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On the Origin of Ultramylonites

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Deformation of lithospheric rocks regularly localizes into high-strain shear zones that include fine-grained ultramylonites. Occurring as quasi-straight layers of intimately mixed phases that often describe sharp transitions with the host rock, these structures may channelize fluid flow^[1,2] and could serve as precursors for deep earthquakes^[3]. However, although intensively documented, ultramylonites originate from still unknown processes. Here I focus on a mylonitic complex that includes numerous mantle ultramylonites in the Ronda peridotite (Spain). Among them, I was able to highlight one of their precursors that I better describe as a long and straight grain boundary, along which four-grain junctions are observed with randomly oriented grains of olivine and pyroxenes. This precursor starts from a pyroxene porphyroclast and extends to an incipient, weakly undulated ultramylonite, where intimate phase mixing arises with asymmetrical grain size distribution. While the finer grain size locates on one side, describing a sharp – but continuous – transition with the host rock, the grain size gradually increases towards the other side, giving rise to a smooth transition. All phases have a very weak lattice preferred orientation (LPO) in the ultramylonite, which strongly differs from the host rock where olivine is highly deformed with evidence of high dislocation densities and a strong LPO. Altogether, these features shed light on the origin of mantle ultramylonites that I attribute to a migrating grain boundary, the sliding of which continuously produces new grains by phase nucleation, probably at the favor of transient four-grain junctions. Nucleated grains then grow and progressively detach from the precursor as it keeps on migrating depending on the dislocation densities in the host rock. Although such an unusual grain boundary remains to be understood in terms of source mechanism, these findings provide new constraints on the appearing and development of ultramylonites.

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[2] Précigout, J., Prigent, C., Palasse, L. & Pochon, A. Water pumping in mantle shear zones. *Nat. commun.* **8**: 15736, <https://doi.org/10.1038/ncomms15736> (2017)

[3] White, J. C. Paradoxical pseudotachylite – Fault melt outside the seismogenic zone. *J. Struct. Geol.* **38**: 11–20 (2012)