A new UHP unit in the Western Alps: First occurrence of coesite from the Monviso Massif (Italy)

Stefano Ghignone1,*, Emanuele Scaramuzzo2, Marco Bruno1, and Franz A. Livio2

1Earth Sciences Department, University of Turin, Via Valperga Caluso 35, 10125 Torino, Italy
2Department of Science and High Technology, University of Insubria, via Valleggio 11, 22100 Como, Italy

Abstract

The Western Alps are one of the most studied exhumed subduction-accretionary complexes worldwide. Ultrahigh-pressure (UHP) metamorphism has been documented there since the 1980s. We now report the first discovery of coesite in the meta-ophiolitic suite of the Monviso Massif, corresponding to the fourth UHP unit defined on the Western Alps. Previous petrographic studies and results from thermodynamic modeling already suggested that these Alpine units may have experienced UHP metamorphism, but no occurrences of index minerals, such as coesite, have been reported to date. The newly discovered coesite inclusions from the Monviso Massif occur as intact single crystals (10–60 μm) hosted by garnet. The observations suggest that they have escaped re-equilibration and maintained all the original features from the trapping time. The reduced size of the crystals and the lack of re-equilibration significantly differ from the typical textural features described in past findings (i.e., radial cracks, palisade texture of quartz surrounding coesite relics). Detailed garnet inclusions analysis and thermodynamic modeling constrained the metamorphic peak conditions at $P = 2.8$–$2.9$ GPa and $T = 500$–$520$ °C within the coesite stability field.

The Lago Superiore Unit represents the fourth UHP unit discovered on the Western Alps. The UHP metamorphism on the Western Alps was considered rare due to the escape process of unusual units from mantle depths. In our view, the implication of our discovery provides new insights into UHP processes that seem to be more common than expected. Further tectonic reconstructions should take into account the common features observed in the UHP units to better constrain the subduction- and exhumation-related mechanisms that drove the actual stacking of mountain belts.

Keywords: Coesite, UHP, ophiolite, Monviso, Western Alps

Introduction

The ground-breaking finding of natural coesite ($\text{SiO}_2$) in the Western Alps, made by Chopin (1984), revolutionized the geodynamic models of subduction-accretionary complexes. This finding first proved that rocks can be subducted deep enough to experience mantle conditions (>80 km) and then exhumed (Chopin 2003; Gilotti 2013). The discovery of such ultrahigh-pressure (UHP) mineral-bearing rocks also extended the possible depths covered by metamorphic cycles by at least one order of magnitude (e.g., Chopin 2003) or, alternatively, opened the possibility for invoking non-lithostatic pressure variations (e.g., Tajčmanová et al. 2021).

Despite more than three decades of research in the field of UHP and the reconnaissance of ca. 20 UHP units worldwide (e.g., Gilotti 2013; Gonzalez et al. 2020), mainly distributed in Phanerozoic subduction-accretionary complexes, the discovery of new UHP units remains a rare event.

This is particularly true for the Western Alps, where only two additional UHP units have been reported after the very first discovery (Reinecke 1991, 1998; Frezzotti et al. 2011; Manzotti et al. 2022; Fig. 1a). Although other direct evidence is lacking, the possible occurrence of other UHP units in the Western Alps has been widely inferred through indirect methods, including thermodynamic modeling and microstructural observations (Angiboust et al. 2012; Gilio et al. 2020; Ghignone et al. 2021). Groppo et al. (2016) further supported the possible attribution of a Western-Alpine origin to an unknown source based on coesite-bearing rocks unearthed at an archeological site nearby.

In this paper, we report a new occurrence of intact garnet-inclusions of coesite (10–60 μm) within para-derivative micaschists belonging to the meta-ophiolitic suite of the Monviso Massif (MM), Western Alps. This discovery constrains the peak pressure conditions reached by the unit within the coesite stability field, and possibly implies that ultrahigh-pressure metamorphism (UHPM) in the Western Alps is more common than expected.

Geological background

The Western Alps (Fig. 1a) represent part of an exhumed subduction complex (Bousquet et al. 2008; Butler et al. 2013; Schmid et al. 2017) consisting of an assemblage of high- (HP) and ultrahigh- (UHP) pressure continent-derived (Adriatic and European margins) and ocean-derived units (i.e., Piedmont Zone, the former Tethys ocean). The UHP units cropping out in the Western Alps are narrow lens-shaped bodies with dimensions on the order of one kilometer (Compagnoni and Rolfo 2003; Groppo et al. 2009; Manzotti et al. 2022) that strongly differ from the dimensions of hundreds to thousands of kilometers of the Norwegian Caledonides (e.g., Wain 1997) or the Dabie Shan (e.g., Rolfo et al. 2004).