The 2024 Noto Peninsula Earthquake and the million year preceding it

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On January 1st 2024, a Mw 7.6 earthquake shook the Noto Peninsula on the Sea of Japan coast of Central Japan causing over 202 casualties and >100 missing (at the time of submission). The quake follows a period of intensifying seismic activity starting in 2020. The Mw 6.3 Oku-Noto earthquake of May 5 2023 was the previous largest event of the sequence. The Jan. 1 2024 Noto Peninsula earthquake significantly impacted the Peninsula. A large number of landslides and rockfalls dissected the road network. Liquefaction damaged infrastructure up to 150 km away from the epicenter. Meter-scale coseismic uplift modified the northern shoreline with displacement of the coastline by up to 200 m seaward discernible on SAR and aerial image data. Coseismic displacement measured geodetically shows uplift of up to 4 m (SAR) in the northwest of the peninsula (Wajima-shi), and. The uplift magnitude decreases gradually to the SE. The uplift is near zero (SAR) or -0.3 m (GPS) on Noto Island (Nanao-shi) 30 km to the south of the town of Wajima. Surface deformation goes back to near zero (GPS) a further 20 km to the south.

The south-southeast tilt of the coseismic deformation pattern broadly reflects the deformation recorded by many geologically young (a couple hundred thousand years) elements of the Noto landscape. Faster rock uplift in the north (on the order of 1 mm/yr since 120 ka) gives way to a complex history of long-term slow uplift around Noto Island that likely includes sustained episodes of subsidence, highlighted by its sinuous “drowned” coastline. Along the western shore (Shika-machi), marine terraces presumed to be 120 ka (last Interglacial) show a gradient in elevation also decreasing to the south. In the north, the coseismically emerged platform does not have a higher marine terrace counterpart of similar size but multiple narrower benches identified as Holocene terraces exist. This may reflect the relationship between high wave power and moderate rock uplift resulting in the long-term retreat of the coastline and erosion of any terrace.

Beyond a couple hundred thousand years, the Noto landscape does not reflect a tilting geometry. The common mode of rock uplift recorded by marine terraces older than MIS 7 appears to be spatially uniform around 0.3–0.4 mm/yr. The fluvial landscape of the Peninsula is also not equilibrated to the current tilt and can be explained by the progressive emergence of an asymmetric inverted basin under uniform rates of uplift.

The similarities between recent landscape morphology and coseismic displacement suggest that the Jan. 1 2024 rupture fits a recent pattern of crustal strain in Noto Peninsula (at least up to 240 ka). Earlier deformation pattern (>240 ka) likely happened along different faults and/or at different rates as reflected by the transient drainage network.

