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An active shear zone, southwest Japan: electromagnetic geophysics and noble gas geochemistry

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In 1997, the Kagoshima earthquake doublet with two Mw ˜6 strike-slip events struck 5 km and 48 days apart in southwest Japan, where an E-W trending discontinuity along 32 degree N latitude in GPS velocities across southern Kyushu Island is clearly defined, indicating a highly active left-lateral shear zone. However, there was no obvious prefaulting indication at surface (active fault) in relation to the shear zone. Three-dimensional inversion of magnetotelluric sounding data observed in the source region of the the earthquake doublet reveals a near-vertical conductive zone with a width of 20 km, extending down to the base of the crust and perhaps into the upper mantle. The prominent conductor corresponds to the western edge of the active shear zone. Elevated 3He/4He ratios of groundwaters sampled around the seismic source region suggest the emission of mantle-derived helium from the electrical conductor. The geophysical and geochemical observations provide significant evidence that the invasion of mantle fluids into the crust, driven by upwelling asthenosphere from the Okinawa trough, triggers off the notable left-lateral shear zone in the present-day subduction system. In addition, the conductive fluids enhance stress concentration in the seismogenic layers leading to mechanical failure of strong asperities, resulting in the occurrence of the 1997 earthquake doublet.

Keywords: 1997 Kagoshima earthquake doublet, active shear zone, magnetotelluric sounding, helium isotope