# APPLICATION OF TL DATING IN THE RESEARCH OF FAULT ACTIVITY IN YUDONG RESERVOIR, YUNNAN, CHINA

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**Abstract:** By using the author's self-made RS-81-1 TL dating device, the TL dating and microscopic structure analysis on calcite veins in 2 fault shatter belts in Yudong reservoir, Yunnan Prov., China, are done. The result shows that there are 4 groups of calcite veins which form in different time, among them 3 groups have been deformed. $F_1$ fault since $15\times 10^4$ years and $F_2$ fault since $25\times 10^4$ years have no evidence of activity. The surface characteristic analysis on quartz coarse-grain indicates the same result with TL dating method.

**Key words: Yudong reservoir in Yunnan; TL dating; Fault activity; Calcite vein**

## 0 Introduction

The Yudong reservoir locats at 18 km northwest to Zhaotong Basin, Yunnan province, and in the Mabian—Daguan—Zhaotong seismic zone. From 1216 two $M\geqslant 7$ earthquakes occured in the zone, and the epicenters of events are 80100 km off the reservoir. The intensity of Daguan $M$7.1 earthquake in 1971 to the reservoir area is Ⅶ degree, and no significant impact from anther $M$7 earthquake. Seismicity is comparatively weak in the reservoir and adjacent areas, excepting some earthquakes with magnitude 45, nor record of strong earthquake with $M\geqslant 6$. The basic intensity of reservoir area is rated as Ⅶ degree①.

The bed-rocks in the reservoir area are limestone and basalt of Permian and Triassic Period. Holocene sediments which forms the first terrace is distributed along Sayu River, and is not deformed. Two major faults are distributed in reservoir area: Sayu River fault ($F_1$) and Wujiayuan fault ($F_2$) with NE direction(Fig. 1).

## 1 Profiles of the faults and sample collecting

### 1.1 Profiles of the faults

The lengths of 2 faults are 60 km and 20 km respectively which form the shatter belts ranging from several meters to over 10 meters in Permian system. In the belts beside the fault clay and fault breccia, it develops crisscross multi-group of calcite veins. The density of the veins decreases from main fault plane to both sides, indicates that their formation are closely related to activities of the faults. The trench survey demonstrate that four stages of the vein formation can be distinguished according to the crisscross relationship among the veins,

① Seismological Bureau of Yunnan Province. Appraisal report of the basic seismic intensity for Yudong Reservoir area in Zhaotong county.

and the stages relate to four active periods of faults.

$F_1$ and $F_2$ faults appear to be in linear structure on landform. The faults cut early Pleistocene stratum and make it to slant deformation in the area out of the reservoir, but both faults are covered by late Pleistocene stratum and layer of river terrace Ⅱ, without any deformation. So it is can be determined that last active time of the faults is in middle Pleistocene, and not active from late Pleistocene Epoch(Fig. 23).

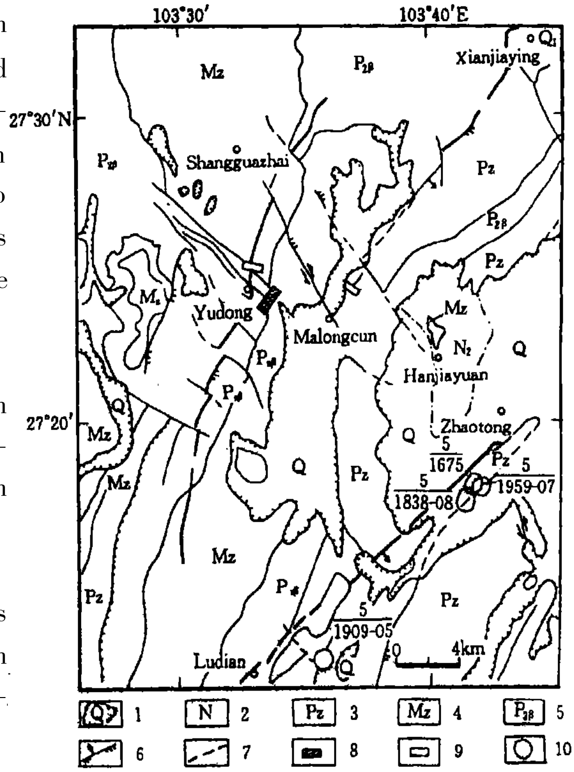
## 1.2　Sample collection

Sixteen calcite vein samples are collected in the trench pit in different times and kept without light. The characters and collecting positions of calcite sample are shown in Table 1.

## 1.3　The microscopic structure analysis on calcite veins

Based on microscopic structure analysis, deformations are found in three groups among four groups of calcite vein in the shatler belts of $F_1$ and $F_2$. The last group keeps unchanged.

Deformation structure is occurred under the stress force of fault activity after the formation of calcite vein. Its microscopic structure shows: it commonly develops 13 groups of mechanic twin crystal plane in the veins, and the twin-striations in part of crystal grains are displaced and bended, crystals are wrinkled and fractured, twin planes are glided and form kink structure. The crystal in undeformed vein seldom develops twin crystal, no deformation construction is found. Therefore, deformed calcite vein is one of the symbols of the fault activity.



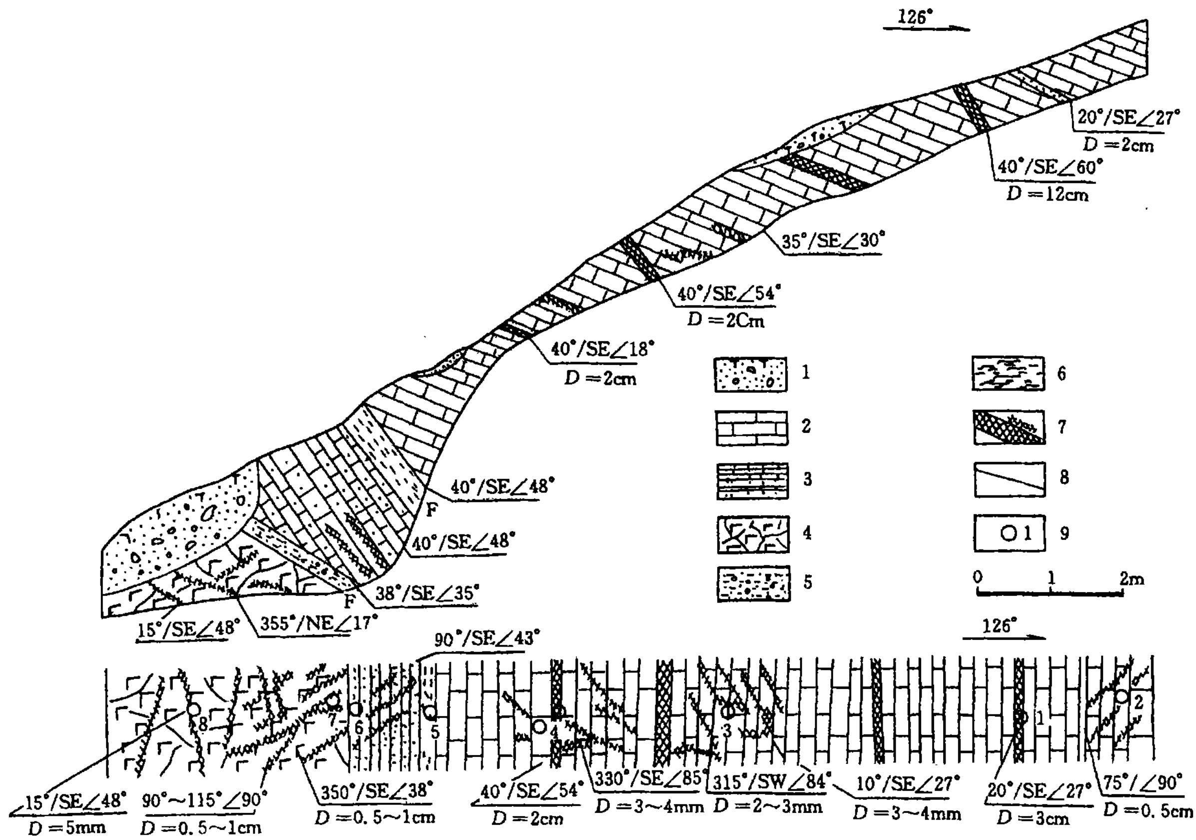

1. Quatemary; 2. Neogene; 3. Paleozoic; 4. Mesozoic; 5. Pemian Ermei Mountain basalt; 6. pressure fault; 7. Estimated fault; 8. Dam of reservoir; 9. Site of profile; 10. Earthquake epicenter

Fig. 1　Distribution of earthquakes and faults in Yudong reservoir and the adjacent rigion, Zhaotong county, Yunnan.

The density of deformed calcite crystal twin-striations is related to deforming degree[1,2]. Using the method of Jamison W. R. and Spang J. H.[3], we measured the density of calcite vein twin-strictions in shatter belts of $F_1$ and $F_2$. The mean differential stress values $\Delta\delta$ in every stage are: in stage Ⅰ $\Delta\delta=8331744$ Pa; in Stage Ⅱ $\Delta\delta=571800$ Pa in stage Ⅲ $\Delta\delta=401633$ Pa. The differential stress value in early stage is higher than late stage. The variation of differentiate stress value indicates that there is a difference of deformation degree among different stages of calcite veins.

# 2　TL dating process and outcome

The samples are strictly kept from the heat and light. Calcite veins are separated carefully from its surrounding rock under the red light, then crushed to grains. We select the grain with diameter of 10 mm ± and saturate them in 1% hydrochloric acid, then rinse them with distilled water till pH=7. In the author's self-made sample selector, grains are separated on 40 small aluminum discs with diameter of 10 cm, each sample portion weights 3 mg. The sample selector is very precise and works speedily, with error rate only about 5%.




1 Brown slope sediments; 2 Bioclastic limestone of Permian ; 3 Marl of Permian;
4 Fragmental Basalt of Permian; 5 Fault gouge; 6 Schistositive fragmental rock;
7 Calcite vein; 8 Fault plane; 9 Position of sampling and number

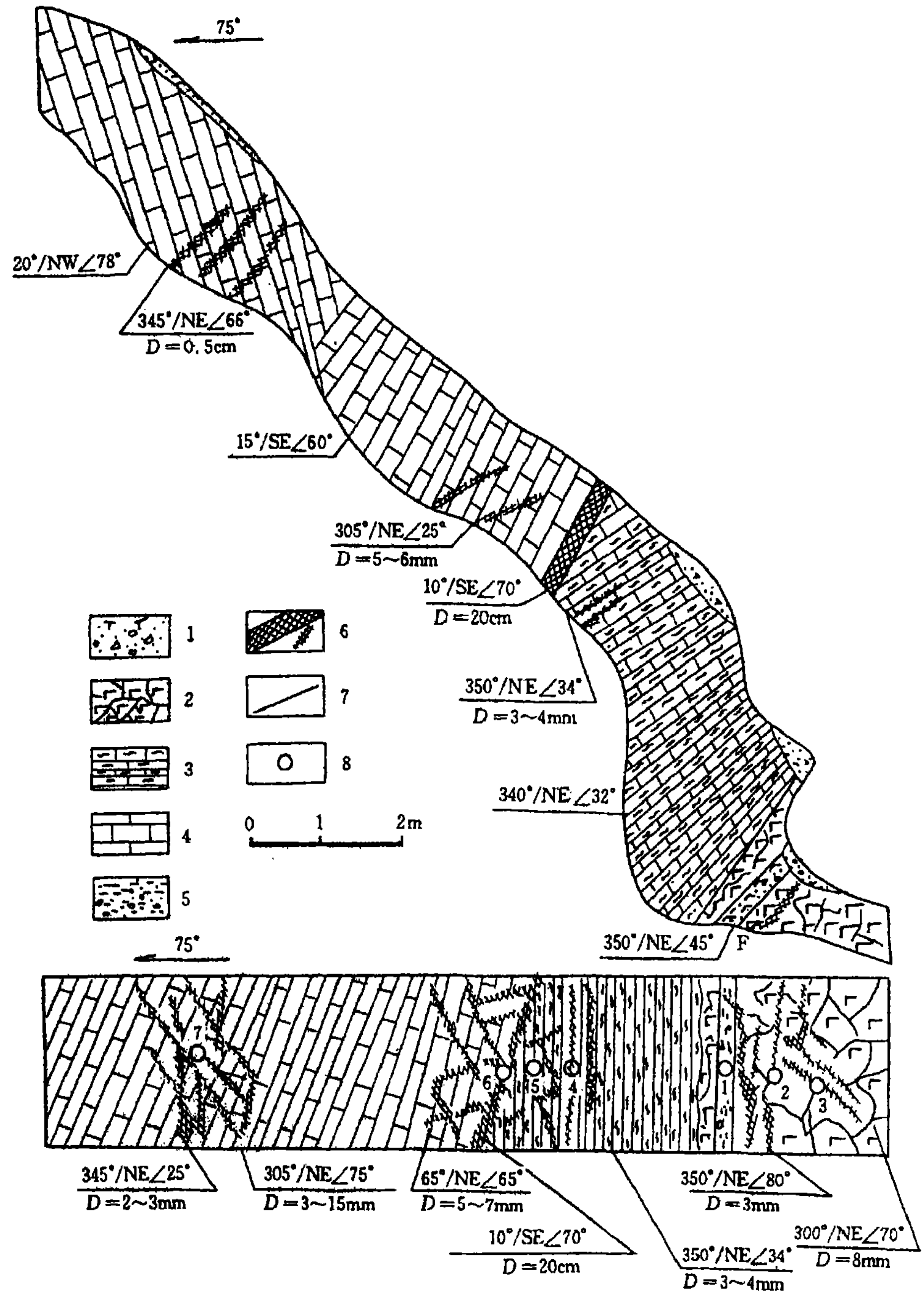
Fig. 2 Sketch of CY—1 trench wall on Sayu River fault ($F_1$).

It can meets the requirement of TL dating.

While in testing, the author's self-made RS-81-1 type of TL dating device is applied, which is adopted by appraisal in 1987 and won the Third Degree of science and technology progress award from National Seismological Bureau. In the device we use EMI 9635 QB photomultiplier tube, heat absorbing filter and blue light filter. Before the samples being heated, the heating oven should be evacuated to vacuum, put into high purified nitrogen, and use $P_2O_5$ to absorb moisture. Five groups of sample are irradiated by different dose of β ray to test its TL, while another group of sample is directly tested TL without β ray irradiation as a comparison. TL signal and temperature signal are sent to X-Y recorder to make the TL growth curve.

In the experiment, a "plateau" on the curve of each sample must be plotted to confirm if the TL contains anomalous fading, and to decide whether the TL is stable in certain temperature zone, then tests its accumulated dose. Figure 4 shows TL growth curve of CY1—9 sample. We select 280 °C peak value as the accumulating dosage, because if the temperature is below that, TL will have anomalous fading, if above that, peak value is staturated[4, 5]. The trap depth of peak value of 280 °C is 1.56 EV, and its electronic lifetime is $1.0\times10^6$ a[4].

There are two ways to get the palcodose, linear fitting and sablinear fitting. We take linear fitting method (see Figure five). The fitting curve we take has an intersection point A on X axis, then give samples another irradiation with different doses to measure TL, the new fitting curve has a intersection point B on $X$ axis. The




1. Brown slope sediments; 2. Fragmental basalt of permian; 3. Schistositive fragmental rock of permian;
4. Lime stone of permian; 5. Fault gouge; 6. Calcite vein; 7. Fault plane; 8. Position of sampling and number.

Fig.3　Sketch of CY—2 trench wall on Wujiayuan fault ($F_2$).

distance between A and B is PD (paleodose).

The error of the linear fitting curve must be taken into account, the equation is

$$E=\frac{1}{Q_\beta}\left[\left(\frac{\partial Q_\beta}{\partial G_1}\Delta G_1\right)^2+\Lambda+\left(\frac{\partial Q_\beta}{\partial G_i}\Delta G_i\right)^2\right]^{\frac{1}{2}} \tag{1}$$

In the equation: $Q_\beta$ is paleodose; $G$ is TL value.

The neutron activation method is applied to measure annual dose, the equation is

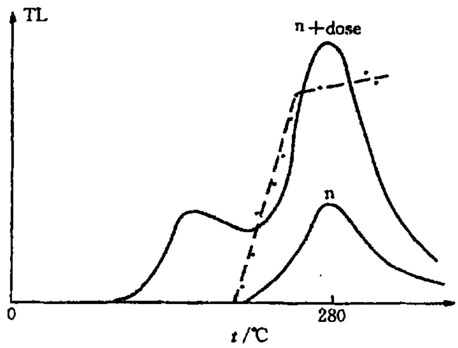



Fig.4 TL growth curve of CY1—9 sample.

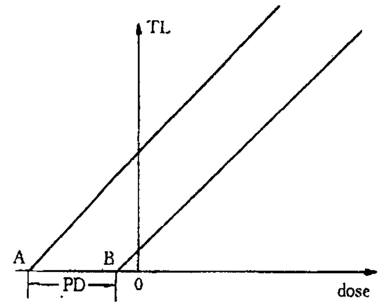



Fig.5 Linear fitting curve of TL dose.

$$t(year) = \frac{Paleodose}{Annual\ dose} \tag{2}$$

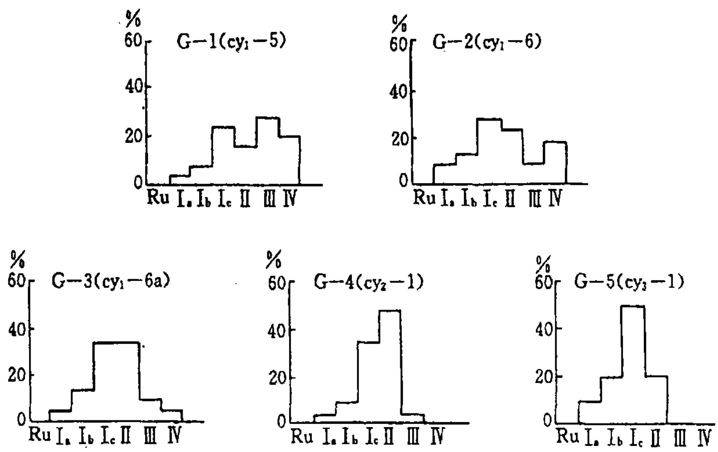
Using above method we test the samples from Yudong reservoir area, the result is shown in Table 1. From the table, we can find that activities of the $F_1$ and $F_2$ occurs in middle Pleistocene, the last activity time is 1625 $\times 10^4$a B. P..

**Table 1 Outcome of TL dating and character of microscopic structure of the calcite vein**

| Fault and trench | stage | Sample number | Character of microscopic structure | Differentia value of stress/Pa | TL dating /$\times 10^3$ a | Occurrence of vein |
|---|---|---|---|---|---|---|
| Sayu River Fault ($F_1$), Trench CY—1 | Ⅰ | CY1—3① | Developes twin crystal and other deformation structure | 940 | 738.0±133.0 | 315°/SE∠84° |
| | Ⅱ | CY1—9 | wrinkle deformation in crystal | ⩾800 | 434.0±66.0 | 40°/SE ∠48 |
| | Ⅲ | CY1—4<br>CY1—7 | Developes twin crystal and other deformation | 500<br>521 | 240.0±44.0<br>344.0±32.0 | 40°/SE∠54°<br>110°/ ∠90° |
| | Ⅳ | CY1—3②<br>CY1—8 | No twin crystal | | 159.0±86.0<br>166.0±51.0 | 15°/SE∠48° |
| Wujiayuan Fault ($F_2$), Trench CY—2 | Ⅰ | CY2—6 | Developes twin ctystal and fracture deformation | 833 | 881.0±137.0 | 10°/SE∠65° |
| | Ⅱ | CY2—5② | Developes twin crgstal and other deformation structure | 571 | 543.0±22.0 | 65°/SE ∠65° |
| | Ⅲ | CY2—5①<br>CY2—7 | Develops twin crystal and other deformation sturcture | 401<br>575 | 318.0±12.0<br>365.0±65.0 | 305°/NE∠65°<br>300°/NE∠67° |
| | Ⅳ | CY2—2 | No twin crystal | | 255.0±56.0 | 350°/NE∠80° |

## 3 SEM microscopic structure analysis on surface of quartz coarse-grain in fault gouge

With three samples are taken from $F_1$ and two from $F_2$, by scanning electron microscope, we count that the dominant surface morphological structure of quarty coarse-grain is eroding type (Fig.6). According to Kanaori Y. method[7], it is found that the last active time of $F_1$ is Plioceneearly Pleistocene; and of $F_2$ is early—middle Pleistocene. Since the late Pleistocene, about 150, 000 years, no movements are found in 2 faults.




$R_u$: fracted conchoidal; $I_a$: subconchoidal; $I_b$: thansition form;
$I_c$: orange—peel like; II: Scaly and lichenaceous;
III: stalatitic and worm eaten; IV: helcoid and coralliform

Fig.6　Frequency distribution of SEM morphological structure types on quartz coarse-grain from $F_1$ and $F_2$ fault clay.

## 4 Discussion

The calcite vein in $F_1$ and $F_2$ fragmented belt has relation with the fault activities, their TL dating reflects the fault's movement times. The undeformed calcite vein is the symbol of the fault's last movement.

The TL dating result shows that there are 4 activities on $F_1$ and $F_2$ in Middle Pleistocene ($1688\times10^4$ a B.P. ), the last one is in $16\times10^4$ a B.P. on $F_1$ and in $25\times10^4$ a B.P. on $F_2$. The microscopic structure analysis on quartz coarse-grain surface from fault clay demonstrates also that $F_1$ and $F_2$ move in Middle Pleistocene, and stop in Late Pleistocene in $15\times10^4$ a B. P..

In conclusion, there is no structure condition for large earthquae with $M>6$ in Yudong reservoir area, Zhaotong county, Yunnan province. The research provides sufficient geological evidence in chronology for basically asssessing the earthquake intensity of this zone.

In the TL dating we used RS-81-1 type of TL dating device which is made by authors, and the result shows that the device is practical and reliable.

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# 热释光年代测定方法在鱼洞水库地区断层活动性研究中的应用

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摘要：用作者研制的 RS-81-1 型热释光仪对云南昭通鱼洞水库地区两条断层的破碎带内发育的方解石脉进行了热释光年代测定和显微构造分析. 结果显示：2 条断层破碎带内发育 4 期方解石脉, 其中有 3 期发生了变形. $F_1$ 断层距今 $5\times10^4$a 以来, $F_2$ 断层距今 $25\times10^4$a 以来没有强烈活动的迹象. 断层泥中石英颗粒表面形态分析结果与热释光法相同.

关键词: 云南鱼洞水库; 热释光法; 断层活动性; 方解石脉
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