# Did the Adula nappe (European basement) endure UHP metamorphism during the Alpine Orogeny?

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The mafic-ultramafic rocks in the Adula nappe, and its western extensions Alpe Arami and Cima Lunga units (hereafter Cima Lunga), preserve the only record of regional high- to ultrahigh-pressure metamorphism (~13-35 kbar) in the Central Alps. These rocks are hosted within felsic country rock gneiss that is up to 25 kbar lower in peak-pressure conditions. The Adula-Cima Lunga nappe is traditionally interpreted as a tectonic mélange of the European continental basement, metasediments and metavolcanics of Valais Ocean and mantle-derived ultramafic rocks. The exhumation and emplacement of ultrahigh-pressure (UHP) rocks into lower-pressure units remains enigmatic; even more so is the subduction of a large piece of continental crust to mantle depths.

This study investigates the kinematics of (U)HP eclogite and the surrounding country rocks in the Cima Lunga unit through structural mapping and a microstructural and textural analysis. Structural mapping allows for a re-interpretation of the lower Cima Lunga nappe boundary. Paired with structural, textural and geochemical observations, the mafic-ultramafic (U)HP rocks are presented here as a nappe separating lithology rather than lenses within a basement nappe unit.

We examine the lattice preferred orientation in omphacite using electron backscatter diffraction to determine the deformation regime active under (U)HP conditions. Our microstructural observations reveal limited evidence for simple shear; instead, textural data of eclogite rocks show affinity for a flattening strain geometry. When comparing our textural observations with published data from the Cima Lunga and the main Adula nappe, we consistently observe a contrast in omphacite texture between the two areas. Geochronological and thermobarometric data from published studies show similar contrasts: the main Adula nappe has experienced two orogenic cycles of (U)HP subduction and exhumation, while the Cima Lunga unit has only experienced one cycle during the Alpine orogeny.

U-Pb and REE analyses of metamorphic zircon inclusions from garnet in the Alpe Arami eclogite rocks gave individual U-Pb spot ages of ca. 40-30 Ma and all spots show typical “eclogite” REE distribution patterns. The Ti-in-zircon temperatures on the same analytical spots apparently increase with time. Zircons in two eclogite samples from Cima di Gagnone, separated in the traditional way, gave similar results although larger scatter in grain shapes and composition. Zircons from granitoid gneisses beneath and above the layer containing mafic and ultramafic rocks gave very consistent rim ages with mean and lower intercept ages at ca. 31.6 Ma. Age depth-profiling on zircon prism faces yielded ages of 30-33 Ma on the outer one micron.

Major and trace-element whole rock analyses of most mafic eclogite samples from Adula and Cima Lunga units are indicative of MORB origin. While samples from the Cima Lunga and Alpe Arami units are very similar, they bear consistent differences to the samples from the Adula nappe suggesting a different geodynamic setting of the protoliths.

Structural position, age, and compositional discrepancies between the main Adula nappe and the Cima Lunga unit leads us to suggest that these two units experienced different geodynamic histories and can be considered as two separate lithotectonic units. In summary, we suggest that only the ultramafic rocks of the Cima Lunga domain have endured UHP metamorphism (> 30 kbar), while the Adula nappe was subducted during Alpine orogeny as a coherent body to maximum depths of “only” 24 kbar.