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Near-surface structure and morphology of an offset mud volcano constrain the structure and Holocene kinematics of a reverse strike-slip fault in the Coastal Plain of southwestern Taiwan

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The Taiwan mountain belt results from the rapid convergence of the Luzon volcanic arc and Chinese continental margin. While GPS observations showed the progressive decrease in westward shortening across most of the island, they also revealed the tectonic escape of the southwestern part of the island, that is moving towards the southwest at a rate of 4-5 cm/yr. In the past decade, InSAR studies suggested the existence of a southwest striking right-lateral fault in the Holocene Coastal Plain that could play a significant role in this extrusion mechanism.

This study investigates the structure and the Holocene kinematics of this inferred fault based on near-surface geological and geophysical data mainly acquired during a geotechnical consulting project. The study site locates in the Coastal Plain, where the InSAR deformation gradient is highlighted by a topographic scarp and the presence of a mud volcano. The mud volcano displays a dome-shaped topography, 1-km in diameter, cut and offset by the inferred fault. We investigate the deformation of buried Holocene strata using 19 shallow boreholes, radiocarbon (^{14}C) dating, U-Th dating and Resistivity Image Profiling for stratigraphic correlation across and along the inferred fault.

The fault-perpendicular cross-sections show that the bedrock and Holocene strata on the southeast block have been uplifting along a fault dipping 70^{o} to the southeast. The boreholes allow to identify a characteristic sandy layer, interpreted as a shoreface environment and dated at 4.7 ka. Along fault-parallel sections, this layer lies sub-horizontally, in contrast to the dome-shaped topography. Near the mud volcano mouths, the cores show mud dikes within this 4.7-ka layer and several mud flows within the overlying layer, which base was dated 4.1 ka. This suggests that the dome-shaped topography is the result of accumulated mud flows at the surface with mud-fluid transported through fractures induced by fault activity and/or fluid overpressure. The formation of the dome-shaped topography coincides with the transition from a shallow marine to a coastal and then continental environment at 4.1 ka. In parallel, using a high-resolution topographic dataset, we use the morphology of the mud volcano to estimate the right-lateral offset accumulated since 4.1 ka or later. We estimate an average horizontal offset of 54.4 ± 6.7 m and a minimum horizontal fault slip rate of 13.2 ± 1.6 mm/yr since 4.1 ka. Using the vertical offset of distinct layers across the fault leads to a vertical fault slip rate of 4.2 ± 1.8 mm/yr since 10 ka. The horizontal slip rate in our study is compatible with the horizontal deformation gradient of 15 mm/yr observed from GPS during 2015-2018. While GPS observations suggest that the fault may be at least partly creeping, the presence of Holocene growth strata at our study site suggest the possible occurrence of earthquakes during the Holocene.

Keywords: Active tectonics, fault slip rates, mud volcanoes, Gutingkeng formation, Holocene