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Principles for Interpreting the Sedimentological Record

Monte Fleming

Over and over again I have been struck with the extraordinary differences between the processes that formed many geological formations and those that are currently shaping the earth's surface.

The Pisco Formation is a good example. It is a unit of Neogene sediments on the coast of Peru, containing large quantities of volcanic ash and diatoms, famous for its extraordinary abundance of marine fossils and their excellent preservation. While the Pisco is clearly a coastal marine deposit, the characteristics of its deposition are strikingly different from modern coastal deposits, and many distinct lines of evidence point to its extremely rapid deposition.

Based on my experience researching the Pisco Formation and other formations throughout the geologic record, here are a few principles I would suggest for reinterpreting the geologic column in ways that are compatible with catastrophism:

Think big. While studying ancient deposits, we should assume that they were formed in an event that affected a large area. A noteworthy example of the use of this principle is the work Art Chadwick has done on paleocurrents.[1] In my own work in the Pisco Formation, I applied this principle in two ways. The first was to note the striking similarities between the Pisco Formation and the Monterey Formation on the California coast, both formed during the time equivalent to the Miocene Epoch, and observe that the same processes affected both coasts simultaneously. The second was to recognize depositional events up to the scale of meters rather than just millimeters or centimeters.

The scale of depositional events was important, because radiometric dating gives a time of approximately 13 million years for the deposition of the Pisco Formation. One can derive a deposition rate of 49 mm/kyr by dividing the 640 m of the Pisco Formation's deposits by the supposed 13 million years of deposition.[2] If this slow rate is correct, then it is natural to look for depositional events on the millimeter or sub-millimeter scale. My data showed clear evidence of deposition on the meter scale, however, and if I had been convinced of the 49 mm/kyr deposition rate, I might have missed clear data pointing to much faster deposition.

Do not expect or insert erosion or deposition where none is apparent. Ariel Roth's work on paraconformities, or "flat gaps" as he calls them,[3] showed how extraordinarily widespread this phenomenon is in the geologic column, both laterally and vertically. Processes that create extensive flat surfaces are extremely rare in modern depositional environments. The rule is that erosion creates topographic relief, so it should be extremely surprising to find abundant flat depositional hiatuses throughout the geologic column that supposedly sat exposed to the elements for millions of years without, in many cases, the slightest hint of topographic relief.

Others have noted that the problem of gaps is systematically exacerbated as one studies older and older rocks. Sadler, for example, states that "As the time span of measurement lengthens, longer hiatuses tend to be incorporated into the estimated [sedimentation] rate."[4] This principle also applies on small scales. Again, the Pisco Formation is a good example. There are many evidences of rapid deposition in the Pisco Formation. At one research location, I found evidence of several meters of sediment being deposited in less time than it takes for whale flesh to decay, and numerous studies have shown that the fossils in the Pisco Formation were buried very quickly.[5] Thirteen million years must leave a mark somehow, and we simply do not see that mark in the Pisco Formation.

Pay close attention to data that falsifies long ages. Coastal erosion rates are a good example. Even using conservative measurements of coastal erosion, the continents would have been consumed by the ocean many times over in their supposed history of at least four billion years. Basinal erosion rates tell a similar story—we can measure the sediment that rivers and streams carry to the ocean and use it to calculate the erosion rate of the continent. Even without the help of coastal erosion, basinal erosion would have carried the continents to the ocean grain by grain many times over. One might counter that the continents are renewed from beneath, but this cannot be the answer to the problem created by assuming long ages because a significant volume of old sediments is still present on the continents.

Pay close attention to anomalies in general—if they are real and persistent, they may point to a better model. As we have learned more about the geological history of the earth, it has become clear that the past was very different than the present. In the present, depositional processes on the continents tend to operate on relatively small scales. In the past, it was common for depositional processes to affect entire continents. In the present, local catastrophic events may leave small marks on the topography of the earth. In the past, events of extraordinary magnitude rocked vast portions of the globe. In the present, sediment is usually deposited slowly and quickly churned up by burrowing organisms and other processes. In the past, vast quantities of sediment were deposited extremely rapidly, and only rarely do we see complete bioturbation in ancient sediments.

As a general rule, the ability of modern analogues to fully explain the depositional record breaks down in older deposits.[6] While we recognize many facies and sedimentary structures that are still being deposited today, many Mesozoic and Paleozoic deposits cover such vast areas and evidence such violent depositional conditions that we should apply concepts developed from modern analogues with extreme caution. Nevertheless, we should assume uniformity of law—that is, the laws of nature governing the dynamics of the deposition of the sedimentological record have not changed. If we assume uniformity of law, we are not without tools in piecing together the events of the earth's greatest catastrophe to date and the many smaller catastrophes that followed.

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