Surficial Breccias Produced from Chemical Weathering of Eocene Limestone in Haiti, West Indies

ROBERT R. SHROCK, Massachusetts Institute of Technology

A common surface feature in limestone areas where chemical weathering is unusually active is a veneer of angular fragments of the rock that is being attacked. Under favorable conditions, on slopes and in channels and crevices where waters saturated with soluble salts circulate, the fragmental material may be cemented sufficiently to form a rigid, sheetlike mass. In this manner, certain ancient formations composed of angular fragments and commonly referred to as breccias may well have been formed. The purpose of this brief article is to describe a case in which a surface veneer of angular fragments—a potential surficial breccia—is being produced by chemical weathering of limestone.

During the spring of 1945, while conducting geological exploration in the Republic of Haiti, West Indies, the writer had an unusual opportunity to observe how limestones respond to tropical weathering at an elevation of 1500 to 2000 meters.

Rains on the high plateau around Mt. La Selle, where chemical weathering is so active, are seasonal, with two periods of heavy precipitation alternating with two periods of lighter precipitation or none at all. Initial drainage is largely downward and laterally through the limestones until the flow reaches a major valley trenching the plateau. Here, along the steep slopes, the water issues as springs. The features discussd below are related to the geologic work performed by the waters while they are flowing through the surficial debris and the limestone beneath.

The limestone involved in the weathering is a remarkably pure, white, rather dense and fine-grained rock of Eocene age which typically shows quite thick beds with only a few prominent joints. Close examination of the rock, however, reveals myriads of closely spaced but tight incipient joints, both straight and curved, which are characteristically enlarged during the weathering. There are several distinct stages in the weathering process and these will now be discussed.

In the initial stage the limestone surface is attacked most noticeably along the many tight joints and takes on the appearance of a slightly etched mosaic (Fig. 1A). In addition to the etching along joints, intervening blocks of the mosaic often develop a fretted or corrugated surface.

The second stage is reached when solution along joints reaches deeply enough into the rock that individual joint-controlled blocks stand almost completely free from the rock mass as a whole. Early in this stage it is not uncommon for numerous eyelets, pipes, and round cavities to develop along the joints and late in the stage the rock exhibits a cavernous nature on a grand scale (Fig. 1A).

The third stage is marked by partial or complete disintegration of the rock into surficial rubble composed of angular fragments that

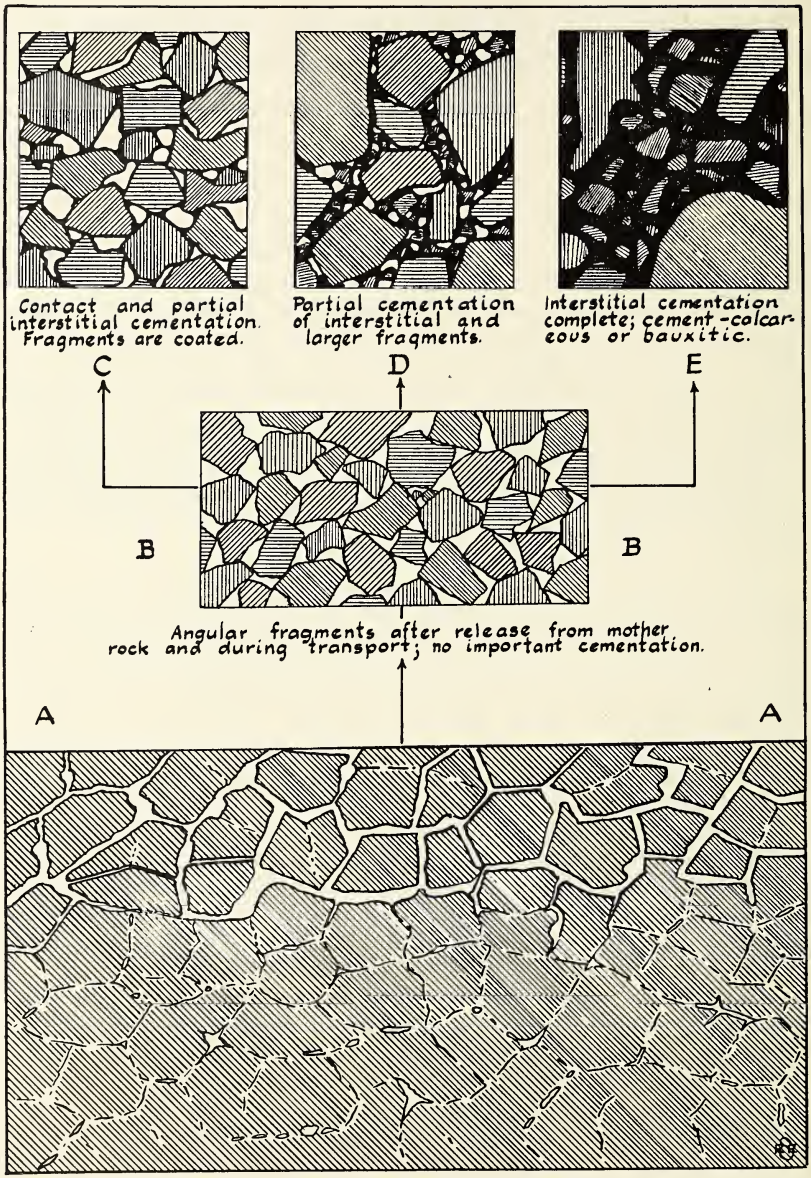

Fig. 1. Diagram showing how massive, incipiently jointed limestone is gradually disintegrated into polyhedral fragments with planar and curved surfaces. These angular fragments, after release from the mother rock, are transported down slopes mainly by sliding. When they come to temporary or permanent rest, circulating ground waters precipitate calcareous material in the interstices and cement the fragments into a rigid mass. Small fragments and residual soil may filter downward into the mass and fill a large portion of the interstitial space. In these cases also circulating ground waters may bring in calcareous matter and partially or completely cement the entire mass (D and E). These sketches are based on specimens and observations made in the field.

usually can be measured in inches. If the slopes are gentle, the rubble is almost certain to be cemented into a continuous layer before it moves far. If, on the other hand, the slope of the surface closely approaches or exceeds the angle of repose for the materials involved, the fragments may slide downward for considerable distances before coming to rest in a stable position. Then they too are likely to be cemented (Fig. 1A-B).

In the third stage the accumulation of angular fragments may develop either of two characteristic textures. In the simpler type, fragments of essentially uniform size are packed together loosely with maximum interstitial space. Such texture favors free and rapid circulation of ground water and since these waters are heavily charged with calcium carbonate, the fragments are quickly cemented together where they touch and are coated where their surfaces are not in contact. Continued deposition in the interstitial spaces ultimately produces a rock composed of angular fragments firmly cemented together by calcareous material which fills part or all of the interstices (Fig. 1C).

The more complex type of texture consists of a skeleton of large fragments, like those of the simpler type, with interstices filled by smaller angular fragments of several sizes which have sifted down through the larger interstitial openings. During subsequent cementation some of the smallest interstices are left unfilled whereas the larger are completely filled. The coating so commonly observed in the simpler type of texture is uncommon in the more complex type.

The fourth and last stage in the weathering process is that of extended or complete cementation. The resulting surficial crust or layer lacks any semblance of stratification and if incompletely cemented has the appearance of coarse concrete aggregate to which only a limited amount of fine aggregate and cement have been added for binding. The completely cemented rock breaks across fragment and cement alike and a surface has the appearance of a mosaic (Fig. 1E).

This general type of surficial breccia has not been recognized in any of the better known classifications of breccias[1], but the writer does not propose a term for it here pending further investigations.

During the weathering cycle just discussed, red residual earth, often with composition approaching that of bauxite, is left behind as the soluble limestone is dissolved. It may filter downward along with small limestone fragments into the enlarged joints of the country rock or into interstices of the surficial rubble and itself in conjunction with calcareous material act as a cement to bind the fragments into a rigid mass. Rock of this kind is not uncommon at various localities in Haiti and the writer has observed the same thing in Jamaica. In this type of breccia the white limestone fragments appear in some instances to float in the red bauxitic matrix. Woodring[2] has suggested *solution breccia*

[1] Bonney, T. G., On the relation of certain breccias to the physical geography of their age, Quart. J. Geol. Soc. London, **58**:185-206 (1902); Norton, W. H., A classification of breccias, J. Geol., **25**:160-194 (1917); Reynolds, S. H. Breccias, Geol. Mag., **65**:97-107 (1928); Twenhofel, W. H., *Treastise on Sedimentation*, 2nd edition, Williams and Wilkins, 1932, pp. 236-239.

[2] Woodring, W. P., et al., *Geology of the Republic of Haiti*, Dept. Public Works, Port-au-Prince, 1924, p. 109, 132, 134.

for the type here illustrated in figure 1E. In suggesting the designation he states (p. 109), "Cavities dissolved in the limestone are commonly refilled with soil and sediment that is recemented with calcareous material, producing a mass of rock that may aptly be termed solution breccia . . ."

Fragmental deposits of the type here described are probably not common in the geologic column because they are made where active solution is going on above the base level of erosion and are likely to be destroyed as the general terrane is reduced. Under abnormal geological conditions, however, as for example faulting, such a deposit might be buried and preserved. It would undoubtedly be designated some sort of limestone breccia but its origin might not be obvious. The characteristics of these unusual types of surficial breccia have, therefore, been considered worth recording so that they might be tested as a possible explanation of certain sedimentary breccias now preserved as rock in the geologic column.