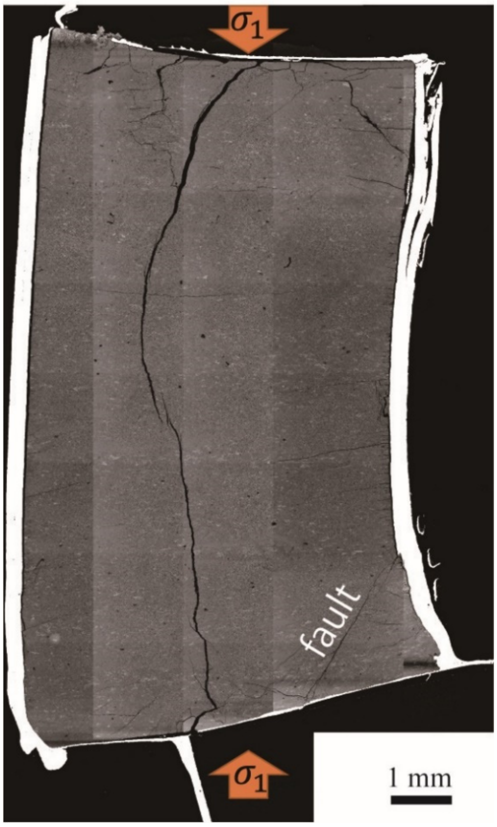

Fig. 3.6-3: Backscattered electron image of Sample A (grain size: < 10 µm). The vertical direction corresponds to the maximum compression direction (σ_1). A fault cuts the lower right part of the sample.

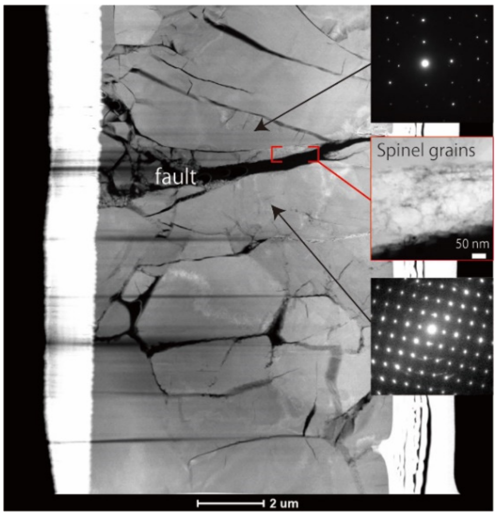

Fig. 3.6-4: STEM image of a fault and associated spinel in sample A (grain size: < 10 µm). The insets are selected area electron diffraction patterns of olivine across a fault and show that the crystal orientations of two olivine grains (upper and lower insets) across the fault are different. Spinel grains nucleated along the fault and olivine grain boundaries.

d. *Nanoscale cation-diffusion modeling in garnet-hosted omphacite: A preliminary result (R. Fukushima and T. Tsujimori/Sendai; N. Miyajima)*

Garnet and omphacite are the most common minerals in eclogites of high-pressure/ultrahigh-pressure (H*P*/UH*P*) metamorphic complexes. In typical low- to medium-temperature (*T*) eclogite, garnet occurs commonly as mm- to cm-sized porphyroblasts, whereas omphacites form the matrix and are often enclosed in the garnets. Owing to its high resistance to plastic deformation, such porphyroblastic garnet acts as a 'time capsule' to preserve various mineral and fluid inclusions that coexisted during the garnet growth. Thus, sophisticated analyses of these enclosed materials can provide valuable information on the growth of host minerals, and thus unravel the tectonic histories of eclogite-bearing complexes.

Among eclogites in various geological settings, low-*T* eclogite, which is formed by the prograde subduction metamorphism of oceanic crust at depths > ~ 60 km, is particularly intriguing. Since the eclogite-forming metamorphic reactions involve intensive dehydration, petrological/mineralogical analyses of high-*P*/low-*T* rocks that underwent low-*T* eclogitization has the potential to clarify the behaviour and characteristics of fluids in subduction zones. For example, oscillatory zonings in minor- or trace-element concentrations are frequently observed in the rim regions of garnet porphyroblasts, and suggest that their formation is related to episodic fluid infiltrations during eclogitization of the subducting slab. Although recent studies have suggested such fluid pulses can occur within a period of less than a few million years (Myr), the lack of temporal resolution in geochronological approaches precludes further conclusions about this enigmatic phenomenon.

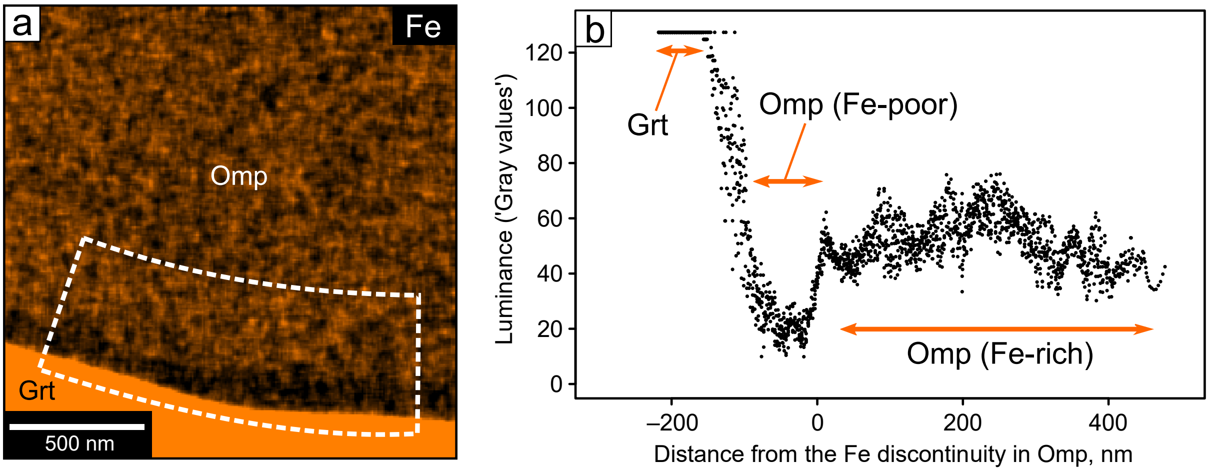

Fig. 3.6-5: Fe concentration profile in a garnet-hosted omphacite in the Syros low-*T* eclogite: (a) X-ray map (Fe Kα) of the investigated omphacite. Along the garnet-omphacite boundary, a syngenetic omphacite rim with distinctly lower Fe content is observed. (b) Representative Fe concentration profile of the area enclosed by the white dashed rectangle shown in (a). Omp = omphacite, Grt = garnet.

To overcome this limitation, we performed simple, nano-scale diffusion modeling based on a previously observed, syngenetic omphacite inclusion in garnet of the Syros eclogite. Focusing on Fe compositional heterogeneity in the garnet-hosted omphacite revealed by a Scanning TEM X-ray map (Fig. 3.6-5a), we conclude that the peak-*T* residence time of the eclogite was too short to erase the compositional profile by Fe^{2+}–Mg interdiffusion. We obtained the averaged concentration profile of Fe with the image processing program ImageJ (Fig. 3.6-5b). By fitting the profile with the calculation software PACE and tentatively fixing a value of the diffusion coefficient, we constrained the maximum annealing time to be no more than 50-5,000 years.

This suggests that the oscillatory-zoned garnet rim (~ 300 μm in width), which is a thin portion just outside the omphacite inclusion, grew rapidly at a rate of > 6-600 $cm^3 \cdot Myr^{-1}$. This nominal value is consistent with previously reported episodic garnet-growth rates. Although the uncertainty in the diffusion coefficient requires further careful consideration, our preliminary estimate might provide a critical constraint on fluid-enhanced garnet-growth kinetics during the low-*T* eclogitization. Specifically, this preliminary result demonstrates the potential of nano-scale geochemical analyses for discussing the short span (< ~ 10^6 years) of geological events enhanced by the presence of fluids, which have never been considered previously.