55.1.781(78)

Article XVI.— PETROGRAPHIC ANALYSIS OF THE BRIDGER, WASHAKIE, AND OTHER EOCENE FORMATIONS OF THE ROCKY MOUNTAINS.

By Albert Johannsen.

With Introductory Note by W. D. Matthew.

Introductory Note.

During the last few years we have come to a much better appreciation of the source and method of deposition of the Tertiary formations of the western interior region.

A clear and correct understanding of the nature of these strata is of fundamental importance in paleontology, because the physical and geographic conditions under which they were formed constituted the environment of the mammalian life of the western Tertiary as we know it. So far as the environment conditioned the evolution of our tertiary mammals, a correct interpretation of the stratigraphic record is a necessary prerequisite to understanding the causes of their evolution.

Two general conclusions have resulted from the physiographic, stratigraphic, and paleontologic re-study of these beds in recent years.

1. They are in the main of fluviatile and loess origin. True lacustrine strata are of subordinate importance.

2. Volcanic ash and tuffs, either of primary deposition, or worked over to a varying extent by water, form a surprisingly large percentage of their material.

In order to determine the proportion of volcanic material in these rocks, petrographic examination is indispensable. Preliminary examinations, especially in the Bridger and Washakie beds, by W. J. Sinclair, had shown that these formations were chiefly composed of volcanic material more or less reärranged by stream action, and that volcanic dust, altered to a varying degree and mixed with normal sedimentary materials, constituted at least a large part of other Tertiary formations of the Mountain and Plains regions. Realizing the important bearing of this determination upon several problems of correlation and evolution upon which he was engaged, Professor Osborn, as Vertebrate Paleontologist to the United States Geological Survey, submitted to the Survey for examination a fairly complete and typical series of rock specimens from the formations of the Western States from which Eocene mammals have been chiefly obtained. This more thorough and exact examination was intrusted by the Director of the Survey to Dr. Albert Johannsen, Acting Chief of the Section of Petrology, whose report is published herewith, through the courtesy of the United States Geological Survey.

The examination confirms in the main the preliminary results obtained by Dr. Sinclair. The specimens examined from the Middle and Upper Eocene formations are chiefly tuffs of volcanic origin; in the Lower and Basal Eocene the sediments are of more normal type, and volcanic material, if present, so much altered by resorting and mixing with normal sediment as not to be clearly recognizable.

It should be observed, however, that the specimens from the Lower and Basal Eocene were few in number and so much altered by weathering that Dr. Johannsen does not pronounce positively as to their nature.

In Dr. Johannsen's paper, for purposes of comparison, the series of specimens has been arranged in order of their geologic sequence in the various formations, from above downward.

The successive horizons are shown in the accompanying diagram (Fig. 1).

The more exact sequence in the Washakie formation is shown in Fig. 2.

Dr. Johannsen observes that although the minerals of the tuffs are those of a dacite (quartz-andesite), the quartz grains may be of sedimentary origin, and the volcanic rock may be an andesite.

He does not confirm Sinclair's identification of the Bridger tuffs as rhyolitic; this removes a serious difficulty in the correlation of the Upper Bridger with the Lower Washakie, which was based by Osborn on faunal evidence, and is now in conformity with the petrographic evidence.

Dr. Johannsen's report and accompanying letter follow.

W. D. Matthew.

American Museum of Natural History.

Letter of Transmittal.

Prof. H. F. Osborn,
American Museum of Natural History.

Dear Sir:

To answer the question as to the origin of rocks altered as much as the specimens sent by you, and the Bridger rocks I received from the National Museum, is very difficult. From the hand specimens and the thin sections it is generally impossible to determine whether the material was transported by water, or whether the rock is almost a direct sediment from a volcanic eruption. That the fragments of minerals in the rocks have been derived from volcanic rocks is plain, but nothing, unless it is sometimes a slight rounding of the grains, indicates whether or no they have been transported. The separation line between a sediment from eruptive material and a tuff seems to me a very uncertain one and based on the distance of transportation. In the specimens determined for you, the appearance of the minerals in most of the slides is that of broken fragments from igneous rocks. In many of the slides they appear like the fragments of minerals from a rather coarsely crystalline quartz diorite rather than from a dacite. The large amount of apparently primary quartz would indicate a quartz monzonite or some similar rock as having been the source. It is possible, however, that these are fragments of the minerals of the rock through which the eruption took place, and that the groundmass represents glassy material of the new lava. Many of the slides do undoubtedly contain particles of glass dust. The groundmass in almost all of the sections is so largely altered to secondary minerals that it is impossible to say whether it was originally the dust of a volcano or whether this glassy material might not have been washed down later with fragments of the granular rock. In many of the slides the character of the cement is also modified by the infiltration of calcite.

Personally, I am inclined to believe that the rocks are largely tuffs, perhaps modified in part by slight transportation, enough to add the many quartz grains found. The rocks in many cases contain fragments of other eruptive rocks which have probably been brought up from the strata broken through by the rising lava. Some of the rocks in which the material is that of an eruptive rock may actually be sedimentary. This may also account for the presence of such a large amount of quartz in the sections, that is, *instead of being eruptive dacite tuffs they may be formed of the materials of an andesite, with sedimentary quartz grains.*

Yours truly,

ALBERT JOHANNSEN,
Acting Chief,
Section of Petrology.

United States Geological Survey,
Washington, February 4th, 1909.

Petrographic Report on Rocks.

UINTA.[1]

No. 4.— Altered Eruptive; probably Dacite Tuff.

Locality: Uinta. Hor. C.

Megascopic: A grayish green fine-grained rock with a rough feel, containing many small black spots of biotite.

Microscopic: Irregular broken fragments of CaNa plagioclase, biotite, hornblende, muscovite, quartz?, and some secondary zeolite, in a yellowish green partially devitrified groundmass. There is considerable glass.

No. 3.— Altered Eruptive; probably Dacite Tuff.

Locality: Uinta. Top of Hor. B or base of Hor. C.

Megascopic: A greenish gray fine-grained rock, with a rough feel.

Microscopic: Irregular broken fragments of quartz, CaNa plagioclase, and a dark altered indeterminable ferromagnesian mineral in a dirty dark brown groundmass similar in appearance to No. 2. There are traces of what appears to be glass.

No. 1.— Altered Eruptive; probably Dacite Tuff.

Locality: Uinta. Top of Hor. B.

Megascopic: A pale green, fine-grained rock containing large dark brown inclusions.

Microscopic: Irregular broken fragments of CaNa plagioclase, biotite, and some quartz and apatite in a greenish brown anisotropic groundmass. This groundmass is full of secondary sericite, and is probably a devitrified glass although no remnants of glass remain. The rock has much the appearance of a dacite tuff. No fragments of the dark inclusions appear in the thin section.

No. 2.— Altered Eruptive; probably Dacite Tuff.

Locality: Uinta. Hor. B.

Megascopic: A red-brown, fine granular rock.

Microscopic: Irregular broken fragments of CaNa plagioclase, quartz, apatite, and a dark altered indeterminable mineral in a dark brown altered groundmass containing much calcite, sericite and iron oxide. No fresh glass seen.

No. 6.— Probably a Sediment.

Locality: Uinta. Hor. B.

Megascopic: A pinkish rock containing many small rounded pebbles.

---

[1] All from Uinta basin, northeastern Utah.

Microscopic: Rounded and irregular fragments of CaNa plagioclase, quartz, garnet, augite, and fragments of other rock in a dirty yellowish brown groundmass, which consists of calcite, probably some zeolites and

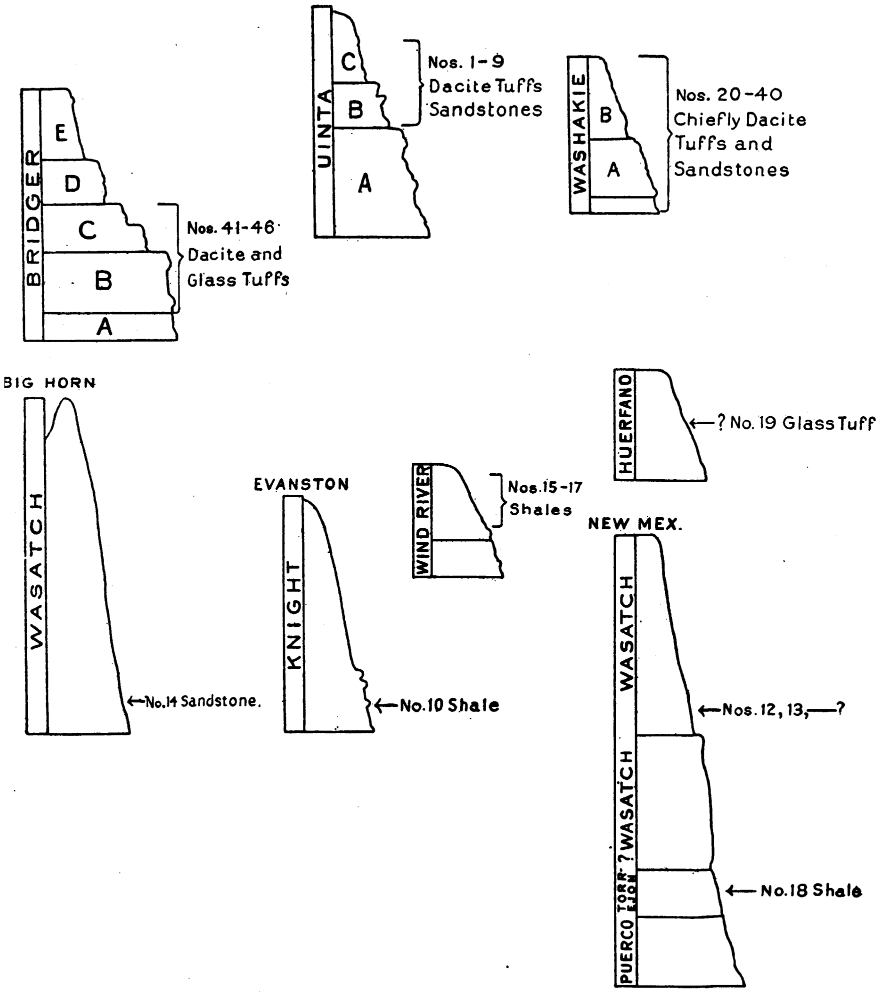

Fig. 1. Key to the chronologically successive and overlapping formations from which specimens Nos. 1 to 46 were obtained.

glass. In the hand specimen the rock looks like a sandstone. Under the microscope it closely resembles many flow breccias.

No. 8.— Possibly SEDIMENTARY.

Locality: Uinta. Hor. B.

Megascopic: Similar in appearance to 5 and 6. It is coarser than 5 and finer and more compact than 6. In color pinkish brown. It shows rounded as well as broken grains in a granular groundmass. Microscopically it has much the appearance of a sandstone.

Microscopic: Irregular fragments of CaNa feldspar, quartz and a rock with microlitic texture, either andesite or basalt, in a groundmass which is largely calcite, some zeolites.

No. 7.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: Uinta. Hor. B.

Megascopic: A pinkish brown, rough, fine granular rock containing included fossils.

Microscopic: Very small fragments of CaNa feldspar, quartz? and altered ferromagnesian mineral in a very dark brown groundmass almost opaque, consisting in part at least of calcite. The rock may be a tuff or a sediment.

No. 5.— MINERALS of a DACITE or DIORITE; possibly a SEDIMENTARY ROCK.

Locality: Uinta. "Base of Hor. B."

Megascopic: A brownish, fine granular, rough rock.

Microscopic: Broken and rounded fragments of quartz, CaNa plagioclase, hornblende, a dark altered indeterminable mineral, fragments of andesite or basalt. These minerals are in comparatively large grains nearly touching each other, and united by a small amount of cement which is largely calcite. The rock may be a sediment with the materials derived chiefly from a diorite.

No. 9.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: Uinta. Hor. A.

Megascopic: Yellowish, medium-grained, rough rock containing a few rounded pebbles.

Microscopic: Irregular broken and rounded fragments of quartz, CaNa feldspar, hornblende, biotite and fragments of an andesite or basalt in a dirty brown groundmass, which is chiefly chlorite with some calcite. The grains are rather large and are partly rounded. They form most of the rock with the exception of a rim of chlorite, etc., around each.

WASHAKIE.[1]

No. 39.— GRIT. Minerals derived from granite.

Locality: Washakie. Hor. B. Summit of formation.

Megascopic: Coarse rounded quartz grains, stained a light green, in a small amount of calcareous cement.

[1] All from Washakie basin, southern Wyoming.

Microscopic: Similar in appearance to No. 38. Each grain is surrounded by a yellowish green rim of chlorite and iron oxide.

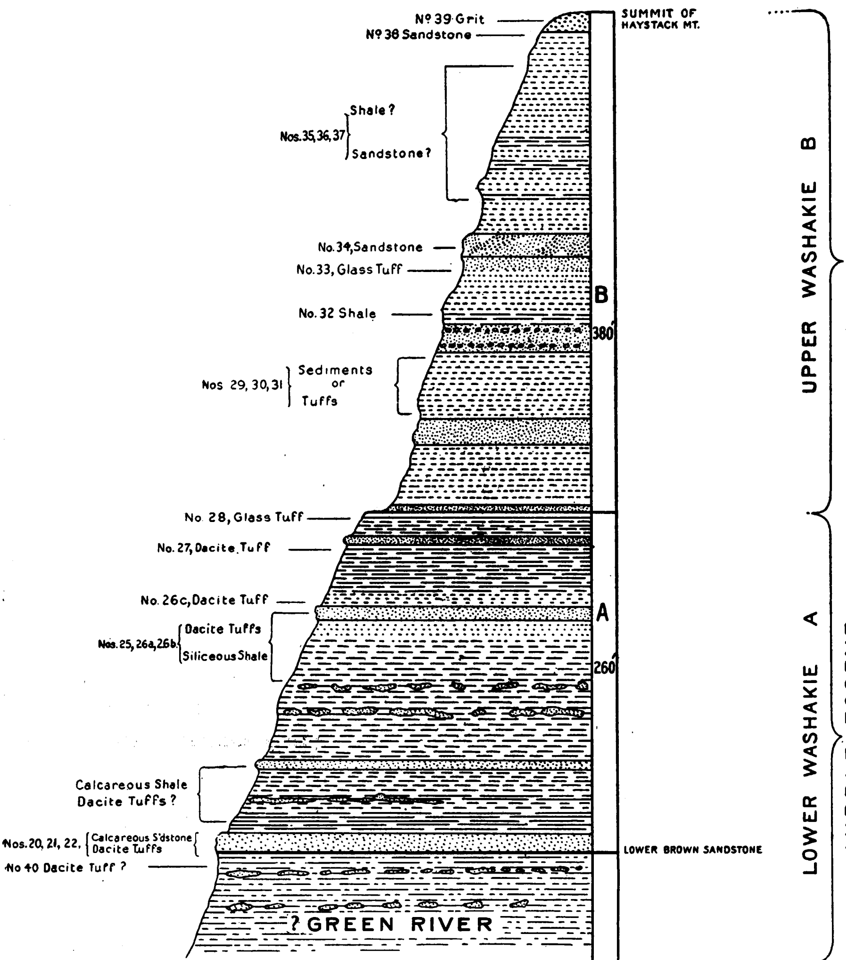

Fig. 2. Section through the Washakie beds near Barrel Springs, Southern Wyoming, showing the approximate levels of specimens Nos. 20 to40. After Granger, with modifications.

No. 38.— Sandstone. Minerals derived from a granite.
Locality: Washakie. Hor. B (Barrel Springs Section 22)[1].
Megascopic: A coarse granular light brown rock.

[1] The numbers in parentheses refer to the section, by Walter Granger, of the Washakie beds near Barrel Springs. See Bull. Amer. Mus. Nat. Hist., Vol. XXVI, 1909, p. 19.

Microscopic: Rather rounded grains of quartz and microline in a cement of secondary crystals. Similar in appearance to No. 34.

No. 37.—

Locality: Washakie. Hor. B (Barrel Springs Section 21).

Megascopic: A light green, slightly sandy rock.

Microscopic: The section was almost destroyed in grinding. All that remains are a few very small broken mineral grains. The rock was possibly an altered eruptive.

No. 36.— SHALE?

Locality: Washakie. Hor. B (Barrel Springs Section 21).

Megascopic: A compact shale-like rock, light green in one part and light brown in another.

Microscopic: Anisotropic, consisting largely of minute grains of iron oxide and sericite?

No. 35.— SANDSTONE? TUFF?

Locality: Washakie. Hor. B (Barrel Springs Section 21).

Megascopic: A fine-grained, light red, sandy rock. Looks like a sandstone.

Microscopic: Chiefly broken quartz grains, with some plagioclase in a greater amount of a yellow groundmass.

No. 34.— Coarse SANDSTONE derived from a granite.

Locality: Washakie. Hor. B (Barrel Springs Section 20).

Megascopic: A rather coarse rock consisting of rounded grains of quartz and feldspar, with almost no cement.

Microscopic: Quartz and microcline and a very few hornblende fragments, generally rounded, with a very small amount of yellowish green cement which is largely calcite.

No. 33.— GLASS TUFF.

Locality: Washakie. Hor. B (Barrel Springs Section 19).

Megascopic: A compact white rock similar in appearance to No. 28.

Microscopic: A very few exceedingly small fragments of hornblende?, quartz ?, and feldspar in a slightly devitrified groundmass of angular glass particles.

No. 32.— SHALE? TUFF?

Locality: Washakie. Hor. B (Barrel Springs Section 18).

Megascopic: A compact, pale yellow, fine-grained rock.

Microscopic: Few and small fragments of quartz and plagioclase? in a dirty brown indeterminable groundmass, which is partly calcite and sericite.

No. 31.— Minerals of a DACITE or QUARTZ DIORITE. The rock may be a sediment.

Locality: Washakie. Hor. B (Barrel Springs Section 15).

Megascopic: A light green, friable, sandy rock similar in appearance to No. 27.

Microscopic: Fragments of quartz, NaCa feldspar, augite, hornblende and an opaque alteration product in a groundmass of a greenish color, consisting largely of chlorite and calcite. The mineral fragments are very much altered.

No. 30.—

Locality: Washakie. Hor. B (Barrel Springs Section 15).

Megascopic: A pale pink, rather friable, sandy rock showing rounded quartz and augite? grains in a light-colored opaque groundmass.

Microscopic: A very few grains of quartz, hornblende, NaCa feldspar and a microlitic rock in a groundmass which consists chiefly of calcite, with some zeolite? patches.

No. 29.— Minerals of the DACITE. The rock may be a SEDIMENT or a TUFF.

Locality: Washakie. Hor. B (Barrel Springs Section 15).

Megascopic: A yellowish green, friable, sandy rock similar in appearance to No. 27.

Microscopic: Rather rounded irregular grains of quartz, NaCa plagioclase and other rock fragments in a deep brown groundmass.

No. 28.— GLASS TUFF.

Locality: Washakie. Hor. A (Barrel Springs Section 10).

Megascopic: A white compact rock showing deposition lines and inclusions.

Microscopic: A very few small broken fragments of hornblende and quartz? in a partially devitrified glass. Some of the glass is rather fresh. This rock is a transition stage between a fresh glass tuff and the tuff showing but little fresh glass in the groundmass. The outlines of the original angular glass particles are perfectly preserved.

No. 27.— ALTERED ERUPTIVE, DACITE TUFF?

Locality: Washakie. Hor. A (Barrel Springs Section 9).

Megascopic: A pale green, rather coarse granular rock, rough to the touch. It is coarser than 26c.

Microscopic: Rather coarse broken fragments of quartz, CaNa plagioclase, augite, hornblende, other rock fragments and iron oxide in a yellowish groundmass which appears to be partly devitrified glass. Remnants of glass remain. There are some zeolites. The broken crystal fragments are about equal in amount to the groundmass.

No. 26*c*.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: Washakie. Hor. A (Barrel Springs Section 7).

Megascopic: A fine-grained pale greenish rock, rather rough to the touch. Slightly banded. Similar in appearance to 26b.

Microscopic: Quartz, CaNa plagioclase, microcline, hornblende and an opaque, black, altered ferromagnesian mineral in rather coarse, irregular, broken fragments in a brown groundmass which consists largely of calcite and partially devitrified glass. A chemical test on the pulverized material to determine whether a glass or a zeolite is present in the groundmass shows no gelatinization. Consequently the isotropic material in the groundmass, which has an index lower than Canada balsam, is glass.

No. 26*b*. The minerals are of an ERUPTIVE ROCK. May be DACITE TUFF, or a sediment derived from a dacite tuff.

Locality: Washakie. Hor. A (Barrel Springs Section 6 and 8).

Megascopic: A greenish yellow, slightly rough, fine-grained rock.

Microscopic: Small irregular broken fragments of quartz, CaNa feldspar and an altered ferromagnesian mineral in a dirty brown groundmass, which contains zeolites, sericite, iron oxide, and possibly glass?.

No. 26*a*. SILICEOUS SHALE?

Locality: Washakie. Hor. A (Barrel Springs Section 6).

Megascopic: A mottled green to brown siliceous rock.

Microscopic: Extremely fine-grained slightly anisotropic material, consisting of an indeterminable anisotropic mineral, sericite, and small grains of red iron oxide. It appears to be a siliceous shale.

No. 26.— DACITE TUFF, or a sediment formed from the minerals of a dacite.

Locality: Washakie. Hor. A (Barrel Springs Section 6).

Megascopic: A grayish rock, rough granular, and coarser than No. 25. Similar in texture to No. 22 though lighter in color.

Microscopic: Quartz, NaCa feldspar, augite, an opaque altered ferromagnesian mineral, garnet and a microlitic rock. All in irregular broken fragments in a cement which may be devitrified glass. It has more the appearance of a sediment than No. 22.

No. 25.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: Washakie. Hor. A (Barrel Springs Section 2).

Megascopic: A pale green rock, very similar to No. 24.

Microscopic: Broken fragments of quartz, NaCa feldspar, augite, some freshly altered ferromagnesian mineral in a pale yellowish devitrified groundmass. Zeolites or remnants of glass in the groundmass.

No. 24.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: Washakie. Hor. A (Barrel Springs Section 2).

Megascopic: A light gray, very fine-grained, slightly rough rock.

Microscopic: Few and small fragments of quartz, NaCa feldspar and an altered ferromagnesian mineral in a pale yellow groundmass, which is anisotropic in spots but shows the glassy texture, and remnants of an unaltered glass. This is a transition stage between the totally devitrified groundmass and the fresh glass. There is considerable chlorite and sericite in the groundmass, possibly some zeolites.

No. 23.— IMPURE LIMESTONE OR CALCAREOUS SHALE.

Locality: Washakie. Hor. A (Barrel Springs Section 2).

Megascopic: A yellowish gray fine-grained rock.

Microscopic: Very fine granular. It consists almost entirely of calcite grains, with a few fragments of augite, quartz, iron oxide and a few other altered minerals.

No. 22.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: Washakie. Hor. A. (Barrel Springs Section 1).

Megascopic: A yellowish rock, rough to the touch, showing fine quartz and mica grains in an altered yellowish groundmass.

Microscopic: Irregular broken fragments of quartz, NaCa feldspar, hornblende, biotite (considerably altered), an opaque black ferromagnesian mineral, garnets, and an altered microlitic rock, all broken and irregular in a yellow anisotropic, speckled groundmass, probably devitrified glass. Secondary zeolites and possibly some unaltered glass? occur. It has the appearance under the microscope of an altered tuff, although the hand specimen shows some rounded quartz grains which suggest that the minerals were deposited by water.

No. 21.— ALTERED CALCAREOUS SANDSTONE, the minerals derived from an igneous rock.

Locality: Washakie. Hor. A (Barrel Springs Section 1).

Megascopic: Rather coarse greenish yellow rock showing rounded quartz and other mineral grains in a small amount of yellowish calcareous cement.

Microscopic: Irregular broken fragments of quartz, NaCa feldspar, augite and a microlitic rock (probably andesite) in a groundmass of perfectly crystalline calcite. The minerals are entirely fresh and were derived from an igneous rock. The appearance of the mineral suggests a diorite, although the rock is probably a sediment.

No. 20.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: Washakie. Hor. A (Barrel Springs Section 1).

Megascopic: A rough, yellowish, fine-grained rock showing a number of dark flakes, apparently biotite.

Microscopic: Broken irregular fragments of quartz, NaCa feldspar, hornblende and another altered ferromagnesian mineral, probably biotite, in a brown, slightly anisotropic altered groundmass which shows zeolites and possibly some unaltered glass.

No. 40.— ALTERED ERUPTIVE; probably DACITE TUFF.

Locality: ? Washakie. (Below lower brown sandstone 1).

Megascopic: A light gray fine grained rock, slightly rough to the touch.

Microscopic: A few very small grains of quartz, NaCa feldspar and altered biotite? in a groundmass which is partly calcite and partly glass. The calcite appears to be entirely secondary. Secondary zeolites.

BRIDGER.[1]

No. 46.— Dacite Tuff?

Locality: Burnt Fork. Hor.? D.

Megascopic: Similar in appearance to No. 45 though a little greener in color..

Microscopic: Somewhat coarser than No. 45. Irregular grains of quartz, CaNa feldspar, hornblende, black iron oxide, biotite? and fragments of a microlitic rock in a yellowish chloritic groundmass.

No. 45.— Glass Tuff.

Locality: Sage Creek. Hor. C.

Megascopic: Soft, friable, white rock, rough to the touch, and containing numerous very fine black particles.

Microscopic: A few quartz and hornblende? fragments in a groundmass made up entirely of coarse angular particles of stringy glass full of bubbles. There is a little secondary calcite.

No. 44.— Dacite Tuff?

Locality: Smith's Fork. Hor. B.

Megascopic: A greenish gray fine-grained rock.

Microscopic: Fragments of quartz, NaCa feldspar, hornblende and black iron oxide in a dirty brown groundmass consisting of sericite, chlorite and calcite. No glass seen.

No. 43.— Green Altered Tuff; probably Dacite Tuff.

Locality: Church Buttes. Hor. B.

Megascopic: A rather dark green sandy rock, showing some flakes of a dark mineral. The rock breaks in flat sheets showing bedding.

Microscopic: Fragments of quartz, NaCa plagioclase, a little alkali feldspar, red and black iron oxide, an altered ferromagnesian mineral and fragments of another rock in a groundmass consisting of calcite and chlorite. The material may have been deposited in water.

No. 42.— Dacite Tuff?

Locality: Church Buttes. Hor. B.

Megascopic: A fine-grained grayish rock containing a few fossils and numerous black specks of hornblende and possibly mica.

Microscopic: Irregular broken fragments of quartz, NaCa feldspar, hornblende, fragments of other rocks and black iron oxide in a groundmass which contains considerable calcite, sericite and other secondary products. It may be a devitrified glass but no remnants remain.

No. 41.— Dacite Tuff?

---

[1] All from Bridger basin, southern Wyoming.

Locality: North of Church Buttes. Hor. A.

Megascopic: Rather coarse, rough, granular rock of a dirty green color.

Microscopic: Fragments of quartz, NaCa feldspar, hornblende and a microlitic rock in a groundmass consisting of calcite, chlorite and sericite. No glass seen.

HUERFANO.

No. 19.— GLASS TUFF.

Locality: Huerfano basin, Colorado.

Megascopic: White volcanic dust.

Microscopic: Irregular angular fragments of clear, fresh and unaltered glass. There are a very few small indeterminable fragments, perhaps quartz.

WIND RIVER.

No. 17.— SANDY SHALE?

Locality: Wind River basin, Wyo.

Megascopic: A pale green, rough, very fine, friable, granular rock.

Microscopic: Irregular fragments of quartz, altered biotite and feldspar? in a greenish, much altered groundmass consisting partly of sericite and chlorite. The rock may be a sediment or an altered eruptive. Indeterminable.

No. 16.— Probably SHALE.

Locality: Wind River basin, Wyo.

Megascopic: A pale green aphanitic rock containing a few reddish fragments.

Microscopic: Very small indeterminable mineral fragments, probably quartz, in a yellowish groundmass which is largely sericite, and a mineral with low birefringence, either feldspar or quartz.

No. 15.—

Locality: Wind River basin, Wyo.

Megascopic: Mottled green and reddish brown. The green patches appear to be fragments of shale.

Microscopic: The thin section shows chiefly the dark red rock. It consists of fragments of quartz and CaNa feldspar in an opaque groundmass, which in places where ground very thin shows a red rim. It is probably hematite. There is only one small fragment of what appears to be the green part of the rock. This is much more transparent than the remainder of the slide, and consists of many grains of red iron oxide in a pale greenish anisotropic groundmass of sericite and an indeterminable mineral, probably partly chlorite. It has the appearance of a shale.

WASATCH.

No. 10.— CALCAREOUS SHALE.

Locality: Evanston, Wyo.

Megascopic: A yellowish white fine-grained rock.

Microscopic: Extremely fine-grained. It consists chiefly of calcite, with considerable iron oxide and quartz.

No. 14.— SEDIMENTARY ROCK.

Locality: Bighorn basin, Wyo.

Megascopic: A reddish brown, friable, sandy rock.

Microscopic: Irregular and rounded grains of quartz and feldspar ?, a little biotite, and some dark altered ferromagnesian mineral in a groundmass of calcite.

No. 12.— A pink and yellow, very much DECOMPOSED ROCK.

Locality: San Juan basin, New Mexico.

Megascopic: Pink to yellow rock; has the appearance of a dried clay.

Microscopic: Small grains of quartz and plagioclase ? in a very much altered groundmass containing considerable calcite. The rock is too much altered to determine.

No. 13.— Probably a SEDIMENT with the minerals of a RHYOLITE.

Locality: San Juan basin, New Mexico.

Megascopic: A sandstone-like pale green rock containing rounded quartz grains in a compact groundmass.

Microscopic: Irregular fragments of quartz and an altered alkali feldspar in a yellowish groundmass, very much altered.

TORREJON.

No. 18.— SHALE?

Locality: San Juan basin, New Mexico.

Megascopic: A dirty reddish brown fine-grained rock, rather rough to the touch.

Microscopic: Some quartz, plagioclase and altered ferromagnesian mineral in a dominant dark brown groundmass. This groundmass is very much altered and now consists of sericite, chlorite and other secondary products. Its original character is indeterminable.