Three-dimensional resistivity structure of the epicenter area of the 1997 Kagoshima earthquake doublet, Japan

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SUMMARY

We utilized broadband magneto-telluric (MT) data to analyze the 3-D resistivity structure around the epicenters of the 1997 Kagoshima earthquake doublet, Japan. Our study aims to assess the potential for significant earthquakes by examining the spatial correlation between earthquake ruptures and resistivity patterns. We re-analyzed previous MT data and further obtained additional MT data. As a result, we imaged low resistivity zones at the edges of the main shocks.

Keywords: magnetotelluric, the 1997 Kagoshima earthquake doublet, resistivity structure

INTRODUCTION

Kagoshima northwest earthquake doublet, consisting of a pair of M6-class earthquakes occurred In March and May, 1997. It generated a F-shaped aftershock zone extending in both east-west and north-south directions. The slip distribution of the two earthquakes was estimated from K-net strong-motion data (Horikawa 2001, BSSA). Previous research (Umeda et al., 2014, Tectonophysics) estimated a resistivity structure in this region, identifying a near-vertical low resistivity zone extending to the base of the crust, possibly linked to mantle fluid intrusion. However, the previous study did not investigate the spatial relationship between earthquake rupture and resistivity structure due to limited spatial resolution.

METHODS

To address this gap, we expanded upon the work by incorporating additional MT data, resulting in a total of 86 data points. Our dataset combines data from Umeda et al. (2014), Kyushu University (obtained in 2016, 2017, and 2022) and newly acquired data (obtained in 2024). The frequency bands of the MT response functions are 3×10^{-4} ~ 320 Hz. For the calculations of MT response functions by the Kyushu University, we used BIRRP code (Chave and Thomson, 2004, GJI) with remote reference processing. We used an unstructured tetrahedral mesh and FEMTIC code (Usui, 2015; Usui et al., 2017, GJI) for estimating a 3-D resistivity structure. Input data of the inversion are four components of impedance tensor and two components of Tipper at 20 frequencies (3×10^{-4} ~ 80 Hz). In the inversion, we gave the fixed air (10^8 Ωm), the fixed ocean (0.33 Ωm) and unfixed land (100 Ωm), respectively. We gave an error of 10% for the diagonal component of the impedance, 5% for the off-diagonal component, and 0.05 for the tipper.

RESULTS

Our findings reveal low-resistivity zones near the eastern and western edges of the aftershock region at depths of 5-10 km. The hypocenters of the M6 earthquakes are located near the edge of the low-resistivity zones. A distinct high-resistivity zone is sandwiched between two low-resistivity zones at depths of 0-3 km, corresponding to the distribution of a granodiorite body. The slip distribution of the March M6 earthquake is located beneath this shallow granodiorite body and is sandwiched by the low-resistivity zones.

CONCLUSIONS

Rupture of the March mainshock started from the edge of the low resistivity zone and stopped near another low resistivity zone. Therefore, low-resistivity zone may have influence on the initiation and arrest of the rupture of the 1997 Kagoshima earthquake. This relationship is similar to the result of the 2016 Kumamoto earthquake (Aizawa et al. 2021). In the presentation, we show the best resistivity structure by conducting 3-D inversions with various settings and discuss the spatial relationship between the earthquake's rupture and resistivity structure.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Japan Atomic

Energy Agency (JAEA) for allowing us to use wideband MT data of Umeda et al. (2014). This work is supported by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) under its Earthquake and Volcano Hazards Observation and Research Program.

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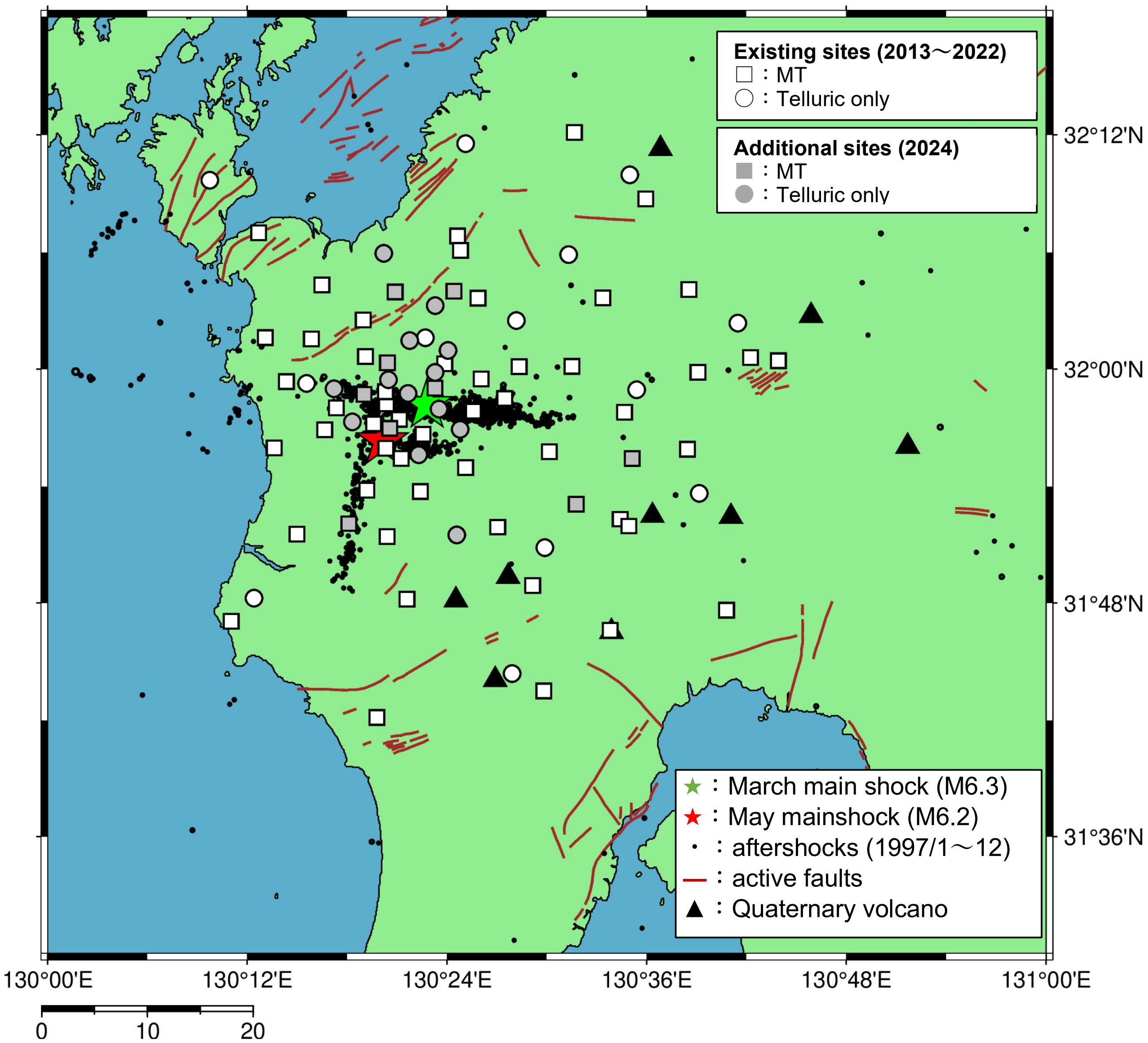

Figure 1 : The location of the magnetotelluric observation sites in the research area