Journal of Metamorphic Geology

WILEY

Journal of METAMORPHIC GEOLOGY

ORIGINAL ARTICLE OPEN ACCESS

Coesite Discovery in Eclogites Confirms UHP Metamorphism in the Orlica-Śnieżnik Dome (SW Poland)

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Received: 12 April 2025 | **Revised:** 13 November 2025 | **Accepted:** 10 December 2025

Keywords: coesite | eclogite | inclusions | phase equilibria modelling | quartz-in-garnet barometry | UHP metamorphism

ABSTRACT

Eclogite lenses are exposed within the orthogneiss-dominated core of the Orlica-Śnieżnik Dome in the Sudetes, which forms the northeastern margin of the Bohemian Massif (Variscan Belt of Central Europe). The presence of coesite inclusions in garnet and omphacite confirms that these eclogites underwent ultrahigh-pressure metamorphism. This interpretation is further supported by phase equilibria modelling, which indicates peak-pressure metamorphic conditions of 2.9–3.2 GPa and 750°C–830°C. The results are consistent with estimates derived from conventional geothermobarometry and Zr-in-rutile thermometry applied to rutile inclusions in garnet. Based on quartz-in-garnet elastic barometry, a maximum entrapment pressure of approximately 2.0 GPa is obtained. We interpret this discrepancy as a result of viscous relaxation of garnet at high temperature. The first stage of re-equilibration during decompression occurred at a pressure of 2.0–2.2 GPa and a temperature of 680°C–770°C. The observed rock associations exhibit similarities to other UHP occurrences within the Saxo-Thuringian Zone, suggesting a comparable exhumation mechanism. This likely involved initial buoyancy-driven exhumation within a subduction channel, followed by crustal-scale folding. Furthermore, the maximum pressure recorded in the eclogites may partly reflect nonlithostatic components, such as transient pressure variations arising from rheological heterogeneity between the eclogites and their host rocks.

1 | Introduction

Ultrahigh pressure (UHP) metamorphic terranes are the key to understanding deep subduction and continental collision processes. The initial discovery of coesite (Chopin 1984; Smith 1984) reshaped our understanding of the limits of metamorphism and subsequent exhumation processes. Since then, further coesite and microdiamond findings have been documented (e.g., Nasdala and Massonne 2000; Sobolev and Shatsky 1990), which triggered discussions on the mechanisms behind the formation of coesite and other UHP phases in crustal rocks, as well as their preservation during exhumation to the Earth's surface. Traditionally, a prevailing interpretation was that the presence of a UHP phase implied that the entire rock unit experienced such extreme metamorphic conditions under deep subduction of the crustal material to depth exceeding 100 km followed by exhumation (e.g., Chemenda et al. 1995). Smith (1984) proposed an alternative explanation invoking either local or regional tectonic overpressure, thereby reducing the need for deep subduction.

Numerous mechanical models have been proposed to explain UHP metamorphism and subsequent exhumation during deep continental subduction (for a summary, see Hacker and Gerya 2013 and references therein). The main driving forces for subduction of crustal material to mantle depth are global tectonic forces (slab pull), whereas buoyancy is often (but not always) considered responsible for its exhumation. Models explaining exhumation of predominantly quartzofeldspatic