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PETROLOGY AND MINERALOGY OF THE MOUNT ROSA AREA, EL PASO AND TELLER COUNTIES, COLORADO III. LAMPROPHYRES AND MINERAL DEPOSITS[1]

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ABSTRACT

Widely scattered dark gray lamprophyre dikes in the Mount Rosa area strike generally north-northwest and dip steeply. Outcrops of the lamprophyres, which can usually be traced for less than 500 feet, range in width from 2 to 25 feet. The lamprophyres are of two types, sodic syenites and sodic diorites. They intrude Pikes Peak granite, its variants, and Mount Rosa-type pegmatites. The lamprophyres are believed to be of late Precambrian age and their period of intrusion overlapped that of Mount Rosa-type pegmatites.

Veins of fluorite strike mainly north or northeast and dip steeply. These are probably of Tertiary age. Strongly radioactive altered zones in Mount Rosa granite contain uranothorite and thorogummite, which also occur as late hydrothermal minerals in Mount Rosa-type pegmatites.

INTRODUCTION

In this concluding article on the petrology and mineralogy of the Mount Rosa area, El Paso and Teller Counties, Colorado, we report the results of studies on nearly 50 fine-grained lamprophyre dikes and of the study of fluorite and barite veins and radioactive zones. Descriptions of the granites and pegmatites of the area have recently been presented (Gross and Heinrich, 1965, 1966). The presence of lamprophyres in this area was first recorded by Finlay (1916).

LAMPROPHYRES

Distribution. No general structural pattern of lamprophyre distribution appears from plotting the locations of the widely scattered outcrops. The predominant strike of the dikes is north-northwest with dips nearly vertical. A few dikes strike northeasterly and dip steeply northwest or southeast. Their outcrops can be traced for less than 500 feet, and the dikes range in thickness from 2 to 25 feet. A few small bodies, which appear, from outcrop, to be rectangular in outline, do not exceed 300 by 100 feet.

Small dikes occur along and adjacent to the Gold Camp Road near Wade Cutoff, on the south-facing slope of Kineo Mountain, and one particularly long dike can be traced from near Bruin Inn northward to Bear

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Creek (Fig. 2, Gross and Heinrich, 1965). The two rectangular lamprophyre bodies that occur in the area are north of Kineo Mountain and near Stove Mountain adjacent to the Gold Camp Road.

Petrology. The lamprophyres are dark gray to black, fine-grained rocks which are generally very resistant to erosion. Mafic minerals predominate, with scattered microphenocrysts of feldspar producing a spotted appearance. Rarely small clots of amphibole grains can be seen in the larger rectangular bodies. In many places the feldspar crystals are aligned sub-parallel to the trend of the dikes.

TABLE 1. MODES OF SELECTED LAMPROPHYRES, MOUNT ROSA AREA, COLORADO

No.	4–6	32–16	32–1A	60–8
Olivine (altered)	29.5			
Augite	32.0			
Titanaugite				22.0
Aegirine				10.0
Barkevikite		45.9		
Biotite		11.5	41.3	
Andesine (Ab62)	28.0			
Oligoclase (Ab70–72)		39.3	46.5	
Anorthoclase perthite				58.0
Accessory (magnetite)	10.5			10.0
Fluorite & magnetite			12.2	
Magnetite & apatite		3.3		
Johannsen No.	3212	3212	2212	2110
Classification	Olivine diorite	Meladiorite	Diorite	Sodic syenite

Locations:

- 4–6 At head of East Beaver Creek, Teller County.
- 32–16 One-half mile southeast of Kineo Mtn., El Paso County.
- 32–1A Near trail, North Cheyenne Creek, El Paso County.
- 60–8 One-fourth mile northwest of pegmatite 61-4, El Paso County.

Thin section studies indicate that the lamprophyres belong to two major types: sodic syenites and sodic diorites.

a) *Sodic syenites:* Most commonly the phenocrysts are of anorthoclase which forms rounded single crystals or, less usually, glomeroporphyritic groups. This feldspar shows marginal replacement-type perthitization and moiré structure. The chief matrix feldspar is similar, except the grains are invariably more strongly perthitized, usually throughout their entirety.

The matrix texture most commonly is anhedral-granular with neither the feldspars nor the mafics showing any crystal boundaries. In a few, however, the matrix alkali feldspar forms euhedral tablets with the mafics in smaller, anhedral, interstitial grains and clusters. These feldspar tablets may have a criss-cross arrangement or show poorly developed flow structure (trachytoid).

The mafic species are aegirine, barkevikite, biotite ($Fe^{3+} \pm$ Ti-rich).

TABLE 2. CHEMICAL ANALYSIS OF A SODIC SYENITE

SiO_2	61.46
Al_2O_3	14.55
Fe_2O_3	2.30
FeO	5.78
MgO	.50
CaO	2.74
Na_2O	4.71
K_2O	4.88
H_2O^+	.74
H_2O^-	.54
TiO_2	1.07
P_2O_5	.27
MnO	.25
BaO	.17
F	.14
S	.01
ZrO_2	.02
	100.13

Cuts Pikes Peak granite, one-half mile east of Jones Park, Teller County. G. Steiger, Analyst. Finlay, 1916.

Mineralogy: Aegirine, barkevikite, biotite, anorthoclase-perthite; accessory zircon, quartz, allanite, fluorite.

Aegirine appears as rare rounded phenocrysts and as matrix granules; both are uralitized by the sodic amphibole. Less commonly titanian augite may also be present. The amphibole forms clots of larger grains in a few rocks but usually is confined to the matrix where some of it replaces aegirine. Uncommonly thin veinlets of barkevikite cut the syenites, attesting to the late development of the amphibole. Biotite is restricted to the matrix. Accessory minerals include riebeckite, allanite, zircon, apatite, magnetite and fluorite. In Table 1 (No. 60–8) is presented the mode of a pyroxene syenite lamprophyre. Table 2 gives the chemical analysis of a syenitic lamprophyre.

b) *Sodic diorites:* The dioritic lamprophyres show even greater mineralogical variability than their syenitic counterparts. Some contain the combination of augite and olivine (Table 1, No. 4–6); others have a sodic amphibole as the chief mafic species (Table 1, No. 32–16); whereas in a third type biotite is the sole mafic mineral (Table 1, No. 32–1A). The olivine is completely altered to an antigorite-calcite pseudomorph which retains the original olivine crystal outline. The plagioclase ranges from Ab_{62} to Ab_{72}, with the more calcic varieties occurring in olivine-pyroxene rocks. Amphibole and biotite dioritic lamprophyres may contain accessory perthitic alkali feldspar.

In these rocks the bulk of mafics may appear as phenocrysts in a dominantly feldspathic matrix that is fine-grained and felted. Accessories are magnetite, allanite and abundant apatite.

Age relations to other intrusive rocks. The lamprophyre dikes transect the Pikes Peak granite and its variants. Contacts between the two are sharp with no apparent exo- or endomorphic effects. Although no lamprophyres have been found intruding the Mount Rosa granite, Mount Rosa pegmatites are cut by them. However, in one occurrence a Mount Rosa-type pegmatite cuts a very small lamprophyre. This indicates that although *most* of the Mount Rosa pegmatites had been emplaced prior to lamprophyre intrusion, initiation of the latter process began just before termination of the pegmatitic stage. Thus the age of the lamprophyres is Precambrian, post-Mount Rosa, or slightly younger than 1010–1080 my (Gross and Heinrich, 1965, 1966).

Other Colorado lamprophyres. Geological and petrological data on other Colorado lamprophyres are summarized in Table 3. The four Precambrian groups (Table 3, 1–3, plus that of this paper) all are apparently among the very youngest Precambrian rocks of the state. The others (Table 3) are Eocene to Miocene in age. Most of the swarms are spatially and genetically related to "central" igneous complexes (Table 3, Nos. 1, 2, 6, 7) that are somewhat to strongly alkalic. The Mount Rosa swarm is related at least in distribution and in time to an alkalic granite body and is unique in this respect among Colorado lamprophyre swarms. The three others (Table 3, Nos. 3, 4, 5) are not relatable to any "central" alkalic complex.

Discussion. Reviews of theories on the origin of lamprophyres have been published by Eskola (1954), Kaitaro (1956), and Turner and Verhoogen (1960). The state of our knowledge regarding their genesis can best be summarized by the statement of Turner and Verhoogen, 1960, p. 255, "It must be admitted that no completely satisfactory explanation of the origin of lamprophyre has yet been proposed". Indeed most theories are highly unsatisfactory. This includes Barth's (1962, p. 193) explanation: " . . . much evidence supports the view that lamprophyres are diabases that have been altered by metasomatic processes." In Colorado diabases and lamprophyres occur side by side (*e.g.*, the Lookout Mountain area), but the diabases are older and no transitional rocks nor relict features exist even to suggest that lamprophyres are derived by the alteration of diabases.

Turner and Verhoogen (1960, p. 254) state also that "Today any direct comagmatic relation between granite and associated lamprophyres is generally denied". The Mount Rosa lamprophyres are perhaps somewhat unusual in the following ways:

1. They are syenitic to meladioritic; gabbroic, peridotitic and feldspathoidal types are absent.
2. Feldspars are not confined to the rock matrixes.
3. $CaCO_3$ is not abundant; in fact, it is rare to absent in most varieties.
4. They show a temporal relationship to terminal stages of Mount Rosa igneous activity.

That the lamprophyre magma is a late derivative of the Mount Rosa magma is not suggested by any observational data. It seems rather that the former was intruded, from a genetically separate source, along fractures in Pikes Peak granite that were formed in response to stresses related to the emplacement of the Mount Rosa sheet.

Mineral Deposits

Fluorite veins. A few scattered breccia zones containing fluorite have been prospected in the St. Peters Dome district. All of these veins dip steeply and transect Pikes Peak granite, mostly near fayalite granite bodies.

Only one of the larger breccia zones has been mined for fluorite (the Hughes Boss claim); this zone can be traced for more than two miles and has been named the St. Peters Dome fault (Boos and Boos, 1957). The mineralized zone has a thickness of more than 6 feet and is well exposed at a caved drift near Rock Creek Canyon. The vein strikes N. 55° E. and dips 56° SE. Northward the strike of the fracture zone changes to N. 15° W., and the dip to 76° SW., and it increases in thickness. At the summit of the ridge the fluorite vein is 4 to 6 feet thick and trends N. 30° W. Near Duffield the vein strikes N. 22° E. where exposed in a shaft. Many small offsets along the fracture zone cause changes in strike. Pinch-and-swell structure is common. The wall rock is normally Pikes Peak granite, but at one spot the vein cuts fayalite granite.

The breccia zone consists of many ramifying veinlets of fluorite from

TABLE 3. EXAMPLES OF OTHER COLORADO LAMPROPHYRES

Location	Petrology	Consanguineous alkalic complex and related rocks	Geological age	References
1. McKinley Mtn. area, Northern Wet Mtns., Custer and Fremont Cos.	"lamprophyres" phenocrysts of augite, hornblende or biotite in a fine-grained dark gray matrix.	Democrat Gulch gabbro-syenite-breccia complex. Other dikes are 1) syenites, 2) dark syenites, 3) andesites, andesite porphyries, basalts, 4) gabbros. Lamprophyres may be youngest dikes.	youngest Precambrian rocks of the area, 595 my.	Christman *et al.*, 1959; Heinrich and Dahlem, 1966
2. Lookout Mtn. area, Fremont Co.		McClure Mtn.-Iron Mtn. gabbro-syenite-nepheline syenite-ijolite complex. Dike sequence is: 1. Olivine gabbro and lherzolite 2. nepheline syenite 3. augite-barkevikite spessartite 4. plagioclase spessartite 5. vogesite 6. trachyte 7. carbonatite	Part of youngest Precambrian rock group in the area, possibly also 595 my.	Dahlem, 1965; Heinrich and Dahlem, 1966

TABLE 3—(*Continued*)

3. Northern Sawatch Range	"resemble minette, vogesite and spessartite"	None indicated. Occur in gneiss and granite, have been metamorphosed to amphibolite facies.	Their intrusion constitutes almost the youngest Precambrian event of the area.	Pearson, 1959
4. Front Range, Boulder Co.	limburgite	Dikes of monzonite porphyry, diorite porphyry; latite breccia	Last event in Tertiary intrusive and mineralization sequence; Probably Eocene.	Lovering and Goddard, 1950. E. N. Goddard, pers. comm.
5. South Park, Park Co. Secs. 20, 21, T. 11S., R. 75W.	Two composite bodies (one dike, one sill) of older analcite trachydolerite and younger analcite syenite	none known	Post-cretaceous, Pre-Oligocene	Jahns, 1938; Stark *et al.*, 1949
6. Raton Mesa region, south-central Colo.	syenite lamprophyre, olivine gabbro lamprophyre, foidal gabbro lamprophyre	West Spanish Peak of syenodiorite porphyry. Lamprophyres are in "subparallel group" of dikes which is younger than radial dike swarm.	Late Eocene to Early Oligocene	Knopf, 1936; Johnson. 1960, 1961, 1964.
7. Cripple Creek district, Teller Co.	trachydolerite, vogesite, monchiquite	Latite-phonolite "Basin breccia," syenite phonolite	Miocene	Cross, 1897; Lindgren and Ransome, 1906

less than an inch to several feet thick. Locally along the zone the breccia blocks have been chloritized and silicified. The vein minerals are chiefly fluorite, quartz and chlorite with minor amounts of sphalerite and galena. Gold in pyrite and small quantities of chalcopyrite and barite have been reported by Stevens (1949), who states that the ore is known to continue to a depth of at least 600 feet.

A few other small prospects in the vicinity contain fluorite and chlorite or barite. These deposits show considerable brecciation of Pikes Peak granite and weak sulfide mineralization.

Within the Mount Rosa area these mineralized breccia zones are found cutting Pikes Peak granite, fayalite granite, and the lamprophyres, all Precambrian rocks. As no younger rocks are present in the area, the breccia veins can only be dated crudely by comparison with fluorite deposits in adjoining regions. Stevens states that the Mount Rosa veins resemble structurally and mineralogically the Cripple Creek fluorite deposits and thus may be of Miocene age.

Nine samples of fluorite ores from six deposits were analyzed for Be, with generally negative results. The highest value was 5 ppm Be in a gray-green fluorite from a narrow vein on the north trending spur of Cookstove Mountain, north of the Duffield area, a prospect not described by Stevens (1919).

Radioactive deposits. Many pegmatites and one small area of altered Mount Rosa granite were uncovered as the result of prospecting for radioactive minerals. The radioactivity stems from zircon and thorite, less commonly from pyrochlore, microlite or thorogummite. These deposits have a high concentration of thorium but are low in uranium.

The radioactive pegmatites are composed primarily of quartz, microcline, riebeckite and zircon. Radial fracturing of quartz around metamict zircon and thorogummite is common. In a few pegmatites, olive-green euhedra of pyrochlore are associated with zircon, and the border zones of some pegmatites contain a few yellow-orange crystals of radioactive microlite. Secondary uranium minerals are rare, although uranophane has been identified from a pegmatite containing zircon, thorite and pyrochlore. None of the radioactive pegmatites have proved to be of any commercial value.

A small area three miles northeast of Rosemont on the Summit Wye Road contains two trenches from which were shipped 500 tons of radioactive ore. Core drilling indicated variable amounts of radioactive ore at a depth of 100 feet in Mount Rosa granite. Assays indicated thorium exceeded uranium in the ore, which contained thorogummite (Carl Quinn, pers. comm.). The ore bodies are irregular-shaped pods within the Mount

Rosa granite along a northeast-trending ridge. A radiometric survey with scintillation counter indicated that most of the bodies are elongate, trending northeast.

At the Rosa No. 1 trench nearest the Summit Wye Road, fayalite granite is bleached light gray and the highly radioactive Mount Rosa granite is stained red-violet by hematite. The mineralized Mount Rosa granite is composed of altered feldspar, quartz and riebeckite, some of which has been converted to biotite or chlorite. Uranophane coats most of the individual grains, and small grains of thorite are disseminated through the rock. A highly radioactive brownish-black vitreous coating of uranothorite less than 3/8 inch thick occurs along fractures. Fluorescent pale-green opal is visible along some fractures. Page (1956, p. 630) states that ". . . small stocks, sills, and dikes of alkalic and fluorine-rich intrusives showing abundant deep-red to purplish-red oxides are guides to possible deposits of thorium."

The Mount Rosa granite of the altered area is radioactive owing chiefly to thorogummite and uranothorite. Much hematite is also present along with supergene uranophane and uraniferous opal.

Thorite in the pegmatites formed in an "intermediate to late period in the hydrothermal replacement stage" (Gross and Heinrich, 1966). It seems probable that the deposits of thorite in fracture zones in Mount Rosa granite on the Summit Wye Road represent time and genetic equivalents of their pegmatitic dimorphs but which were formed by the late-stage hydrothermal solutions that had migrated beyond their usual pegmatitic boundaries.

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