The Research of Huizhou Urban Active Fault Detection

Yuhui Li
Xi’an Research Institute Co., Ltd, China Coal Technology and Engineering Group, Xi’an, PRC
E-mail: liyuhui1@cctegxian.com

Abstract. With the rapid development of society and economy, the speed of urban construction is accelerating, social wealth is rapidly gathering and the population is high. The degree of concentration is obvious and the damage caused by urban earthquakes is obviously on the rise. Underground fault zone activity causes the culprit of an urban earthquake. The ground rupture caused by the earthquake is causing damage to buildings and people’s lives. This paper studies the activity of Huizhou urban active faults by comprehensive methods such as drilling, earthquake, chronology analysis, and sedimentary environment analysis. It is determined that the Huizhou fault is an early Quaternary fault and is currently not active.

1. Research Background
China is a country with many earthquakes. A large number of earthquake cases show that the earthquake active fault is not only the source of the earthquake but also the most severe damage along the fault line during the earthquake. The casualties are also significantly larger than other areas on both sides of the fault. Therefore, detecting the distribution of underground faults in Huizhou city, studying its activity characteristics and taking corresponding preventive measures is a major issue to ensure the sustainable development of the city and protect the interests of the people. It has very realistic and long-term economic and social significance.

Since the Quaternary, the southeast coast is still dominated by a slight rise and the Quaternary sediments are thin, mainly distributed along the coast. In the Haihekou Plain and Delta, tectonic movements have gradually weakened. But in the eastern Guangdong Chaoshan area, type rift basins have a Quaternary sedimentary thickness of more than 100m and many destructive earthquakes occurred in the basin [2][3].

Neotectonic movements in the study area manifested as neotectonic ascending and descending movements, fault activities, seismic activities, and geothermal anomalies (Figure 1). In the northern part of the study area, the neotectonic movements are dominated by uplifts with intermittent elevating movements. Complex, old fault resurrected. The differential activity of fault blocks in the southern part of the study area is significant and the new activities of regional faults are significant. Strong and moderate earthquakes are active. The neotectonic movement in the study area showed an intensification trend from inland to coastal.
2. Research Method

2.1. Shallow shear wave seismic exploration

Due to the shallow overburden in this area, the shallow artificial seismic surveying land used the transverse wave reflection wave method to cover the observation system multiple times (Li, 2018). It strived to obtain stable and continuous reflected waves on the bedrock surface under the seismic geological conditions of the thin overburden. It is easy to obtain the time difference between the two discontinuities in the Quaternary, the bedrock surface, and the strong and weak weathering layers. So as to improve the reliability of shallow breakpoint interpretation.

The direction of the survey line is likely to detect the strike of the structure vertically and the length of the survey line is based on the position where the survey structure can be controlled. The line spacing is based on the principle of better control of structural plane distribution. Name the numbers in accordance with the principles of the west, the east, the south, and the north. A total of 9 survey lines are arranged with a total length of 10.27 km. Take DZ2 line as an example:

![Figure 1. Regional seismic tectonic map.](image1)

The time profile of this survey line has relatively high signal-to-noise, clear wave impedance interface, obvious wave group characteristics and easy comparison. The lines of the survey area are integrated to explain the two reflection interfaces. The T0 wave group is the reflection wave group of the weathered crust bedrock surface and the T1 wave group is the reflection wave group at the lithological interface of the clay layer and the gravel layer. On the whole, the thickness of the clay layer is uneven (6-15 m). The western section of the survey line gradually becomes thinner near the front of the mountain and the middle section is relatively stable at about 11 m. The undulations have a buried depth of about 20 ~ 28 m. A total of 2 breakpoints are explained on the survey line, which tends to East.

![Figure 2. DZ2 line interpretation depth section.](image2)
Among them, the HZF2-1 fault has an apparent inclination angle of about 60 ° and an upper breakpoint burial depth of about 23m. The fault cuts the weathered crust bedrock surface without extending upward. The characteristics of the two reflection wave groups are significantly different. The reflected weather wave on the bedrock surface of the weathered crust formation shows two strong phases with low frequency, while the reflection wave group on the bedrock surface of the lower plate shows 1-2 strong phases with relatively high frequencies. After verification of the joint profile of the borehole across the abnormal point, the point is reliable. It is inferred that it is the main section of the Huizhou fault.

At the HZF2-2 breakpoint, the time profile shows obvious discontinuities. The drop of the weathered crust bedrock surface on both sides of the breakpoint is obvious. But the possibility of the breakpoint has been denied by drilling across the abnormal point. A comparative verification of three drill holes was performed (Figure 3), where ZK2-1 is located on the upper plate explaining the breakpoint. ZK2-2 and ZK2-3 are located on the lower plate explaining the breakpoint. The hole spacing of ZK2-1 and ZK2-2 is 34 m and the hole spacing of ZK2-2 and ZK2-3 is 60 m. The results reveal that the thickness of the clay layer is 3m between the two of ZK2-1 and ZK2-2. The interface is basically flat and free of drop and the bedrocks are all purple-red conglomerate of the Lishui Formation. Therefore, it is inferred that the anomaly point is an artifact of displacement of the bedrock surface caused by local lateral unevenness of the overburden, excluding the existence of this breakpoint.

2.2. Chronological analysis
Accurate and reliable chronological data is one of the most critical technical indicators for drilling exploration. Coarse-grained quartz OSL dating and 14C dating are used to determine the absolute age of bored cores in the target area [4][5].

2.3. Results and discussion of photoluminescence (OSL) dating
The dating results are shown in Table 1. It can be seen from the table that the OSL age of the sample is the largest at 11.8±1.1 ka, the smallest two ages are 0.4±0.1 ka and 0.7±0.1 ka, and the remaining ages are roughly 5.9~9.3 ka. It shows that the sedimentary strata are mostly Holocene and modern sediments.

2.4. Results and discussion of 14C dating
The 14C dating results are shown in Table 2. A total of 9 14C ages corrected for the caliber 602 calendar age are given. As seen from the table above, most of the 14C ages are close to or exceed their dating limit.
Table 1. Photoluminescence(OSL) dating results( Institute of Disaster Prevention OSL Lab)

| Field number | Depth (m) | U-238 (Bg/Kg) | Th-232 (Bg/Kg) | K-40 (Bg/Kg) | moisture content( %) | Saturated water content(%) | Annual dose rate(Gy/ka) | Equivalent dose (Gy) | Age (cal.BP) |
|--------------|----------|---------------|---------------|-------------|----------------------|---------------------------|--------------------------|----------------------|--------------|
| Ω-8-5        | 4        | 22.0±4.2      | 34.0±1.7      | 752.3±22.6  | 11                   | 26                        | 3.2±0.3                  | 211.2±20.0          | 65±            |
| Ω-8-1        | 6.2      | 106.7±23.3    | 206.8±10.3    | 397.1±11.9  | 21                    | 30                        | 6.9±0.7                  | 221.1±15.1          | 32.1          |
| Ω-8-3        | 12.2     | 23.0±4.1      | 39.0±2.7      | 762.3±22.9  | 2                     | 15                        | 3.6±0.3                  | 185.5±21.9          | 51.1          |
| Ω-8-6        | 18.9     | 27.7±2.3      | 45.7±2.3      | 728.2±21.8  | 17                    | 29                        | 3.2±0.3                  | 190.3±12.2          | 59.1          |
| Ω-8-8        | 21.4     | 70.6±4.3      | 78.5±3.9      | 941.9±28.3  | 4                     | 17                        | 6.1±0.6                  | 266.8±19.0          | 44.1          |
| ΩK2-2        | 4        | 14.2±1.0      | 45.8±2.3      | 297.8±8.9   | 19                    | 37                        | 2.0±0.2                  | 202.4±19.8          | 103           |
| ΩK2-3        | 9.4      | 10.4±1.0      | 12.0±1.2      | 822.9±24.7  | 23                    | 44                        | 4.8±0.5                  | 58.9±2.0           | 12.1          |

2.5. Results and discussion of Paleontology dating

Ten samples taken from the HZK-2 borehole were sent to the South China Sea Ocean Research Institute of the Chinese Academy of Sciences for identification of micro-archaeological fossils. The sampling depth range of the samples analyzed in the laboratory is 4.5-15.6 m. The lithology is silty clay, silt silty clay, and fine sand. In the experiment, a total of 10 foraminifera and mesophila samples were analyzed. According to lithological differences and experimental needs, about 10g samples were weighed for laboratory processing and analysis and identification.

Microscopic analysis was performed on each sample sheet and only a small amount of biological particles were found in the HZK-2-SP1 sample sheet. Due to the poor preservation of the biological shell, the individual was incomplete and difficult to identify. According to the size of the biological shell (100-200 μm) and main structural features (reticulated sponge bones are developed on the surface of the shell, the shell holes are sub-circular to irregular and the trusses between the holes are clear) (Figure 4), it is suspected to be radiolarian foam Shells of insects (Spumellaria). The sedimentary facies may be marine.
Figure 4. Microscopic observation of the sample sheet (a) and (c) are the suspected radiolarian shells (in red boxes) in the HZK-2-SP1 sample, and (b) and (d) are magnifications of the red box areas of (a) and (c), respectively. In the figure, the biological features in the upper right part of the specimen in (c) and (d) are relatively clear and the lower left part is covered by cuttings. The white bar scales are all 100 μm.

Figure 5. NS section of Huizhou.

2.6. Quaternary stratigraphic division
The joint profile of the three drilling sites in Huizhou is shown in Figure 5. It can be seen from the section view that the bedrock surface generally faces. The north slope reflects that the ancient East River is located in and to the north of HZK1. The current surface (the top surface of the Quaternary System) is concave in the middle. The modern East River is located between HZK1 and HZK2.

According to the comparison of regional data, from the bottom up, the bedrock is covered with the bottom gravel layer of Qp2.River (lake) deposition during drilling the first transgression, terrestrial weathered variegated clay of Qp3-2 and alluvial sediments from the second transgression during Qh1. It is overlaid with modern artificial fill or cultivated soil Qh2. Among them, according to the analysis of microfossils, the lake sediments of Qp3-1 are suspected to have marine organisms and their distribution elevation is -1 ~ 5 m, which is presumed to be due to the jacking effect of seawater on the East River during the first transgression period.

The residual slope of Qp2 is a yellow-brown gravel layer. The main component of the gravel is quartz and the gravel content accounts for about 90%. The particle size is mainly between 0.5 and 1
cm, with gravels of about 5 cm. This set of strata is mainly the remnants of the underlying Cretaceous glutenite weathered crust after flowing water. The formation age is the Middle Pleistocene.

3. Conclusions and Discussion
Evaluation result of the maximum potential earthquake occurrence probability of the target fault segment. The probability value given here is conditional probability and the definition of conditional probability is: 
$$P(T \leq t \leq T+\Delta T \mid t > T) = \frac{F(T) - F(T+\Delta T)}{F(T)},$$
where $T$ is the elapsed time; $\Delta T$ is the prediction period; $F(T) = \int_{T}^{\infty} f(t)dt$, where $F(0) = 1$ and $F(\infty) = 0$ for any probability model. For Poisson models: $P=1-e^{-\lambda t}$. Based on the evaluation results of the Poisson model, the Huizhou target fault MS6.0 earthquake recurrence interval is 2351a. Calculating the probability of occurrence of the largest potential earthquake in the target fault at different periods will be in the future. The comprehensive evaluation results of the probability of the same period are listed in Table 3. It is based on the above results, the maximum magnitude, activity parameters and future.

Table 3. Results of seismic risk assessment of target faults

| Target Fault   | Maximum magnitude/Ms | Recurrence interval/a | Forecast period | Probability     |
|----------------|----------------------|-----------------------|-----------------|----------------|
| Huizhou Fault  | 6.0                  | 2351                  | 50a             | 2.10×10^{-2}   |
|                |                      |                       | 100a            | 4.16×10^{-2}   |
|                |                      |                       | 200a            | 8.15×10^{-2}   |

The seismic environment and tectonic setting of the target fault, geological, geomorphological features at various scales, the fault surface features of the bare surface, geophysical prospecting, row drilling, and quaternary dating results have not shown that the target fault has occurred in the late Quaternary. Based on the relationship analysis of fault evolution history, the analogy of fault activity structure and the isotope dating of fault materials, it is comprehensively and conservatively considered that the Huizhou fault is an early Quaternary fault.

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References
[1] Chappell J 2002 Sea level changes forced ice breakouts in the Last Glacial cycle new results from coral terraces Source Quaternary Science Reviews 21 1229-1240
[2] Guo L and Li Y 2008 Coupling Effects of Climatic Change and Sea Level Eustasy Since Late Quaternary in Pear River Delta——Discussion of Fault Activities in Pearl River Delta Area South China of Seismology 28 53-58
[3] Guo L, Wang P and Zhang K, et al 2013 OSL and 14C ages of the Late Quaternary sediments in the east Pearl River Delta Geology in China 40 1842-1849
[4] Li Y 2018 Application of shallow seismic exploration in urban active fault detection China Energy and Environmental Protection 40 93-97
[5] Simms A R, DeWitt R and Rodriguez A B, et al 2009 Revisiting marine isotope stage 3 and 5a(MIS3-5a) sea levels within the northwestern Gulf of Mexico Global and Planetary Change 66 100-111