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Assessment of active fault zones by soil CO_2 flux measurements in the Yangsan fault system, South Korea

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The Gyeongju earthquake (M_L 5.8) that occurred on September 12, 2016, had a great impact on South Korea and is believed to be related to the Yangsan fault system (YSF) located in southeastern Korea. As more than 1 million people live in this area and industrial facilities are concentrated near the YSF, identifying active faults is necessary to reduce the possibility of earthquake damage. For this purpose, we present the results of CO_2 flux measurements and $\delta^{13}C$-CO_2 analysis for natural springs and diffuse soil gases in the Gyeongju, Yeongduk, and Pohang areas near the YSF. The CO_2 flux measurements were performed at more than 200 points using the accumulation chamber method, and the analysis of the flux values was carried out by the graphical statistical analysis (GSA) method. Elevated CO_2 fluxes were observed in both natural springs (98 g m^{-2} d^{-1} to 77,699 g m^{-2} d^{-1}) and soil gases (1.3 g m^{-2} d^{-1} to 1,240 g m^{-2} d^{-1}). The high flux group includes all measurements of natural springs and some values of soil, which may be related to active faults. The statistical distribution and carbon isotope composition ($\delta^{13}C$) of CO_2 in natural springs (-9.85‰ to -7.44‰) and soils (-21.05‰ to -14.77‰) indicate multiple origins of CO_2; shallow biogenic and deep mantle sources. The released CO_2 is thought to be the result of the mixing between two distinct sources as the fluid ascends from the mantle through the highly permeable pathway, suggesting that the YSF can connect to the depth of the mantle. Therefore, our CO_2 flux measurements provide important clues for future studies to identify the active fault distribution in this area.