A more likely origin of massive dolomite deposits

Michael J. Oard

Dolomite is the common name for a carbonate rock mostly composed of the mineral dolomite ($CaMg(CO_3)_2$).[1] It is sometimes called dolostone. To qualify as dolomite, more than 50% of the carbonate must be the mineral dolomite. Intermediates between limestone, calcite ($CaCO_3$), and dolomite are high magnesium calcite or 'protodolomite'. Sedimentary rocks usually have a high percentage of limestone and dolomite, but rarely possess much of the intermediates,[2] although a perfectly stoichiometric dolomite with 50% calcium and 50% magnesium is rare. There is usually a small percentage more calcium.

Dolomite occurrence

Although estimates vary, carbonate rocks make up from 20 to 25% of all sedimentary rocks.[3] Dolomite is most extensive in the Precambrian and early Paleozoic. It is also poorly fossiliferous. The abundance of dolomite in the Proterozoic suggests that these rocks were deposited in a different environment from today: "The extraordinary abundance of dolomite in the Proterozoic challenges our understanding of Precambrian marine environments."[4] The amount of dolomite varies vertically through the Phanerozoic rock record, being more than 50% of all carbonates in the Ordovician to Lower Carboniferous and the Triassic to Mid Cretaceous of the geological column.[5] Limestone dominates the late Paleozoic, the late Mesozoic, and the Cenozoic.[4] Some scientists dispute this trend, claiming the amount of dolomite increases with older age.[6] If dolomite is half the carbonate rocks, then dolomite makes up a little more than 10% of all sedimentary rocks.

Dolomite can be thick and widespread, such as massive Cambrian dolomite in the Yangtze Gorges (China) area that "has a thickness ranging from several hundreds to more than one thousand meters across an area of ~500,000 square kilometers."[7]

The dolomite problem

In contrast with such thick widespread dolomites in the sedimentary rocks today, dolomite formation is rare and isolated. Moreover, sedimentary rock dolomite is mostly stoichiometric and ordered, while dolomite formed today is not. Ordered dolomite is the condition in which all calcium ions and all magnesium ions alternate in layers with the CO_3 ion in between. There is no mixture of calcium and magnesium ions in any one layer. When dolomite does form today it does so only in very warm saline water. Therefore, the origin of dolomite presents a conundrum for uniformitarianism. This has been dubbed the 'Dolomite Problem'. Scientists have attempted to solve this problem for over 200 years and have published hundreds of research papers attempting to account for its formation. Ning *et al.* summarize:

> "The origin of ancient massive dolostone, i.e. continuous dolostone sequence with a thickness >100 m and a platform-wide distribution, is the key issue of the 'Dolomite Problem' that cannot be clearly demonstrated by any existing dolomitization model individually or sequentially. … Dolomite, one of the most enigmatic minerals, is abundant in pre-Cenozoic strata but rare in Cenozoic and modern sediments. … [This dolomite problem] has puzzled geologists for more than 200 years (Warren, 2000). … How ancient 'massive dolostone', referring to continuous dolostone deposition with hundreds to thousands [sic] meters in thickness and hundreds of thousands [sic] square kilometers in area (or platform-wide distribution), could be formed, given modern dolomite is restricted in specific geographic environments and normally presents as thin layers."[8]

Dott earlier stated that the origin of dolomite is one of several major geological puzzles:

> "When I was a student half a century ago, the origin of pure quartz sheet sandstones, then called orthoquartzites [now called quartz arenites], was considered a major puzzle. Together with the origin of dolomite, red beds, black shale, and banded iron formation, they made up a group of seemingly intractable geological problems. Even now, 50 odd years later, their origins are still being debated."[9]

Clearly, uniformitarian scientists still cannot explain why ~10% of sedimentary rocks are dolomite.

Primary or replacement dolomite?

Primary dolomite is dolomite that precipitates directly from solution, while replacement dolomite is believed to have replaced limestone by high magnesium fluid flow. For this to be true both the amount of fluid flow[10] and the amount of available magnesium[11] must have been huge. It is estimated that 1,000 units of fluid flow is needed to dolomitize one unit volume,[5] and 350 kg of Mg is needed to dolomitize 1 m^3 of limestone with a porosity of 7%.[11] Of course the fluid flow of magnesium ions decreases away from a potential source—one of the many problems with dolomitizing a huge limestone formation. This is one reason why it supposedly takes millions of years for dolomite to form. The problem with primary precipitation is that a tremendous kinetic barrier exists.[12] Presently seawater is 10–100 times supersaturated with magnesium,[10] yet dolomite is not precipitating today. Land discovered that dolomite would not precipitate even at 1,000-fold supersaturation at temperatures of 25°C after 32 years.[13] This kinetic barrier can be overcome by increasing the temperature of the fluid (see below).

In hot saline pools today, dolomite, other carbonates, and evaporites[14] are being locally deposited with the help of microbes that overcome the kinetic barrier.[12] Most of the dolomite is precipitated in the pores of other sediments.[10] This has given rise to the microbial theory for sedimentary rock dolomite,[15] but this theory is still under debate.[16]

Because of the difficulties involved in the formation of large-scale massive dolomite at present-day temperatures, replacement has become the consensus for the origin of dolomite: "It is typically a consensus that ancient massive dolostone was generated by the replacement of Ca-carbonate precursors."[7] The replacement process is also called dolomitization. But most researchers at least believe some dolomite is primary.[17] Still, replacement has its own problems:

> "Massive dolostone formation not only needs to overcome the kinetic barrier imposed by Mg^{2+} hydration, but also requires sufficient Mg-bearing fluids and a long-term pumping mechanism."[7]

The amount of fluid that must flow through the limestone is impressive (see above). What would be the origin of these fluids? Then what kind of pump could have lasted unchanged for a million years?

Secular explanations

Numerous models have been invented to try and explain the Dolomite Problem. All of them have severe limitations:

> "However, the application of these models individually or sequentially to interpret ancient massive dolostone is difficult … . For example, it remains unclear whether massive dolostone formation involves with [sic] a single or multiple dolomitization events [sic] or how to recognize/sequence dolomitization events in the stratigraphic record. Neither is [sic] known about the Mg source or the mechanism that effectively pumps Mg into thick carbonate deposits in [sic] the platform scale."[7]

Multiple injections of dolomitization fluid?

Ning *et al*. add another hypothesis, which is that there may have been multiple numerous dolomitization events on a layer thickness of 1 m over millions of years. They point out that dolomitization is not by hydrothermal flow, since there is an absence of hydrothermal veins. With multiple events, the huge volume of limestone need not be

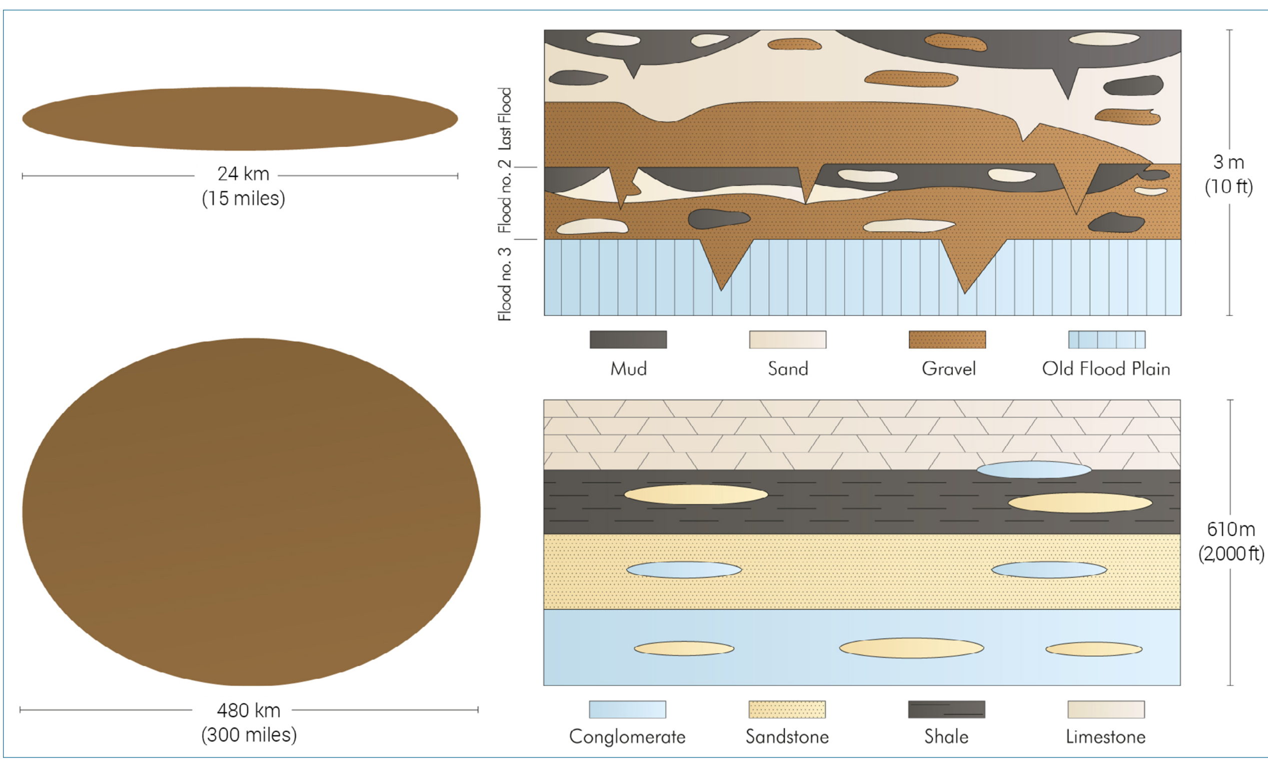

Figure 1. A schematic comparing the dimensions of sediments laid down today over small areas (top left) with rapid vertical and horizontal sediment changes (top right) to sedimentary rock lithologies commonly laid down over much larger areas (bottom, left) and much thicker (bottom, right). Note the different scales. The top right panel, representing today, indicates erosion of previously laid down sediments with changing small-scale horizontal and vertical facies changes. This is unlike what is *actually* observed today in the rocks with one layer laid on top of another with little or no erosion (bottom right). (Drawn by Melanie Richard.)

dolomitized all at once. So this solves a major problem.[18] The researchers suggest possible multiple sea level changes as a cause for these many events, believing slight changes in the Mg isotope (δ^{26}Mg) ratio can explain the cycles. The Mg isotope cycles only vary between –1.5‰ and –1.9‰ (per mil or one one-thousandths). These differences are quite small, making it likely other processes could mask small changes in this ratio. The idea is considered only 'a possible solution'.[18]

Possible Flood explanations

The Dolomite Problem may hinge on the widespread commitment to uniformitarianism. Secular scientists assume that dolomite formed under near present-day Earth surface temperatures.[19] This is the major reason why the Dolomite Problem has been such a strong challenge for over 200 years.

It is also unlikely that dolomitization of limestone could produce massive dolomite deposits hundreds of metres thick over hundreds of thousands of square kilometres in the short timescale of biblical Earth history. Therefore, I believe that the massive dolomite deposits were primary deposits with only some later minor secondary dolomitization. The massive scale of dolomite deposition matches the scale of deposition during the global Flood, laying down these carbonates over vast areas with one deposit forming on top of the other in quick succession. This is exactly what we see today in the layers of sedimentary rocks.[20] These huge formations defy uniformitarianism, which should produce only small-scale local horizontal and vertical sedimentation patterns (figure 1).

It is known that dolomite much more easily precipitates at higher temperatures and higher Mg/Ca ratios.[19] Stoichiometry ordering increases under these conditions, similar to many dolomites found in the rock record. So, high water temperatures seem able to account for the origin of dolomite:

> "Only at temperatures over about 100°C, well beyond those expected for synsedimentary dolomite formation, can dolomite be readily precipitated in experiments."[21]

The temperature should be over 150°C, and the higher the temperature the faster dolomite precipitates and the more ordered the atomic structure.[22,23]

During the Flood, high temperatures would most likely exist early due to the onslaught of the waters from the fountains of the great deep and associated volcanism. This is possibly why most of the thickest dolomite is found in the Precambrian and in the Paleozoic, tailing off in the Mesozoic and virtually ending by the time of Cenozoic deposition. Temperatures would likely have remained hotter in the early basins and cooled as thick sediments were deposited on the continents during the Mesozoic and Cenozoic, forming predominantly limestone in the upper layers.

This pattern suggests that the pre-Flood/Flood boundary may be below at least some of the Precambrian sedimentary rocks.[20] This deduction is supported by raindrop imprints, black shale, impacts, etc. in the Precambrian that continue up into the Paleozoic.[24,25]

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