Are ultrahigh-pressure minerals caused by climate?

Michael J. Oard

One of the most surprising discoveries in the earth sciences is the finding of ultrahigh-pressure (UHP) minerals, such as coesite (figure 1), stishovite, and garnet peridotite, as well as microdiamonds, on the surface of the earth.[1] These UHP minerals are commonly found in mountains. They are found in small areas as well as extensive areas:

> "In Norway and China, rocks containing coesite or diamond crop out over areas of at least 5000 km^2, and contiguous high-pressure [HP] rocks crop out over areas >20,000–30,000 km^2."[2]

Rocks containing high-pressure (HP) minerals, such as blueschist and eclogite, have been known for a long time and found at hundreds of locations across the earth.[3] The HP and UHP minerals in the rocks suggest they experienced the high pressures that are assumed to exist deep in the upper mantle, down to about 20–100 km for HP minerals and about 100–400 km for UHP minerals.[4] The fact that these rocks are found on the surface of the earth is very difficult for uniformitarian scientists to explain.[5] I will focus on UHP minerals since their presence is much harder to explain than HP minerals.

Rocks with HP and UHP minerals formed by subduction?

Uniformitarian scientists believe UHP minerals are within continental rocks that were buried deeply and exhumed quickly, so 'fast' that the metamorphic grade did not revert to what it was before. 'Fast' according to them is a few cm/yr. They believe that the only possible way such minerals can form is by subduction (i.e. by being thrust deep into the mantle) within the plate tectonics (PT) paradigm. It once was an axiom of plate tectonics that lighter continental rocks could *not* subduct, but the discovery of UHP minerals changed that:

> "For most of the following two decades [after the 1960s], conventional wisdom in the geosciences held that Earth's continental crust does not subduct into the mantle at convergent plate boundaries because continents are much less dense than the underlying mantle. This inference was challenged in dramatic fashion by the discovery of 'ultrahigh-pressure' (UHP) mineral assemblages in exposed continental rocks in the western Alps and the Scandinavian Caledonides."[6]

So, despite a significant density problem, they concluded that continental rocks do indeed subduct. This has been identified at several subduction zones; for instance, the Adriatic microplate is continental crust, which supposedly subducts north under the western Alps, west under the northern Apennine Mountains, and east under the Dinaric Mountains.[7] Another example is the northwest African continent, which subducts under the Eurasian plate.[8]

After continental rocks are deeply subducted into the mantle, they need to rapidly rise. Again, this is believed to be somehow related to subduction or continental collision.[9] Uniformitarian scientists are greatly challenged:

> "Almost all metamorphic petrologists have interpreted these [UHP] assemblages as evidence of the subduction of continental rocks deep into the mantle. But this interpretation begs the question of how UHP rocks that are deeply buried are subsequently returned to the surface (exhumed), and for this many possible mechanisms have been proposed."[6]

All such models that have been developed depend upon convergent zone exhumation:

> "Exhumation of these [UHP] rocks to the surface and the processes responsible still remain a matter of debate … . Quantitative insights are provided by thermo-mechanical numerical models … most of

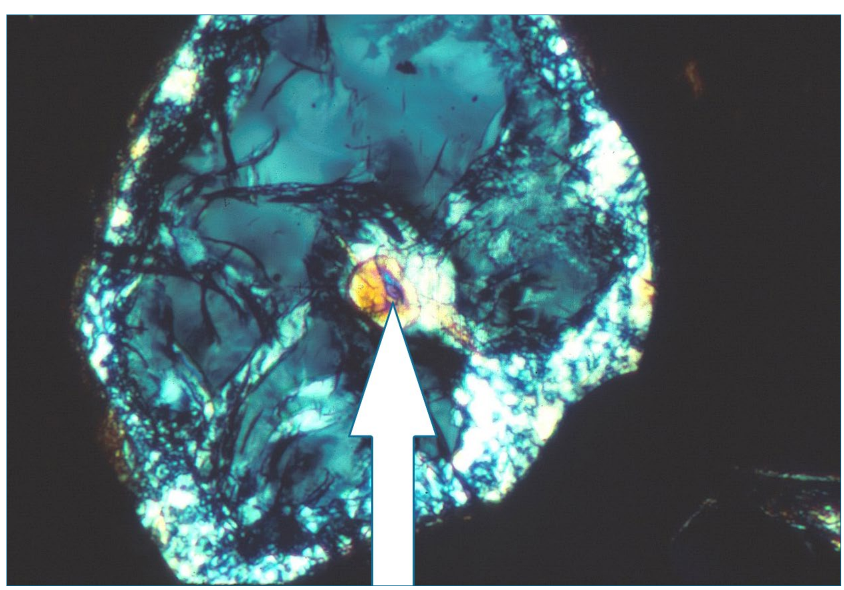

Image: J. Smyth/CC BY-SA 1.0

Figure 1. Crossed-polars image of coesite grain (grey) ~1 mm across in eclogite (arrow). Small coloured inclusion is pyroxene surrounded with polycrystalline quartz.

which rely on synconvergent exhumation."[10]

'Synconvergent exhumation' is the local exhumation of crustal material that occurs at the same time as plate convergence. In this they posit a 'subduction channel',[11] a layer of mostly sediments from the lower plate that is squeezed between the upper and lower plates during subduction.

Early in the days of PT, it had been assumed that the sediments that overlay the lower plate, being of low density and mostly unlithified, would have been scraped off into 'accretion prisms' which became attached to the top of the upper plate. This early PT belief has gone partly to the wayside due to complications at subduction zones, such as some convergent margins that have little accretionary sediments. So, after deep continental subduction and metamorphism to UHP states, the rocks quickly rose to the surface through the 'subduction channel' because of their strong positive buoyancy. But some scientists believe this exhumation process is unlikely:

"The comparison of these characteristics with numerical exhumation models suggests that exhumation of (U)HP rocks by buoyancy-driven return flows within a subduction channel under near-lithostatic pressure is unlikely."[12]

43 locations for UHP minerals supposedly related to climate

To make matters worse, the number of locations with UHP minerals continues to increase. UHP minerals, not including UHP mantle xenoliths, are now found at 43 locations worldwide on all continents, except Australia.[9] Five UHP terranes are found in the Precambrian, as old as the Paleoproterozoic, 'dated' at 1.86 Ga.[13] Seeking to explain these many finds, some at current high latitudes, Yan and Zhang plotted them according to their 'paleolatitude', i.e. the (supposed) latitude they were at when they were metamorphosed. They discovered that the paleolatitudes were from the tropics and subtropics, 0–30° latitude. The average was 5.1°. Although Yan and Zhang are confident that UHP minerals were caused by subduction, they believe that was ultimately controlled by the climate:

"Our results show that all the UHP rocks exhumed in the orogens were limited to low latitudes, indicating that the UHP exhumation requires particular climatic conditions and seems to be controlled by the climate."[14]

The authors speculate that the connection between climate and exhumation is due to heavy precipitation, rapid erosion, and active faulting. Presumably, heavy erosion causes isostatic uplift that must aid the exhumation of UHP minerals. They also said exhumation occurred during 'interglacials' between major ice ages.[15] It is easy to understand why the authors admit that this idea is a subjective argument.

Flood significance

Flood geologists have more options for explaining UHP minerals. The Catastrophic Plate Tectonics model may be able to overcome some of the deficiencies in the uniformitarian PT models.

Further, we also would expect great upward vertical tectonics, but we place it during the Flood, which implies compensatory downward vertical velocity. It is not uncommon to find mantle rocks, such as peridotite, serpentine, and talc, in mountains, for instance in the Pyrenees and Baetic Mountains of Spain.[16,17] I have found serpentinite from mantle peridotite in the Swauk Formation near Blewett Pass, Washington, and in the mountains of north-central Oregon. Such occurrences indicate that at least upper mantle rocks were exhumed in mountain building. Now UHP rocks indicate that the vertical uplift could be hundreds of kilometres. This poses the question: was the entire mantle involved in Flood tectonics?

Another variable during the Flood is meteorite impacts. These are known to produce UHP minerals, including microdiamonds.[18] However, the microdiamonds could be different from those formed in UHP terranes.

Faulting was a common occurrence during the Flood. The pressure exerted by these faults added to the lithostatic pressure. Hence this tectonic overpressure could aid in the formation of UHP minerals so the depths of exhumation would not need to be nearly as great.[19–21] However, some uniformitarian authors think the added pressure is only about 0.5 GPa, or around 10% of the necessary lithostatic pressure.[22] However, in a highly catastrophic Flood model, high-pressure faulting, meteorite impacts, powerful volcanism, catastrophic plate tectonics, and rapid differential vertical tectonics would cause much greater tectonic overpressure than uniformitarian scientists propose. Therefore, tectonic overpressures during the Flood likely explain much of how UHP minerals formed at much shallower depths.

References

1. Oard, M.J., The uniformitarian challenge of ultrahigh-pressure minerals, *J. Creation* **20**(1):5–6, 2006; creation.com/the-uniformitarian-challenge-of-ultrahigh-pressure-minerals.
2. Searle, M., Hacker, B.R., and Bilham, R., The Hindu Kush seismic zone as a paradigm for the creation of ultrahigh-pressure diamond- and coesite-bearing continental rocks, *J. Geology* **109**:143, 2001.
3. Maruyama, S., Liou, J.G., and Terabayashi, M., Blueschists and eclogites of the world and their exhumation, *International Geology Review* **38**:485–594, 1996.
4. Green II, H.W., Psychology of a changing paradigm: 40+ years of high pressure metamorphism, *International Geology Review* **47**:439–456, 2005.
5. Yan, L.-L. and Zhang, K.-J., Is exhumation of UHP terranes limited to low latitudes? *J. Geodynamics* **130**:41, 2019.
6. Hodges, K.V., Subduction undone, *Nature* **543**:44, 2017.
7. Sun, W., Zhao, L., Malusà, M.G., Guillot, S., and Fu, L.-Y., 3-D P_n tomography reveals continental subduction at the boundaries of the Adriatic microplate in the absence of a precursor oceanic slab, *Earth and Planetary Science Letters* **510**:131–141, 2019.

8. Platt, J.P., Behr, W.M., Johanesen, K., and Williams, J.R., The Betic-Rif Arc and its orogenic hinterland: a review, *Annual Review of Earth and Planetary Science* **41**:313–357, 2013.
9. Yan and Zhang, ref. 5, pp. 41–56.
10. Liao, J., Malusà, M.G., Zhao, L., Baldwin, S., Fitzgerald, P.G., and Gerya, T., Divergent plate motion drives rapid exhumation of (ultra) high pressure rocks, *Earth and Planetary Science Letters* **491**:67, 2018.
11. Hacker, G.R., Gerya, T.V., and Gilotti, J.A., Formation and exhumation of ultrahigh-pressure terrances, *Elements* **9**:289–293, 2013.
12. Schenker, F.L., Schmalholz, S.M., Moulas, E., Pleuger, J., Baumgartner, L.P., Podladchikov, Y., Vrijmoed, J., Buchs, N., and Müntener, O., Current challenges for explaining (ultra)high-pressure tectonism in the Pennine domain of the Central and Western Alps, *J. Metamorphic Geology* **33**:869–886, 2015.
13. Yan and Zhang, ref. 5, p. 53.
14. Yan and Zhang, ref. 5, p. 54.
15. Oard, M.J., *Ancient Ice Ages or Gigantic Submarine Landslides?* Creation Research Society Books, Chino Valley, AZ, 1997.
16. Teixell, A., Labaume, P., Ayarza, P., Espurt, N., de Saint Blanquat, M., and Lagabrielle, Y., Crustal structure and evolution of the Pyrenean-Cantabrian belt: a review and new interpretation from recent concepts and data, *Tectonophysics* **724–725**:146–170, 2018.
17. Mazzoli, S. and Martín Algarra, A., Deformation partitioning during transpressional emplacement of a 'mantle extrusion wedge': the Ronda peridotites, western Betic Cordillera, Spain, *J. Geological Society* **168**:373–382, 2011.
18. Goresy. A.E., Gillet, P., Chen, M., Künstler, F., Graup, G., and Stähle. V., In situ discovery of shock-induced graphite–diamond phase transitions in gneisses from the Ries Crater, Germany, *American Mineralogist* **86**:611–621, 2001.
19. Moulas, E., Podladchikov, Y.Y., Aranovich, L. Ya., and Kostopoulos, D., The problem of depth in geology: when pressure does not translate into depth, *Petrology* **21**(6):527–538, 2013.
20. Schmalholz, S.M., Duretz, T., Schenker, F.L., and Podladchikov, Y.Y., Kinematics and dynamics of tectonic nappes: 2-D numerical modelling and implications for high and ultra-high pressure tectonism in the Western Alps, *Tectonophysics* **631**:160–175, 2014.
21. Oard, M.J., Metamorphic rocks can form at shallow depths, *J. Creation* **29**(2):13–15, 2015; creation.com/images/pdfs/tj/j29_2/j29_2_13-15.pdf.
22. Palin, R.M., Reuber, G.S., White, R.W., Kaus, B.J.P., and Weller, O.M., Subduction metamorphism in the Himalayan ultrahigh-pressure Tso Morari massif: an integrated geodynamic and petrological modelling approach, *Earth and Planetary Science Letters* **467**:108–119, 2017.