Numerical model results also show that transform faults initiate in the brittle crust close to the surface and propagate downward, thus indicating a top-down controlled formation process. This has important implications not only for transform fault formation, but potentially also for the seismic cycle at transform faults, as deformation of the brittle near-surface layer may be the controlling factor for fault deformation.

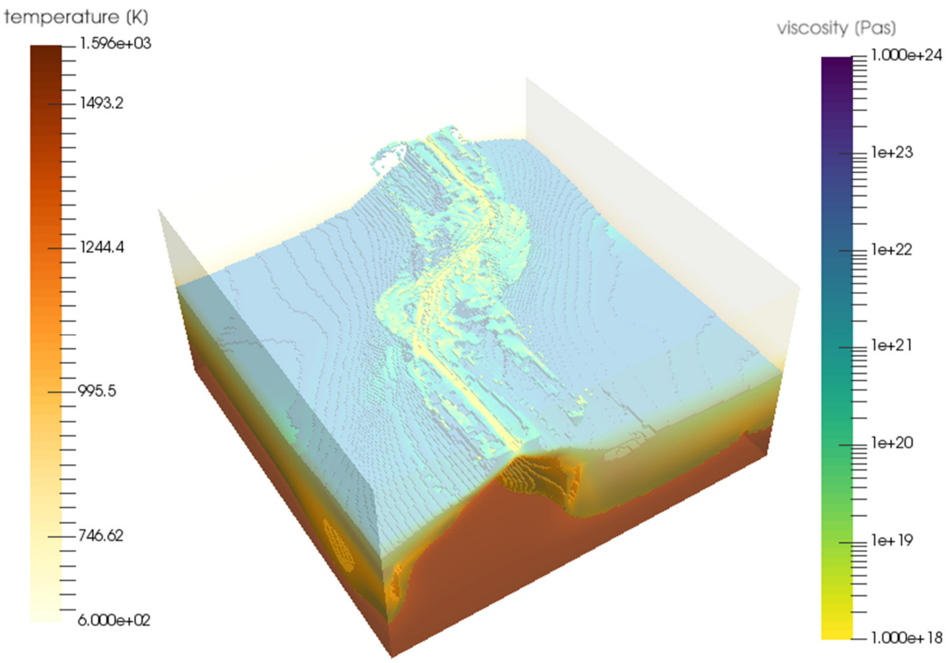

Fig. 3.6-4: Formation of a transform fault formation that offsets a mid-oceanic ridge in a 3D model. Shown is the temperature field (in brownish colors) overlain by the viscosity field. For visibility purposes, only the viscosity structure of the lithosphere is shown. The mid-oceanic ridge and the nascent transform fault that offsets it can be seen as a low-viscosity zone close to the surface.

e. *Revising estimates of antiphase domain size in eclogite-facies omphacites (R. Fukushima and T. Tsujimori/Sendai, N. Miyajima)*

Omphacite, an important clinopyroxene whose chemical compositions are close to $Ca_{0.5}Na_{0.5}[Mg,Fe^{2+}]_{0.5}Al_{0.5}Si_2O_6$, is one of the main minerals occurring in eclogites. It is thus ubiquitous in high-pressure (H*P*) and ultrahigh-pressure (UH*P*) basic metamorphic rocks. Omphacites at higher temperatures have the cation-disordered structure (*C*2/*c*), whereas those at lower temperatures, especially in blueschists and most orogenic eclogites, can have the cation-ordered structure (*P*2/*n*). Since omphacite can nucleate with the *C*2/*c* structure as a metastable state at low temperature (*T*), its cation ordering processes can occur not only with cooling but also during prograde metamorphism.

By observing low-*T* omphacites with transmission electron microscopy (TEM), we can understand how cation ordering occurs; the process generates bubble-like or columnar microstructures called 'antiphase domains' (APDs). On the basis of the dependency of the size of APDs on annealing time and temperature, Carpenter (*Contrib. Mineral. Petrol.*, 78, 441, 1981) proposed geothermometry/geospeedometry determinations based on the average size of equiaxed APDs in omphacite, and showed their potential for determining the kinetics of eclogitization.

However, there are two major problems in applying analytical methods to natural low-T omphacites: 1) omphacite can lose its APD structures when it recrystallizes, and 2) it is not certain whether the 'average' APD size is truly appropriate for understanding the timescales of metamorphic events. Therefore, we propose a new image-analytical method to elucidate the APD size distributions, especially in order to resolve the second problem.

We binarized acquired digital TEM images using the Trainable Weka Segmentation method bundled in the image processing package Fiji, which is a modified version of the open source, Java-based image processing program Image J. After excluding the noise and APDs with abnormal shapes by setting thresholds of their circularities, we calculated their size distributions. Our result shows that all of the obtained size-distributions are non-Gaussian (Fig. 3.6-5). This creates controversy concerning the 'average' APD-size analyses because the mean value is significantly larger than the major mode, by no less than 38 nm for one of our samples (Fig. 3.6-5b). Besides, since they seem to be slightly multi-modal size distributions, we might have to consider the complicated histories of multiple cation ordering events. Although the explicit relationships between the non-Gaussian size distributions and their growth kinetics remain to be resolved, further analyses of APD sizes will facilitate discussion about the timescales of low-T metamorphic processes in subduction zones.

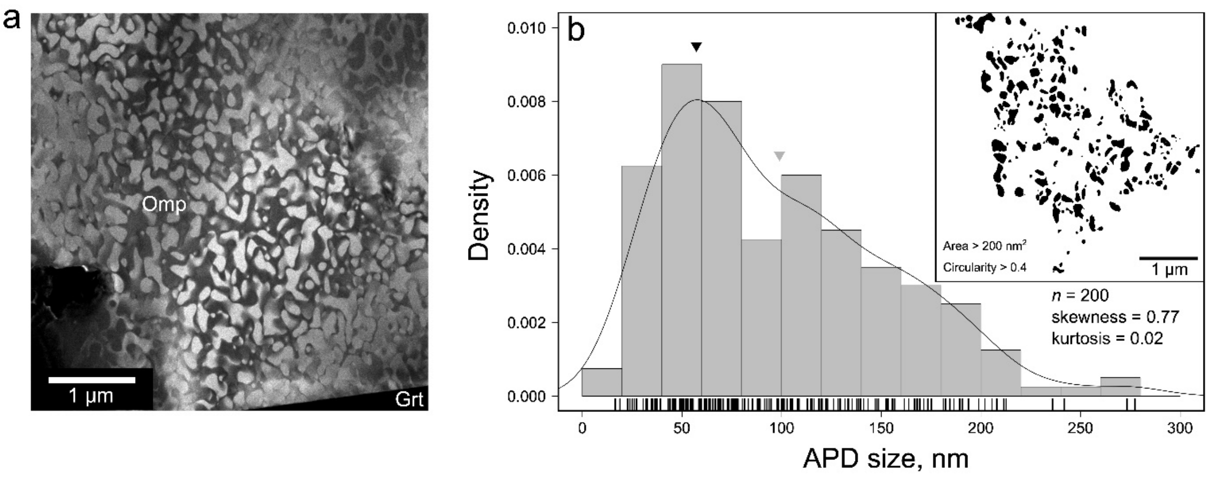

Fig. 3.6-5: An example of equiaxed antiphase domains in omphacite obtained from a low-T eclogite from Syros. Greece. a) Dark-field TEM image (g = 050) that includes a garnet–omphacite phase boundary; b) histogram of the measured APD sizes. As an inset, we show binarized dark-field images from which noise and highly distorted APDs are excluded. Results of the kernel density estimates are also shown (band width = 17.07 nm). The black and gray triangles indicate its mode (~ 60 nm) and mean (~ 98 nm), respectively. In (a), Omp = omphacite, Grt = garnet.