

surface of the Redwall Limestone contains many ancient caves, water-carved gullies, blocky knolls, and small mesas up to 40 feet high. There are also ancient sinkholes with down-dipping strata surrounding them. All these are marks of erosion, weathering, and dissolution which normally take place in a limestone formation which is exposed to the atmosphere and rains for long periods of time. In fact, most of these same features are present in large areas of southern Indiana and Kentucky at the present time. They are due to the continuous dissolving and eroding of the limestone beds for thousands of years, as they are exposed to the weather, resulting in what is called "karst" topography. The upper surface of the Redwall Limestone is a typical karst surface. After these severe erosion and dissolution features were produced, the area was resubmerged and covered with the contrasting sediments of the Supai Formation.

The trail of movement of these contrasting sediments can now be traced down through the ancient channels where they settled and became lithified. Figure 27 shows some of these eroded cavities and channels which were later filled with contrasting sediments which became rock. Thus in many places streaks and pockets of mudstone, siltstone, and unsorted cave breccia are now found permeating the upper 100 or more feet of the Redwall Limestone. This is especially true in the eastern canyon region. In this area the eroded surface and the rock-filled caverns were later sealed over by at least 1,800 feet of additional sedimentary rock layers. These constitute the Supai, Hermit, Coconino, Toroweap, and Kaibab Formations.

One could of course not legitimately postulate that the channels and caves which we have been describing were formed as, or soon after, the sediments were being laid down. This is because any such sediment mass has to have stability due to lithification processes before a cave or channel could be formed in it. Otherwise, the sediments surrounding the cavity would immediately slump into and fill the opening. It is equally impossible to suppose that the cavities were formed recently, because the top surface of the Redwall Limestone is much too deeply buried for karst topography to develop on it. Also, after deep burial, there was no way for the mudstone and other filling in the channels and caves to have been moved into them.

As a final feature for which an understanding of carbonate rock characteristics is of value, we will cite the porous nature and very evident lack of compaction which exists in various parts of the Redwall Limestone. The presence of masses of delicate, but unbroken, fossils in several parts of the formation is one of the evidences of a lack of compaction.<sup>27</sup> Another is the presence of numerous fossilized algal mats, forming small bridges across cavities in the sediments on which they were growing. Other algal mats are found binding together certain masses of sediment into distinctive forms which have been preserved intact in the rock.<sup>28</sup> Thus it is evident that the long periods of time which are required for lithification of carbonate sediments transpired before any heavy weight of additional sediment was added above. Even the weight of a 300 foot high column of carbonate sediment 1 x 1 inches square is approximately