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Fine S-wave velocity structure and genesis of mudflows in Zhongchuan Township, China

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On December 18, 2023, a Ms 6.2 magnitude earthquake struck Jishishan, Gansu, China. The epicenter was located in the transition zone between the Qinghai-Tibet Plateau and the Loess Plateau, with a maximum intensity of VIII, accompanied by numerous aftershocks. This resulted in the destruction and collapse of buildings and caused casualties, as well as multiple landslides and other geological disasters. Additionally, the earthquake triggered a severe liquefied mudflow in Zhongchuan Township, Gansu Province, burying 51 houses and causing over 20 fatalities. The formation process was puzzling as the mudflow source area was on a flat loess platform. To investigate the cause of the mudflow in Zhongchuan Township, we employed the active source multi-channel analysis of surface waves (MASW) method to obtain two high-resolution 2D S-wave velocity profiles of the subsurface structure in the mudflow source area. The profiles reached a depth of 30 m, with S-wave velocities ranging from 120 to 420 m/s, divided into four layers. From the 2D S-wave velocity profile perpendicular to the mudflow movement direction, significant changes in the stratigraphic structure were observed, leaving clear wave traces. The measured residual waveform frequency was 2.7 Hz, which was consistent with the predominant frequency of 2.4 Hz measured by microtremors, providing key evidence for the hypothesis that the earthquake caused resonance in the loess layer, leading to the liquefaction of the saturated loess layer. The liquefaction layer was located 12 m below the surface, with a thickness of about 10 m. The 2D S-wave velocity profile along the mudflow movement direction clearly demonstrated the flow characteristics and channels of the liquefied soil layer. These findings not only provide important foundational data for further study of such mudflows but also significantly aid in improving disaster prevention and mitigation strategies in the region.