiogranite (γo_2), which is offwhite and weakly-heavily weathered. In addition, the quartz-diorite (δo_2) and few of basic magmatic rocks are found in the western slope of the Moganling landslide, and the sandy slate of Triassic Baiguowan Formation (T_{3bg}) is exposed on the left bank of the Mogangling landslide. The quaternary sediment is composed of landslide deposit (Q^{4del}), colluvial deposit ($Q^{4col+dl}$) and alluvial deposit ($Q4^{al}$). Meanwhile, the landslide deposit is mainly located in the back edge of the landslide, and the alluvial deposit is mainly found in the fluvial terrace.

The Mogangling landslide is located at the western boundary of the Huangcaoshan block, which is surrounded by Moxi fault, Daduhe fault and Jinpin fault, and characterized by frequent seismicity. It has been recorded that 9 earthquakes with magnitude larger than Ms7.0, 22 earthquakes larger than Ms6.0, and 75 earthquakes larger than Ms5.0, had occurred within 300 km of this area. Additionally, the largest earthquake of the Moxi Ms7.8 earthquake occurred on 1786, and the last strong earthquake was the Moxi Ms6.8 earthquake that occurred on Sep. 5, 2022.

✧ Knowledge from the landslide geohazard chain caused by historical earthquake

It is recorded that an Ms7.8 earthquake occurred between Kangding and Moxi on June 1, 1786. The seismic intensity in the epicenter reached X degree, it also reached IX degree in the Mogangling landslide that close to the epicenter of this earthquake. This earthquake triggered the Mogangling landslide (Fig.7), and blocked the Dadu River ~9 days (Fig.8). Then, the landslide dam-break resulted in floods in the Leshan, Zhibin and Luzhou along the Dadu River, and caused more than 100,000 deaths. As far as we know, it may be the most catastrophic event due to the landslide dam-break in the world ever. Some works have been carried out to detect the location, magnitude, and intensive of the 1786 Kangding-Luding earthquake (Wang, 1987). In addition, Dai et al. (2005) attempt to research the Mogangling landslide dam-break by reconstructing the peak flow of the landslide dam, consulting historical documents, and investigating the local geomorphology. However, we still have a limited knowledge of the Mogangling landslide dam caused by this earthquake until present.

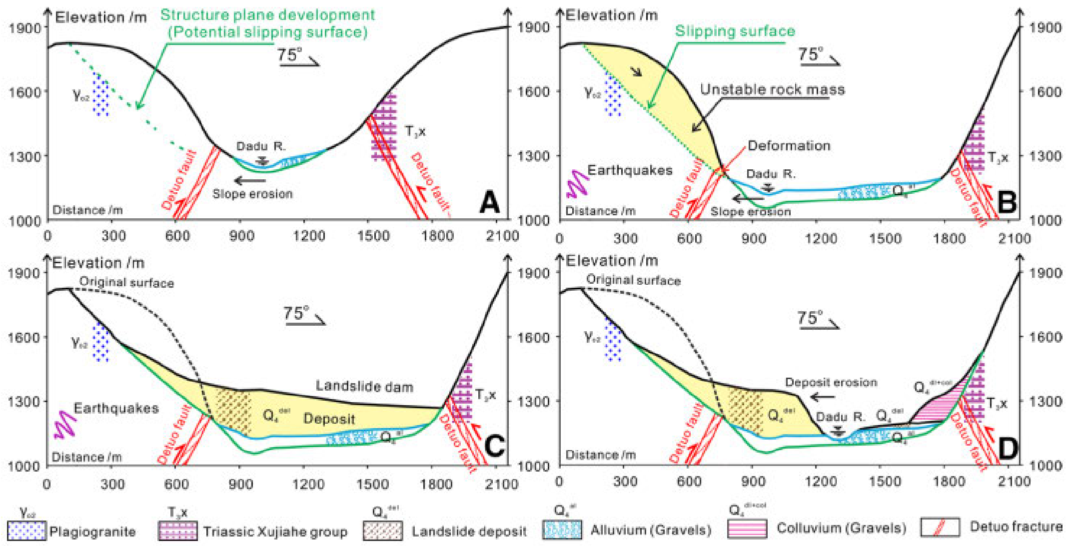

Fig.7 Failure process of MGL landslide.

a: Concave incision erodes slope foot continuously, **b:** Detuo faultdeteriorated the slope stability further, **c:**MGL landslide was triggered by Moxi earthquake and blocked the Dadu River, **d:**long-term river erosion formed current topography

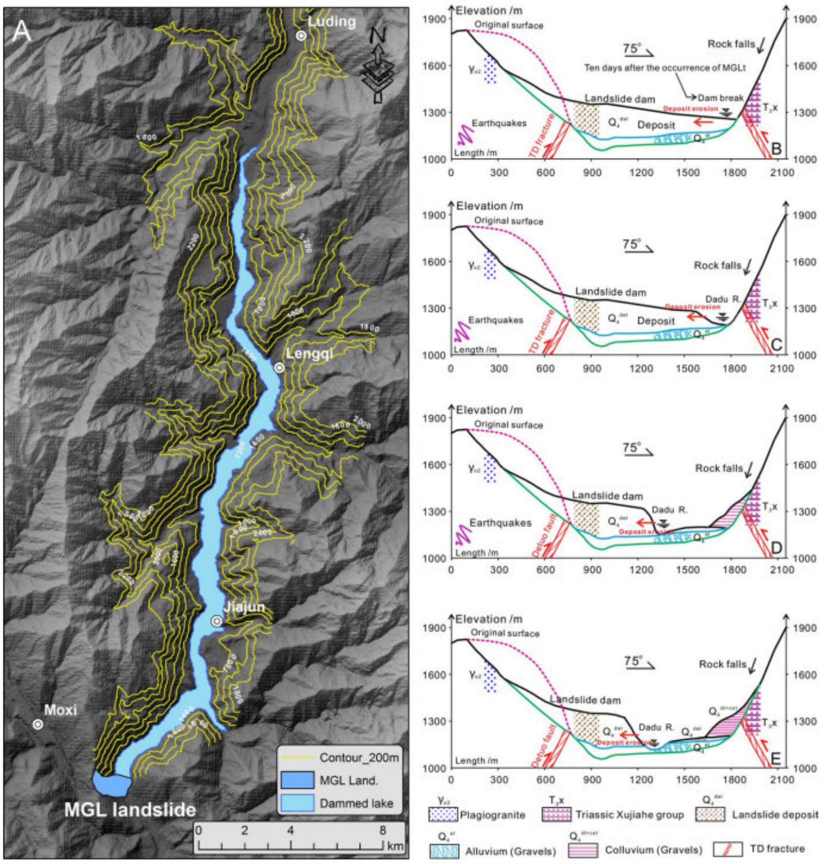

Fig.8 Dam Lake and dam erosion evolution process.

A) Dammed lake distribution after MGL landslide, B) Dam-break ten days after the occurrence of MGL landslide, C, D and E show the landslide dam erosion evolution process with time going.

✧ **Reference**

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7. Moxi Mesa

✧ General Background

Moxi Mesa is located in the south of Luding County, Ganzi Prefecture, on the east slope of Gongga Mountain Scenic spot, and at the entrance of the Haluogou Glacier Forest Park. Moxi Town is ~304 km away from Chengdu city, 52 km and 70 km away from Luding and Kangding County, respectively. The front part of the ice tongue has reach to this area during the Quaternary glacial period, and a glacial water (glacier) deposit with a length of ~20 km, width of 200 ~ 1000 m, and thickness of 80 ~ 300 m was formed due to the motion of glacier combined with the glacio-fluvial activity.

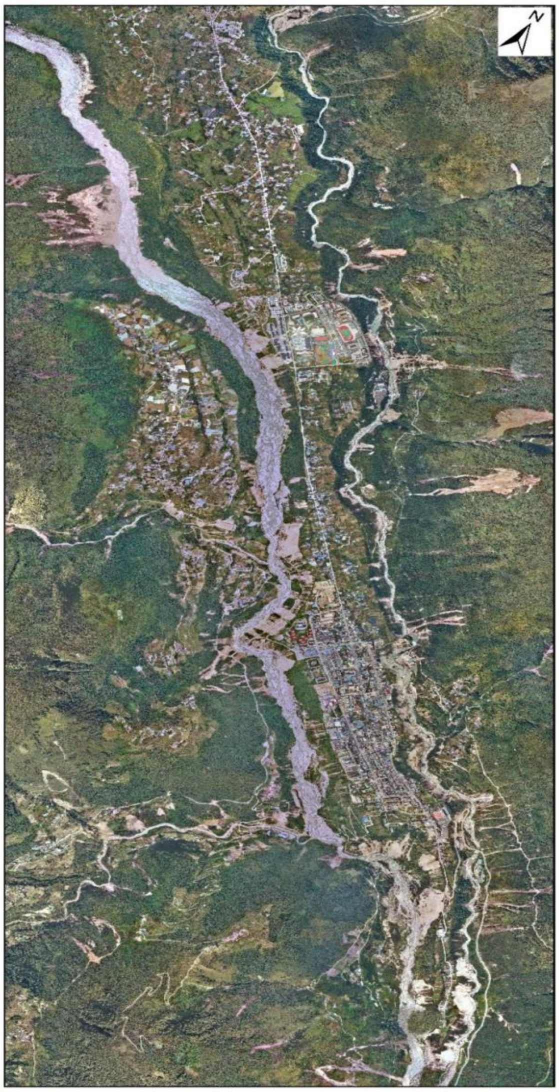

Fig. 1 Moxi Mesa area

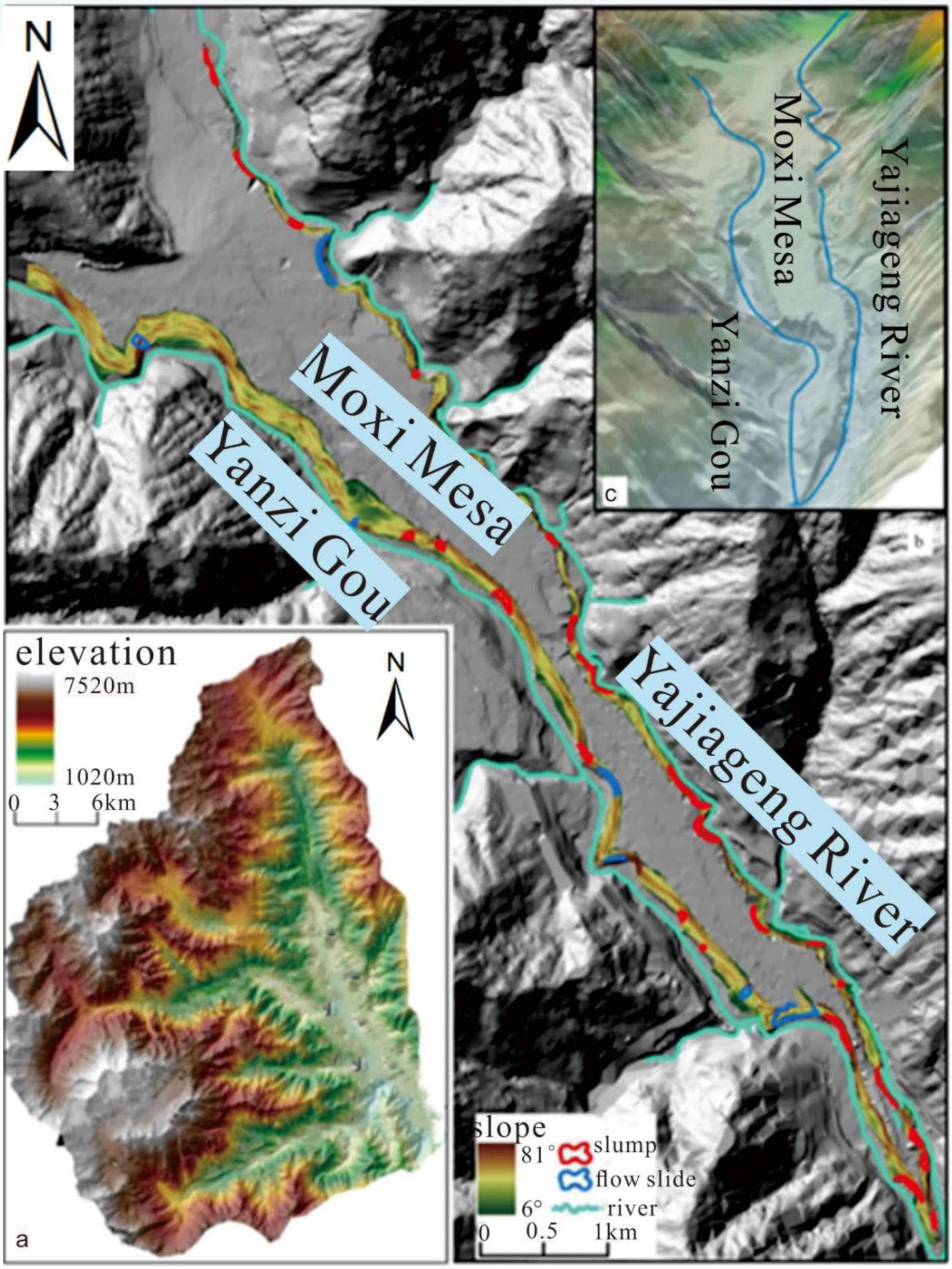

Fig.2 Distribution characteristics of landform and geological disasters in Moxi Mesa

Fig. 3 Topography and geomorphic features of Moxi Mesa

Fig.4 The collapse characteristics of Moxi Mesa edge after '9.5' Luding Ms 6.8 earthquake

Fig.5 Distribution characteristics of geological disasters around Moxi platform after '9.5' Luding Ms 6.8 earthquake

✧ **Geology background**

The Moxi Mesa is located in the eastern of the Gongga Mountain, where is the transitional zone between the Western Sichuan Plateau and the Sichuan Basin. It is found that the east, west and north of the Moxi Mesa are higher than its middle and the south part. In addition, the terrain is extremely changing in Moxi Mesa, and the highest elevation is 7520 m located in the Gongga mountain peak. The Moxi Mesa has a very complex geomorphic type including low mountain valley, high mountain, and extremely high mountain. Many faults including the Sichuan-Yunnan tectonic belt, Longmenshan fault-fold belt, Xianshuihe fault-fold belt, and the Jintang arc tectonic belt had been developed in this area, which caused that multi-stage tectonic movements in this area since the early Proterozoic. Moreover, the Moxi Mesa is composed of glacial deposits, underlying granite, diorite, and limestone. And the epicenter of the '9.5' Luding Ms 6.8 earthquake is located in the Moxi fault belt southeast of the Mesa.

Fig.6 Development characteristics of geological disasters around Moxi Mesa induced by '9.5' Luding Ms6.8 earthquake

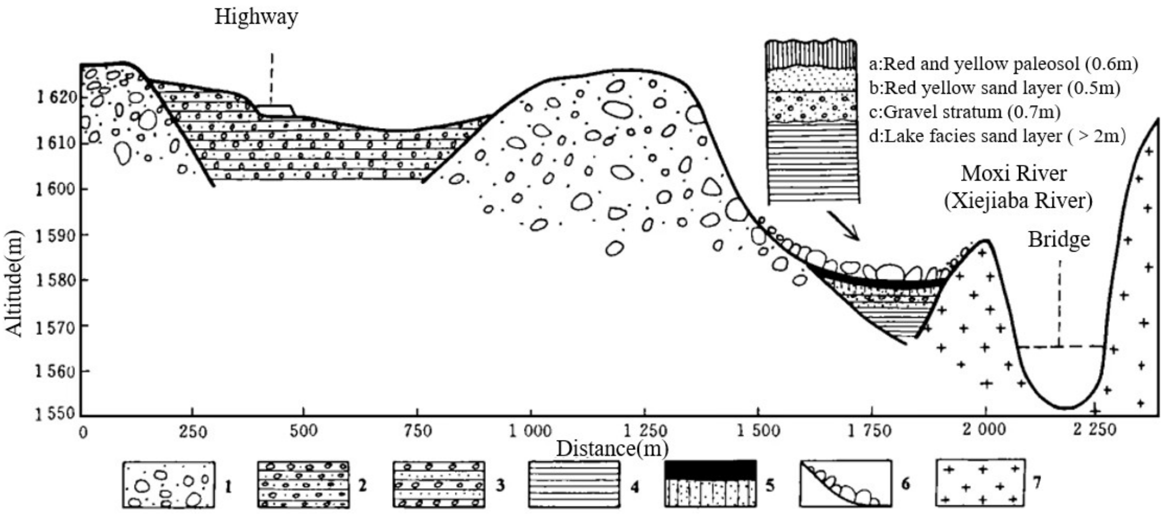

Fig.7 Quaternary glacial, glacial-lacustrine sedimentary profiles in the eastern Moxi Mesa, Luding County.

1. Glacier deposition ; 2. Ice-water phase ; 3. Lakeshore facies ; 4. Lake facies ; 5.Red-yellow paleosol and yellow sandy soil layer ; 6. Collapsed boulders ; 7. Granite

✧ **Inspiration of Moxi Mesa geological environment protection**

The Moxi Mesa is composed of ice water deposits, it remains intact and stable after several strong earthquakes. The edge of the mesa is affected by heavy rainfall, strong earthquake and gully erosion, resulting in a large number of collapses and landslides, which play an important role in the geomorphic evolution of the Moxi Mesa. However, more and more human engineering activities (e.g. the new building and road) were carried out in the Moxi Mesa, they are significantly affect the stability of the Moxi Mesa. To protect the Moxi Mesa, some efforts including the limitation of engineering activity, and provide more propagations of importance of the protection of Moxi Mesa, which have significantly raised the awareness of local people to protect the geological environment of Moxi Mesa.

✧ **Reference**

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Tentative programme：

1st Day Program-September 26, 2023

8:00: departure from Chengdu by bus

11:30: arrive in Luding around 11:30 a.m. and check in the Yuma hotel

12:10: lunch break

14:30: visit Yakang Bridge

16:30: visit Luding Hydropower Station

17:20: visit Luding Chain Bridge

18:20: dinner in Luding County

2nd Day Program-September 27, 2023

8:00: check out

9:00: arrive at Wuzhisuo landslide

10:30: arrive at Mogangling landslide

12:00: have lunch in Moxi Ancient Town

13:30: arrive at Moxi Mesa

14:30: departure to Chengdu by bus (expected arrive Chengdu at 18:00)