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SOME ASPECTS OF GEOLOGY AS A SERVICE TO THE PUBLIC

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The Geology Department of the University of Arkansas performs a little known, rarely publicized service to the public. This service consists of (a) the identification of rocks, minerals, fossils, and man-made substances sent to the Department and (b) the distribution of boxes of rock samples from Arkansas to primary and secondary school students working on earth science projects. The boxes are prepared by members of the local chapter, Alpha Psi, of Sigma Gamma Epsilon, an honorary scientific society devoted to earth science. About two dozen boxes are requested annually by students from all sections of the United States and are provided free of charge.

During the two-year period, 1958-60, the writer examined samples of rocks, minerals, and man-made substances submitted by 23 Arkansas residents. There were nine rock samples which included varieties of carbonate rock, shale, siltstone, and sandstone. Twenty-six mineral samples were submitted representing 16 mineral species which included: calcite, chalcopyrite, dolomite, galena, garnet, goethite, hematite, hemimorphite, limonite, marcasite, psilomelane, pyrite, quartz (including chert), selenite, smithsonite, and sphalerite. Man-made substances included fragments of bottle glass and furnace products of silicate, carbide, or metal alloy composition.

Two of the samples merit special consideration because of their unusual character and the length of time required to establish their identity and origin. One of the samples consists of alluvial material collected from deposits along the Saline River near Poyen, Arkansas. The other sample, a curious white ball, was discovered in the vicinity of Searcy, Arkansas.

The sender of the alluvial sample reported that it was collected from roadbase material used in the construction of a lumber road along the Saline River. The sender wished to learn why the alluvium never produced ruts in the road during and after rainfall.

The distribution of mineral and rock fragments in the alluvium presumably is responsible for the inability to form ruts after soaking, and a routine size analysis therefore was made on the sample by means of graduated sieves. The weighed sieve fractions (Table I) produced a nearly linear cumulative curve (Fig. 1, Curve I). Subsequent binocular examination of each of the 14 sieve fractions revealed that a portion of every fraction was composed of small, round, cohesive aggregates of particles. Each particle must have been smaller than the sieve opening which retained the fraction. One type of aggregate consisted of small particles attached to a larger grain or grains. These grains ranged from sand through pebble sizes. Another type of aggregate consisted of uniformly small particles without a nucleus of larger grains.

In order to obtain an accurate measure of size distribution, disaggregation of the sample was necessary. N/67 sodium oxalate was employed as the disaggregating agent (1). The silt-clay portion of the treated sample was separated from the coarser material by means of settling velocities based on the application of Stoke's formula (4). The coarser portion of the sample was dried and resieved. The cumulative curve (Fig. 1, Curve II) representing the weighed fractions of the entire disaggregated or treated sample is markedly displaced from the untreated sample (Fig. 1, Curve I) and is also rather linear.

The sieve analyses of the sample before and after disaggregation are presented in Tables I and II. Table IV indicates the extent of weight loss from each fraction after disaggregation, except in the silt-clay fractions (<0.062 mm) where a striking weight gain is recorded. This gain can be explained only by the addition of the small disaggregated particles. In all fractions coarser than silt, the aggregated portion of each must have been composed of silt-clay particles. Figure 2 is a graphic plot of the degree of aggregation, expressed as a ratio, against the sieve opening for each fraction. In general, the sand sizes show a higher degree of aggregation than do other sizes.

A comparison of statistical parameters for the frequency distribution of particle sizes in the untreated sample and the same sample after disaggregation (Curves I and II respectively of Fig. 1) indicates the effect of aggregation on the alluvial material. The calculated frequency distributions, based upon quartile measurements, are presented in Table III. One aspect of aggregation is indicated by an apparent median size 17 times larger than the median size of the treated alluvium. Another aspect of aggregation is manifest in an apparent 2-fold increase in the sorting index of the treated sample over the untreated sample. In other words, aggregation of the silt-clay particles makes the alluvium appear to be better sorted than it is in reality.

Consideration of the weight percentages of the sample show it is composed of subequal amounts of sand, silt, and clay. One-tenth of the sample, approximately, is represented by granule-pebble sizes. Such a broad size distribution coupled

TABLE I

SIEVE ANALYSIS OF THE INITIAL UNTREATED SAMPLE

Sieve opening in mm.	Wt. in gm.	Wt. percent	Cumulative wt. percent
3.36	50.20	19.02	19.02
2.38	15.52	5.90	24.92
1.68	12.90	4.91	29.83
1.19	15.59	5.92	35.75
.84	13.39	5.08	40.83
.59	17.02	6.46	47.29
.42	17.15	6.51	53.80
.297	16.91	6.42	60.22
.21	14.47	5.49	65.71
.15	13.18	5.01	70.72
.105	11.14	4.23	74.95
.062	17.42	6.62	81.57
< .062	48.96	18.43	100.00
	263.85	100.00	

TABLE II

SIEVE ANALYSIS OF THE DISAGGREGATED SAMPLE

Sieve opening in mm.	Wt. in gm.	Wt. percent	Cumulative wt. percent
3.36	29.66	11.48	11.48
2.38	7.21	2.79	14.27
1.68	5.18	2.00	16.27
1.19	5.18	2.00	18.27
.84	4.23	1.64	19.91
.59	5.61	2.17	22.08
.42	9.30	3.60	25.68
.297	10.38	4.02	29.70
.21	9.25	3.58	33.28
.15	9.35	3.62	36.90
.105	9.13	3.53	40.43
.062	8.73	3.38	43.81
.004	75.46	29.17	72.98
< .004	69.80	27.02	100.00
	258.47	100.00	

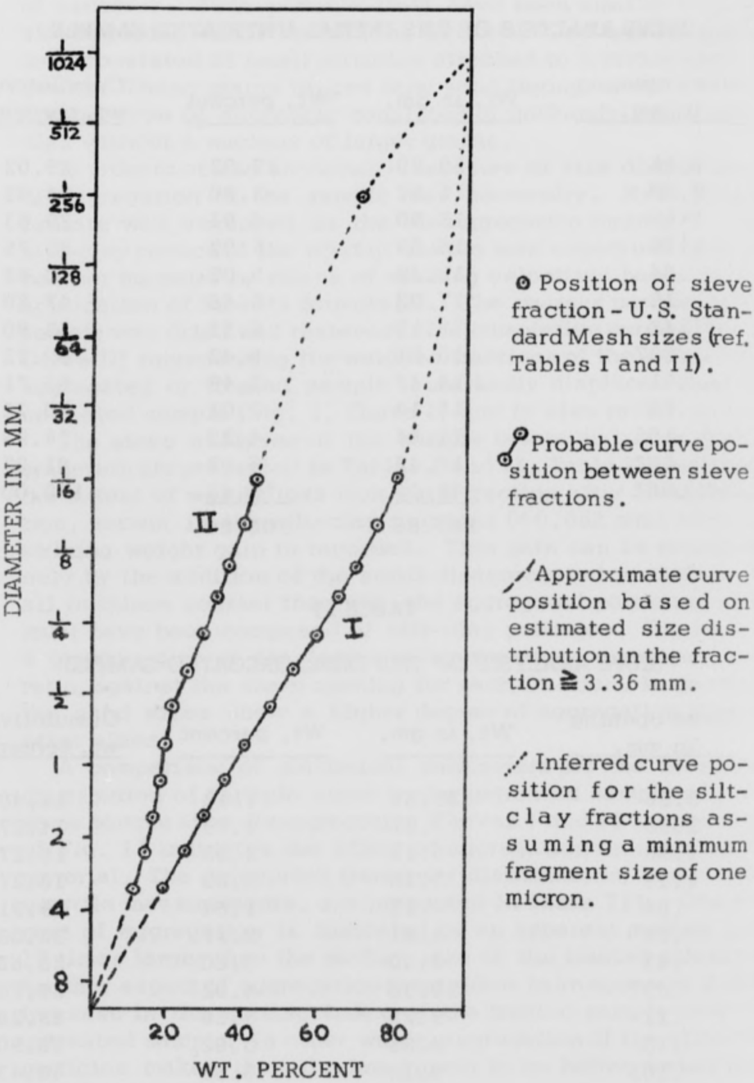

Figure 1. Cumulative Curves of the original (I) and the disaggregated (II) alluvial sample from the Saline River near Poyen, Arkansas.

TABLE III

Parameter	Name	Calc. Value for Curves I	II
Aver. size	Median	0.5 mm	0.03 mm
Sorting	Coeff. of sorting	4.75	10.72
Symmetry	Skewness	1.00	2.00
	($\log_{10}$Sk)	0	0.30
Peakedness	Kurtosis	0.38	0.06

with the relatively small amount of clay (ref. Table II) can account for the lack of cohesiveness in the alluvium after wetting and, therefore, for its avility to form ruts.

If the sample is representative of the Saline River alluvium near Poyen, Arkansas, then why does the alluvium contain aggregated particles? In lieu of actual geological reconnaissance of the area, a possible reason is suggested by the composition of the river water. One analysis* available to the writer is as follows:

Component	mg/liter
Dissolved solids	90
Chloride	3
Hardness	54
Alkalinity	135

The alkalinity value shown by the analysis suggests an alkaline water (L. E. Porter, personal communication) and a possible tendency toward flocculation, especially with respect to calcium salts (3). Silts and most insoluble particles of less than 20 microns diameter (except for clay minerals), are flocculated most readily by calcium salts in water whose pH

*John M. Little, collector and analyst. The water sample was taken about 15 miles upstream from Poyen, near Benton, Arkansas.

is at or close to 7(1). Such a chemical environment could be aggregation of silt-clay particles as was observed in the untreated sample.

TABLE IV

Sieve opening in mm	Wt. loss (-) or gain ( ) in gm	Aggregation Ratio*
3.36	- 20.54	1/2.4
2.38	- 8.31	1/1.9
1.68	- 7.72	1/1.7
1.19	- 10.41	1/1.5
.84	- 9.16	1/1.5
.59	- 11.41	1/1.5
.42	- 7.85	1/2.2
.297	- 6.53	1/2.6
.21	- 5.22	1/2.8
.15	- 3.83	1/3.4
.105	- 2.01	1/5.5
.062	- 8.69	1/2.0
<.062	+ 96.30	1/0.5

*The ratio of the weight of the disaggregated portion, expressed as unity, to the weight of the untreated sample.

The curious white ball from Searcy, Arkansas, allegedly was discovered in a large rock, implying therefore that it is a naturally occurring substance. Laboratory studies of the ball, however, offer conclusive evidence that it is artificial or man-made in origin. Consider the following facts:

1. Dimensions of the ball in mm: 24.1 x 22.3 x 22.2
2. Habit: spherical, with spherical laminations, and peppered with tiny bubbles.
3. Color: snow white
4. Weight in gm of the ball: 29.15
5. Specific gravity: 3.65
6. Hardness (Moh's scale): 9
7. Wadell sphericity index: 0.95

These facts rule out the more common minerals. The surface of the ball is rather smooth and irregularly abraded. Certain artificial substances might fit this description.

Petrographic examination of ground fragments from the ball

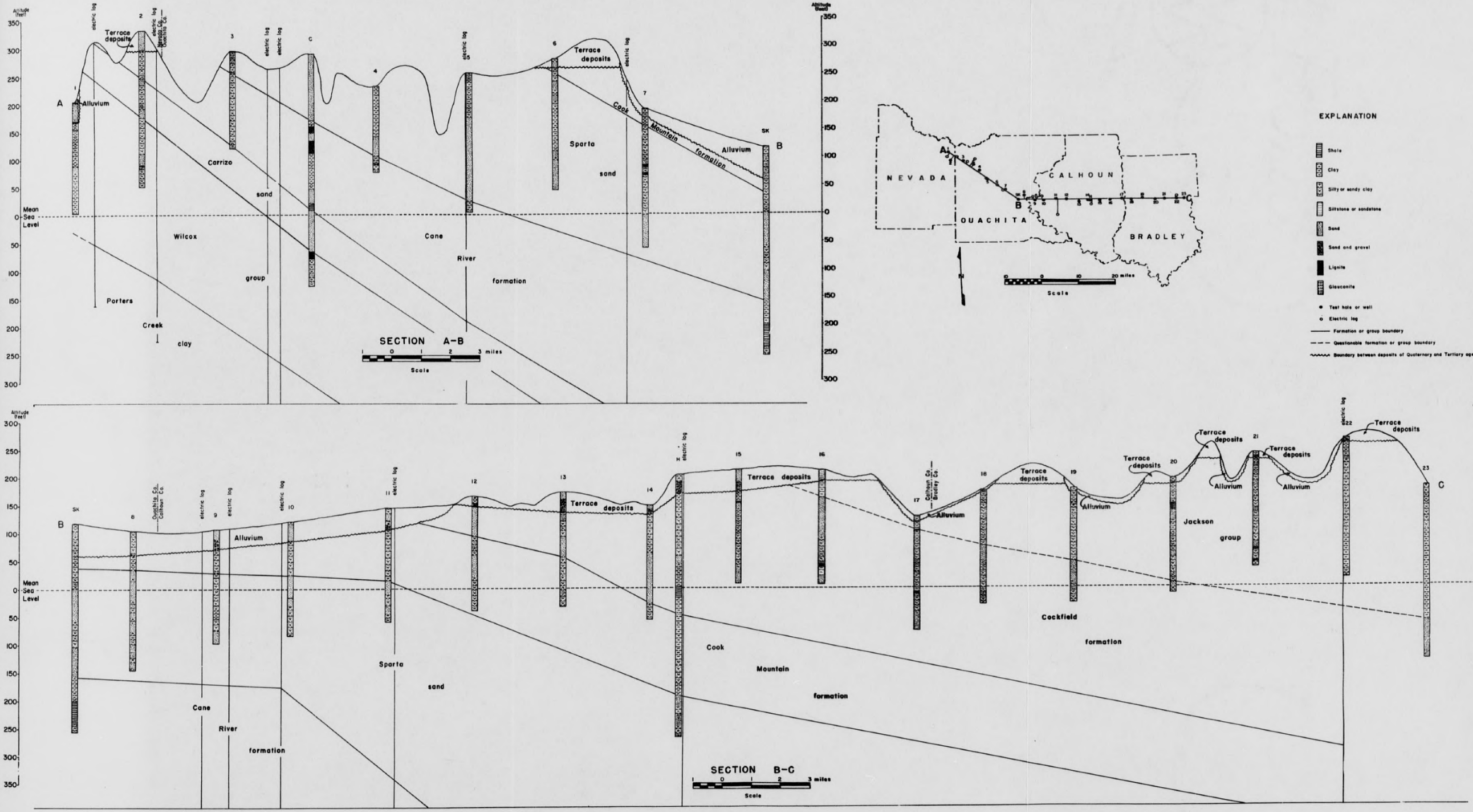

Figure 2.--Geologic sections from Nevada to Bradley Counties, Arkansas.

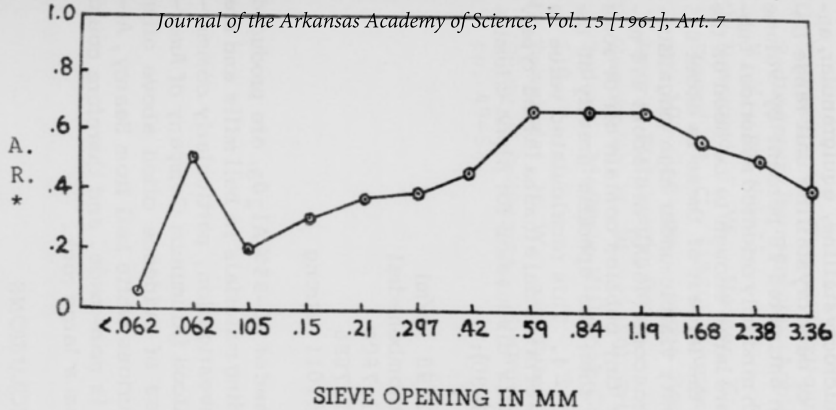

Figure 2. Graphic plot of the degree of aggregation of the sieved fractions from the sample of Saline River alluvium.

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*A.R. The aggregation ratio of Table IV plotted as a decimal fraction. Increasing decimal values are proportional to the degree of aggregation.

provided some additional data:

1. Birefringence: low, first order gray to white
2. Uniaxial negative
3. Epsilon: slightly less than 1.76
4. Omega: slightly greater than 1.76
5. Dispersion: strong

The fragments appear as a microcrystalline, equigranular, anhedral mosaic. Dimensions of each crystalline unit range between 0.17 and 0.7 mm. An estimated 10 percent by volume of each unit is peppered with randomly oriented spherical bubbles. Many of the bubbles are large enough to be seen on the ball without magnification; the largest of these is about 0.5 mm in diameter. The smallest, visible under high magnification of the petrographic microscope (450X), are about 1.8 microns in diameter. If these tiny bubbles contain air or some gas of comparable density, then the specific gravity of the ball can be recalculated to ±4. This recalculated value is similar to the specific gravity of artificial alumina (alpha type).

Some data pertinent to this discussion for alpha-alumina is as follows (2, pp. 10, 29-30):

1.	Density	3.98 g/ml
2.	Crystallography	rhombohedral
3.	Epsilon	1.7604
4.	Omega	1.7686
5.	Dispersion	0.011 strong

Alpha-alumina balls, composed of 80-95% Al_2O_3, are produced for use as high density grinding materials in ball mills and are similar to the ball under investigation, particularly commercial type, T-164, made by Alcoa (Aluminum Company of America). The comparative lines of evidence cited above offer strong assurance that the curious white ball from Searcy, Arkansas, is an alumina ball, is man-made, and therefore could not have been recovered from a large rock.

CONCLUSIONS

Although the majority of rocks and minerals sent to the Geology department are readily identifiable, some are not and require additional study. This is especially true of man-made substances. Two examples, a natural alluvium and a man-made alumina ball, were presented herein to show a few of the various methods of study employed in the identification of some problematical substances. A necessary consideration given to all peculiar looking substances must be a decision as to a natural or a man-made origin. Such a rudimentary decision can avoid unnecessary delay and misleading interpretations in the ultimate identification processes.

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