Chapter 7

Consolidated Sedimentary Rocks

Another criterion that can be used to ascertain the location of the Flood/post-Flood boundary is the process of hardening or consolidation of sediments into sedimentary rocks. Sediments laid down in water do not automatically become sedimentary rocks. It requires cementation, a rather difficult process that requires special conditions today.

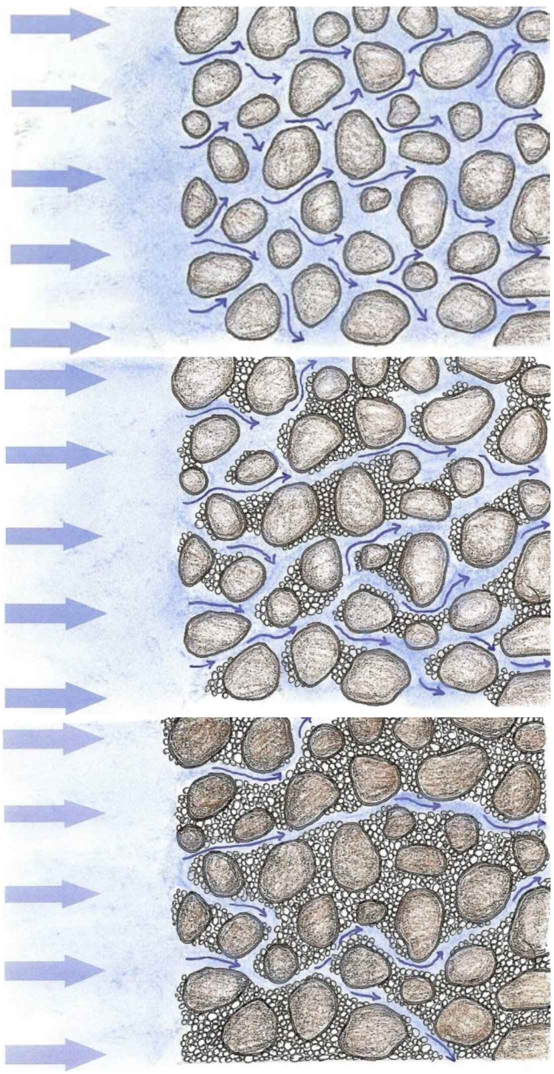

Figure 7.1. Schematic of the cementing of a sand into sandstone by water flowing through the pores and depositing cementing chemicals (drawn by Mrs. Melanie Richard).

How Are Sediments Cemented into Sedimentary Rocks?

Sediments are converted into sedimentary rock by two processes, a combination of compaction caused by deep burial from thousands of feet of sediment, and by precipitation of cement within the pores around sediment grains.[1] The cementation is called consolidation or

[1] Plummer, C.C. and McGeary, D., 1996. *Physical Geology*, seventh edition, Wm. C. Brown Publishers, Dubuque, IA, p. 117.

lithification, and there are many variables that act in the process.[2,3,4,5,6]

For cement to work its way into the sediments, groundwater must flow freely through the pore spaces, at least during early cementation. The cement attaches itself to the grains and gradually fills the pores. As a result the flow slowly decreases (Figure 7.1), transporting fewer cementing agents into the sediment. Sometime during this process the sediment turns into sedimentary rock. It is common for different sedimentary rocks to alternate between hard and soft rocks, which may have depending upon the efficiency of the cementing process. Of the many variables, time is only one. How fast sediments consolidate is more about having the *right conditions*.

Calcite and silica, two very common minerals, are the main cementing agents. Iron oxides, other carbonate minerals, and clay minerals are minor agents. Dissolved ions of mainly calcite and silica within water must flow through the pore spaces and precipitate in the voids between the grains.

The cementation process is even more complicated. Even the sediment grains themselves can dissolve in the consolidation process and be re-deposited as cement or transported out of the particular sediment. For instance, after depositing calcite cement, the pore water could change chemistry and dissolve the calcite or replace it with another cementing mineral, like dolomite. Furthermore, the pore fluid can have different chemical properties in space and time.

The Flood Would Provide the Ideal Environment for Rapid Cementation

The Genesis Flood would rapidly deposit thick sediments, which would quickly compact due to their weight. Hot water from crustal or mantle sources, "the fountains of the great deep," would easily dissolve chemicals both within the Floodwater and the water within the sediments.

The rock record shows abundant evidence that calcite and silica were common in the Flood sediments. Calcite makes up 8% of the sedimentary rocks. Silica layers in the form of chert are less abundant but significant. A fair amount of chert layers, lenses, and nodules are found within many carbonates across the earth. Moreover, nearly all of the earth's rocks have cracks that are commonly filled with silica (Figure 7.2) and calcite (Figure 7.3), indicating there were abundant highly charged cementing chemicals in the subsurface fluids.

When Flood sediments were first deposited they were saturated with ion-charged water. The weight of the rapidly deposited sediments would increase the pressure of the water between the sediment grains, and force the water to flow through the sediments with increasing hydraulic pressure. The rapid flow of water would result in the deposition of cement within the pores of the sediment particles. Hence, rapid consolidation of sediments would occur, especially the deeper the burial. It is of course expected that consolidation would be either absent or partial in some sediments due either to a lack of compaction, not enough cementing agents, the porosity rapidly decreased so the water could not flow through the sediment fast enough, or other variables.

[2] Pettijohn, F.J., Potter, P.E., and Siever, R., 1987. *Sand and Sandstone*, second edition. Springer-Verlag, New York, NY, pp. 447–467.
[3] McBride, E.F., 1989. Quartz cement in sandstones: a review. *Earth-Science Reviews* 26:69–112.
[4] Bjørlykke, K. and Egeberg, P.K., 1993. Quartz cementation in sedimentary basins. *AAPG Bulletin* 77(9):1,538–1,548.
[5] Haddad, S.C., Worden, R.H., Prior, D.J., and Smalley, P.C., 2006. Quartz cement in the Fontainebleau Sandstone, paris Basin, France: crystallography and implications for mechanisms of cement growth. *Jurnal of Sedimentary Research* 76:244–256.
[6] Molenaar, N., Cyziene, J., and Sliaupa, S., 2007. Quartz cementation mechanism and porosity variation in Baltic Cambrian sandstones. *Sedimentary Geology* 195:135–159.

Figure 7.2. Quartz dike in granite in the Black Hills, South Dakota.

Cementation Very Difficult Today

In today's environment, compaction by deep burial would be very rare, and cementing agents lacking. Molenaar *et al.* write:

> Evidently a source of silica must exist with a mechanism to transport silica towards the site of cement precipitation, as well as a precipitation mechanism involving suitable nucleation sites.[7]

They go on to state there is no realistic cementation mechanism for sandstones:

> Many models attempting to explain quartz cementation still conclude that external sources of silica are needed to explain the observed quantity of quartz cement (see review by McBride, 1989; Dutton and Diggs, 1990). However, realistic silica sources and transport mechanism are generally lacking and the increase in silica content is difficult to explain [from observed sandstones]… Large volumes of diagenetic fluids are needed for quartz cementation…[8]

These researchers are thus looking for an internal mechanism of dissolving sediments to provide cement.

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[7] Molenaar *et al.*, Ref. 6, p. 135.
[8] Molenaar *et al*., Ref. 6, p. 154.

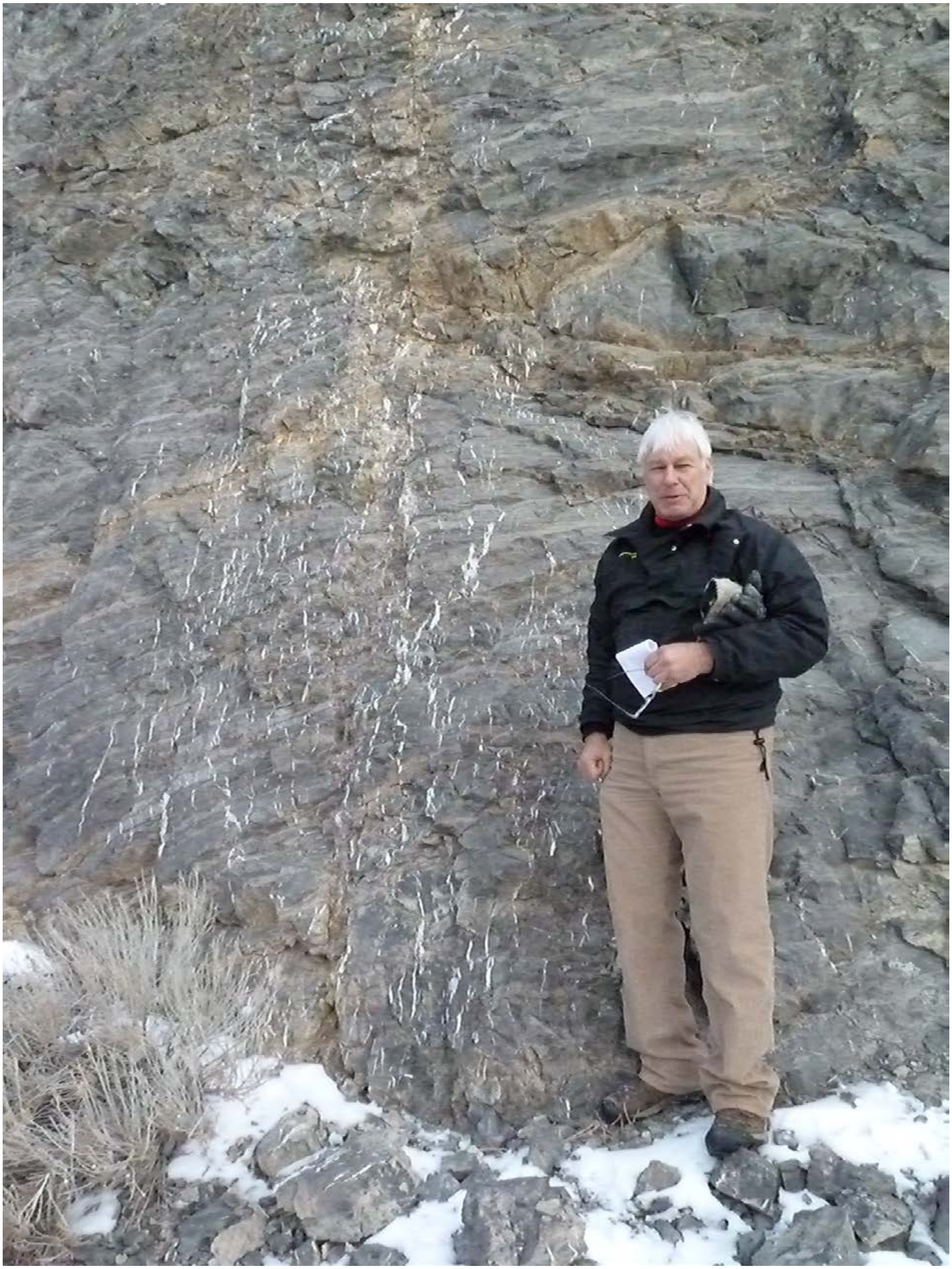

Figure 7.3 Likely calcite veins or dikes in a gray limestone at Lewis and Clark Caverns, Montana (courtesy of Sherry Foth with Perry Fishbaugh for scale).

The cementing of sediments is actually a severe problem for uniformitarian thinking. Pettijohn states that in the lithification of a 100-meter thick layer of sand, 25 to 30 meters of cement must be deposited within the pore spaces (assuming little compaction).[9] But, the origin of this cement, and how and when the sediment is cemented, is unresolved:

> Cementation, moreover, is the last step in the formation of the sandstone, and our knowledge is incomplete and unsatisfactory unless the origin and manner of emplacement of the cement are fully understood. ...The problems of how and when sands become cemented and the source of the cementing material are still unresolved.[10]

So, cementation by present processes (uniformitarianism) is very difficult. Occasionally it does happen in special environments charged with calcite or silica, like mines or some hot springs.

Would Huge Post-Flood Catastrophes Help?

It is difficult to imagine any post-Flood mechanism that would collect sediments thick enough to cause significant compaction. It is impossible to know whether post-Flood catastrophes can tap even a fraction of the hot groundwater and dissolved cementing agents.

So, it appears at first glance that possible post-Flood catastrophes would be short on compaction and cementing agents to consolidate sediments into sedimentary rock. Regardless, sediments in say the top few thousand feet would likely remain unconsolidated due to lack of compaction and cementing agents. There are very few places on the surface of the earth, where there are thousands of feet of unconsolidated rock. Sedimentary rocks are commonly found at the surface or a little below a relatively thin, surficial soil. All these problems do not favor post-Flood catastrophism being able to cement particles to rock.

Consolidated Sediments—A Good Boundary Criterion

Therefore, consolidated sedimentary rocks would be a good general criterion for distinguishing between Flood and post-Flood deposits. The vast majority of sediments would have cemented during the Flood, while thin unconsolidated sediments would more likely come after the Flood. Therefore, the Flood/post-Flood boundary would be *above* the consolidated sediments. It is likely the Flood left a coating of unconsolidated mud in places above the hard rock.

Exceptions are expected to this criterion, however. The Flood could have left both thick and even thin unconsolidated sediments in places; while rare, local post-Flood environments could have consolidated some sediment. But, post-Flood processes would not be expected to have consolidated layers of rock over even modest areas. Because of the few exceptions, multiple criteria are required to determine the Flood/post-Flood boundary.

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[9] Pettijohn, F.J., 1975. *Sedimentary Rocks*, third edition, Harper and Row, New York, NY, pp. 239-245.
[10] Pettijohn, Ref. 9, pp. 239, 242.