

## Dating a 'princess': U–Pb age determination of 'nunakawaite' (strontio-orthojoaquinite)

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'Nunakawaite' (strontiojoaquinite) is an orthorhombic variety of strontiojoaquinite [ $\text{Sr}_2\text{Ba}_2(\text{Na,Fe})_2\text{Ti}_2[\text{Si}_4\text{O}_{12}]_2\text{O}_2(\text{O,OH})_2\cdot\text{H}_2\text{O}$ ]; it is a rare joaquinite group mineral that is only found in a riebeckite-bearing albitite in the serpentinite-matrix mélange of the Itoigawa–Omi area. The mineral was originally named after 'Princess Nunakawa' (*nunakawa hime*) in the Japanese Shinto mythology '*Kojiki*'.

'Nunakawaite' is characterized by remarkably high Ba, Zr, Nb, Zn, LREEs, MREEs, and enriched in U ( $35.8\text{--}721 \mu\text{g}\cdot\text{g}^{-1}$ ), Pb ( $2.2\text{--}31 \mu\text{g}\cdot\text{g}^{-1}$ ), and Th ( $7.42\text{--}2365 \mu\text{g}\cdot\text{g}^{-1}$ ). LA-ICPMS analyses show highly variable U/Pb ( $^{238}\text{U}/^{206}\text{Pb} = 9.245\text{--}68.98$ ) and Pb ( $^{207}\text{Pb}/^{206}\text{Pb} = 0.0758\text{--}0.756$ ) isotope ratios, and the scattered trend define an isochron line with a lower intercept at  $89.19 \pm 1.07$  Ma. The 'nunakawaite' U–Pb age confirms that the 'nunakawaite'-hosted riebeckite-bearing albitite formed at late Cretaceous. This implies that the serpentinite-matrix mélange unit with early Paleozoic jadeitites and late Paleozoic blueschist, eclogite and amphibolite was reactivated by a significantly younger tectonic event.

In-situ Sr–Pb isotope analyses show two different isotope trends between Sr-rich accessory minerals in riebeckite-bearing albitite ('nunakawaite' and ohmilite) and those in jadeitite (itoigawaite, stronalsite, vesuvianite, Sr-rich epidote). The Sr–Pb isotopes also support the idea that the riebeckite-bearing albitite formed by a fluid-induced metasomatic event different from the jadeitite-forming metasomatism at early Paleozoic. The formation of riebeckite-bearing albitite at  $\sim 90$  Ma is coeval with late Cretaceous granitic intrusion of the Omi area (youngest zircon U–Pb:  $90.8 \pm 1.1$  Ma: Nagamori et al. 2018). The granitic intrusion might have acted an important role in the formation of 'nunakawaite'. In other words, reactivation of metasomatic mineralization in the Paleozoic serpentinite mélange is recorded in the Cretaceous riebeckite-bearing albitite.

Keywords: 'nunakawaite' (strontio-orthojoaquinite), U–Pb dating, metasomatism, serpentinite mélange, Itoigawa–Omi area