Tectonic geomorphology and paleoseismology of the northern Neodani fault around Mt. Nogo-Hakusan, central Japan

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In the 1891 Nobi earthquake (Mw 7.5), central Japan, three left-lateral active faults, the Nukumi, Neodani, and Umehara faults ruptured simultaneously, resulting in enormous disaster. Although many studies have been conducted after the earthquake along the central and southern Neodani fault, the fault activity and paleoseismic history of the northern section is poorly known principally due to mountainous environment. In order to clarify the activity and earthquake history of the northern part of Neodani fault, we conducted detailed geomorphological interpretation using the airborne LiDAR data and field geological mapping as well as trench excavation at the uppermost Nukumi-Shiratani Valley, southwest of Mt. Nogo-Hakusan, where previous studies reported presence of a fresh fault scarp.
Four fluvial terrace surfaces occur in our study area: NS-I to NS-IV surfaces in descending order. A clear uphill-facing fault scarp cuts across the NS-II surface with a vertical displacement of 3.0 -/+ 0.1 m. In addition, a tributary valley dissecting the surface shows a left-lateral offset of 28 -/+ 5 m, where a fault cutting the NS-II gravels against conglomerate bedrock is exposed on the valley wall.
We excavated a ~5.5-m-long, ~1-m-wide and ~1.5-m-deep trench across the fault scarp. The sediments exposed on the trench walls are topsoil, black peat, lacustrine gray clay, eolian yellowish-brown silt, and gravel layer. The boundary between the yellowish-brown silt and gray clay is very clear, suggesting a drastic change in sedimentary environment. In addition, the gray clay layer bends up towards the fault, which is unconformably overlain by the black peat layer. The organic-rich horizons in the black peat layer are further deformed toward the fault. Based on stratigraphic and structural evidences including those mentioned above, we identified four paleoseismic events after deposition of the NS-II gravels. Our tephra analysis revealed that three of them occurred after the K-Ah tephra fall (~7.3 ka), the latest one possibly correlating to the 1891 Nobi earthquake. Since abandonment of the NS-II surface predates the K-Ah tephra fall but postdates the AT tephra fall (~30 ka), we estimated the left-lateral slip late of this section of the Neodani fault to be at least 2.6 -/+ 1.9mm/yr based on the amount of the stream offset mentioned above.
Our results suggest that the slip rate of the northern Neodani fault is comparable to or even higher than that of the central main section. Of particular interest is that despite presence of such a high slip-rate fault, there are few recognizable tectonic landforms along this section of the Neodani fault except for our study site. This is probably due to high erosion rate in high-relief mountains, suggesting that high slip-rate faults elsewhere may not accompany clear tectonic landforms in high-relief mountainous environment. Tectonic landforms are locally preserved at our study site probably because they are located in the uppermost Nukumi-Shiratani Valley above a clear knickpoint, where severe postglacial erosion has not reached yet.

Keywords: active fault, paleoseismology, LiDAR, Nobi earthquake

