Postseismic deformation caused by the 2024 Noto Peninsula earthquake

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The 2024 Noto Peninsula earthquake that occurred on January 1, 2024 caused large crustal deformation across central Japan. Postseismic deformation has also been observed. The mechanisms of postseismic deformation include afterslip, viscoelastic relaxation, and poroelastic rebound, but this paper mainly reports on the details of deformation caused by viscoelastic relaxation.

As for horizontal deformation, northwestward deformation dominates over the entire area (Fig. 1a). However, in some areas on the northwest coast of the Noto Peninsula, deformation near zero or eastward was observed. In addition, southeastward deformation was observed at the Hegura Island station, the only site located northwest of the epicenter. As for vertical deformation, subsidence was observed throughout the Noto Peninsula, while uplift was observed in the surrounding areas, Toyama and Niigata prefectures (Fig. 1b). The spatial pattern of these postseismic deformation is significantly different from those of coseismic deformation pattern. The coseismic deformation in the Noto Peninsula were overwhelmingly larger than those in the surrounding areas (Toyama and Niigata prefectures), with the ratio of the magnitude of displacement being about 10 times (Fig. 2a), but the deformations after the earthquake were about 1 to 3 times larger. The direction of the coseismic deformation in the Noto Peninsula was also from west-northwest to west-southwest, but after the earthquake, deformations in the northwest direction prevailed. Furthermore, as for vertical movements, a large uplift on the northwest coast of the Noto Peninsula was characteristic at coseismic deformation (Fig. 2b), but after the earthquake, subsidence prevailed throughout the Noto Peninsula, including the areas that were greatly uplifted during the earthquake. In contrast, uplift was observed both during and after the earthquake in the areas around the epicenter (Toyama and Niigata prefectures).

Deformation due to viscoelastic relaxation depends heavily on the viscoelastic structure and the viscosity. In this paper, we assumed a two-layer model and calculated the optimal elastic layer thickness and the viscosity with Burger model. Using data on horizontal and vertical deformation for six months after the earthquake and stations within 200 km from the epicenter, we examined the parameters with the smallest residuals for the horizontal and vertical components. As a result, the optimal elastic thickness was 35 km and the viscosity was 4×10^{18} Pa・s (Maxwell viscosity, Kelvin/Maxwell ratio is set to 0.1). The horizontal deformation due to viscoelastic relaxation is characterized by deformation toward the epicenter, that is, toward the northwest in the southern coast of the Noto Peninsula and in Toyama and Niigata prefectures, and toward the southeast in the sea area on the northwest side of the Noto Peninsula (Fig. 1c). The vertical deformation is characterized by subsidence centered on the epicenter and uplift in the surrounding area, that is, subsidence centered on the northern coast of the Noto Peninsula and uplift from

Toyama Prefecture to Niigata Prefecture. Looking at the spatial patterns alone, all of the features are consistent with the observed postseismic deformation. Viscoelastic relaxation has been able to nearly reproduce the spatial pattern and temporal changes of the deformation observed in the six months after the earthquake. However, looking at the residuals, it is particularly difficult to explain the observed deformations on the northern coast of the Noto Peninsula and Sado Island, and it is difficult to explain all the observed deformations by viscoelastic relaxation alone. This is probably the effect of afterslip, and we are currently working on estimating the afterslip.

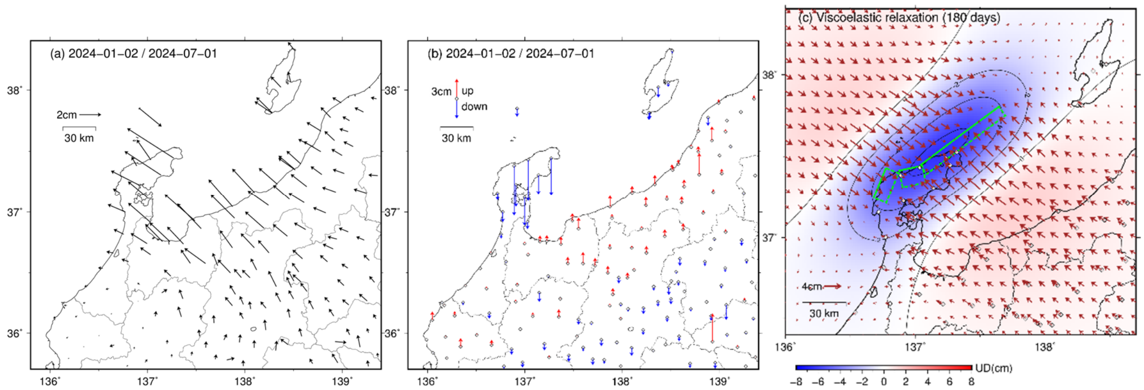

Fig. 1 Postseismic deformation for 180 days after the earthquake. (a) Observed horizontal deformation. (b) Observed vertical deformation. (c) Computed deformation due to viscoelastic relaxation.

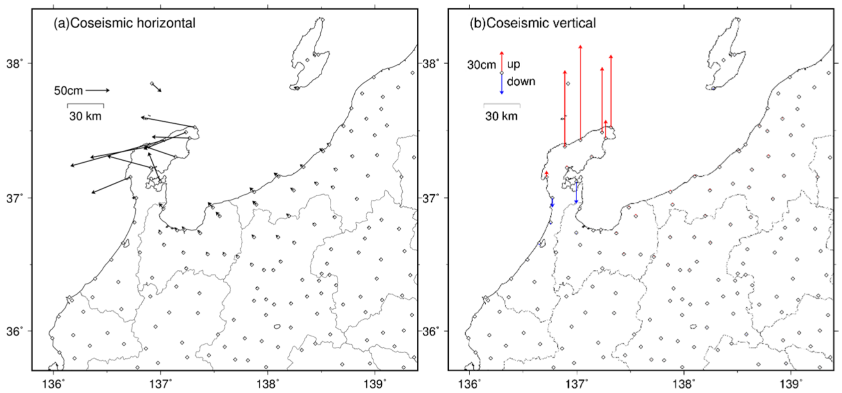

Fig. 2 Observed coseismic deformation. (a) Horizontal deformation. (b) Vertical deformation.