

that this gigantic mass of limestone was formed by natural processes of carbonate sediment production. Any process of transporting that much accumulation of carbonate sediments from other places where it might have been produced would have mixed large amounts of land-derived sediments with it (unless the entire area and adjoining regions were already sealed over with thick beds of pure limestone).

Of significance also, with regard to the calcium carbonate and calcium-magnesium carbonate (dolomite) content, is the fact that the Redwall Limestone has many abrupt changes from the former to the latter, as one proceeds up the stratigraphic column. Beds of true limestone rest directly upon thick beds of fossiliferous dolostone, indicating that there were distinct changes of environment as sediment deposition proceeded. Thus there were times when a recently produced limestone layer had no opportunity to be converted to dolostone, but at other times there were extended periods when conditions were favorable for the slow process of dolomitization.<sup>25</sup>

A knowledge of some of the characteristics of limestone deposits can also be used for understanding physiographic characteristics of the Redwall Formation. These include various kinds of unconformities, the effects of erosion, the dissolving of large cavities in the limestone, and the refilling of those cavities.

As described earlier, an unconformity is a boundary surface between rock layers, which shows that there was a definite time break between the times of deposition of the two types of rock. When the zone of contact between the Redwall Limestone and the underlying Temple Butte Limestone is closely examined, a very irregular surface caused by erosion of the underlying rock is evident. Then farther up, about one-half way to the top of the Redwall, there are even more definite marks of ancient erosion and chemical changes due to weathering than are found at the base. These of course are a record of the passage of considerable amounts of time before more strata were added to the formation. Thus there were different stages in the development of the Redwall Limestone.

Near the top, and also precisely at the top of this formation, there are two other such zones of extreme weathering and erosion.<sup>26</sup> It should be realized that we are not here referring to any recent erosion, or to the downcutting of the Canyon; but that these are ancient erosion surfaces, which extended far back into the land mass on each side of the Canyon. In fact, these surfaces were eroded and then covered over long before the Grand Canyon was cut out. Present erosion on the sides of the canyon merely uncovers additional cavities, worn rock surfaces, sediment pockets, and other features of the ancient unconformities.

The uppermost of the Redwall unconformities is of special interest to the student of limestone formations, and has some characteristics similar to those previously noted in the Great Bahama Bank. We here refer to the highly eroded and dissolution-marked upper surface of the Redwall Formation, where it makes contact with the (much different) Supai Formation which lies upon it. The upper