

Twenty-five years of ultrahigh-pressure metamorphism Preface

This special issue of the European Journal of Mineralogy is dedicated to ultrahigh-pressure (UHP) metamorphism and its increasing role in the geosciences. The term UHP metamorphism refers to those rock types that were formed or embedded in shallow levels of the continental or oceanic lithosphere and subsequently experienced PT-conditions within or above the lower limits of the coesite stability field.

It was 25 years ago that Christian Chopin discovered metamorphic coesite in “pyrope-quartzites” from the Dora-Maira Massif, Italian Western Alps (Chopin, 1984). In the same year, Dave Smith found coesite in eclogites from the Western Gneiss Region, Norway (Smith, 1984). At that time, UHP metamorphism was thought to represent a rather “exotic” type of metamorphic grade. However, the worldwide importance of these rocks is now documented in more than 25 recognized UHP terranes. Thus, UHP metamorphism is far from an “exotic” process, and reflects its significance regarding global endogenic forces. Only through the application of fundamental mineralogical and petrological methodologies was it possible to decode burial and subsequent exhumation of UHP metamorphic rocks. It is clear that all other disciplines of solid earth sciences are affected as a consequence of these studies, and that textbooks in mineralogy and geology require dramatic revision.

Until the mid 1980s, classical metamorphic facies diagrams were restricted to upper pressures of about 10–12 kbar, thus reflecting the “normal” thickness of the continental crust. With the new petrological data at hand, nobody could deny the convincing evidence that crustal rocks must have been subducted to mantle depths of at least 100 km and later exhumed to the surface by tectonic processes. These discoveries have enormous implications, particularly in petrology, geodynamics, global tectonics, seismology, and geochemical recycling.

It was then only a matter of time until diamond was discovered in crustal metamorphic rocks: Sobolev & Shatsky (1990) found micro-inclusions within garnet and zircon in gneisses and associated rocks from the Kokchetav Massif, Kazakhstan. Since then, about 10 localities with metamorphic diamonds have been described. Due to this finding, the PT-diagram of metamorphic conditions realized by the Earth’s crust had to be extended up to 40 kbar, coinciding with burial depths of about 140 km. In recent years, modern nanoscale techniques (e.g., synchrotron infrared spectroscopy, nano-secondary ion mass spectrometry, focused ion beam techniques) have had an increasingly important role in the discovery of new indicator phases/associations for UHP-metamorphism, like TiO₂ with an α -PbO₂-structure, majoritic garnet, supersilicic titanite, supersilicic clinopyroxene, high-K clinopyroxene, high-P clinoenstatite, or even apparent pseudomorphs after stishovite which require continental subduction to depths of at least 300 km. The new field of UHP metamorphism inspired an increase in related high-pressure experimental studies and computer modelling. Such studies often significantly exceed “normal metamorphic pressures”: for example multi-anvil technology can achieve pressures of about 26 GPa (equalling depths of about 700 km); using the diamond-anvil-cell technique even several 100 GPa may be reached. What a revolutionary challenge in geodynamical processes to understand!

As a result of the increasing role of UHP metamorphism in geoscience, numerous books and review papers but also a number of international conferences have focussed on this topic. Every two years, the “International Eclogite Conference” (IEC) takes place, where the field of UHPM study is an integral part. This year Xining/China hosted the 8th IEC and in 2011 the host will be the Czech Republic with field trips in its border regions with Germany and Austria. Since 1994 the “International Lithosphere program” (ILP) has sponsored UHP-research: A first workshop on “UHP metamorphism and tectonics” was held at Stanford University. ILP project III-6 (1994–1998) focussed on “Ultrahigh-pressure metamorphism and geodynamics in collision-type orogenic belts”, the second one (III-8) “Processes and Geodynamics in the Formation and Exhumation of Ultrahigh-Pressure metamorphic Terrains” lasted from 2000–2004 and the recent one “Ultra-Deep Continental Crust Subduction” (II-10) commenced in 2005 will be finished this year. Regularly, during conferences like the fall meeting of the American Geophysical Union (AGU) or the International Geological Congress (IGC), special sessions related to UHP metamorphism are organized. The IGC in Oslo in 2008 with the interdisciplinary symposium “Ultra-high pressure metamorphism: Mineral reactions, geochemistry, thermobarometry and geochronology” (UHP-04) and the GSA annual meeting 2008 in Houston with the session “Exhumation of Continental Ultrahigh-Pressure Terranes” were indeed a trigger of this special issue.



The present volume reflects not only current results on the topic of UHP metamorphism but also documents the breadth of research foci. Important contributions on regional UHP-provinces like Western Gneiss Region, Norway, NE Greenland Caledonides, Armorican Massif (France), Pohorje (Slovenia), Dora-Maira (Western Alps), North Qaidam and Sulu (China), Kokchetav Massif (Kazakhstan) are presented, in addition to different research topics like geochronology, trace-element geochemistry, Raman mapping, and field petrology with its consequential geodynamic implications. Besides various modern and small-scale techniques available, we should bear in mind that all these pioneering investigations were only possible through the very thorough petrographic investigation using the polarizing microscope, which remains a fundamental and important tool in geoscience!

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