Study on the relationship between pre-earthquake variation of resistivity and regional stress field

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SUMMARY

The occurrence of earthquakes is closely related to tectonic stress. MT can obtain electrical structures related to fluids and their variations at different depths. The deep fluid content and its changes can reflect the underground stress state. In the paper, We use the long-term continuous observation data of MT response over time during the occurrence of two moderate to strong earthquake swarms in Yunnan, and analyzes their pre earthquake characteristics. It is found that the variation of apparent resistivity in pre-earthquake is closely related to regional stress. About 2 month before the earthquake, there was a significant decrease in the apparent resistivity of the stress stretching direction in the regional stress extension zone, while the performance in the vertical direction was not significant change. This variation gradually disappeared in impending time.

Keywords: earthquake, variation of apparent resistivity, stress field, abnormal, fluid.

INTRODUCTION

The stress exceeds the rock fracture strength, causing the crustal rock to rupture and produce earthquakes. However, direct observation of stress is very difficult, and scientists often monitor stress changes underground through observations of underground fluids and other factors to achieve earthquake precursor monitoring. However, underground fluid monitoring often detects variations in fluid related parameters near the surface, making it difficult to obtain the true situation of underground fluids at the depth of the earthquake source.

Magnetotelluric（MT） is a one of the most useful geophysical method for detecting the crust resistivity structures, which obtains resistivity at different depths through inversion of apparent resistivity and impedance phase at different frequencies . The porosity and crack of crustal rocks are highly developed, and the electrical resistivity of the crust is closely related to the porosity and crack of the rocks. Therefore, the observed changes of the resistivity also reflect changes in crustal stress.

Data and earthquake swarms

From January 2021 to April 2022, two moderately strong earthquake swarms occurred in Yangbi and Ninglang in Yunnan province of China, with maximum magnitudes of Ms6.5 and Ms5.5 of main shock, respectively. Within a range of 200km from the epicenter of the earthquake, Yunnan Lijiang electromagnetic observatory conducted long-term continuous MT monitoring, with distances of approximately 170km and 88km from the main earthquakes in Yangbi and Ninglang, respectively. By processing long-term continuous MT data from Lijiang observatory, and analyzing the changes in apparent resistivity and impedance phase over time during this period, it was found that the variation curves of apparent resistivity and phase observed at Lijiang Station showed significant abnormal changes approximately 2 months before the earthquake sequence, with a frequency range of 0.5-9.4 Hz and corresponding depths of 5-15 km. The apparent resistivity Ryx of the frequency 0.9 Hz and 3.9 Hz (fig.2) shows a significant decrease in amplitude with about 50%, while Rxy slightly increases, and the magnitude of Ryx variation is significantly greater than Rxy. The impedance phase Pyx shows an increase in variation, while Pxy decreases.

Analysis and discussion

The Lijiang observatory is located at the intersection of two strike slip faults. The focal mechanism solutions of the two main shocks indicate that the stretching direction of regional stress is in the near east-west direction, and the compression state is in the near north-south direction. The study on the

focal mechanism of the study area in the past decade indicates that the tectonic stress environment in the area is also in a north-south compression and east-west stretching state.

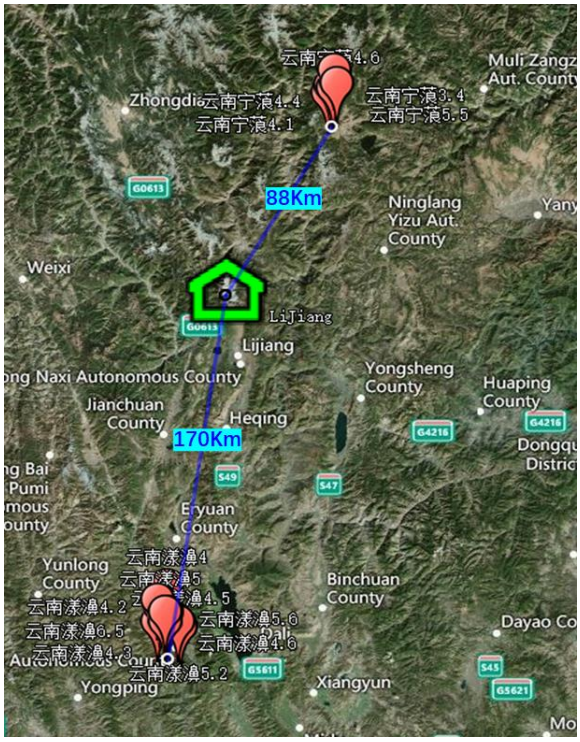

Figure 1. Location of MT observatory and earthquake swarms.

The variation of apparent resistivity observed at Lijiang Electromagnetic Observatory before occurrence of the two earthquake swarms indicate a significant decrease in the amplitude of the corresponding stress stretching apparent resistivity Ryx, reflecting fluid enhancement. We can understand that during earthquake preparation, the resistivity of the fluid containing medium in the crust decreases perpendicular to the direction of strong shear force (stress stretching and compression), while the resistivity slightly increases parallel to the direction of shear force (stress compression).

CONCLUSIONS

Therefore, we can draw the following conclusion:
1) The change in the resistivity of the underground medium before an earthquake is related to the seismic structure and the location of the station, and the magnitude of the change in apparent resistivity at different frequencies is related to the depth of the seismic source. The reason may be that the changes in the regional tectonic stress field before the earthquake cause changes in the fracture structure of the medium, leading to changes in the underground fluid content and resulting in changes in apparent resistivity;

2) During the pregnancy earthquake, under the action of strong shear force, the expansion zone of the stress area is observed perpendicular to the direction of shear fault distribution, and the apparent resistivity decreases and changes before the earthquake, with a large amplitude of change in resistivity; The resistivity parallel to the direction of shear force (stress compression) slightly increases.

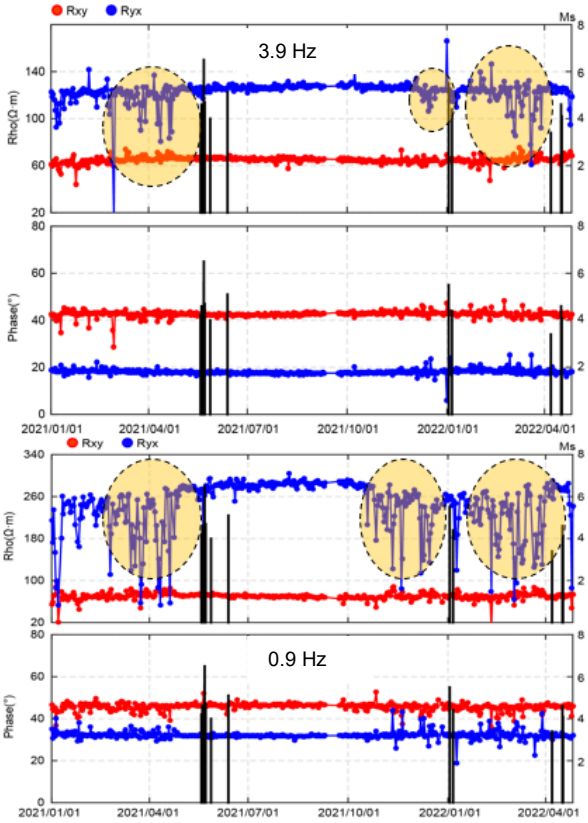

Figure 2. Variations of apparent resistivity and phase for time period of 01/01/2021~14/4/2022. Up is frequency 3.9 Hz ,below is frequency 0.9 Hz

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