Fingerprints of subducted noble gas and halogen in the Franciscan serpentinite, California.

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The Franciscan Complex of western California is a tectonic mélange that principally composed of meta-graywacke, chert, and volcanic rocks. The Complex is an accretionary wedge that formed during paleo-subduction and commonly records high-pressure/low-temperature metamorphism (e.g., Bailey and Blake, 1969; Ernst, 1970). Serpentinite bodies scattered within the Franciscan Complex occur as small slivers less than several kilometers. The origin and the mechanism of incorporation for serpentinite bodies into sedimentary mélange is unclear. For example, one possibility is as a part of abyssal peridotite within subducting oceanic plate (Wakabayashi, 2004; Hirauchi *et al.,* 2020). Alternatively, the serpentinite bodies may be a series of slivers derived from mantle wedge (Cloos and Shreve, 1988; King et al., 2003). Due to the complexity and ambiguity of the serpentinite masses, overall, there has been very little work done focusing on the Franciscan Complex serpentinite.
The aim of this study is to use halogen and noble gas geochemistry to identify the origin(s) of the Franciscan Complex serpentinite bodies and to unravel the fluid movement during primary and secondary metamorphism. The distinct elemental and/or isotopic compositions of halogens and noble gases in different reservoirs (e.g., MORB-source mantle, seawater, subducted sediments, and seafloor basalt) make them good tracers for fluid origin in subduction zones.
We analyzed noble gases and halogens in the Franciscan serpentine samples from three regions: 1. San Francisco and Redwood City; 2. Sand Dollar Beach, and 3. Santa Catalina Island. A portion of each sample was neutron-irradiated to convert halogens into noble gas isotopes, which can be analyzed with lower detection limits than direct analyses of halogens with other methods. Stepwise crushing was conducted in order to extract and analyze gases in fluid inclusions. The irradiated and un-irradiated portions were analyzed by noble gas mass spectrometry at the University of Tokyo, to determine halogens and noble gases, respectively.
Noble gas compositions of fluids in the Franciscan serpentinite show severe assimilation by atmosphere/seawater for Ne and Ar isotopes. On the contrary, He partially preserved the original mantle signal of high isotopic ratios, with some contribution of radiogenic component. In addition, for the regions that have suffered shear-related chrysotile recrystallization, the recrystallized part or schistosity zone exhibits higher radiogenic He contribution than fresh blocky serpentinite, which is considered to derive from a secondary fluid interfusion in the crust environment. These suggest a secondary alteration of fluid after primary serpentinization. On the other hand, halogen elemental ratios range so widely that a single mixing model could not explain, which could result from the multisource of metamorphic fluids. Nevertheless, the involvements of halogen components from subducted materials (sedimentary fluid and seafloor basalt) indicate that some of the serpentinite bodies have formed by a reaction with hydrous fluid from subducted slab. We infer that the serpentinite bodies within the Franciscan Complex could be of mixed origin, and the serpentinization is caused by slab-derived fluids but a secondary alteration of fluid is also significant.

Keywords: The Franciscan Complex, Serpentinite, Halogen, Noble gas

