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Shapes and origins of notches and caves on sea cliffs, the Noto Peninsula, central Japan

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In the Noto Peninsula, there are many notches and caves on sea cliffs. Their major origins may be salt weathering and wave erosion, but few detailed studies have been carried out in the past. A level of wave-cut notch indicates a paleo-sea level, and is useful to estimate uplift rates of the area. Therefore we aimed to classify them into notches and caves formed by wave erosion and those formed by other processes such as salt weathering in this study.

We studied coasts of the Noto Peninsula, and carried out 3D laser scan survey in western coasts where these features are abundant. We obtained red relief image maps which show detailed topographic features of the sea cliffs from DSM (Digital Surface Model) data taken by a laser scan survey to recognize the caves and notches. We also performed geological survey and X-ray diffractometry analysis to determine their origins.

We recognized many caves and notches on sea cliffs composed of Miocene volcanic rocks in western and northern coasts of the Noto Peninsula. In western coasts, Their shapes are classified roughly into two types, linear type and ellipsoid or polygonal type. The former includes vertical, horizontal, and oblique continuous shapes, of which sizes are less than a meter in width. Some of them observed at an altitude of 2 meters in several areas show the scale of a meter in width and horizontal continuous shapes with benches at their base, indicating that they were formed by wave erosion. The caves of the latter are distributed widely over cliffs, and they are dozens of centimeters to several meters in diameter. The occasional existence of white powder, which is composed of gypsum ($CaSO_4 \bullet 2H_2O$) according to X-ray diffractometry analysis, in caves of the latter, indicates that salt weathering is closely related to the formation of this type.

Assuming that wave-cut notches recognized in this study were formed at the same stage, uplift rates of western coasts of the Noto Peninsula are equal after their formation. Therefore it is necessary to determine the age of their formation.

Keywords: the Noto Peninsula, sea cliff, 3D laser scan survey, topography analysis, wave erosion, salt weathering