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title: **Research on the Karst Hydro-geological structure in
Jinping Hydropower Project Area**

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INTRODUCTION AND PREVIOUS WORK

Located at Jinping mountain, between Qinghai-Tibet Plateau and the Sichuan Basin, Jinping Hydropower Station is one of the biggest ones in China. The projection area of the station is around by the Big Bend of Yalongjiang river in western Sichuan province, where the Landscape is very complex with big and high mountains, deep gorges. And the karst landscapes are also well developed, with big karst springs, peak cluster and peak forest. The deep rivers and rich precipitation in the projection area cause a large hydraulic gradient as well as abundant potential Hydropower resources.

The aim of the Hydropower Project is to straighten Yalongjiang river at the the Big Bend by tunneling 6 tunnels (with up to 18 km for each) from the West side of Jinping mountain to the East side of Jinping mountain, in order to access to the more than 300m water level drop's hydraulic power for Generate electricity. Preliminary investigation shows a relatively complex geological structure, with many different kinds of closed folds, faults, and the limestone and marble of middle Triassic distributed alternately with sandstone and slate of upper Triassic. The project area, a typical karst mountain canyon area, also shows a significant regional or lithological difference in karst Development. There are three big karst springs in the project area: Mofanggou spring, Lao Zhuangzi spring, and Sangushui spring. Some scientists and scholars put a proposal of dividing the Lithostratigraphic units into three grades of karst development formations based on their geological survey and karst groundwater investigation and mapping: The strong (T_{2b}), medium (T_{2Z}) and weak (T_{2y}) ones (East China Investigation and design Institute under CHECC, 1992). Five hydro-geological divisions are also put forward. They also agreed that, the Mofanggou spring and Lao Zhuangzi spring are two separate hydro-geologic units, and a real karst groundwater divide exists between Mofanggou spring and Lao Zhuangzi spring (Zhigang, Ning, 1993). Finally they gave a suggestion to tunnel at the groundwater divide of the two major karst groundwater systems: from a place in Western Yalongjiang riverbed, near Jingfeng bridge, at a height of 1600 m above sea level, West side of Jinping mountain, to Dashuigou, a place in Eastern Yalongjiang riverbed, at a height of 1300 m above sea level, East side of Jinping mountain. The suggestion was accepted by the Hydropower station policy-making department.

PROBLEMS

The tunneling began from 1993, and with the progress of different kinds of tunnels, more and more tunnel water inrushing revealed, which shows the suppose above was incorrect. Up to end of 2009, about more than dozens of large scale of tunnel inrush events appeared during the excavation of the long geological exploration tunnels (at 1993), the auxiliary tunnels (from 2003 to 2009) and the diversion tunnel (since 2008). Large scale of caves or concentrated zones of karst water flow are also encountered. Up to 2009, the total flow of inrushing ground water is nearly 10 m³/s, which caused the completely drying of Mofanggou spring and seasonal drying of Laozhuangzi spring. The groundwater levels in the project area dropped rapidly from about 2170 m above sea level to about 1600 m above sea level, which cause a seriously damage to the ecological environment.

NEW THINKING ABOUT THE KARST HYDRO-GEOLOGICAL STRUCTURE

In order to solve the problems appeared above in the process of tunneling, a new detailed karst hydro-geological investigation and relative research work, such as hydro-geochemistry research, geological mapping, long-term's karst hydrological monitoring, cave exploration, etc., are carried out. The following new understanding was put forward based on the comprehensive analysis on data from the works above and long-term's hydrological monitoring for the inrushing groundwater, as well as the Experimental data of more than 6 times of large-scale karst groundwater tracing from 1993 to 2010 (Zulu et al., 2010).

- (1) No underground divided exists between Mofanggou spring area and Lao Zhuangzi spring area. on the contrary, the karst groundwater is gathered in the "geological structure low" from places around, to form a unified "Jinping Karst water storage structure" between the two big karst spring areas. The tunnels designed are just pass through the center of "Jinping Karst water storage structure", which lead to a serious damage to the original hydro-geological structure (that is "Jinping karst groundwater storage structure"), and thus a large scale of groundwater inrushing appeared while tunneling, and finally the tunnel become the new karst groundwater discharge center with the rapid drop of groundwater level. The completely drying of Mofanggou spring and seasonal drying of Laozhuangzi spring is just the direct result of the human behavior.
- (2) A new proposal is put out according to the property of regional litho-stratigraphic units, gushing water position, outflow revealed and karst development, that the litho-stratigraphic units should be divided into three grades of karst development formation groups: The strong (T_{2b} , T_{2y^5} , T_{2y^6}), medium (T_{2z} , T_{2y^1} , T_{2y^2} , T_{2y^3}) and weak (T_{2y^4}) ones, with the relative aquifer media type of karst conduits, karst fissures with limited conduits, and isolated karst fissures separately. The last one (T_{2y^4}), together with the sandstone and slate (T_3), consists the border of Jinping Karst water storage structure.
- (3) Jinping Karst water storage structure has a unified groundwater level: about 2130~2170 m above sea level during wet period, and less than 1580m above sea level in the dry season, then a forecast of up to 15.0 m³/s of potential total flow of inrushing groundwater was given when tunneling at an altitude of more than 1600 m above sea level based on the present tunnel inrushing hydrological data.
- (4) The main geological section of tunnel groundwater inrushing is located between the boundary of T_{2y}/T_{2b} and the boundary of T_{2y^5}/T_{2y^4} in the east wing of Jinping syncline.
- (5) Affected by the low regional erosion base level in the East, the situation that, the groundwater level in the East is much lower than that in the West, lead to a general trend of groundwater flow from the West to the East, and a leakage recharge exist at the boundary of the two hydro-geological division: from the hydro-geological division (T_{2b}) to the hydro-geological division ($T_{2y^5}\backslash T_{2y^6}$). The inrushing water points at present concentrated mainly in the T_{2y} marble in the east wing of Jinping syncline.

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