PETROGRAPHIC REPORT ON ROCKS FROM THE UNITED STATES-MEXICO BOUNDARY.

By Edwin C. E. Lord, Ph. D.

The material upon which this report is based was collected by Dr. E. A. Mearns, of the International Boundary Commission, and deposited by him in the U. S. National Museum.[1]

The method used in collecting the rock specimens may be briefly described as follows:

Beginning at a point on the Rio Grande about 3 miles above El Paso, Texas, the line of survey extended across the continent, a distance of more than 725 miles, through a geologically unexplored country. At certain monument stations along the route special halts were made for the purpose of collecting and shipping specimens of scientific value. Only those monument stations, however, in the immediate vicinity of which petrographic material was obtained, have been given on the map.[2]

Owing to the rapid progress of the survey these halting places were frequently far apart and the geologic data obtained of a very fragmentary nature. In view of these facts it has been found necessary to treat the subject exclusively from a petrographical standpoint and describe the rock in petrographic groups without regard to their geological relationship.

The geographical order of occurrence, however, has been strictly maintained in each group, and the monument numbers (Mon. Nos.) attached to each locality can be readily found on the map. The specimen numbers appear in parentheses.

[1] The specimens were accompanied by many field notes. These and a small scale map of the boundary line, prepared especially by Dr. Mearns, have been of great value to the author, who also wishes to express his indebtedness to Prof. G. P. Merrill, head curator department of geology, for the many privileges accorded him in the Museum.

[2] For more exact data concerning the topography of the country the reader is referred to the large scale ($\frac{1}{60000}$) topographic map of the boundary line soon to appear with the report of the commissioners under the auspices of the State Department.

CLASSIFICATION OF THE ROCK TYPES.

On preliminary examination many of the specimens were found too much decomposed to warrant the preparation of thin sections.

The comparatively fresh rock from which slides were made may be arranged under the following headings:

I. Intrusive rock.
- *a.* Granite.
- *b.* Gabbro-diorite.
- *c.* Uralite-diabase (proterobase).
- *d.* Diorite-porphyry.

II. Effusive rock.
- *e.* Rhyolite.
- *f.* Hornblende-mica-andesite.
- *g.* Augite-andesite and andesite breccia.
- *h.* Basalt.

Under Group I are classified rock-types with a granitic-granular and holocrystalline-porphyritic structure.

Granite is composed chiefly of quartz, orthoclase, and biotite.

Gabbro-diorite consists principally of augite (diallage), green hornblende (uralite), biotite, and plagioclase.

Uralite-diabase has uralite and plagioclase as chief mineral constituents.

Diorite-porphyry contains plagioclase, hornblende, and quartz as chief ingredients.

Under Group II are united rock-types of porphyritic structure. They represent the effusive forms of granitic, dioritic, and gabbro magmas.

Rhyolite is made up of phenocrysts of sanidine, quartz, and biotite, in a holocrystalline or vitreous groundmass, and shows in some instances structural phenomena of special interest. (See pp. 777, 778.)

A peculiar development of this magma is seen in the spherulitic nodules from an obsidian flow near Aqua Dulce. (See pp. 778, 779.)

Hornblende-mica-andesite has essentially the same mineral constituents as diorite-porphyry without quartz.

Augite-andesite contains augite (diopside), plagioclase, and magnetite as chief ingredients.

Basalt is composed principally of olivine, augite, plagioclase, and magnetite. A rare instance of olivine occurring in two generations is observed in the basalt from Tule Mountains, Gila County, Arizona. (See p. 782.)

DESCRIPTION OF THE ROCK IN GROUPS.

I. INTRUSIVE ROCK.

a. Granite.—Nogales, Mon. No. 122 (No. 53266). La Osa, Pima County, Arizona, Mon. No. 140 (No. 53267). Pozo Verde, Sonora, Mexico, Mon. No. 141 (No. 53268). Quitobaquita, Sonoyta Valley, Arizona, Mon. No. 172 (No. 53269). Tenajas Altus, Gila Mountains, Yuma County, Arizona, Mon. No. 191 (No. 53272). Colorado River, right bank, Yuma, Arizona, Mon. No. 206 (No. 53270). Gila Mountains at Gila City, Yuma County, Arizona, near Mon. No. 206 (No. 53271). Eastern base Coast Range, California, Mon. No. 224 (No. 53273).

The specimens of granite vary but slightly in structure and mineral composition.

These are, with one exception (No. 53273, original No. 513), coarse grained, and show in some instances evidence of excessive mechanical deformation (Nos. 53267, 53269, 53270, original Nos. 392, 433, 458) which is revealed by foliated structure (No. 53270) or by a system of rifting and the accompanying formation of a secondary quartz-mosaic (Nos. 53267, 53269, original Nos. 392, 433). They are characterized mineralogically by an extensive development of plagioclase, which occasionally equals in amount the orthoclase. Microcline is quite common in those specimens that have undergone mechanical crushing. Biotite is especially plentiful in specimen No. 53268 (original Nos. 404, 405) from Pozo Verde and No. 53273 (original No. 514) from the eastern base of the Coast Range. The latter rock contains also an occasional green hornblende. Quartz, orthoclase, and the accessory constituents muscovite, magnetite, apatite, zircon, and titanite (Nos. 53269, 53273, original Nos. 433, 514) are of normal development.

The plagioclase may be regarded as oligoclase with an average extinction angle of about 5° on pinacoidal cleavage plates. The crystals show the usual polysynthetic structure. In two sections (Nos. 53269, 53272, original Nos. 433, 482) feldspar individuals were observed, composed of an inner andesine core much decomposed, and extinguishing at an angle of 9°, and a perfectly fresh outer zone with the extinction angle of oligoclase (5°).

In many of the specimens of granite—notably Nos. 53267, 53268 (original Nos. 390, 398, 405)—decomposition by atmospheric agencies has reached an advanced stage. The feldspar is altered to kaolin and muscovite; the biotite to chlorite, epidote (No. 53268, original No. 395), and calcite, and the magnetite to leucoxene (No. 53271).

b. Gabbro-diorite.—Coast Range, California, Mon. No. 224 (No. 53274).

This is a peculiar coarse-grained rock composed of quartz and plagioclase, together with considerable biotite and diallage in about equal proportion. Accessory minerals are magnetite and apatite.

The most interesting feature disclosed by the microscope is the paramorphic alteration of diallage to green hornblende (uralite). This process of molecular readjustment has taken place without change in bulk or appreciably altering the contour of the original augite crystal. The secondary amphibole has a distinctly massive structure in contrast to the commonly fibrous character of uralite, but shows the usual crystallographic orientation in regard to the parent mineral. On sections approximately parallel the plane of symmetry (the angle $\mathfrak{c}:c$) measures about 40° for the augite and 18° for the inclosing hornblende.

This process of uralitization has progressed to such an extent that in many instances the original pyroxene has entirely disappeared.

The plagioclase of the gabbro-diorite is tabular formed after M (010), but usually of irregular crystal outline and striated by polysynthetic twinning lamellæ. Sections parallel (010) show a maximum extinction of 16°, which corresponds with that of basic andesine.

c. Uralite-diabase (proterobase).—Pozo Verde, "El Banorie," Sonora, Mexico, Mon. No. 141 (No. 53276).

The specimens vary in color from grayish green (No. 53276, original Nos. 401, 415) to a dark green (No. 414). They are characterized macroscopically by an outspoken even granular structure. Under the microscope a panidiomorphic development of the rock constituents is apparent, although the original structure is considerably obscured by excessive chloritization and uralitization. Mineralogically the rock consists of green hornblende, lath-shaped labradorite, magnetite, quartz (No. 415), and apatite, besides the secondary products chlorite, epidote, muscovite, and calcite. In slide (No. 415) the ferro magnesian constituents are completely altered to chlorite and epidote.

The hornblende of the proterobase has the physical properties of uralite, and appears to be an alteration product from a preexisting monoclinic pyroxene, retaining generally the crystal form of the parent mineral (No. 414).

The plagioclase crystals of this rock are extended in the direction of *a*, and are usually twinned after the albite law. On M section a forms an angle of about 20° with the principal sections of the nicols. Decomposition products are muscovite, kaolin, and a colorless low double-refracting mineral surrounding the altered labradorite crystals, and resembling an outer zone of secondary enlargement. This mineral, however, is uniaxial, optically positive, and extinguishes parallel with the sides of the feldspar crystal (No. 414). It is insoluble in dilute hydrochloric acid, and can be nothing else than quartz.

d. Diorite-porphyry.—La Osa, Pima County, Arizona, Mon. No. 140 (No. 53275).

The specimen represents a coarse grained porphyritic rock, containing abundant phenocrysts of plagioclase, green amphibole, biotite, quartz, and magnetite. The groundmass reveals upon microscopic investigation a similar mineral aggregation with a preponderance of quartz and feldspar.

The hornblende crystals are of prismatic development and frequently twinned after (100). They show strong pleochroism—dark green parallel $\mathfrak{b}$ and $\mathfrak{c}$, yellowish green parallel $\mathfrak{a}$—and an average extinction angle on (100) of 17°.

The plagioclase is tabular formed after M (010), and, apart from a well-defined zonal structure and a more perfect crystal outline, resembles the feldspar of the gabbro-diorite very closely. The crystals are, however, far from fresh; being extensively altered to muscovite and kaolin.

The biotite of the diorite-porphyry is in a highly altered condition, in contrast to the remarkably fresh hornblende; the crystals are in many cases completely replaced by chlorite and epidote.

e. Rhyolite.—Fifty-eight miles west of the Rio Grande on parallel 31° 47′ at Mon. No. 19 (No. 53277). Six miles west of Lake Palomas, Mexico, Mon. No. 20 (No. 53278). Carrizallilo Mountains, south of Carrizallilo Springs, New Mexico, Mon. No. 33 (No. 53279). South of Dog Spring, Dog Mountains, Mon. No. 55 (No. 53280). West side of San Luis Mountains, Mon. No. 73 (No. 53281). San Bernardino River, Mon. No. 77 (No. 53282). Nogales, Mon. No. 122 (No. 53283). Warsaw Mills, Pima County, Arizona, Mon. No. 132 (No. 53284). Pozo Verde, "El Banorie," Sonora, Mexico, Mon. No. 141 (No. 53285). Sierra Moreno, Pima County, Arizona, Mon. No. 146 (No. 53286). Aqua Dulce Creek, Mon. No. 172 (No. 53287.)

The specimens of rhyolite vary in character from a pitchy black obsidian (Nos. 53281, 53287, original Nos. 338, 483) to a light gray porphyritic rock with holocrystalline groundmass (Nos. 53278, 53279, 53280, 53283, 53284, 53285, 53286, original Nos. 150, 168, 314, 370, 389, 396, 412, 419, 432). Intermediate types showing microscopically a felsitic (No. 53277, original No. 133), spherulitic (Nos. 53279, 53282, original Nos. 170, 343), or glassy groundmass (Nos. 53277, 53280, original Nos. 129, 136, 137, 312) are not uncommon.

The holocrystalline variety is the more common and consists mineralogically of orthoclase, quartz, plagioclase, biotite, and magnetite of intratelluric origin, and a groundmass of cryptocrystalline quartz and feldspar, through which are scattered minute particles of biotite and magnetite. Many specimens bear evidence of a preexisting residual glass-base, now completely devitrified. The products of devitrification are either quartz (Nos. 150, 314, 412, 419, 432), or quartz accompanied by chalcedony (Nos. 53277, 53279, 53280, original Nos. 136, 167, 168, 170, 312, 315). Opal occurs in specimens Nos. 129 and 137. In many instances the mica constituent of the rhyolite is completely decomposed (Nos. 396, 412, 419, 432).

Amygdaloidal types are highly colored by infiltrated limonite (Nos. 136, 168, 170, 315).

A mineralogical peculiarity of the rock from the region about Mon. No. 19 (Nos. 129, 133, 136, 137), Lake Palomas (No. 150), and from the Dog Mountains, Mon. No. 55 (Nos. 312, 314, 315) is the abundance of triclinic feldspar (andesine) among the porphyritic constituents. In some instances it occurs in sufficient quantity to render the determination of the rock as dacite permissible.

A holocrystalline rhyolite from Nogales, Mon. No. 122 (No. 370), contains among the phenocrysts large grains of brown tourmaline with strong absorption —O>E.

The successive stages of crystal development from a vitreous obsidian (No. 183) to a spherulitic rhyolite (No. 343) are beautifully illustrated in specimens Nos. 483, 338, 133, 343. No. 483 represents a homogeneous, pitchy-black rock glass with conchoidal fracture and without crystal development of any kind. No. 338 is dark steel-gray pitchstone with greasy luster, even fracture, and microperlitic-sondering. In this rock the first evidences of crystallization are seen in parallel, yellowish-brown bands of microfelsite and in other minute crystallitic forms, including some small spherulites. No. 133 is a light-gray banded pitchstone porphyry, consisting of a groundmass of glass and microfelsite in about equal proportion, and a few small phenocrysts of quartz, feldspar, and mica.

No. 343 is a light gray, beautifully banded rhyolite, differing from No. 133 in the holocrystalline, spherulitic condition of the groundmass.

The spherulites of this rock are about one-tenth of a millimeter in diameter, very symmetrical in form, and arranged in approximately parallel lines. They are separated by micropoikilitic areas of quartz and feldspar, containing minute crystals of magnetite and biotite, and by bands of microfelsite, which give the rock its characteristic banded structure.

The spherulites are very dense and are made up of radiating fibers of an optically-negative feldspar elongated parallel *à;* thus differing from those found in the compound spherulites from Aqua Dulce (No. 53285, original No. 483) (see p. 779), which are uniformly positive in longest dimension. This fibrous feldspar is not always confined to the spherulitic bodies, but extends frequently into the adjoining poikilitic areas, and there assumes the form of well-developed radiating crystals with extinction angles of 10° to 12°.

This relatively large angle is characteristic of soda orthoclase.

Quartz could not be directly determined in the spherulites, but on examination between crossed nicols, however, an anomalous divergence in the arms of the dark cross would suggest its presence. Streams of dark crystallitic grains, presumably magnetite, follow the general parallel structure of the rock only deviating from their course to avoid phenocrysts and some spherulitic forms containing feldspar nuclei.

Peculiar spherulitic nodules are found in the obsidian flows (No. 53285) which, alternating with sheets of rhyolite, form a high bluff on the right bank of Aqua Dulce Creek close to the United States border.

These nodular masses are thick-lenticular in shape, and with their irregular botryoidal surfaces bear some resemblance to full-blown roses. Some forms are more spherical with less uneven surfaces and are not unlike tulip bulbs.

The spherulites are of a brown terra-cotta color and vary from 1 to 2½ inches in greater diameter. They occur singly or in groups and always with ribbed or net-veined surfaces. These veins consist of secondary quartz which has filled shrinkage cracks in the nodules and now stands out in considerable relief. In thin sections it is evident that these nodules, although apparently homogeneous in mineral composition are structurally extremely complex. They are made up of an intricate intergrowth of brown, finely fibrous spherulites composing the botryoidal surface forms and a bluish gray, more coarsely crystalline rock mass confined chiefly to the interior portion of the nodule, and consisting of fine prismatic crystals of orthoclase, allotriomorphic quartz, and minute particles of magnetite and biotite. These feldspar needles are optically positive and elongated parallel ċ, with symmetrical position of the plane of optical axes. They show weak double refraction and extinguish at an angle of not more than 5°, and have either a divergent fibrous structure, with at times a slight tendency to fluidal arrangement, or are intergrown poikilitically with quartz, as was the case in the coarser grained areas of the rhyolite from the San Barnardino River (No. 343) (p. 778).

The denser spherulitic aggregates forming the surface of the nodules consist principally of optically positive feldspar fibers with a few films of biotite; quartz, if present, is too finely distributed to be recognized by optical tests.

Owing to unequal development in different directions these denser portions of the nodules assume all manner of irregular discoidal and plume-like forms, frequently overlapping and interpenetrating in such a manner as to render it difficult to determine where one ceases and the one adjoining begins.

The brown color of the nodules is due to the oxidation of trichites and minute ferritic particles that intersect them in parallel lines regardless of their complex inner structure.

The chemical composition of these peculiar types of compound spherulites is given under Analysis No. I, and differs not essentially from that of the dark blue spherulites from Obsidian Cliff as given by Iddings[1] (No. II). They contain somewhat less SiO_2 and more Fe_2O_3.

Analysis of spherulites.

Constituents.	No. I.	No. II.
SiO_2	74.75	76.70
Al_2O_3	12.01	12.30
Fe_2O_3	3.72	1.43
CaO	.54	.39
Na_2O	4.02	3.89
K_2O	4.73	4.73
Ign	.52	.66
Total	100.29	100.10

f. Hornblende-mica-andesite.—Fifty-eight miles west of the Rio Grande River, Mon. No. 19 (No. 53288). Corner Mon. Apache Mountains, Mon. No. 40 (No. 53289). Dog Spring, Dog Mountains, Mon. No. 55 (No. 53290). Tule Mountains, Mon. No. 186 (No. 53291). San Isidro Ranch, north of Signal Mountain, Mon. No. 224 (No. 53292). Coast Range, Mon. No. 224 (No. 53293).

These are fine-grained porphyritic rock types, varying in color from steel gray to reddish brown according to the state of preservation.

[1] J. P. Iddings, Obsidian Cliff, Yellowstone National Park, Seventh Ann. Rept. U. S. Geol. Surv., III, 1885-86, p. 282.

Macroscopically phenocrysts of plagioclase, hornblende, and biotite are, in most cases, easily recognizable in a dense aphanitic groundmass.

Under the microscope this groundmass resolves itself into a finely felted mass of delicate hornblende needles, plagioclase laths, and minute grains of magnetite (No. 53288, original No. 127).

The porphyritic plagioclase crystals are tabular formed after M (010) and are almost rectangular in cross sections. They show characteristic albite twinning and many individuals are frequently united in accordance with the carlsbad law. Judging by an extinction angle on M (010) sections of 15°, they are acid labradorites. Zonal structure is not uncommon. The crystals consist of a corroded inner core of more basic feldspar and an outer shell of acid labradorite. The inner portion is heavily charged with rock glass and extinguishes at a considerably larger angle than the homogeneous outer zone (No. 127).

The hornblende phenocrysts of the andesite are distinctly prismatic in habit, showing the prism faces (110) combined with the clinopinacoid (010). Twinning parallel (100) is quite frequent. The crystals have a brownish-green color and are strongly pleochroitic: $\mathfrak{a}$ greenish yellow, $\mathfrak{b}$ yellowish brown, $\mathfrak{c}$ greenish brown. The angle of extinction, measured on prismatic sections, is small: the angle $c:\mathfrak{c}$ = about 12°.

This mineral is one of the first to undergo decomposition. It is replaced in most sections by limonite and chlorite, or by epidote (No. 53293, original No. 506).

Biotite occurs in the form of yellowish-brown, hexagonal plates with strong pleochroism in the rock from the vicinity of Mon. No. 19 (Nos. 127, 142). It is, however, usually altered to magnetite (Nos. 53289, 53291, original Nos. 157, 467) or chlorite (No. 53291, original No. 464).

Small, purplish brown, prismatic crystals of apatite with strong absorption ($E > O$) are very plentiful in slide No. 127 from Mon. No. 19.

Magnetite is of normal development.

The delicate network of the andesite groundmass is in many cases greatly obscured by the infiltration of secondary quartz and limonite (Nos. 53288, 53292, 53293, original Nos. 126, 492, 506), and calcite (Nos. 53289, 53291, 53293, original Nos. 157, 464, 465, 508).

Chalcedony occurs abundantly in rifts formed in the rock from Dog Springs (No. 53290).

g. Augite-andesite.—Six miles west of Lake Palomas, Mexico, Mon. No. 20 (No. 53294). San Clemente Island, Pacific Ocean, Mon. No. 258 (No. 53295).

The specimens of augite-andesite are dark brown in color, being considerably weathered. They differ from the rock just described in the vitreous condition of the groundmass and by the presence of augite in place of hornblende and mica.

Augite occurs both in the groundmass and among the porphyritic constituents. It is pale yellowish green in color and has the large extinction angle common to this mineral: the angle $\mathfrak{c}:c$ = 47°. The products of atmospheric weathering are similar to those of the hornblende. In an extremely vesicular specimen (No. 53294, individual No. 153) the amygdaloid cavities were partially filled by chalcedony and cryptocrystalline quartz.

The glassy andesite from San Clermente Island (No. 53295, original No. 515) is peculiar in that it contains abundant phenocrysts of enstatite. The groundmass of this rock consists of a brown andesitic glass filled with microlitic grains of augite and magnetite and minute lath-shaped plagioclase crystals.

The enstatite is of prismatic form and perfectly colorless and shows the effect of extensive magmatic corrosion. The crystals are surrounded by a resorption rim of light-green augite grains similar to those of the groundmass. These grains are frequently somewhat elongated and have a tendency to radial arrangement around the core of the parental mineral.

Inclusions of glass are very frequent in the phenocrysts of this rock.

Two types of andesitic breccia (No. 53296, original Nos. 495, 520) may be mentioned here. One from San Diego, Mon. No. 258 (No. 495), a highly altered volcanic arkose, is extremely rich in chlorite, epidote, chalcedony, and secondary biotite; the other, from San Clermente Island, Mon. No. 258 (No. 520), consists of fresh fragments of andesite, scoriaceous basalt, and vitreous rhyolite cemented together by coarse granular calcite.

h. Basalt.—Fifty miles west of the Rio Grande River, Mon. No. 15 (No. 53297). San Bernardino River, Mon. No. 77 (No. 53298). Nogales, Mon. No. 122 (No. 53302). Pozo Verde, "El Banorie," Sonora, Mexico, Mon. No. 140 (No. 53299). Quitobaquita, Sonoyta Valley, Arizona, Mon. No. 172 (No. 53300). Tule Mountains, Arizona, Mon. No. 186 (No. 53303). Tucson, Arizona, 60 miles north of Mon. No. 122 (Nos. 53301, 53304).

Two distinct types of basalt are represented. One a scoriaceous, andesitic variety, rich in feldspar and poor in olivine; the other a normal holocrystalline rock, with a preponderance of olivine and augite.

The specimens vary in color from dark steel gray (Nos. 53297, 53298, 53299, 53300, 53301, original Nos. 56, 346, 426, 449, 533); to a brownish red (No. 439); intermediate shades being brown (Nos. 53299, 53303, 53301, 53304, original Nos. 406, 473, 529, 531) or yellowish brown (No. 53302, original No. 364) according to the state of preservation.

The andesitic type is by far the more common (Nos. 56, 346, 406, 426, 439, 449, 529, 533). It is identical mineralogically and structurally with the young Tertiary basalts from the Snake River Valley and Great Basin of the West and requires but a brief description. The dark-gray, sometimes almost black, color of the rock is due to the vitreous groundmass, consisting of an opaque, finely granulated glass-base, rich in skeleton crystals of magnetite, lath-shaped labradorite, and granular augite. The porphyritic constituents are tabular-formed labradorite, prismatic augite, olivine, and magnetite.

The labradorite phenocrysts have on M (010) faces an extinction angle of from 20° to 22°, and are consequently somewhat more basic than those of the andesite.

The amount of feldspar varies considerably in the different specimens of this rock. It decreases, apparently, in proportion to an increase in the ferro-magnesian constituents.

Olivine occurs in beautiful idiomorphic crystals showing very distinctly the combination of prism (110) with an acute brachydome (021) and the brachypinacoid (010). Inclusions of magnetite, augite, and rock glass are frequent.

The olivine is often colored yellowish brown by limonite, which, with serpentine, form its chief decomposition product.

Augite, magnetite, and apatite are analogous to those of the andesite.

Normal olivine-basalt is represented by Nos. 53302, 53303, and 53304.

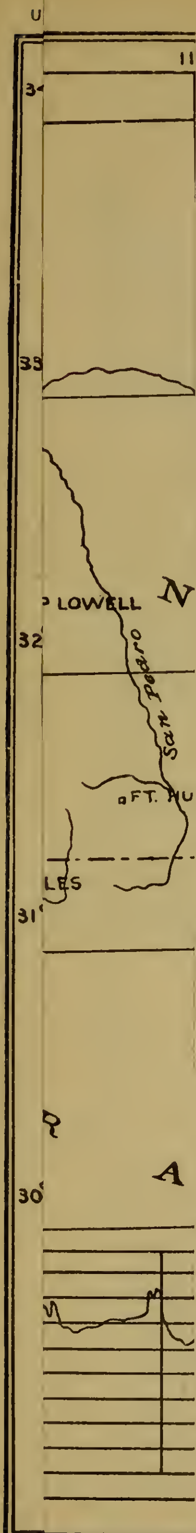
The difference between this and the foregoing type lies principally in the holocrystalline development of the groundmass, which contains besides labradorite, augite, and magnetite, a large amount of small, idiomorphic olivine crystals (No. 53303).

The porphyritic constituents consist chiefly of olivine with a few scattering crystals of augite, labradorite, and magnetite (No. 53302).

The olivine of both generations, especially those of the groundmass, are yellowish brown, being strongly impregnated with limonite; from which it would appear that they belong to a ferruginous variety.

Exogeneous inclusions of slightly fused sandstone are of rather frequent occurrence in the scoriaceous andesitic basalt from Mon. No. 15 (No. 53297).

From what has been said it is seen that the rock types encountered by the survey vary from an old, in part highly metamorphosed, granite to the most recent form of basaltic lava. A detailed mapping of the geology of the boundary line on the scale of the topographic map already referred to is much to be desired and would lead undoubtedly to many interesting results concerning the geological relationship of the igneous rock of the southwestern border of the United States.



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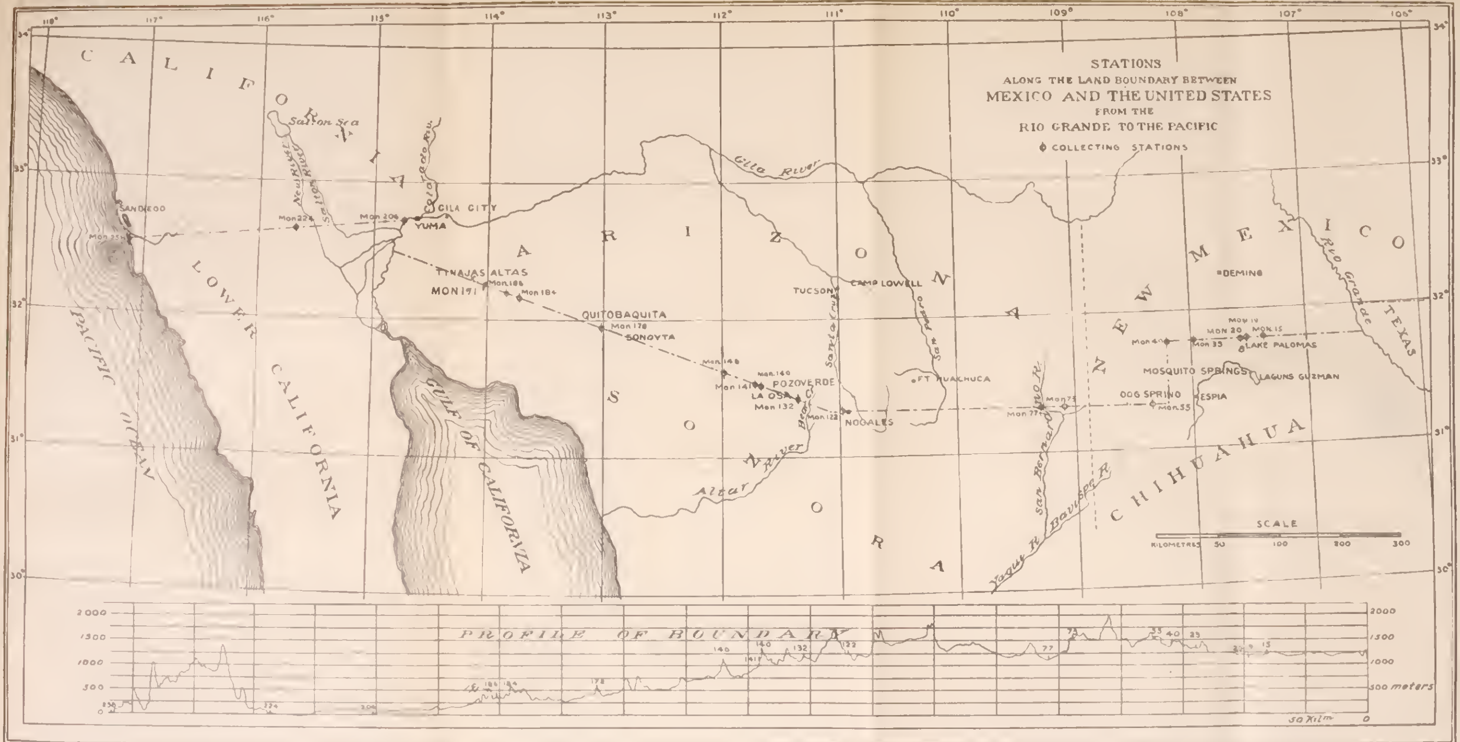
STATIONS
ALONG THE LAND BOUNDARY BETWEEN
MEXICO AND THE UNITED STATES
FROM THE
RIO GRANDE TO THE PACIFIC
COLLECTING STATIONS
CALIFORNIA
ARIZONA
NEW MEXICO
TEXAS
LOWER CALIFORNIA
SONORA
CHIHUAHUA
PACIFIC OCEAN
GULF OF CALIFORNIA
Salton Sea
Gila River
Colorado Riv.
New River
Salton River
Santa Cruz
San Pedro
Altar River
San Bernardino R.
Bavispe R.
Yaqui R.
Rio Grande
SAN DIEGO
Mon 224
Mon 204
YUMA
GILA CITY
TINAJAS ALTAS
MON 191
Mon 186
Mon 184
QUITOBAQUITA
Mon 178
SONOYTA
Mon 146
Mon 140
Mon 141
POZOVERDE
LA OSA
Mon 132
Mon 122
TUCSON
CAMP LOWELL
FT HUACHUCA
NOGALES
Mon 73
Mon 77
DOG SPRING
Mon 55
ESPIA
MOSQUITO SPRINGS
LAGUNA GUZMAN
Mon 40
Mon 33
MON 20
MON 19
MON 15
LAKE PALOMAS
DEMING
SCALE
KILOMETRES 50 100 200 300
PROFILE OF BOUNDARY
2000
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