

Diller
(Educational)

U.S. Geological Survey, 1898
No. 150 - Pp. 217-----254
Education Series of Rock
Specimens - J. S. Diller
Lassen Peak Dacites, etc.

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Pp. 217-219, No. 82. DACITE
(From Lassen Peak, California)

Lava which is characterized by lime-soda feldspars and quartz is dacite. It is sometimes called quartz-dacite.

Lassen Peak, like Mount Shasta, Mount Hood, and many other prominent peaks of the Cascade range, was once an active volcano, and of its newer lavas, dacite forms by far the greater portion. It is widely distributed about the base of the peak, and at one place, known as Chaos, it is of so recent eruption that it still remains in its original extremely rough, broken, rocky condition.

It is a porphyritic gray rock, which has a rough fracture and porous structure. At first sight it looks somewhat like granite, from which, however, it differs essentially in containing a large amount of glassy base.

Among the phenocrysts embedded in the light-gray groundmass, hornblende and biotite are the most conspicuous. Plagioclase is most abundant. Quartz is common and pyroxene scarce. Idiomorphic phenocrysts are rare; the crystals are nearly all rounded or broken by the movements of the lava at the time of its eruption.

The hornblende is black where fresh, becoming brownish by alteration. It appears occasionally in well-defined crystals, but usually its form is broken or irregular. Pyroxene is occasionally found grown upon hornblende in parallel position. Grains of magnetite are frequently included in hornblende, but the black border so common about the hornblende and mica in many andesites is entirely absent here. Apatite, almost black, as seen in the hand specimen, by transmitted light appears deep brown and strongly pleochroic. It sometimes contains inclusions of both magnetite and apatite.

The feldspar phenocrysts, as shown by Hague and Iddings, are all plagioclase, and belong chiefly if not wholly to andesine. Well defined crystals are rare. The usual form is rounded or broken, and frequently contains numerous glass inclusions.

The quartz, when seen in thin sections, is found to be well rounded, and generally contains the characteristic dihexahedral glass inclusions.

The pyroxene is chiefly hypersthene, although augite is sometimes present. The crystals are usually so small that they belong rather to the groundmass than to the phenocrysts.

Lassen Peak Dacite - Diller - Continued

The gray groundmass is porous, sometimes fibrous and pumiceous, a feature which can be best observed in the hand specimen with a small lens. In the thin section it is seen to be composed chiefly of clear glass swarming with acicular colorless crystallites. It contains comparatively small crystals and grains of feldspar with a smaller proportion of hornblende, hypersthene, biotite, and magnetite, besides round or irregular dark gray felty spherulitic patches.

The chemical composition of the lava at Lassen Peak shows that it is a typical dacite. Analyses have been made of different flows and are given in the accompanying table.

Analyses of lava from Lassen Peak, California

	1	2	3	4	5	6	7
	Per cent	Per cent	Percent	Percent	Percent	Percent	Percent
SiO ₂	69.51	68.20	68.72	68.32	55.14	65.77	76.75
TiO ₂	-	-	0.31	0.31	0.52	-	-
Al ₂ O ₃	15.75	16.98	15.15	15.26	19.10	21.51	12.32
Cr ₂ O ₃	-	-	none	none	none	-	-
Fe ₂ O ₃	3.34	3.95	1.16	1.66	6.16	-	-
FeO	-	-	1.76	1.26	0.54	trace	1.36
MnO	-	-	0.11	0.04	0.11	-	-
CaO	1.71	4.33	3.30	3.26	8.36	5.72	1.18
SrO	-	-	0.03	trace	0.07	-	-
BaO	-	-	0.07	0.07	trace	-	-
MgO	2.09	2.07	1.28	1.32	4.23	none	none
K ₂ O	3.34	1.52	2.78	2.81	1.04	0.83	3.98
Na ₂ O	3.89	2.98	4.26	4.27	3.71	5.92	3.55
Li ₂ O	-	-	trace	trace	trace	-	-
H ₂ O	0.56	0.44	0.74	1.37	0.91	0.34	0.54
P ₂ O ₅	-	-	0.09	0.12	0.18	-	-
Total	100.19	100.27	99.76	100.07	100.07	100.09	99.68

1. Gray dacite at southeast base of Lassen Peak. Analyst, T. M. Chatard.
2. Reddish dacite at northeast base of Lassen Peak, Analyst, T. M. Chatard.
3. Dacite of latest eruption at Chaos, north base of Lassen Peak, Analyst, W. F. Hillebrand.
4. Gray dacite, west base of Lassen Peak, envelopes 5.
5. Nodule contained in 4.
6. Feldspar (Am. Jour. Sci., 3d series, Vol. XXVI, p. 232, Sept. 1883) Analyst, P. W. Shimer.
7. Glass base (Am. Jour. Sci., 3d series, Vol. XXVI, p. 232, Sept. 1883), An., Shimer

Lassen Peak Dacites, Diller - Continued

In the first column is given an analysis of the material in this series. The composition of the feldspar, determined by Messrs. Hague and Iddings, is given in column 6, and that of the glass base in column 7, where it appears that the latter contains the chief portion of the potassium and that none of the feldspar is sanidine. It is evident also that the glass base contains a larger percentage of silica than the crystallized portion of the dacite. It is almost always true that in the process of crystallization the basic elements become mineralized with greater rapidity, relatively, than the silica, so that the amorphous residue in hypocrySTALLINE eruptive rocks is generally richer in silica than the average of that portion which is crystallized.

Although the great mass of dacite at Lassen Peak contains a larger proportion of glass base and has attained a lower degree of crystallization than most of the other lavas in the same region, there are within the mass isolated nodules, as seen in Pl. XXI, that are holocrystalline, or contain a relatively small amount of glass base. The complete crystallization of the mass at the time of its eruption was doubtless prevented by the condition of the magma taken in connection with its environment. The irregular holocrystalline nodules, on account of their higher degree of crystallization, may be regarded as the first portion of the mass to solidify.

In these nodules hornblende is much more abundant than in the dacite which envelops the nodules. It is frequently allotriomorphic against the feldspar, as the augite is diabase; biotite and pyroxene are usually less abundant, and olivine is occasionally present, and some tridymite. The feldspar are generally lath-shaped. A chemical analysis of one of these nodules, with that of the enveloping dacite, is given in the table.

Similar nodules are found in many eruptive rocks, especially such as granite, diorite, etc., which have crystallized at a considerable depth beneath the earth's surface. They are generally more basic than the rock inclosing them, and are regarded by many petrographers, but not all, as the part of a once homogeneous magma, separated out in the process of differentiation and first to crystallize.

Dacites are sometimes holocrystalline, but frequently contain more or less amorphous matter. In a general way they are intermediate in the rock series between rhyolite and andesite. The structure and habit of many dacites appears most closely related to those of rhyolite, but in the field they are commonly found associated with andesites. In the Lassen Peak region the dacites and rhyolites are of approximately the same age, and both are younger than the andesites which they have overflowed.

Material excerpted from U. S. Geological Survey, No. 150, 1898

"The Educational Series of Rock Specimens" - J. S. Diller

Pp. 245-249, No. 95. GABRO-BASALT FAMILY
(From Snag Lake Cinder Cone, Lassen County, California)

Volcanic sand is sand that has been produced from molten rock material by a volcanic explosion. Taken with volcanic dust, it is often referred to as volcanic ash, but is not ash in the same sense as is that resulting from the burning of wood or coal. In order that its formation may be more clearly understood, it is necessary to consider some of the conditions and surface features of volcanic eruptions.

Deep borings, mines, and wells have been sunk at many points on the earth's surface, and wherever observations have been made the temperature has been found to increase downward toward the earth's interior. The increase is by no means regular, and yet the rate generally does not vary greatly from an average of about 1 degree F. for every increase of 57 feet in depth.

If the temperature increased at this rate regularly to a depth of 20 miles the temperature would be over 1,850 degrees F. and at 50 miles over 4,600 degrees F., or far higher than the fusing point of all rocks under ordinary conditions.

We need not stop here to inquire further into the condition of the earth's interior, whether it be solid or liquid, or as to the source of heat, whether it is a residue of the original incandescent earth, or is due to chemical action, or is produced by the mechanical crushing of rocks. Let it be sufficient for our purpose to know that the interior portion of the earth, below a depth of a few miles from the surface, is very hot.

Rain falls on the mountain slopes. Some of it gathers into rills, runs into brooks, creeks, and rivers, and finally finds its way back into the sea whence it came. Another portion enters the soil, and, under the influence of gravity, passes through the pores, cracks, and fissures of the rocks to various depths within the earth. On the lower slopes of the mountains and in the valleys much of the water which entered above reappears from springs, most of which are cool and refreshing. In some cases, however, the water penetrates so far into the earth before reappearing in springs that it is warmed by the internal heat. Thus warm springs, hot springs, and boiling springs are produced.

In those boiling springs in which the outlet is large enough to allow the heat to escape, the movements of the water are comparatively uniform; but in certain cases the outlet is narrow in proportion to the length of the more or less vertical tube in the ground, and there is not sufficient opportunity for the heat to escape. The heat increases until the expansive force of the highly heated water and steam is sufficient to produce an explosion. The overlying water and steam are thrown into the air by the eruption. Such springs are geysers, and steam is the motive power in their eruption.

Gabro-Basalt Family, J. S. Diller - Continued

Next more important than eruptions of water in geysers are eruptions of mud. A notable one occurred in 1898 at Bandai-san in Japan. Large quantities of mud, saturated with steam or highly heated water under pressure, were developed a short distance beneath the surface. A great explosion occurred, removing the whole side of the mountain. A vast quantity of steam escaped, and streams of mud flowed down the valley, damming water courses to form lakes, and destroying a number of villages.

In true volcanic action the material transferred from the interior of the earth to the surface is neither simple water, as in the geyser, nor mud, as in the semivolcanic eruption at Bandai-san, but melted rock. It may come from greater depths than either of the others, where the temperature is higher, and the rocks may be either in a molten condition or so hot that when the pressure upon them is relieved they fuse and become eruptible.

A fine example of a truly volcanic eruption is afforded by the stupendous explosion of Krakatoa, in the Straits of Sunda, in August, 1883. The explosion was heard for a distance of more than 150 miles, and a mass of matter $1\frac{1}{8}$ cubic miles in bulk was blown to pieces and hurled high into the air in the form of pumice, ashes, and fine dust. The dust, very like that of specimen N8. 58 (volcanic dust (rhyolitic) from Gallatin Valley, Gallatin County, Montana, p. 146), was thrown to a height of 17 miles in the air and spread far and wide by the winds. Some of it fell hundreds of miles from its source. The air wave set in motion by this great explosion traveled around the earth three times, and the sea in the neighborhood was thrown into waves, one of which was computed to have risen more than 100 feet above tide level, destroying villages and 38,380 people.

The eruption at Krakatoa differed from that at Bandi-san chiefly in that the material was, at least in large part, not in the form of mud, but in a state of aqueo-igneous fusion, i.e., actually molten. In the geyser and the eruption of mud the material is impelled to the surface by steam. The same is true also in the final delivery of molten rock, or magma, in such eruptions as that of Krakatoa, where the explosion must have been due chiefly to the expansive force arising from water or its component elements. In that case, however, all the molten material was blown out by the explosion. None of it flowed out.

The large quantities of steam given off by volcanoes in eruption is illustrated by the great clouds of vapor which rose from Vesuvius during its eruption in April, 1872. The steam clouds were given off not only near the summit of the mountain where the eruption took place, but also from the streams of molten rock coursing down its sides. These streams are marked by lines of vapor. On the left the lava reaches the very base of the mountain, while on the right are two separate streams reaching nearly to its base. This eruption differed from those already noted in that some of the material was blown out by explosion at the mountain's summit, while the larger part of the molten material flowed out and formed lava streams or coulees.

Gabro-Basalt Family, J. S. Diller - Continued

It must not be supposed from the fact that attention has been called to the action of steam in volcanic eruptions that it is the principal agent involved; such a conclusion would be incorrect; steam has probably little to do with the raising up of great masses of molten material from the earth's interior; the cause of such upraising is not well understood, but when the molten material has reached the earth's surface, steam has much to do with the form of its delivery.

Volcanic eruptions are of two forms--explosive and effusive. In the first form the material is blown to fragments and violently hurled into the air; in the second, the magma, that is, the molten rock material, wells up within the volcano and flows out upon the surface, forming coulees. In some cases the volcanic eruption is wholly explosive, as at Krakatoa; in others it may be wholly effusive, as at Mauna Loa, in Hawaii; but generally both forms occur together, as at Vesuvius.

The same was true also at the small volcano at Snag Lake, 10 miles northeast of Lassen Peak, California, where the products of the explosive and effusive eruptions are quite distinct, one forming the cinder cone, and the other a lava field, both of which are illustrated in part by Pl. XXXIV.

Volcanic sand, specimen No. 95, was obtained from the sand field shown in the foreground in PL. XXXIV. Lapilli, specimen No. 96, came from the cinder cone in the distance, and quartz basalt, specimen No. 101, was collected from the lava field to the right, where the lava was not covered by sand as in the view.

The finest material blown from this volcano, volcanic sand, spread in all directions from the vent, covering the ground as a sheet for a distance of about 8 miles. The coarser fragments fell close to the vent, and, piling up, formed the cinder cone, surmounted by a cup-shaped crater from which its material was blown.

The maximum thickness of the sand at the base of the cinder cone could not be distinctly ascertained. It is loose and slides easily, so that a great deal of excavating is required to get through it where the layer has considerable magnitude. One-fourth of a mile from the base of the cone, where specimen No. 95 was collected, the sheet of fragmental material is 4 feet 4 inches thick. It consists of two portions. The upper part is properly called volcanic sand; the lower part, however, is composed of small, light brown pumiceous fragments, ranging in size from that of a pea to an inch in diameter. The fragments are very vesicular but still not sufficiently light to float on water like ordinary pumice. They are very rough and jagged, with surfaces torn by the bursting cells once filled with steam or other eruptive gases. Some of them were produced by concussion. The pieces hurled violently into the air frequently struck others, and all were partially pulverized as in a great mill. This sort of sediment is more abundant in the volcanic sand which overlies the pumiceous material, and was therefore ejected at a subsequent stage of the eruption. Many of the sand grains are vesicular, but less so than the pumiceous fragments, and are generally rounded. Other grains are angular and composed of compact lave with few vesiculae.

They are bounded by fracture surfaces, and were evidently produced by the violent concussion of larger fragments. A few grains of quartz, feldspar or olivine of early crystallization, are present.

The sand exhibits irregular stratification, due to the sorting action of the atmosphere upon the subsiding particles during the eruption. The thin layers are lenticular in shape and continuous for short distances only, not as sharply defined as beds laid down in water, but indicating a decided tendency to form beds under favorable conditions. This tendency is most clearly manifested a short distance away from the volcanic vent, where the air was not so much disturbed by the violent current expelled from the crater.

The selective influence of the atmosphere may be seen not only in the imperfect stratification of the sand, as exhibited in a vertical section, but also in its distribution upon the surface. Near the cinder cone the sand is coarse and the bed thick, but the bed becomes thinner and the sand becomes finer as the distance from the cone increases.

On the borders of the large circular field covered by the sediment thrown out from the crater the fine material is sand, and there is no evidence to show that any considerable amount of volcanic dust or material still finer than the finest sand was formed.

The almost complete absence of volcanic dust in this case is surprising when we consider the highly explosive character of the eruption, and it may be attributed in part, perhaps, to the viscous condition of the magma at the time of the outburst. Had the pumiceous fragments in the layer already referred to contained sufficient eruptible gases at the time of the ejection to blow them to atoms, considerable dust would doubtless have resulted.

For an illustrated description of the volcanic phenomena exhibited at this recently active center, reference may be made to Bulletin No. 79, United States Geological Survey, and to the Lassen Peak Folio.

No. 96. LAPILLI

(From Snag Lake Cinder Cone, Lassen County, California)

The volcanic fragments next larger than grains of sand are lapilli. They are usually very porous and differ from the sand particles chiefly in size, ranging from that of a pea to several inches in diameter. Most of them are black, but shades of red and yellow prevail locally, and when abundant may give color to the whole cone. The lapilli of the cinder cone illustrated in Pl. XXXIV, from which specimens 96 were obtained, are generally black, giving it a somber aspect. A cinder cone on Arizona, northeast of Flagstone, noted for the brilliant colors of its lapilli, is called Sunset Peak. Lapilli are also called "volcanic cinders;" hence the name cinder cone, applied to all cones of loose volcanic material about the vent from which it issued.

Lapilli, J. S. Diller - Continued

The lapilli of the Snag Lake cinder cone remained long enough in the air to become completely solidified before striking the ground, for they show no signs of flattening by impact, nor do they show upon their surfaces any lines of flowage, such as are so plainly marked in the next specimen (No. 97), from the cinder cone of another locality.

The following chemical analysis of lapilli from Snag Lake cinder cone, made by W. F. Hillebrand, shows that its composition is essentially the same as that of the lava in the lava field (No. 101). Both are quartz basalt.

Analysis of lapilli from Snag Lake Cinder Cone, Lassen County, Calif.

	<u>Per cent.</u>
SiO ₂	56.53
TiO ₂	.54
Al ₂ O ₃	17.50
Cr ₂ O ₃	trace
Fe ₂ O ₃	1.35
FeO	5.03
MnO	.12
CaO	8.07
SrO	trace (?)
BaO	Trace
MgO	5.94
K ₂ O	1.55
Na ₂ O	3.51
Li ₂ O	trace
H ₂ O	.27
P ₂ O ₅	.15
Total	100.56

Material excerpted from U. S. Geological Survey, No. 150, 1898

"The Educational Series of Rock Specimens" - J. S. Diller

Pp. 251-254, No. 99. BASALT TUFF

(From Battle Creek Meadows, Tehama County, California)

Fine fragmental volcanic material, such as dust, sand, and small lapilli, when cemented so as to be more or less firmly coherent, is tuff. The term is made to cover all pyroclastic rocks of which the component fragments are finer than coarse volcanic conglomerate. It varies greatly, owing to the character and size of the component parts, from a very fine granular, light-colored rock, such as would result from lithifying volcanic dust like specimen No. 58, to a conglomerate made up of lapilli, such as specimen No. 96, and is designated according to the kind of lava fragments it contains, as basalt tuff, andesite tuff, rhyolite tuff, etc.

Specimen No. 99 was obtained near the summit of a cone from whose base issued a stream of basalt that flowed down the canyon of Battle Creek for miles. The cone was made up by the accumulation of volcanic sand and lapilli about the orifice from which they issued, but instead of being loose material, as at the Snag Lake cinder cone, it is cemented and forms a tuff cone. The cementation probably occurred in connection with the volcanic outbreak. Eruptions are generally accompanied by rains from condensed steam. When the rain is sufficiently copious the saturated mass of fragmental material may flow as mud and become consolidated, forming tuff. Mud flows are sometimes disastrous. Pompeii was buried by such a stream from the slopes of Vesuvius. Cones made of tuff are tuff cones. They are generally less steep than cinder cones, and distinctly stratified.

The basalt tuff, specimen No. 99, is strongly contrasted with the andesite tuff (No. 79), not only in the size and composition of its fragments but especially in its distribution with reference to the source of material. The sand and dust of which the andesite tuff was made spread far and wide over the country, and may have been derived from numerous distant volcanoes about Lassen Peak. They were deposited in a body of water and formed part of an extensive bed. On the other hand, the basalt tuff presented by specimen No. 99 is a land-made deposit, limited in its distribution to one small cone. It is somewhat stratified parallel to the slope of the cone. This arrangement is due to assorting done by the air and sliding of the material down the steep slopes.

No. 101. QUARTZ BASALT

(From Snag Lake Cinder Cone, Lassen County, California)

Quartz-basalt is basalt which is characterized by the presence of primary quartz.

QUARTZ BASALT, Diller - Continued

One of the latest volcanic eruptions in this country, so far as is yet definitely known, occurred a little more than 200 years ago near Snag Lake, 10 miles northeast of Lassen Peak, California. The cinder cone, ash field, and lava field look as fresh as though the eruption took place only yesterday.

There were two lava flows from the base of the cinder cone. The older is partially covered by volcanic sand. The surface of the younger flow is shown to be without any covering of volcanic sand. Specimen No. 101 was collected from the younger flow.

The lava is quartz-basalt. It is a dark, compact, more or less porphyritic rock in which crystals and grains of quartz are distinct, but usually not conspicuous. Under a microscope it is seen to be composed of quartz, plagioclase feldspar, pyroxene, and olivine, together with accessory magnetite and a large proportion of unindividualized material which is generally globulitic. The feldspar is most abundant; then follows pyroxene in nearly equal amount, with less olivine and quartz. The globulitic base makes up nearly 25 per cent of the whole mass.

The olivine occurs in grains or well defined crystals, which often include small coffee-brown isotropic crystals, supposed to be picroite. It is one of the first minerals to crystallize in the magma, and is rarely surrounded by a dark border. The pyroxene is chiefly hypersthene, but augite is sparingly present, especially in the shells surrounding the quartz.

The feldspar occurs in two sets of crystals. The largest have their interiors clouded by a multitude of glass and globulitic inclusions, and their irregular outlines indicate that their initial forms were modified by the corrosive action of the magma. The other feldspar crystals are lath-shaped, polysynthetic twins, such as are common in rocks of this class.

Grains and crystals of quartz in considerable numbers occur uniformly distributed throughout the lava, and are especially remarkable on account of the shell of augite and glass by which they are enveloped. This feature is illustrated in Pl. XXXVII, where it is seen that the quartz is occasionally wholly resorbed by the magma, and its place marked by a group of granular augite.

Quartz-basalts are relatively rare. They hold essentially the same relation to basalts that the dacites do to the andesites, or the rhyolites to the trachytes. A fuller illustrated description of the quartz basalt and its associated volcanic phenomena may be found in Bulletin No. 79, U. S. Geological Survey, by J. S. Diller.