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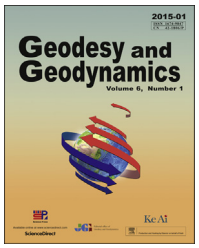

Analysis of coseismic effect on temperature in the Three Gorges well network

Zhang Weihua[a,b,c,*], *Wang Qiuliang*[a,b,c], *Li Jinggang*[a,b,c], *Luo Junqiu*[a,b], *Guo Xizhi*[a,b]

[a] *Key Laboratory of Earthquake Geodesy, Institute of Seismology, China Earthquake Administration, Wuhan 430071, China*
[b] *Wuhan Base of Institute of Crustal Dynamics, China Earthquake Administration, Wuhan 430071, China*
[c] *Key Seismic Monitoring Station of the Three Gorges Project Ecological and Environmental Monitoring System, Wuhan 430071, China*

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ABSTRACT

Through the Three Gorges well network, we examine different coseismic changes in water temperature caused by local earthquakes since 2008, and offer a mechanistic explanation. The relations between the coseismic changes in water temperature and the parameters of distant and local earthquakes are deduced.

1. Introduction

The seismic wave propagation generated by an earthquake can be regarded as a wide range of dynamic processes. The coseismic responses of different underground fluids are reflections of the stress and strain created by these processes. The coseismic variations in groundwater microtemperatures reveal underground reservoir deformation, changes in pores and fractures, and vertical groundwater migration due to crustal deformation and ground vibration [1–3]. Using data recorded in the Beijing region, the work of Che and Yu [4,5] shows that the coseismic response mechanism is attributed to the release of well water gas. Liu [6] summarized the basic types of water temperature coseismic characteristics by collecting the water temperature coseismic data of the Sumatra earthquake on December 26, 2004 recorded by the Chinese continental groundwater network. On the basis of the digital

* *Corresponding author.*
E-mail address: 1071164736@qq.com (Zhang W.).
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observation data of water temperature in the Beijing Tayuan well, Yang [7] suggested that accelerated convection and mixing caused by wellbore oscillation are the primary causes of the water temperature coseismic response. Cooper [8] reported that the groundwater-level response to volume expansion is much greater than the vertical motion.

Mass observation data have been recorded in the Three Gorge well network since 2001, and considerable researches have been performed in this area by both domestic and international experts. According to Che [9], the network layout and construction of the Three Gorges well network were very successful, as indicated by the confined aquifer permeability, closed-cycle storage conditions, mineralization, and other studied factors of each well. Liu [10] reported that the Three Gorge well network has good intrinsic data quality that can provide not only groundwater basis for reservoir-induced seismicity trends above a certain earthquake magnitude but also valuable reference data for research on the seismicity.

Liu [11] systematically studied the water level coseismic characteristics of the Wenchuan earthquake in the wells of the Three Gorge well network based on the "field" platform and reported the coseismic difference and corresponding explanation for each well. Liu [12] investigated the normal dynamics of individual wells in the Three Gorges network in 2001 by systematically analyzing eight wells for water level, four wells for water temperature, and four wells for radon data. The ability of the data to reflect earthquakes was also tested; however, the above studies mostly focused on teleseism and did not consider local earthquakes. As the selected wells have different geologic structures and hydrogeological backgrounds, the abovementioned coseismic mechanism studies are limited to water level coseismic data and lack water temperature data.

Since 2008, numerous earthquakes with magnitudes exceeding M3.0 have occurred in the Three Gorge region. In particular, the Badong M5.1 earthquake on December 16, 2013 and the M4.2 and M4.5 events in March, 2014 provide the best chance to perform a water temperature coseismic study in the Three Gorges well network. Thus, this study attempts to summarize the coseismic variation characteristics and derive empirical correlations between the amplitude of coseismic effects and the magnitudes of six local earthquakes that occurred on September 27, 2008, November 22 and October 31, 2012, December 16, 2013, and March 27 and 30, 2014 by analyzing the water temperature coseismic data of the Dahekou and Zhouping wells. For the Ms8.0 Wenchuan earthquake, the coseismic water temperature data of eight wells in the Three Gorge network were analyzed, and the differences in water temperature coseismic characteristics and influencing factors of the near earthquake and the local earthquake were obtained. On the basis of this analysis, a mechanism for studying the water temperature coseismic effects of local earthquakes and near earthquakes was proposed.

2. The coseismic characteristics of well water temperature

The Three Gorges well network comprises eight wells (Fig. 1). Well-bore water temperature detectors were placed at depths of 70–140 m to monitor the temperatures of the aquifers and their surrounding areas. The amplitude of the underground water temperature change was in the range of 10^{-1} °C–10^{-4} °C. In this study, the coseismic variations in groundwater temperature were analyzed for the dates of six local earthquakes (September 27, 2008, November 22 and October 31, 2012, December 16, 2013, and March 27 and 30, 2014). The differences in the coseismic variation of groundwater temperature between local earthquakes and near earthquakes were analyzed, and the influencing factors were then deduced.

2.1. *The Dahekou well temperature coseismic characteristics*

The Dahekou well is located at the south of the Xiannushan Fault zone. Its height above sea level is 241 m, and its burial depth

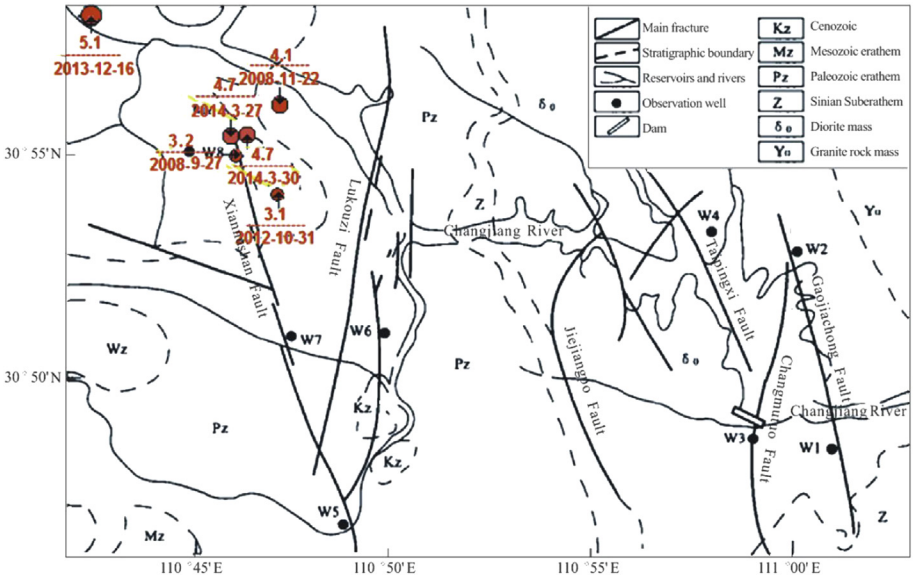

Fig. 1 – Distribution of the Three Gorges well network.