Researchers demonstrate high natural radioactivity of manganese nodules

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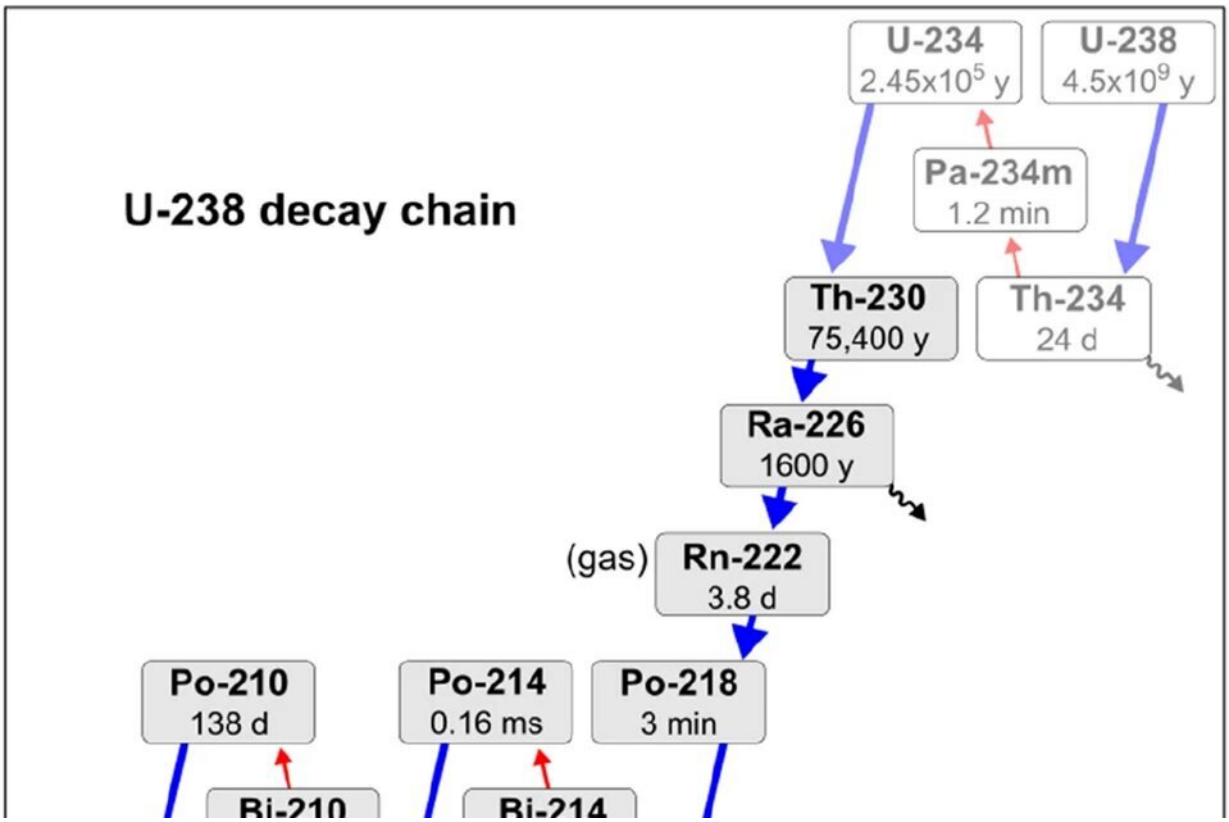

Visualization of the U-238 and U-235 decay chains and the scavenging, adsorption and settling processes involving uranium-series daughters in the slowly accumulating deep-sea environment in the presence of polymetallic nodules at the seafloor. Scav scavenging, sett settling, diff diffusion, ads adsorption. In the sediments of the NE Pacific Ocean, the activity concentrations of Th-230, Pa-231 and Ra-226 generally decrease with depth as they decay and maximum values in the upper 10 cm of the sediments reach up to 3.2 Bq g−1, 0.08 Bq g−1 and 1.5 Bq g−1, respectively14,15. Thus, activity concentrations in

the topmost 10 cm of the sediments are at least one order of magnitude lower compared to polymetallic nodules but may still exceed NORM threshold values (cp. Table 1). Credit: *Scientific Reports* (2023). DOI: 10.1038/s41598-023-33971-w

Manganese nodules at the bottom of the deep sea contain a wealth of valuable metals that are vital to the electronics and steelmaking industries. Accordingly, these sectors and many countries have pinned their hopes on deep-sea mining to meet the growing demand for raw materials like cobalt and rare-earth elements.

In a study just released in the journal *Scientific Reports*, experts from the Alfred Wegener Institute show that such activities could not only have ecological impacts, but also pose health hazards, for example, in connection with the industrial mining and processing of the nodules. According to their findings, in some cases, the radioactivity of radium-226 in the nodules exceeds the safe limit defined in the German Strahlenschutzverordnung (Radiation Protection Ordinance) 100- to 1,000-fold.

Large areas of the ocean floor are covered with polymetallic nodules and crusts. The potato-sized manganese nodules can be found in all oceans, especially in the Pacific Ocean, at water depths between 4,000 and 6,000 meters. Formed over millions of years, they contain valuable metals like copper, nickel, cobalt and rare-earth elements—in other words, a range of elements required for the manufacture of electronic products like computers, smartphones, batteries, magnets, motors and high-tech components.

Accordingly, manganese nodules and deep-sea mining have increasingly gained the attention of industries and politicians over the past several

years.

Particularly large quantities of manganese nodules can be found in the deep ocean of the Clarion Clipperton Zone in the North Pacific Ocean between Mexico and Hawaii. Several countries—including the Federal Republic of Germany—have secured exploration licenses for the zone, entitling them to first gather reference data in the license areas and, on this basis, assess the potential ecological impacts of commercial deep-sea mining of manganese nodules.

In July 2023, the International Seabed Authority (ISA) plans to define concrete regulations for their industrial mining.

"Through the Joint Programming Initiative Oceans projects 'MiningImpact' and 'MiningImpact2' ... and as part of an international consortium bringing together more than 30 partner institutes, we've been investigating the potential impacts of deep-sea mining on the habitats and ecosystems of the sediments and water column in the Pacific Ocean since 2015," explains Prof Sabine Kasten, who leads the MiningImpact subprojects at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI).

"Our new study on the radioactivity of manganese nodules demonstrates that, beyond the consequences for marine ecosystems, there could be human health hazards in connection with mining and processing of manganese nodules, and the use of products manufactured on this basis. It's imperative that this aspect is considered in all future planning."

For their study, which was just released in the journal *Scientific Reports*, the AWI experts assessed manganese nodules retrieved in the framework of two expeditions (2015 and 2019) on board the Research Vessel SONNE in the Clarion Clipperton Zone.

"Based on previous studies it was already known that the nodules' outer layer contains natural radioactive substances like thorium-230 and radium-226, which have accumulated at the nodules' surface from seawater over long periods of time. However, their values had never been considered in the context of radiation protection legislation," says first author and biogeochemist Dr. Jessica Volz.

"Our study shows that in the outer layer of these extremely slowly growing nodules, certain substances, which emit alpha radiation can exceed limits found in radiation protection legislations a 100- to a 1,000-fold."

In the case of radium-226, the AWI team repeatedly measured radioactivity levels of more than 5 becquerels per gram on the nodules' outer layer. For comparison: the limit set in Germany's Radiation Protection Ordinance is 0.01 becquerels per gram. Even when dealing with legacy pollution from uranium ore mining, depending on the situation, a detailed risk assessment is required when limits of 0.2 or 1 becquerel per gram are exceeded.

"Even though we expected high radioactivity levels in the nodules based on earlier studies, the levels that we actually measured still surprised us," explains AWI researcher and co-author Dr. Walter Geibert.

"In particular, the high accumulation rate of the radioactive noble gas radon was a new finding. As such, handling manganese nodules without protective gear can pose a health risk. It is not just through inhaling the dust produced during processing, but also the high radon concentrations that can build up when they are stored in poorly ventilated spaces. Some radioactive substances could accumulate in the nodule products during/after processing, such as actinium-227 in the rare-earth elements."

In future studies, the experts plan to investigate whether manganese nodules from different deep-sea regions reach similar values, and how the ecological, economic and social risks of deep-sea mining and the commercial use of manganese nodules can be estimated on the basis of these new findings.

More information: Jessica B. Volz et al, Alpha radiation from polymetallic nodules and potential health risks from deep-sea mining, *Scientific Reports* (2023). DOI: 10.1038/s41598-023-33971-w

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