Letters

Stone Artifacts: Identification Problems

Ascher and Ascher's perceptive reasoning ("Recognizing the emergence of man," 15 Jan., p. 243) and research techniques for discriminating between stone artifacts and similar objects shaped by natural processes bode well for the understanding of man's clouded history. In keeping with the Aschers' observation that "an ideal characterization . . . must go beyond the single characteristic . . . and include a balanced variety of factors," I offer a few comments on geological matters pertinent to their kind of research.

Many of the simultaneously interacting geological, biological, chemical, and physical factors which figure in ordinary weathering and erosion have profound bearing on the conclusions attainable from the Aschers' and similar research. Indeed, the shape (whether natural or man-made) of fractured gravel pebbles, as recorded in part by the Aschers' angle measurements, would depend largely upon their composition, texture, internal structures, age, and origin. For example, uniform-textured granites have a very different way of fracturing from that of schistose or gneissic rocks of similar composition. The Aschers report that the Leupp (Arizona) pebbles and cobbles which they studied are "predominantly chert"; but they do not say whether they also measured rocks of different composition. Typically, chert is a fairly uniform cryptocrystalline and microcrystalline rock which fractures conchoidally. Thus, it is not surprising that the Aschers found that a large number of their specimens possessed "no measurable angles."

The derivation of the chert pebbles would also have to be considered in evaluating their shape. For example, if they are abraded lag gravels, derived originally from bedded cherts, they might be expected to fracture otherwise than concretionary or nodular cherts. Moreover, if several kinds of chert, formed at different times or under different geological conditions, are combined in the Leupp deposit, each kind could be expected to fracture differently. Thus, the Aschers' statistical evaluation of the measured angles can have little significance until the compositional and textural uniformity of the pebbles, and a variety of other relevant geological factors, are well evaluated.

Likewise, their mention of various agents of rock fracturing such as glacial ice, moving soils, or herds of animals conveys little of significance unless something is known of the kinds of rocks involved. Few hard, texturally uniform rocks of the kinds best suited for shaping into implements could be expected to fracture in moving soil or under the hooves of animals. Rather, such rocks would at best fracture along established planes or zones of weakness, such as veins or laminations, depending to some degree on the other kinds of rocks or sediments that they come in contact with.

Warren's old rock-fracturing apparatus (depicted in the Aschers' Fig. 1) does, as the Aschers state, "require careful evaluation," for it fails by a very wide margin to simulate shear conditions in glaciers. Experimental models actually using ice would be much better. For one thing, the rigid fixation of the pebbles in the Warren apparatus is quite different from the fixation of pebbles in mobile glacial ice, which, as it flows over bedrock, behaves rather plastically. Moreover, the apparatus does not simulate the different conditions of shear that prevail at the same time in a glacier's zone of flowage and in its zone of fracture. From Riecke's principle and the distinctive regelation phenomenon, which involve relations between pressures and freezing points of water, it is known how pebbles embedded in slowly moving ice can be moved within the ice, without fracturing, when subjected to the directive stresses that develop when ice flow carries them against relatively immobile objects. Indeed, the stresses required to fracture rocks are usually much greater than those required for regelation of ice. Moreover, abrasive rounding, not fracturing, of pebbles is generally the rule in glacial deposits.

In 1936, D. T. Griggs [*J. Geol.* **44**, 783 (1936)] failed to disrupt, exfoliate, or even dull the surface of a polished granite which he subjected to repeated temperature changes far more abrupt and extreme than in the harshest deserts. This and other geologic experience has shown that temperature changes alone are insufficient to explain exfoliation and related rock fracturing. Geochemical factors involving hydration and dehydration, and microorganisms, also play an important role. In this connection it would be useful to know the composition of the Leupp pebbles, because the amounts of opaline (hydrated) silica that they contain are bound to affect their resistance or response to fracturing. In all, the Aschers' implication that temperature changes due to "desert atmospheric phenomena probably produce enough stress to account for some natural fracture" is surely an oversimplification.

They rightly point out, however, that "fracture in nature may occur over a long time span." In other words, a few fractures per year over a long period of time could account for the presence of many fractured pebbles in a single deposit. But this very fact tends to detract from the significance that the Aschers attach to the present desert climate for pebble fracturing, because it is certain that the climate of northern Arizona must have varied over the past few thousands of years, especially during the glacial episodes of the Pleistocene.

These observations are but a sample of many that would be relevant to the Aschers' kind of research. They have ably shown the way; and as their research method is extended, skillful use of precise geologic information is bound to further the interpretation of early human history.

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It seems to me that the Aschers' procedure for identifying certain fractured stones as early man-made tools depends, unfortunately, upon circular reasoning. Both the smaller mean angle of fracture of their "industry" stones and the skew of the distribution toward smallness of angle (their Fig. 6)

are artifacts of the process by which they selected "industry" stones from the "environment" population, since the principal criterion of selection was smallness of angle.

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1) We are pleased that our article interested geologists in the problem of recognizing the traces of early man. The two geologists who visited the Leupp Site told us that we were dealing with a uniform brown chert and that there was no reason to believe that the Leupp Site differed in its geological history from other hilltops in the area. Not satisfied with this information, or with what we could find in the geological literature, we investigated further. Our simultaneous measurement of *in situ* rock and ambient temperatures was meant to be suggestive. That the investigation was meant in this way can be seen in the brief and cautious statement about it. We also did a hydration study, not reported in the article. Ideally, all causes of natural fracture relevant to a suspected site should be considered. The problem is to identify the relevant factors and to determine specifically the type and amount of resulting fracture. The intense cooperation of geologists would be most welcome.

2) We direct South's attention to our summary statement on page 247: "The procedure is intended to be used where isolation of an 'industry' has already been made, or can be made, on the basis of criteria other than the small angles of the stones in question." In our application of the procedure, a museum collection of a proposed "industry" already existed. The several collectors of the museum specimens had gathered widely scattered individual stones each of which met some typological notion of utility. These stones were classified by them into such categories as "scrapers," "hand axes," and "choppers" (see our reference *13*). We sampled the entire population of a gravel pavement on a hilltop where the proposed "industry" was said to exist. Then, using the museum-type specimens, we designated any stone in our field collection as belonging to the "industry" if it fitted into one of the typological categories (see p. 247). The original collectors of the "industry" did not collect angles of an "industry" (a population, not a typological concept), nor did we.

We stress our acceptance of Barnes's work as a point of departure. Barnes interpreted his findings as globally significant; that is, his work led to the conclusion that on a statistical basis nature does not simulate human workmanship. In some particular instance, however, the context in which an "industry" is said to exist may be biased. For this reason, we introduced the idea of examining the immediate context in which the industry is said to be found. Figure 6 shows the "industry" and its "environment" at Leupp.

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Academic Degrees and Vested Interests

Thanks to John Walsh for his excellent treatment (News and Comment, 19 Feb., p. 844) of the potential intrusion of quasi-educational federal agencies into the academic preserve of degree-granting. Since he has done this spadework, I wish he would now enlarge the radius of his investigations to determine how many of the rules surrounding earned degrees are truly safeguards against diploma mills and substandard education, and how many are protection of academic vested interests which date back to the medieval universities.

We have all heard of absurd cases —perhaps apochryphal in detail but true in fundamentals—where the validity of graduate credits has been questioned because the student's high school or undergraduate records were faulty in some minor particular. Does it really matter by what path—conventional or unconventional—an educated man or woman attains educational status? Is there not a need for some sort of examining university, performing a function like that of the original University of London? Is there any reason why a candidate should not appear before a panel of competent examiners, demonstrate his grasp of the fundamentals in his field, present already published and paid-for scholarly work in lieu of a problematically valuable thesis, and get his degree without anybody's knowing or caring whether he ever warmed a seat in the eighth grade?

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