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Nationwide Low-Density Geochemical Mapping of Th–U–Zr in Stream Sediments, Korea

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Stream sediment geochemistry provides baseline data for evaluating natural sources of potentially harmful elements and their environmental effects. Korea was divided into 100 km² grid cells. One composite sediment sample was prepared per cell by combining all subsamples, producing 965 nationwide samples. These samples generated geochemical maps for thorium (Th), uranium (U), and zirconium (Zr). These elements were selected for their distinct geochemical behaviors and environmental significance.

Uranium and thorium exhibit similar spatial patterns. This reflects comparable geochemical behavior and strong control by rock type. Thorium concentrations (7.9–328 mg/kg) commonly exceed the upper continental crust (UCC) average of 10.5 mg/kg. Uranium (1.7–35.5 mg/kg) surpasses the UCC average of 2.8 mg/kg in many regions. The highest concentrations occur in the southwestern Gyeonggi Massif. Ancient metamorphic rocks (Paleoproterozoic) are widespread there. This enrichment reflects ancient uranium mineralization in sedimentary rocks and preservation during metamorphism. It represents natural geological conditions rather than human-caused pollution.

Elevated uranium and thorium are also common in ancient metamorphic igneous rocks of the Yeongnam Massif. These are characterized by light-colored gneisses, granitic rocks, and high-grade metamorphic rocks. They contain U- and Th-bearing minerals, including monazite, allanite, thorite, and zircon. In contrast, lower concentrations appear in sedimentary basins such as the Gyeongsang and Yeonil basins. Quartz-rich sedimentary layers dilute primary geochemical signals there.

Zirconium shows a broadly similar distribution to U and Th. It ranges from 159 to 4,298 mg/kg (UCC average 165 mg/kg). However, it displays exceptionally high values in the central Yeongnam Massif. This reflects zircon-rich granitic rocks and zircon's extreme resistance during weathering and sediment transport. Together, integrated Th–U–Zr patterns establish reliable natural baselines for environmental monitoring. They also identify ancient basement rocks with elevated mineral exploration potential. Future research will predict spatial distributions of additional elements related to Th, U, and Zr. It will also evaluate indirect estimation methods through comparison with direct chemical analyses.