ART. XXI.—*Notes on the Composition of Certain "Pliocene Sandstones" from Montana and Idaho*; by GEORGE P. MERRILL.

A YEAR or more ago, while attempting to classify and arrange the rocks of the collections made in Montana and Idaho in 1871 by Dr. A. C. Peale of the Hayden Survey, my attention was called to a series of fragmental rocks from Little Sage Creek; Beaver Head Cañon, Devil's Pathway, Marsh Creek Valley and Port Neuf Cañon, which were labeled as "Pliocene" sandstones. A single glance showed me that these could not be ordinary sandstones, but that they bore a striking resemblance to compacted volcanic dust and sand. A glance at a portion of the dust rubbed from the specimen with the thumb and finger and placed under the microscope was sufficient to confirm my first conclusions, and to show that the stones consisted very largely of minute flakes of pumiceous glass sufficiently compacted to be readily broken out into hand specimens, but yet so friable that in most cases they could be easily disintegrated by the thumb and fingers. On mentioning the fact to Dr. Peale, this gentleman expressed great interest in the matter, and requested that I make a further examination and put my results upon record for purpose of future reference. This I have accordingly done below.

Little Sage Creek, Montana.—Three varieties of the sandstone were found from this locality, one (35890a)* a fine-grained, light gray and rather friable rock, quite homogeneous, and with a sharp gritty feel, agreeing closely in appearance with a pumiceous elastic rock from Citadel Cliff, East Fork of Holmes Creek, collected by the 40th parallel survey. Portions of the dust rubbed off and placed under the microscope showed it to consist wholly of a very light smoky brown, completely amorphous, glass, with the sharp angles and peculiar curved sides so characteristic of pumiceous glasses when in a finely divided state (fig. 1).† Between crossed nicols there is seen rarely a polariz-

* The numbers given refer to the catalogue number of the specimen in the Museum collection.

† Other figures showing the appearance of volcanic dust as seen under the microscope are given in the following papers: On Volcanic Ashes and Cosmic Dust, *Nature*, April 17th, 1884; Volcanic Sand which fell at Unalashka, October 20th, 1883, *Science*, May 30th, 1884; and on Volcanic Dust from Southeastern Nebraska, *Proc. Nat. Mus.*, vol. viii, 1885, p. 99.

ing fragment, and there are also present a few particles of earthy matter.

A second variety (35890*b*) is coarser, has a marly appearance, and effervesces slightly under dilute acid, showing the presence of calcite. The microscope shows but few particles of pure glass, but very many that resemble the pulverized amorphous groundmass of modern lavas. There are also a few crystalline particles too small for accurate determination, but which are probably feldspar, and other greenish dichroic ones apparently hornblende.

A third variety (35890*c*) from this same locality is of slightly coarser texture than either of the last, of a light gray color and distinctly laminated. It contains a very considerable proportion of crystalline calcite which evidently serves as a cement. Fragments of the stone after treatment with dilute hydrochloric acid to remove the calcite are found to consist largely of colorless pumice dust, a few cleavage fragments of feldspar, folia of deep greenish brown mica, and a few earthy and ferruginous particles.

Still a fourth variety (35890*d*) is yet coarser and much firmer in texture, of a light buff color, and appears much like an ordinary fine-grained siliceous sandstone. Under the microscope the individual particles are found to be both quartzose and feldspathic (judging only from appearances, no measurements being possible), with comparatively few flakes of pumice dust. All are much eroded, and have evidently been subjected to attrition by moving waters more than any of the others from this locality.

Beaver Head Cañon.—We have but a single specimen from this locality and this (35891) like the last mentioned, except slightly coarser and with minute flakes of black mica. Under the microscope a few polarizing particles are seen but they are too small for accurate determination. The glass particles are small but stout, and lack the sharp angles noted in the other varieties. They are considerably water-worn.

Devil's Pathway.—But two samples were received from this locality. The first of these (35893*a*) is fine-grained, and light ash color like the finer varieties from Little Sage Creek and Marsh Creek Valley. Like them too it is composed entirely of pumice glass, but of a peculiar appearance such as I have never before seen, nor do I remember to have seen it described. Each fragment, however small, appears, under a power of 105 diameters, to bear upon its surface several or many minute disc-like bodies, colorless and nearly circular in outline. Under a power of 420 diameters these are seen not to be in all cases perfectly circular in outline, but several often coalesce forming continuous chains of irregular form, such as are nicely shown

in the accompanying figures (fig. 2) from Mr. Ridgeway's drawing. I can think of nothing with which they compare in appearance more nearly than that of lunar landscapes, as illustrated in works on popular astronomy.

The second variety from this locality (35893b) is a fine-grained, compact, dark brownish gray rock, bearing little resemblance to the others described. It is not at all friable but effervesces readily with acid. Fragments after treatment with acid till they no longer give off bubbles fall readily to a powder, which the microscope shows to consist almost wholly of quite large pumice fragments, sometimes colorless but often stained a bright yellow by ferruginous matter. A few crystalline particles are present but so stained as to be unrecognizable. The glass in this sample shows no trace of the peculiar disc-like bodies noted on the last.

Marsh Creek Valley, Idaho.—Of the four samples from this locality the first two (35889a) like 35890a from Little Sage Creek, are nearly pure pumice dust, but the particles have suffered more from attrition, and are so filled with minute cavities as to have a dirty appearance under the microscope. The rock is ash-gray and has a sharp gritty feel.

The second (35889b) is much firmer in texture, laminated, slightly coarser and contains black particles. Its composition is, however, practically the same with the addition of a little calcite which serves as a cement. The rock effervesces readily under dilute acid, and the residue is all glass with no crystalline particles whatever.

The fourth specimen (35889c), although coarser and of a brownish color, is also largely pumice dust, but the particles are quite dirty-appearing under a low power, an appearance which a power of 420 diameters shows to be due to their rough, almost granular surfaces. There is but little calcite present.

Port Neuf Cañon.—The two specimens (35892) from this locality compare closely macroscopically with the finer varieties from Little Sage Creek and Marsh Creek Valley. Like them too they are composed wholly of minute fragments of pumice (fig. 3).

These last, like some of the others mentioned, contain evidently two kinds of pumice dust. The one occurs in colorless shreds with curved outlines, which rarely contain tubes or steam

cavities even in the larger forms. The other, however small the fragments may be, is always pumiceous through the presence of innumerable bubbles and tube-like cavities; a slight difference in viscosity of the original magmas having evidently caused one to become coarsely vesicular, which on breaking up through the sudden explosion of the included steam gives rise to fragments each one of which represents a portion of the partition between the cavities or vesicles, while the other, through being more finely pumiceous, gives fragments each one of which, however small, still shows its true pumiceous character. These facts are not indicative of any difference in chemical composition, but as one or the other of the forms is usually found to prevail in samples from various localities the matter seems worthy of note.

All of the above mentioned dusts yielded water when heated in a closed tube, and fused readily, with swelling, before the blowpipe. Samples submitted to Mr. J. E. Whitfield of the Geological Survey for analysis yielded results as follows:

	(35889a)	(35890a)	(35893a)
Ignition	6.00	6.50	5.60
Water*	1.60	1.12	3.46
$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	16.22	18.24†	17.18
SiO_2	68.92	65.56	65.76
CaO	1.62	2.58	2.30
MgO	trace.	0.72	trace.
Na_2O	1.56	2.08	2.22
K_2O	4.00	3.94	3.14
	<hr/> 99.92	<hr/> 100.74	<hr/> 99.66

Accepting the apparently well founded conclusions of others ‡ to the effect that such dusts represent the extreme degrees of acidity of the lavas of which they formed a part, we are led to consider these as of andesitic or possibly trachytic derivation.

Samples, subsequently submitted by Dr. Peale from above Pass and Bridger Creeks near Bozeman, have also been examined.

The first of these (38448), marked as "Dry Creek Pliocene," is a fine-grained friable aggregate of a light yellowish gray color. Tested with acid it was found to contain a little lime, but consists chiefly of glass particles very pumiceous and stained by iron oxides.

* Water given off at 105° C.

† Mostly FeO . Mr. Whitfield appends the following note: These analyses not checked by duplicates, there being but a small amount of material, therefore the iron is put down as *ferric* when most of it is *ferrous*. The ignition, therefore, is not as high as it should be by reason of the oxidation of the FeO to Fe_2O_3 , but is partly balanced by entering the iron as Fe_2O_3 .

‡ See Science, May 30, 1884.

A second variety (38447) from the south side of Bridger Creek, on summit of hill near Bozeman, is like the last but somewhat coarser, and contains also a few colorless polarizing fragments and particles of hornblende. A variety (38450) from the "upper beds," south side of the creek, is of a brown-gray color like that of Dry Creek. It is composed almost wholly of very pumiceous glass like fig. 3. Still a fourth sample (38449), from a bed just below the last is gray in color and much coarser, the fragments being in some cases 0.74^{mm} in greatest diameter. It contains also a few polarizing grains.

Small particles of pumice glass were also found in connection with sundry fossil bones from the Niobrara, Loup Fork and Sweetwater regions. These bones had been quite thoroughly cleansed and handled over many times so that very little of the material in which they had originally been imbedded remained. Nevertheless by carefully picking between the teeth, in cavities and protected places, sufficient material was obtained for microscopic examination which resulted as noted.

While working upon the above, several other instances of the occurrence of this dust came to my notice which perhaps may be of sufficient interest to mention here. One of them sent by a friend in Phoenix, Arizona, is of a white and gray color sufficiently compacted to be cut in blocks of considerable size, and is stated to have been used to some extent for building purposes. It is stated to occur in "blankets" from three to fifteen feet thick, more or less tilted, and cropping out near the base of the Mazatzol Mountains at the edge of Verde River valley. The microscope shows this to be composed of pumice fragments of about 0.25^{mm} greatest diameter, and apparently identical with that described by myself from Southwestern Nebraska* (see fig. 3b), and quite similar to that from east of the Black Hills, Dakota, described by Dr. Wadsworth in *Science* of July 24, 1885, a sample of which he has been kind enough to send me.

About this same time Mr. R. T. Hill, of the Geological Survey, brought me a sample of similar dust which he had collected from near Wray Station (B. & L. R. R.) in Eastern Colorado, on the south side of the Republican River (38430), and a few days later others were brought in by Dr. Peale

* *Proc. Nat. Mus.*, vol. viii, p. 99.

which had been received from Norton (38439) and Phillips (38446) Counties, Kansas. All were pure glass in particles never over 0.3^{mm} in greatest diameter and usually much smaller. They agree closely with those just mentioned, and also with that lately mentioned by Mr. Todd* as occurring in Eastern Nebraska.

In studying the probable origin or sources of these various beds, the distances which the dust can be carried by atmospheric currents is likely to prove of importance. It may therefore not be out of place to state here, that among a collection of pumices, ashes, etc., from the Krakatoa eruption in 1883, and which were donated to the Museum by T. H. Houghton, was a small sample of the dust (36974) that "showered on board ship Beaconsfield at the rate of one inch per hour for three days, in latitude 14° S., longitude 92° E., or at a distance of 855 miles from the scene" of volcanic activity. This dust is a very pure, nearly colorless, gray and highly pumiceous glass, the particles of which vary in size all the way up to 0.25^{mm}.

As a matter of economic interest I may say in conclusion that in Kansas and Nebraska these dusts are collected and sold in paper packages as "diamond polishing powder," or put into soap which is sold for general scouring as well as for dental use under the name of "Geyserite" soap.

National Museum, Washington, April 30th, 1886.