Chapter 20

Special Catastrophic Tectonics during the Cenozoic

The Cenozoic is unique in that in addition to rapid and intense vertical and horizontal tectonics of the earth's crust and upper mantle, there were many other catastrophic tectonic action. These include the emplacement of ophiolites, metamorphic core complexes, and ultrahigh-pressure minerals.

What are Ophiolites?

Ophiolites are claimed to be pieces of the ocean crust and upper mantle that have been thrust up onto the continental crust and are now found especially in mountains and along continental margins.[1,2,3] Numerous ophiolites outcrop extensively in the mountains, from the Alps eastward into the Himalayas.[4] An ideal ophiolite suite consists from bottom to top of peridotite, gabbro, sheeted dikes, basalt with pillow lavas, and sedimentary rocks. The peridotite is an upper mantle rock, while the remainder of the sequence consists of ocean crustal layers. Usually parts of this vertical sequence are missing, but never the upper mantle rocks. Often the sheeted dike complex and the sedimentary rocks are missing. The basalt can also vary from thin to absent. So, ophiolites are mainly identified by upper mantle rocks. They may not necessarily represent an ancient ocean crust since one or more of the oceanic upper crustal components are missing. Ophiolites can be over 6 miles (10 km) thick and sometimes of large scale. The arc-shaped Oman ophiolite is about 95 miles (150 km) wide and 345 miles (550 km) long (Figure 20.1).[5,6] This ophiolite is believed to have been pushed from the Gulf of Oman up and westward onto the coastal area of Oman.

The origin of ophiolites has long been a subject of controversy.[7] A favoured hypothesis is that ocean crust was generated at mid-ocean ridges (MORs) and spread out. After colliding with continents, the oceanic crust was forced up and over the continental crust, in some cases for possibly hundreds of kilometres. Ophiolites sometimes possess high temperature metamorphic

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[1] Dilek, Y., Moores, E.M., Elthon, D. and Nicolas, A. (Eds.), 2000. *Ophiolites and Ocean Crust: New Insights from Field Studies and the Ocean Drilling Program*, GSA Special Paper 349, Geological Society of America, Boulder, CO.

[2] Dilek, Y. and Newcomb, S. (Eds.), 2003. Ophiolite Concept and Evolution of Geological Thought, GSA Special Paper 373, Geological Society of America, Boulder, CO.

[3] Oard, M.J., 2008. What is the meaning of ophiolites? *Journal of Creation* 22(3):13–15.

[4] Moores, E.M., Kellogg, L.H., and Dilek, Y., 2000. Tethyan ophiolites, mangle convection,a nd tectonic "historical contingency": a resultuion of the "ophiolite conundrum"; in: Dilek, Y., Moores, E.M., Elthon, D. and Nicolas, A. (Eds.), *Ophiolites and Ocean Crust: New Insights from Field Studies and the Ocean Drilling Program*, GSA Special Paper 349, Geological Society of America, Boulder, CO, pp. 3–12.

[5] Hacker, B.R., Mosenfelder, J.L., and Gnos, E., 1996. Rapid emplacement of the Oman ophiolite: thermal and geochronologic constraints. *Tectonics* 15(6):1230–1247.

[6] Searle, M., and Cox, J., 1999. Tectonic setting, origin, and obduction of the Oman ophiolite. *GSA Bulletin* 111:104–122.

[7] Dilek, Y., 2003. Ophiolite concept and its evolution; in: Dilek, Y. and Newcomb, S. (Eds.), Ophiolite Concept and Evolution of Geological Thought, GSA Special Paper 373, Geological Society of America, Boulder, CO, pp. 1–16.

rocks at their bases[8], the grade of metamorphism decreasing downward from the base, indicating heating from sliding friction.[9] However, most ophiolites are now believed to have something to do with "subduction zones" in which an oceanic plate is diving below another oceanic plate or a continental plate. How this happens is a subject of dispute.

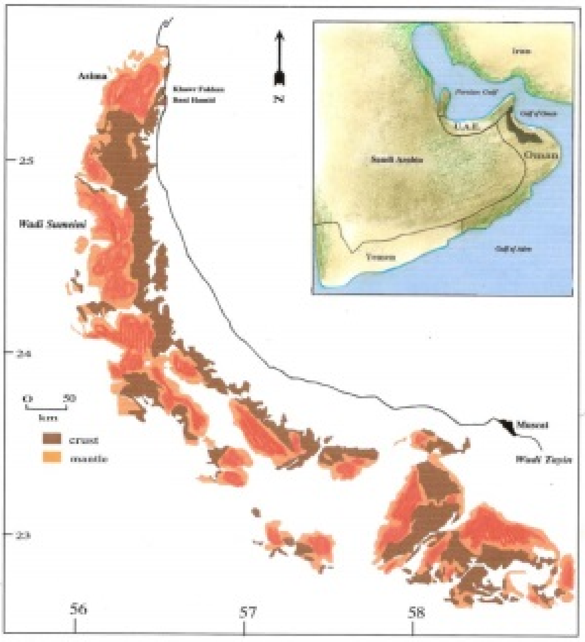

Figure 20.1. The Oman ophiolite, also called the Samail ophiolite (redrawn by Mrs. Melanie Richard from Hacker et al, 1996, p. 1,231).

Another problem is there are no present locations where ophiolites are being 'slammed' against continental crust or being raised in mountains. In other words we have no modern analogues.[10] This is contrary to the uniformitarianism principle upon which all mainstream geological interpretation is based. It also makes it difficult to develop a thorough understanding of any proposed mechanism. In truth, there does not seem to be any credible mechanism for emplacement of ophiolites. Dewey writes, "… no credible mechanisms have yet been devised for ophiolite obduction [pushed up and onto continental crust] from ocean ridges onto rifted continental margins."[11] In regard to the Oman ophiolite, believed to have been thrust 125 miles (200 km) westward onto a passive continental margin, Hacker and colleagues are understandably mystified:

> The emplacement of oceanic lithosphere [crust and upper mantle] onto continents remains one of the great mysteries of plate tectonics—how does ophiolitic material with a density of 3.0–3.3 g/cm^3 rise from its natural depths of ≥2.5 km beneath the ocean surface

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[8] Dewey, J., 2003. Ophiolites and lost oceans: rifts, ridges, arcs, and/or scrapings? in: Dilek, Y. and Newcomb, S. (Eds.), Ophiolite Concept and Evolution of Geological Thought, GSA Special Paper 373, Geological Society of America, Boulder, CO, pp. 153–158.

[9] Whitehead, J., Reynolds, P.H. and Spray, J.G., 1995. The sub-ophiolitic metamorphic rocks of the Québec Appalachians. *Journal of Geodynamics* 19:325–350.

[10] Dilek, Ref. 7, p. 8.

[11] Dewey, Ref. 8, p. 156.

> to elevations more than 1 km above sea level on continents with densities of 2.7–2.8 g/cm^3?[12]

Ophiolites are a challenge for creationists as well, but it is not the purpose of this book to investigate and develop a Flood mechanism, although the large scale and catastrophic action of Flood tectonics has great potential explanatory power. I will discuss the timing of ophiolites assuming the evolutionary/uniformitarian geological column.

Cenozoic Ophiolites—Powerful post-Flood Overthrusing of Ocean Crust onto Land?

Opthiolites are widespread and are dated anywhere from the mid Precambrian, about two billion years ago,[13] to the Cenozoic. I will focus only on the Cenozoic occurrences, which according to the K/T Boundary Model would have had to occur *after* the Flood. There are not many Cenozoic ophiolites; they predominate in the Cretaceous and Jurassic periods. But they exist and need to be explained by post-Flood catastrophism. Cenozoic ophiolites are found mainly in the southwest Pacific, especially Indonesia; the Red Sea area; southern Chili; and Japan.[14] Ophiolites have been studied in the northern Philippine Islands and are dated as late Mesozoic and early Cenozoic.[15] An ophiolite on Macquarie Island, south of New Zealand, is dated as Late Cenozoic.[16]

Considering the thickness of ophiolites and how far they were pushed horizontally and upward over the lighter continental crust, we ask how such forces can be mustered after the Flood, if the Cenozoic is post-Flood?

Metamorphic Core Complexes after the Flood?

Metamorphic core complexes (MCCs) are generally domal or arch-like uplifts of metamorphic and granitic type rock overlain by un-metamorphosed rock that has usually slid downhill at a low angle during doming.[17] The slide is commonly called a detachment fault. The resulting dome can sometimes be called a gneiss dome,[18] since it is mostly gneiss and granite that make up the dome. Sometimes ultrahigh-pressure minerals (see below) are associated with MCCs.[19] MCCs are relatively large structures; they can be a few tens of miles up to around 60

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[12] Hacker *et al.* Ref. 5, p. 1,230.

[13] Kumar, K.V., Ernst, W.G., Leelanandam, C., Wooden, J.L., and Gove, M.J., 2010. First Paleoproterozoic ophiolite from Gondwana: geochronologic-geochemical documentation of ancient oceanic crust from Kandra, SE India. *Tectonophysics* 487:22–32.

[14] Dilek, Y., and Furnes, H., 2011. Ophiolite genesis and global tectonics: geochemical and tectonic fingerprinting of ancient oceanic lithosphere. *GSA Bulletin* 123(3/4):387–411.

[15] Queaño, K.L., Ali, J.R., Aitchison, J.C., Yumul Jr., G.P., Pubellier, M., and Dimalanta, C.B., 2008. Geochemistry of Cretaceous to Eocene ophiolitic rocks of the Central Cordillera: implications for Mesozoic–early Cenozoic evolution of the northern Philippines. *International Geology Review* 50:407–421.

[16] Varne, R., Brown, A.V., and Falloon, T., 2000. Macquarie Island: its geology, structureal history, and the timing and tectonic setting of its N-Morb to E-Morb magmatism; in: Dilek, Y., Moores, E.M., Elthon, D. and Nicolas, A. (Eds.), *Ophiolites and Ocean Crust: New Insights from Field Studies and the Ocean Drilling Program*, GSA Special Paper 349, Geological Society of America, Boulder, CO, pp. 301–320.

[17] Neuendorf, K.K.E., Mehl, Jr., J.P., and Jackson, J.A., 2005. *Glossary of Geology*, Fifth Edition. American Geological Institute, Alexandria, VA, p. 407.

[18] Gressner, K., Wijns, C., and Moresi, L., 2007. Significance of strain localization in the lower crust for structural evolution and thermal history of metamorphic core complexes. *Tectonics* 26, doi:10.2029/2004TC001768

[19] Ring, W., Will, T., Glodny, J., Kumerics, C., Gessner, K., Thomson, S., Güngör, T., Monié, P., Okrusch, M., and Drüppel, K., 2007. Early exhumation of high-pressure rocks in extrusion wedges: Cycladic blueschist unit in the eastern Aegean, Greece, and Turkey. *Tectonics* 26: doi:10.1029/2005TC001872.

miles (100 km) in width.[20] It is believed by many that the domes uplifted around 10 miles (16 km),[21] and the MCCs are often the highest mountains in the region.[22] MCCs are accompanied by considerable volcanism.

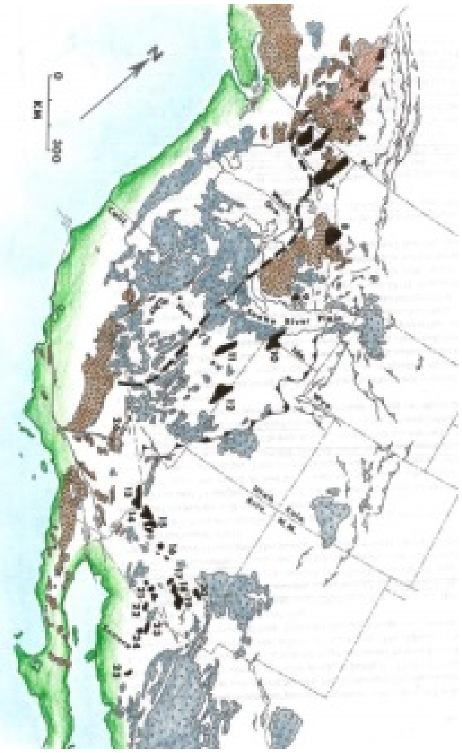

Figure 20.2. Plot of 25 metamorphic core complexes (in black) from British Columbia south into northwest Mexico (from Coney, 1980, p. 10).

MCCs are numerous and their evolutionary/uniformitarian age is *predominantly* Cenozoic.[23] There are twenty-five MCCs near the axis of the mountains of the western United States from southern Canada to northwest Mexico (Figure 20.2).[24] They are dated as both early and late Cenozoic. One of the largest is the Bitterroot dome-Sapphire block of west central Idaho and

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[20] Tirel, C., Brun, J.-P., and Burov, E., 2008. Dynamics and structural development of metamorphic core complexes. *Journal of Geophysical Research* 113, doi:10.1029/2005JB003694.

[21] Boswell, J.T. and Colberg, M.R., 2007. Vertical variations in footwall rocks of the northern Snake Range, Nevada; implications for metamorphic core complex development. *GSA, Rocky Mountain Section Abstracts with Programs* 39(5):41.

[22] Davis, G.H., 1980. Structural characteristics of metamorphic core complexes, southern Arizona; in: Crittenden, M.D., Coney, P.J., and Davis, G.H. (Eds.), *Cordilleran Metamorphic Core Complexes*, GSA memoir 153, Geological Society of America, Boulder, CO, pp. 35–77.

[23] Coney, P.J., 1980. Introduction; in: Crittenden, M.D., Coney, P.J., and Davis, G.H. (Eds.), *Cordilleran Metamorphic Core Complexes*, GSA memoir 153, Geological Society of America, Boulder, CO, pp. 3-6.

[24] Coney, P.J., 1980. Cordilleran metamorphic core complexes: an overview; in: Crittenden, M.D., Coney, P.J., and Davis, G.H. (Eds.), *Cordilleran metamorphic core complexes*, GSA memoir 153, Geological Society of America, Boulder, CO, pp. 7–31.

southwestern Montana, number 8 on Figure 20.2.[25,26] In this MCC, the eastern edge of the Idaho Batholith uplifted and a block of rock 60 miles (100 km) long, 44 miles (70 km) wide, and 9.4 miles (15 km) thick broke off and apparently slid eastward about 38 miles (60 km). The block is named the Sapphire Mountains. Between the Sapphire Mountains and the eastern edge of the Idaho Batholith, the Bitterroot Mountains, is the straight Bitterroot Valley. Along the western edge of the valley, the angle of the mountain slope is the same, about 25°. It represents the slide surface of the Sapphire block. Below the slide surface is several hundred feet of sheared rock, called mylonite, caused by the slide.

Other Cenozoic MCCs are located in the Aegean Sea, Greece, Turkey, Iran, Tibet, Slovakia, Venezuela, Trinidad, New Zealand, and eastern New Guinea. The latter is the youngest, dated at 2 to 8 million years old, the late Cenozoic.[27] It is also associated with ultrahigh-pressure minerals (see below).

MCCs are an evolutionary/uniformitarian conundrum. In regard to the rapid exposure of the core of the MCC in Papua, New Guinea, Little and colleagues stated: “The tectonic [uplift] processes by which this rapid exposure has been accomplished remain poorly understood.”[28] MCCs form during extension when the crust is being pushed apart horizontally. The late date of MCCs, mostly in the Cenozoic, was a surprise.

MCCS represent tremendous tectonic events. Scott Rugg points out that they uplifted rapidly with the sliding of huge blocks late in the Flood.[29] Just as with ophiolites and ultrahigh-pressure metamorphic rocks (see below), catastrophism of the Cenozoic was tremendous. It likely would have been too much violence for man and animals to spread and thrive after the Flood. MCCs fit better with the Retreating Stage of the Flood.

Cenozoic Ultrahigh-Pressure Minerals Imply Post-Flood Uplifts from Below 60 Miles

Over the past forty years or so, ultrahigh-pressure (UHP) minerals, as well as high-pressure (HP) minerals and microdiamonds, have been increasingly discovered on the earth’s surface.[30] These minerals have caused a great deal of frustration to uniformitarian scientists because they imply high pressure metamorphism from deep in the earth. But the minerals are now located in a low-pressure environment at the Earth’s surface.

UHP minerals are believed to have originated predominantly from continental crust, which is lighter than ocean crust. So, how does lighter continental crust sink into denser rock? The UHP minerals have forced uniformitarian scientists to conclude the continental rocks must have been forced downward to great depths and then *rapidly* raised to the surface, This conclusion came about because the rocks often remained at low temperature, based on features of the rocks. Slow

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[25] Hyndman, D.W., 1980. Bitterroot dome-Sapphire tectonic block, an example of a plutonic-core gneiss-dome complex with its detached suprastructure; in: Crittenden, M.D., Coney, P.J., and Davis, G.H. (Eds.), *Cordilleran metamorphic core complexes*, GSA memoir 153, Geological Society of America, Boulder, CO, pp. 427–443.

[26] Hodges, K.V. and Applegate, J.D., 1993. Age of Tertiary extension in the Bitterroot metamorphic core complex, Montana and Idaho. *Geology* 21:161–164.

[27] Little, T.A., Baldwin, S.L., Fitzgerald, P.G., and Monteleone, B., 2007. Continental rifting and metamorphic core complex formation ahead of the Woodlark spreading ridge, D’Entrecasteaux Islands, Papua New Guinea. *Tectonics* 26: doi;10.1029/2005TC001911.

[28] Little *et al.*, Ref. 27, p. 2.

[29] Rugg, S.H., 1990. Detachment faults in the Southwestern United States—evidence for a short and catastrophic Tertiary period; in: Walsh, R.E. and Brooks, C.L. (Eds.), *Proceedings of the Second International Conference on Creationism*, technical symposium sessions and additional topics, Creation Science Fellowship, Pittsburgh, PA, pp. 217–229.

[30] Oard, M.J., 2006. The uniformitarian challenge to ultrahigh-pressure minerals. *Journal of Creation* 20(1):5–6.

descent would have caused the minerals to heat up too much, while slow uplift would have caused what is called reverse metamorphism that would have destroyed the UHP minerals.

Each new discovery of UHP minerals has pushed the depth of descent farther downward, causing a predictable cycle of uniformitarian disbelief following by forced acceptance.[31] I might add that uniformitarian scientists keep finding "solutions" to these great mysteries, showing how untestable is the belief in uniformitarianism. Therefore, a paradigm change has occurred in geology:

> The story of ultrahigh-pressure metamorphism (UHPM) is a confused mixture of surprising, sometimes spectacular, discoveries and emotional reactions. Surprisingly, the process has been a repeating cycle of disbelief followed by confirmation, with little evidence that the community response in a given cycle has learned from previous cycles.[32]

Several ideas have been suggested to account for UHP minerals. Uniformitarian scientists have brought out the idea of continental collisions to account for the data, but the depth of descent is overwhelming. How radical vertical tectonics can occur along with continental collisions remains enigmatic.[33] In fact "clueless" is suggested from the following:

> As a consequence, thermomechanical insights inferred from P-T-t [pressure-temperature-time] reconstruction and structural studies of high-pressure terranes have relentlessly failed to reproduce the trajectories and the velocity field of mass transport in the crust during the entire orogenic [vertical tectonics] period and, most importantly, show no clue to the basic processes responsible for burial and rock exhumation and their relation to the global velocity framework of plate tectonics.[33]

That is not all. An analysis of UHP minerals suggests that some minerals had been driven down to depths of around 190 to 250 miles (300 or 400 km) and exhumed![34,35] Ultrahigh-pressure minerals, therefore, imply rapid sinking and uplift, unless they are the result of asteroid impacts that can actually cause ultrahigh-pressure minerals and microdiamonds.

Another mechanism is to drive down the rocks that contain the UHP minerals in a "subduction zone" and then rapidly raise the rock. Two major problems with the subduction hypothesis is that continental crust is light and difficult to subduct, and then it has to bounce, back to the surface and form mountains after descending a vertical distance of over 60 miles (100 km).

Ultrahigh-pressure minerals are commonly found in the Cenozoic, as in the Alps, implying rapid uplift from about 60 miles (100 km) depth.[36] Late Cenozoic ultrahigh-pressure rocks are found in a gneiss dome in eastern Papua, New Guinea, also implying rapid exhumation at least this same distance.[37] High-pressure minerals from the mountains of southeast Spain are believed

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[31] Green II, H.W., 2005. Psychology of a changing paradigm: 40+ years of high-pressure metamorphism. *International Geology Review* 47:439-456.

[32] Green, Ref. 31, p. 439.

[33] Philippot, P. and Arnaud, N., 2001. Preface to "Exhumation of high-pressure rocks: kinetic, thermal, and mechanical constraints." *Tectonophysics* 342:vii.

[34] Kerr, R.A., 1999. A deeper look beneath tall mountains. *Science* 284:24.

[35] Green, Ref. 31, pp. 448–450.

[36] Janak, M., Froitzheim, N., Lupták, B., Vrabec, M., and Ravna, E.J.K., 2004. First evidence for ultrahigh-pressure metamorphism of eclogite in Pohorje, Slovenia: tracing deep continental subduction in the Eastern Alps. *Tectonics* 23,TC5015, doi:10.1029/2004TC001641: 1–10.

[37] Korchinski, M., Little, T.A., Smith, E., and Millet, M.-A., 2012. Variation of Ti-in-quartz in gneiss domes exposing the world's youngest ultrahigh-pressure rocks, D'Entrecasteaux Islands, Papua New Guinea. *Geochemistry, Geophysics, Geosystems* 13(1):1–27.

to have been uplifted from about 40 miles (65 km) in the *late* Cenozoic.[38] The ultrahigh-pressure rocks in the Himalayas, implying uplift from below 55 miles (90 km), also have a Cenozoic age.[39] Diamonds in rocks from an intrusion in Japan indicate uplift of over 105 miles (170 km)[40] It is interesting that the rock is assumed to be the off-scarped and deformed material from the ocean as the Pacific Plate subducted beneath Japan, which means that the origin of the rock is believed to be from shallow depths, but the diamonds say otherwise. So, the diamonds with their assumed uplift are a uniformitarian mystery.

Catastrophic tectonics would be expected during the Flood, although sinking and uplifts of over 185 miles (300 km) seems problematic. We know the Flood was a time of intense vertical tectonics, as well as impacts from space[41] which may have caused the UHP minerals and microdiamonds. It is unlikely there was radical vertical tectonics *after* the Flood, and yet if the Flood/post-Flood boundary is at the K/T, then that is what advocates of all but the late Cenozoic boundary have to believe. They are left to answer how vertical movements to and from such depths took place after the Flood.

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[38] Sánchez-Vizcaíno, V.L., Rubatto, D., Gómez-Pugnaire, M.T., Trommsdorff, V. and Müntener, O., 2001. Middle Miocene high-pressure metamorphism and fast exhumation of the Nevado-Filábride Complex, SE Spain. *Terra Nova* 13:327–332.

[39] Epard, J.-L. and Steck, A., 2008. Structural development of the Tso Morari ultra-high pressure nappe of the Ladakh Himalaya. *Tectonophysics* 451:242–264.

[40] Mizukami, T., Wallis, S., Enami, M., and Kagi, H., 2008. Forearc diamond from Japan. *Geology* 36(3):219–222.

[41] Oard, M.J., 2009. How many impact craters should there be on the earth? *Journal of Creation* 23(3):61–69.