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Characteristics of Seismic-induced Liquefied Veins and C-O-Sr Isotopes of the Vein-bearing Rocks from the Early Cambrian Dachenling Formation, Western Zhejiang

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The northwestern Zhejiang area is located in the contact position of Yangtze Plate and Southern China Tectonic Belt, which is the southeastern part of the early Paleozoic Zhejiang-Anhui marine basin. The Palaeozoic strata is relatively complete and has received in-depth research, among which the Duibian section of Jiangshan is a GSSP of international Cambrian Jiangshan Stage, and the Huangnitang section of Changshan is a GSSP of national Ordovcian Darriwilian Stage [1-2]. Two stages of seismic-induced sediments were found in the Cambrian Dachenling Formation of western Zhejiang [3-5]. There are liquefied veins with certain thickness for each seismic event. The first is 0.44 m, and the second is 1.65 m. The liquefied vein is one of the important symbols of seismic event deposits. The liquefied veins from Carbonate rocks are easily confused with "molar tooth structures", which is one of the hot issues for current sedimentary petrology. There are even different explanations for veins in the same location and layers[6-7]. 17 rock samples with liquefied veins from the two seismic event sedimentary successions were taken from bottom to top. There are only 3 samples for the first succession because the veins are small and like floating flocculent. In contrast, there are 14 samples for the second succession because the veins are relatively straight and large. The research on the veins and C-O-Sr isotopes of the vein-bearing rocks were carried out. Firstly, the results show that $\delta^{13}C_{PDB}$-w of the two stages of veins is +0.01～-1.09‰, and $\delta^{13}C_{PDB}$-v is -0.07～-1.51‰, both of which belong to the normal marine carbonate sedimentary zone. However, the isotope values of each sample are featured by $\delta^{13}C_{PDB}$-w＞$\delta^{13}C_{PDB}$-v, and carbon isotope of the veins show obviously negative shift compared with the surrounding rocks. The first average negative shift is 0.3‰ and the second is 0.5‰, which was interpreted to be caused by isotope fractionation, late-stage alteration and $\delta^{12}C$ prior migration over $\delta^{13}C$ during water-escape process during seismic events. Secondly, the value of oxygen isotope for the two stages of veins and surrounding rocks is obviously different. The $\delta^{18}O_{PDB}$ of the first stage is -9.9～-11.6‰, which is similar with veins and surrounding rocks and shows slight negative drift, reflecting the original sedimentary environment. The $\delta^{18}O_{PDB}$ of the second stage is -12.7～-18.6‰, which appears to be strongly influenced by aleration. The research shows that the first earthquake event was accompanied with strong tsunami and deposited in deep water environment, and the liquefied veins and surrounding rocks were covered by overlying sediments after earthquake, so the original sedimentary environment was retained. However, the second earthquake occured in very shallow water environment, so water-escape structures were partially and transient thermal altered during formation process, which were easily affected by precipitation and late hydrothermal alteration due to unsubstantial tectonic surfaces after lithification. Thirdly, strontium isotope data of the frst stage is little, so it is not analysed here. The average Sr^{87}/Sr^{86w} of the second surrounding rocks is 0.712635, which is higher than the value reported at home and abroad. The average Sr^{87}/Sr^{86} of the liquefied veins is 0.733804 and even go up to 0.794550, which is higher than the surrounding rocks. This value is different with marine carbonate rocks of common marine, terrestrial and mantle source, but is quite the same with continental deposits, granite and metamorphic rocks. Based on field obvervations and microscopic analysis, the liquefied veins don't have the

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composition of granite, which indicates that when the earthquake happened, the soft sediments were near or exposed to the surface. The ground fissures were formed by seismic liquefaction and water-escape process, which were filled with late continental sediments and cemented by late carbonate. Therefore, the Sr^{87}/Sr^{86} value of the liquefied veins is characterised by continental sedimentation, and the water escape structures are accompanied by short-time thermal alteration, which are also suggested for strontium isotope and consistent with results of carbon and oxygen isotopes.

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Key Words: seismic event, C-O-Sr isotopes, seismic-induced liquefied veins, Cambrian, western Zhejiang

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