GEOMORPHIC EFFECTS OF INDURATED VENEERS ON GRANITES IN THE SOUTHEASTERN STATES

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ABSTRACT

Indurated surficial veneers are a characteristic phenomenon on exposures of unjointed granite in the southeastern states. They are caused by deposition of iron oxides in the interstices between the partially disaggregated mineral grains of the "sap" rock at the surface of the exposure. Breaching of veneers produces such peculiar erosional forms as weather pits, cavernous boulders, and pedestal rocks.

INTRODUCTION

Indurated surficial veneers or case-hardening effects on granite exposures have long been known in arid regions. A. L. Anderson has described them in detail from the "Cassia City of Rocks" in Idaho, where they have had a manifest effect in determining topographic form; but they have passed virtually unnoticed in humid regions, such as the southeast. However, the Idaho veneers as described by Anderson seem to differ little from a surface-hardening phenomenon which the writer has observed quite commonly on granite exposures throughout the southeastern Piedmont. The southeastern veneers, as well as those in Idaho, appear as dark, hardened layers on the surfaces of unjointed granite exposures that are undergoing granular disintegration; and both seem to result from the deposition of iron oxides in the interstices between the partially disaggregated mineral grains.

ORIGIN OF VENEERS

Speaking of the origin of the Idaho veneers, Anderson says:

As the outer or near outer surface of the rock masses tend to become desiccated, capillary action draws water from the interior of the rocks and with them dissolved salts and colloids, and as this capillary water in turn evaporates at or near the surface it deposits its borne substances, thus cementing or closing the fractures in the rock and thereby strengthening the disintegrated rock by the process of case-hardening.

However, the presence of durable veneers in a humid climate such as that of the southeastern states fairly well eliminates the possibility of their having been formed by soluble materials. Studies of thin sections made from the southeastern veneers attest the general applicability of Anderson's theory of origin, but the writer believes that it is dominantly the presence of insoluble hematite in the deposited substances which enables the veneer to resist weathering more successfully than the underlying rock.

From its original source in primary iron-bearing minerals, such as hornblende or biotite, the iron would be released as a soluble ferrous compound which would readily be brought to the surface by capillary water. With evaporation of the water the iron would be deposited in an oxidizing environment and would change to the less soluble ferric form, becoming the weather-resistant cementing agent which rebuilds the par-


2 Ibid., p. 59.
tially disaggregated granite to make the indurated veneer.

Table 1 shows two chemical analyses, for which the writer is indebted to Dr. W. A. Reid, of the department of chemistry of the North Carolina State College of Agriculture and Engineering in Raleigh. These analyses were made from samples of an indurated veneer and the immediately underlying partially disaggregated granite. Both were obtained

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<td><strong>ANALYSIS OF VENEER AND UNDERLYING ROCK</strong></td>
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<td>SiO₂</td>
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<td>Fe₂O₃</td>
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from the outcrop shown in Figures 7 and 8.

Two such isolated analyses are admittedly inadequate as a basis for reasoning concerning the genesis of the veneer, but perhaps it will not be amiss to point out certain indicative relations between them. In general, it will be noted that the differences in the percentages of the several components are quite small. However, one would expect this because the principal difference between the veneer and the immediately underlying rock is the presence of the cementing material in the veneer. And the cement comprises only a very small percentage of the veneer, for the primary mineral grains have not been displaced mechan-ically and the intergranular openings into which the indurating material has been insinuated are exceedingly narrow.

For this reason, minor distinctions in composition may be significant, such as the 0.50 per cent difference between the 2.41 per cent ferric oxide in the veneer and the corresponding 1.91 per cent in the underlying partially disaggregated rock—a difference of 26 per cent in terms of total iron present in the latter. It will also be noted that calcium, although present in small amount, is likewise proportionately much more abundant in the veneer than in the underlying rock. On the other hand, the more soluble constituents, sodium and potassium, show significantly lower percentages in the veneer than in the underlying rock. Probably they have been alternately deposited during periods of desiccation and leached during wet periods.

Heretofore, veneers have been considered the product of an arid climate, but during a four-year period of field work throughout the southeast the writer has observed them on granite exposures in so many widely scattered localities that he is forced to regard them as a characteristic phenomenon of that humid region also. Perhaps the explanation of their presence in the southeast may be found in the fact that they most frequently occur on exposures which have few or no joints. Such exposures are not readily susceptible to the deep chemical weathering which produces the usual saprolitic surface mantle of the southeast. They resist such deep weathering because they do not have any available avenues for the ingress of surface water by percolation. The only available openings are capillary in size and are probably less frequently occupied by the absorption of surface water than by the rising of ground water to replace that
EFFECTS OF INDURATED VENEERS ON GRANITES

which evaporates from the sun-heated rock surface.

In this connection it is interesting to note that the unjointed granites of the southeast characteristically weather by granular disintegration, breaking down into a gruss indistinguishable from that which usually results from the weathering of granites in arid climates. Under arid conditions the rock weathers by granular disintegration because of the dearth of rainfall. Under humid conditions the rainfall, although plentiful, has no ready access to the interior of the rock because of the absence of joints.

Once the indurated layer has been established, it is self-perpetuating, growing at the bottom as erosion removes the surface. It is possible that the constant protective cover which it provides for the underlying sap rock may be a factor in determining the regular surfaces which these unjointed granite masses frequently assume. Certainly it is evident in the field that most irregularities in their surfaces occur where some special circumstance has enabled erosion to break through the veneer.

BREACHING OF VENEERS BY RUNNING WATER

In the southeast there are two common agencies which enable erosion to breach the veneer. Both of them expose the veneer in section and thus manifest its otherwise obscure presence. The more easily recognized one is the concentrated flow of surface water in the small drainageways on the surfaces of the exposures. Where such drainageways cut through the veneer, they usually undercut it by widening themselves in the softer underlying sap rock. Figure 1 shows a photograph of such a drainageway. It will be noted that the veneer has been breached and is prominently displayed as an overhanging lip where it has been undercut.

ORIGIN OF WEATHER PITS

Although the other breaching agency is less readily identified, the depressions which result from its activity are of very uniform character and have been described in the literature as "weather pits." They have been discussed in excellent detail by L. L. Smith and more

Fig. 2.—Small weather pits in granite, near Stone Mountain in Wilkes County, North Carolina.

Fig. 3.—Small weather pits; same locality as Fig. 2. The surface of the granite in the pits has been scraped clean of stain.
casually by F. E. Matthes and J. G. Lester. Lester and Matthes ascribe them to solution, and Smith observes a relationship between exfoliation spalls and the incipient stages of the pits, but none of these writers associates them with indurated veneers. Anderson describes similar depressions from the Cassia City of Rocks. He refers to them as "bathtubs" and properly associates them with indurated veneers, although he attributes their sculpture to running water.

Most of the weather pits which appear in unjointed granite masses throughout the southeastern states seem to have resulted from the breaching of indurated veneers, and it is the writer's opinion that most of this breaching has taken place through the agency of patches of moss or similar vegetation.

In the vicinity of Stone Mountain in Wilkes County, North Carolina, there are unjointed granite bosses which have many small weather pits, such as those shown in Figures 2 and 3. On the same outcrops there are many small circular patches of moss, which seem to be the agency that brings about the breaching of the veneer to make the weather pits.

If, as Anderson suggests, the veneer has been formed through the deposition of soluble mineral matter, it could readily be removed by any agency which enables the upward-moving capillary water to leave the surface of the rock in the liquid state. Because the moss usually remains somewhat moist and protects the rock surface beneath it from insolation, it is probable that the rising capillary water passes directly into it from the rock surface. The water thus enabled to pass through the veneer as a liquid should be able to remove in a short time the soluble mineral matter which previous evaporation would have taken a long time to deposit. Thus it would not seem incredible that the residence of a single moss patch should so weaken the protective veneer beneath it that, after removal of the moss, the rock would be subject to granular disintegration and therefore more vulnerable to erosion than the surrounding veneer-covered rock.

On the other hand, if, as the writer believes, the veneers have been formed largely by the deposition of insoluble iron oxides, the process of their removal would be somewhat similar but probably less rapid. The ferric oxide could not be removed by the water passing into the moss until it had first been acted upon by organic acids—either the humic or carbonic acids produced by the peaty material which characteristically underlies the moss or the carbonic acid produced by the living rootlets.

Fortunately, in the Wilkes County locality there are similarities in the shapes of the weather pits and the patches of moss which support the theory relating them. Many of the pits are of the

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6 P. 58 of itn. 1 (1931).
Fig. 5.—Dumbbell-shaped weather pit; same locality as Fig. 2

Fig. 6.—Dumbbell-shaped moss patch on granite outcrop; same locality as Fig. 2
type shown at the left in Figure 3, toward which the pick is pointed. They differ from the usual type in that they retain a patch of veneer in the center of a ring-shaped depression. Compare with these the moss patches of the type shown in Figure 4. Such ring-shaped moss patches, each with a bare spot in the center, suggest a genetic relation or by lateral growth and coalescence. However, in the example shown in Figure 5 these possibilities are minimized by the rather long, attenuated connecting passage between the two principal parts of the pit. The further possibility of a drainageway connecting these two pits is precluded by the fact that the line connecting them is normal to the slope.

Still further credence is lent to the relationship between the mosses and the pits by the fact that both occasionally occur in dumbbell-shaped forms. Such a pit is shown in Figure 5, and a similarly shaped moss patch is shown in Figure 6. Somewhat similar compound pits could, of course, be produced by partial superimposition of a young pit on an older one.

Because weather pits retain surface water longer than the general surface of the granite, there is a tendency for moss patches to localize in the bottoms of established pits. This leads to the development of younger pits in the bottoms of older ones. Such a compound pit may be seen adjacent to the drainageway in Figure 1.

All the weather pits illustrated in this paper are little more than incipient. However, the larger pits, such as those which occur on the “flat-rocks” of the lower Piedmont, show veneers in their

Fig. 7.—Residual granite boulder showing breached veneer, near Trap Hill, North Carolina
overhanging rims; and the writer believes they are a more mature development of such pits as those described here.

**ORIGIN OF PEDESTAL ROCKS**

Figure 7 shows a result of breaching the indurated veneer on the nearly verti-

cal side of a spheroidal granite outcrop. The reason for the breaching is not clear in this case; but quite possibly it was accomplished by spalling, since an exfoliation crack is visible adjacent to the opening. In other instances, where breaches appear near the bottoms of such spheroidal outcrops, they seem to have resulted from the exposure of unveneered surfaces by rapid erosion of surrounding soil. It is interesting to note in Figure 7 the tendency for the veneer to reform near the bottom of the breach at the center of the photograph. This new veneer has in turn been breached. It is not clear how the sap rock was removed from the breached area to make the deep re-entrant shown; but, because of the long protective overhang of the veneer, it is presumed that the material removed to form the arched cavity must have fallen by gravity after granular disintegration.

E. Blackwelder\(^7\) noted a relationship between hardened rock surfaces and cavernous openings in desert exposures, and J. J. Petty\(^8\) observed an iron-stained crust on pedestal rocks of the southeastern Piedmont but does not suggest that it might have any genetic connection with the peculiarities of their form. G. W. Crickmay,\(^9\) on the other hand, referring to Petty’s observation, states that surface hardening has not been a determining factor on the form of the granite pedestal rocks of the southeast. He prefers K. Bryan’s\(^10\) explanation, which accounts for the undercutting by the differential evaporation of rainwash, which is said to be more rapid upon the cap than on the shaft, thus causing greater hydration on the latter.

In the writer’s opinion the pedestal rocks are caused by the further operation of the same process which produces such breached boulders as that shown in


Figures 7 and 8. The indurated veneer can easily be seen on all the pedestal rocks he has observed, and their form seems to have resulted from the breach encircling the exposure.

Evidence for the influence of the veneer in determining the form of pedestal rocks may be found in the fact that it is usually more strongly developed on the southern side of the cap exposure than on the northern. The photograph in Figure 9, which was taken looking west, is typical. Because of the tendency for the underlying rock to disaggregate and fall away, leaving such overhanging lips of veneer as that pictured in Figure 8, it is possible that veneers have frequently been mistaken for exfoliation spalls.