【Grant-in-Aid for Scientific Research (S)】

A study of the tsunamigenic submarine active fault of the 2024 Noto earthquake (M7.6)

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Purpose and Background of the Research

●Outline of the Research

On January 1, 2024, a large earthquake (M7.6) and the resulting tsunami caused devastating damage in the Noto Peninsula. It is believed that part of the source fault, particularly in the sea area, triggered the tsunami. Recent seismic activity suggests that deep-seated fluids near the fault may have acted as a trigger for the earthquake. This study aims to clarify the nature of the tsunamigenic submarine active fault of the 2024 Noto earthquake through a multidisciplinary approach. Specifically, seismic imaging will be conducted in the source area off the northeastern Noto Peninsula, and high-precision structural imaging and physical property estimation of the submarine active fault systems developed to the seafloor will be performed. The submarine active fault that became the earthquake source will be drilled to reveal its mechanical and hydraulic properties, as well as to decode its faulting history. A high-density analysis of pore fluids in surface sediments and crustal heat flow measurements will be conducted near the submarine active fault to investigate the rise of deep-seated fluids along the fault. The study will also enhance numerical models for earthquake rupture propagation and tsunami generation, aiming to contribute to the high-precision assessment of active fault seismic activities.

●Hypothesis on the 2024 Noto Earthquake and Tsunami Generation (Fig. 1)

<Step 1> A "fluid-rich layer" exists in the deep northeastern part of the Noto Peninsula. <Step 2> Fluid is supplied to the "fluid-rich layer," leading to an increase in pore-fluid pressures. <Step 3> The increase in pore-fluid pressures facilitates fluid intrusion into pre-existing active faults, reducing their shear strength and triggering a large earthquake. <Step 4> If the fault rupture reaches near the seafloor, it can generate a tsunami.

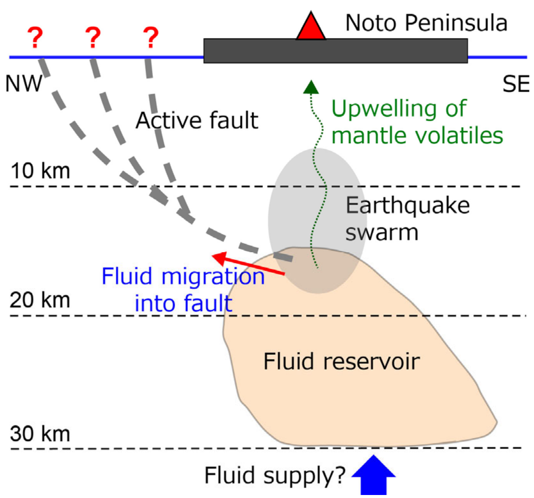

Figure 1. Schematic diagram of the subsurface structure in the northeastern Noto Peninsula (modified after Nishimura et al., 2023, *Sci. Rep.*)

●Scientific Questions for Examining Steps 3 and 4 of the Hypothesis

(1) Which active fault triggered the earthquake and tsunami? (2) Is there any evidence that deep-seated fluids contributed to fault activity? (3) What are the kinematic history, frictional properties, and activity of the tsunamigenic fault? (4) To what extent do deep-seated fluids influence fault rupture propagation and tsunamis?

●Four research teams collaborating through a multidisciplinary approach

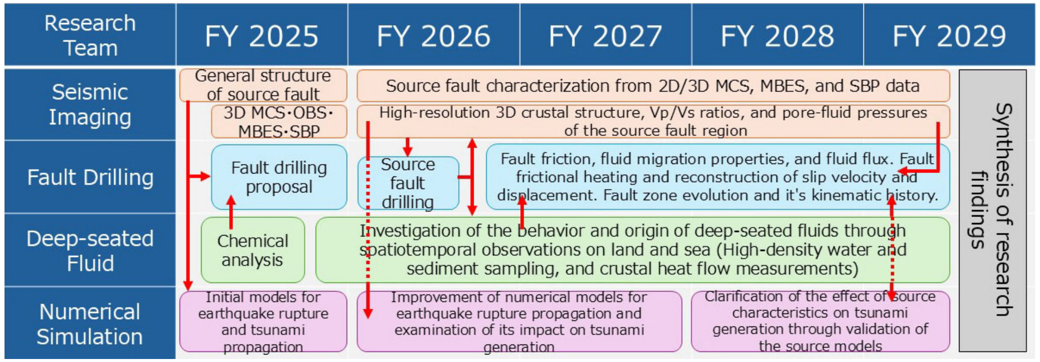

Figure 2. Research plan and method

Expected Research Achievements

●Expected Research Outcomes Regarding the Core "Question" of This Study: "What is the Nature of the Tsunamigenic Submarine Active Fault of the 2024 Noto Earthquake (M7.6)?"

(1) Which active fault triggered the earthquake and tsunami? → If surface sediment samples collected around the source fault contain the mantle fluids, and if frictional heating is detected in samples from the drilled fault zone, then this fault is the most likely source of the tsunami.

(2) Is there any evidence that deep-seated fluids contributed to fault activity? → If the following are identified in the source fault region, as imaged by 3D MCS (Fig. 3) and OBS surveys , it strongly suggests that deep-seated fluids contributed to fault activity: ① low-velocity zones, ② abnormally high Vp/Vs ratios, ③ excess pore-fluid pressure, and ④ high helium isotope ratios.

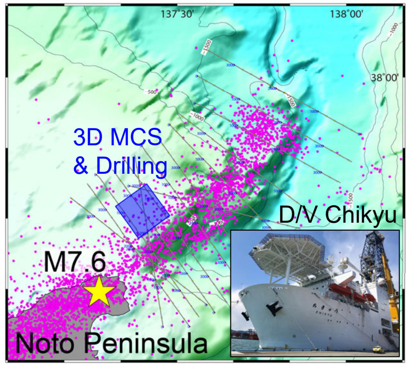

Figure 3. Map of 3D MCS and drilling site

(3) What are the kinematic history, frictional properties, and activity of the tsunamigenic fault? → If the recurrence interval of fault movement in the source fault (Fig. 4) is observed to be ~5,000 years and its frictional strength is significantly lower than that of the reference fault, it indicates a high slip tendency.

(4) To what extent do deep-seated fluids influence fault rupture propagation and tsunamis? → The transition of the fault rupture mechanism from deep to shallow regions is expected to be primarily controlled by the selective intrusion of deep-seated fluids.

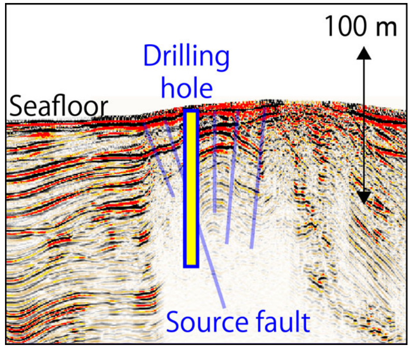

Figure 4. Concept of source fault drilling

●Academic Significance and Social Impact

This research is expected to contribute to disaster prevention and mitigation for large-scale active fault earthquakes, which remain a concern in various regions of Japan.

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