Carbonatite dikes of the Chupadera Mountains, Socorro County, New Mexico

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Introduction

Calcitic carbonatites and thorium-bearing quartz deposits have been identified in the southern Chupadera Mountains in Socorro County. The dikes and quartz veins are hosted by Precambrian metamorphic rocks, whereas jasperoid occurs in Paleozoic carbonate rocks. The deposits occur in protracted sections 20, 21, 28, and 29, T5S, R1W on the northeastern portion of the Pedro Armendaris Spanish Land Grant No. 34 and on the western edge of the Bosque del Apache National Wildlife Refuge. The approximate location of these deposits and the locations and ages of other carbonatites in the region are shown in Fig. 1 and Table 1. The carbonatite dikes in the Chupaderas were discovered during a contract uranium exploration program by United Geophysical Corporation in 1954 (Reim, 1955). At that time the intrusives were described as "radioactive-calcite veins." The "veins" were recognized as carbonatite dikes in 1978 by Tenneco geologists during a mineral reconnaissance program. In 1980, the New Mexico

Bureau of Mines and Mineral Resources independently identified the carbonatites (Kent, 1982; McLemore, 1983).

Geologic setting

The Chupadera Mountains are within a north-trending, west-tilted horst along the western margin of the Rio Grande rift. Carbonatites crop out in a 2 mi² exposure of Precambrian rocks (Fig. 2), which has been mapped and described by Kottlowski (1960), Condie and Budding (1979), Kent (1982), Bowring et al. (1983), and now by the authors of this paper. The Precambrian host rocks are primarily interfingering quartzofeldspathic schist and gneiss, mica schist, and minor quartzite. These steeply dipping metamorphic rocks probably were interbedded argillaceous and arenaceous sediments with locally abundant felsic, volcaniclastic detritus. Condie and Budding (1979) suggested that the rocks were deposited during continental rifting, buried to

depths of 12–15 km, and metamorphosed at temperatures of 500–550°C. The exposed stratigraphic thickness of metasedimentary rocks may exceed 3,000 ft. Schistosity approximates original bedding and is indicative of two or more periods of folding before carbonatite emplacement. There appears to be at least one early west–northwest-trending episode of isoclinal folding followed by a period of northeast-trending open folding (Bowring et al., 1983).

Narrow bodies of biotite schist and amphibolite within the metasedimentary units are probably metabasalt flows and intrusives. Minor dikes of gneissic pegmatite and aplite are also present. Local porphyritic feldspathic schist may be metamorphosed felsic plutons and perhaps volcanic flows. The youngest Precambrian metamorphic rock is probably the foliated megacrystic granite in the southern portion of the Precambrian exposure. Based on zircon U–Pb isotopic data, this metamorphosed granite is 1,659 ± 3 m.y. old (Bowring et al., 1983). Carbonatite is the

TABLE 1—Ages of carbonatites and selected alkalic rocks in New Mexico and Colorado. See Fig. 1 for approximate geographic locations.

Locality	Age (m.y.)	Reference
1. Chupadera Mountains carbonatite	?	This paper
2. Lemitar Mountains carbonatite	449	McLemore, 1982
3. Monte Largo Hills carbonatite	?	Loring and Armstrong, 1980
4. Lobo Hill syenite and carbonatite	<604	Loring and Armstrong, 1980; McLemore, 1984
5. Pedernal Hills syenite	<496	Loring and Armstrong, 1980
6. Caballo Mountains syenite	?	Staatz et al., 1965
7. Florida Mountains quartz syenite	418–750	Brookins, 1974
8. Powderhorn district carbonatites and associated alkalic rock	543–731	Olson et al., 1977
9. Wet Mountains district carbonatites and associated alkalic rock	427–560	Olson et al., 1977; Armbrustmacher and Hedge, 1982

FIGURE 1—Location of carbonatites and selected alkalic rocks in New Mexico and Colorado and schematic location of the Rio Grande rift. See Table 1 for locality names and ages.

youngest pre-Tertiary intrusive rock and is not metamorphosed.

A thin wedge of Paleozoic limestone and arkose unconformably overlies the southern margin of the Precambrian rocks. These sedimentary rocks contain no carbonatite dikes and are presumed to be younger. Poor exposures and major jasperoid zones make identification of the Paleozoic formations uncertain. However, Kottlowski (1960) and Eggleston (1982) have documented the Caloso (Mississippian) and Sandia (Pennsylvanian) Formations in the map area.

To the north and east the Precambrian rocks are covered by a thick Cenozoic section of ash-flow tuff, felsic volcanic flows, basalt, and sedimentary rocks, which compose most of the Chupadera Mountains (Eggleston, 1982). To the west the Precambrian rocks are downthrown by the Chupadera fault.

Carbonatites

The carbonatites occur as a northeasterly trending, arcuate swarm of steeply dipping dikes that cut the foliation of the Precambrian rocks. The dikes typically are exposed within a thin, laterally extensive colluvium as rows of boulders. Wall-rock contacts are rarely observed (Fig. 3). The intrusives are in long, narrow zones which, in some exposures, contain up to three closely spaced, adjacent dikes. Individual dikes commonly are 0.7–4.9 ft thick. Select dikes have been traced continuously in outcrop for up to 200 ft along strike. Four dike zones exceed 1,000 ft in strike length and may exceed 5,000 ft with only minor lateral offset by faults. The extent of carbonatites concealed by Paleozoic and younger rocks is unknown.

Carbonatite textures range from fine to coarse grained and from equigranular to porphyritic. Many of the intrusives are microbreccias, with rounded and irregular carbonatite fragments set in a carbonatite matrix with similar composition. Phenocrysts, carbonatite fragments, and wall-rock inclusions generally align to form flow banding and local flowage segregation. Many dikes are uniform in texture, but some have variable texture along strike. Wider portions of others possibly are composite intrusives with sharp contacts between different phases that are distinguished by textural contrast.

The carbonatites are moderate brown on fresh surfaces and yellowish brown to reddish brown where weathered. Xenoliths and phenocrysts of magnetite, apatite, and bio-
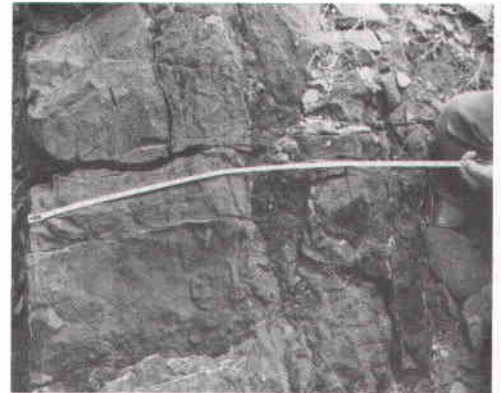

FIGURE 3—Outcrop of a 2.4-ft-thick carbonatite dike. Wall-rock contacts are concealed by colluvium.
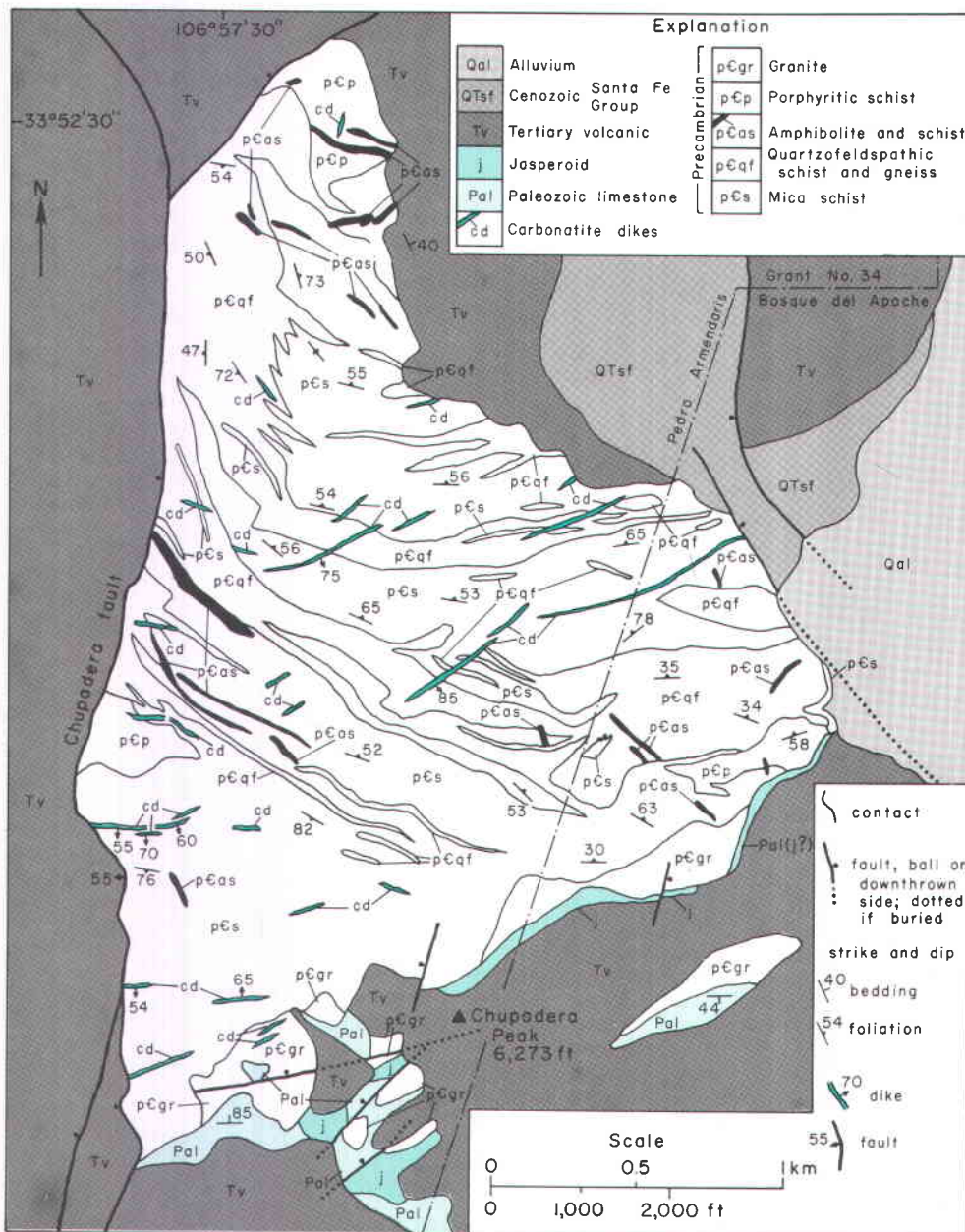

FIGURE 2—Generalized geologic map of carbonatites in the Chupadera Mountains (Precambrian rocks after Kent, 1982; Tertiary rocks after Eggleston, 1982; and mapping by the authors of this paper).

tite characteristically stand in positive relief from weathered carbonate matrix. Angular wall-rock xenoliths in the dikes are up to 0.7 ft long and commonly have reddish rims because of hematization.

Mineralogy

The carbonatites are composed of calcite with trace to moderate amounts of other minerals commonly found in carbonatites (Table 2). A semiquantitative x-ray diffraction analysis of sample 45h indicates 55–65% calcite, 12–15% dolomite, 8–10% apatite, 5–10% kaolinite(?), 3–5% quartz, and trace chlorite. Some carbonatite slabs reveal a swelling clay, perhaps montmorillonite, as possible pseudomorphs after feldspar phenocrysts or inclusions.

Two primary carbonate textures are recognized in thin section (Figs. 4 and 5). Groundmass carbonate (<0.05 mm) appears cloudy because of abundant fine-grained inclusions of iron and titanium oxides. Coarse-grained carbonate (0.05–3.0 mm) is clear and typically occurs as replacements of feldspar and biotite phenocrysts, anhedral mosaics within carbonatite fragments, matrix grains, and thin late-stage veinlets. Calcite is the dominant carbonate mineral in both textures as determined by rapid effervescence in cold, dilute hydrochloric acid. Dolomite is not evident in coarse grains, but is interpreted to be a significant groundmass constituent.

Possible carbonate pseudomorphs after feldspar commonly have blocky feldspar morphology and occasionally exhibit relict polysynthetic plagioclase twinning, which is apparent from oriented clay inclusions within clear carbonate aggregates (Fig. 5). Other chlorite-rimmed carbonate pseudomorphs(?) have replaced an unknown mineral. Some samples contain partly recrystallized, fine-grained carbonate mosaics, making cloudy and originally clear grains indistinguishable.

Carbonatite breccia clasts contain equigranular, anhedral, clear carbonate, partially altered biotite, magnetite, apatite, and zircon. These minerals also occur as isolated phenocrysts. Most carbonatite fragments and phenocrysts are rounded or irregular because of abrasion and partial resorption. Biotite commonly contains hematite lamellae and occasionally is completely replaced by lamellar intergrowths of quartz, sparry carbonate, iron and titanium oxides, and chlorite. These platy aggregates of alteration minerals range up to 1 cm in length. Magnetite crystals vary from less than 0.05 to 5 mm in diameter. Magnetite crystal rims sometimes are altered to secondary iron and titanium oxides. Apatite crystals range in length from less than 0.05 to 5 mm. Magnetite and apatite crystals tend to be euhedral if small and may be broken or irregular if large. Zircon occurs with clear carbonate in crystal aggregates that have rims of ilmenite(?). These clusters may be pseudomorphs of calzirtite, $CaZr_3TiO_9$, or

zirkelite, $(Ca,Th,Ce)Zr(Ti,Nb)_2O_7$. Calzirtite is a primary carbonatite mineral that may be replaced by aggregates of zircon and ilmenite (Kapustin, 1980). Trace pyrite occurs as sieve-textured grains intergrown with a carbonate matrix. Fractures in weathered rocks contain variable amounts of clay and iron and titanium oxides.

Geochemistry

Geochemistry, like mineralogy, is highly variable for carbonatites from different localities. However, whole-rock geochemical analyses of representative carbonatite rock-chip samples from the Chupadera Mountains indicate only minor variances from a "typical" carbonatite chemistry (Table 3). The Chupadera Mountains carbonatites are distinctly calcic, have low sodium and potassium content, and low to average magnesium content. They contain elevated concentrations of silica relative to a "typical" carbonatite, mostly because of biotite phenocrysts, biotite alteration products, and lithic inclusions rich in silicate minerals. The carbonatite samples contain more phosphorus than is "typical" because of apatite content, but they are within the normal range of variation found among common carbonatites. Iron and titanium contents are high, and they vary with crystal segregations within the dikes of titaniferous magnetite and altered biotite.

Trace-element geochemistry of 43 representative carbonatite samples indicates en- ☞

TABLE 2—Modal analysis of five representative carbonatites from the Chupadera Mountains with values in percent. The modes are based on 320–390 point counts per thin section. **ND** = not detected. Sample 45h is partly recrystallized; sample 46b also contains 3% orthoclase xenocrysts; sample 47b contains trace pyrite.

Sample	Groundmass carbonate	Coarse carbonate	Secondary Fe and Ti oxides	Magnetite	Biotite	Chlorite	Apatite	Quartz	Zircon	Clays	Total phenocrysts and carbonatite fragments
45h	31	33	17	<1	3	7	4	2	3	<1	47
46b	18	47	14	ND	ND	14	<1	1	1	1	3
47b	52	14	6	13	7	5	2	1	ND	ND	41
51	47	18	14	6	4	8	1	2	ND	ND	40
53c	32	24	8	12	5	9	5	2	2	1	44
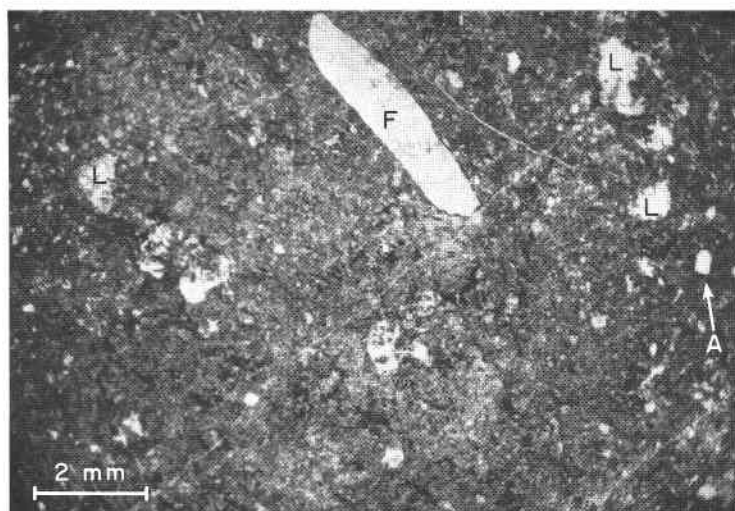
FIGURE 4—Photomicrograph in plane-polarized light of partly recrystallized matrix carbonate, trace apatite (**A**), and sparry calcite after feldspar (**F**), after lithic fragments (**L**), and in minor veinlets.
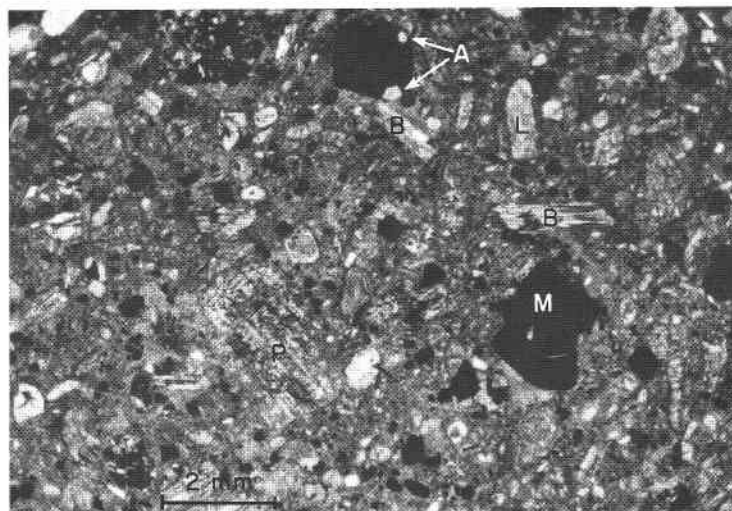
FIGURE 5—Photomicrograph in plane-polarized light of porphyritic carbonatite with partly resorbed crystals of magnetite (**M**), biotite (**B**), and apatite (**A**). Also contains calcite pseudomorphs after plagioclase (**P**) and lithic fragments (**L**).

richment of uranium, thorium, yttrium, and rare-earth elements, which is diagnostic of carbonatites (Table 4). A gamma-ray spectrometer survey has established that radioactivity is extremely variable along dike outcrops and that uranium and thorium generally are unassociated. Dikes in southwestern outcrops commonly have the greatest concentrations of most trace elements.

Linear correlation coefficients (r) better define the interassociation of minor elements (Table 5). Based on student t tests, r values with a variance of 0.34 from zero are indicative of significant positive or negative correlation with greater than 95% confidence for all element pairs except for those containing thorium or rubidium analyses. The five r values greater than +0.6 may indicate strong positive correlation. Cerium and lanthanum are the most correlative (r = 0.87). The sum of cerium and lanthanum correlates well with zirconium, which suggests that these rare-earth elements occur predominantly in zircon and probably not in apatite or in a distinct rare-earth-element mineral. Rare-earth elements can substitute for a portion of the zirconium in zircon when there is partial replacement of silicon by phosphorus (Berry and Mason, 1959). The rare-earth elements perhaps were contained originally in calzirtite or zirkelite.

Certain carbonatites from other localities in the region do not display this association. For example, carbonatites of the Wet Mountains have discrete rare-earth-element minerals and display no correlation between Zr and Ce + La. As calculated from geochemical data of Armbrustmacher and Brownfield (1978), magmatic carbonatites from the Wet Mountains have a Zr to Ce + La correlation coefficient of −0.06, whereas the r value for "replacement carbonatites" is −0.05.

Uranium is associated with yttrium in carbonatite samples from the Chupadera Mountains, but no discrete uranium or yttrium minerals have been identified. An autoradiograph of 45h, the sample with the greatest uranium content, reveals that radioactivity in this sample coincides with finely disseminated hematite in groundmass carbonate. Uranium and yttrium characteristically occur together in carbonate minerals, such as in many of the 18 pyrochlore group minerals. When found, these minerals are often metamict and fine grained. One of these minerals may have existed in the Chupadera Mountains, but was altered. Some of the uranium may have been remobilized in the near-surface environment and locally adsorbed by hematite.

Titanium is associated with iron in the dikes because of titaniferous magnetite, ilmenite, and fine-grained mixtures of iron and titanium oxides. Lead and zinc are correlative and probably coexist as trace constituents within several major minerals.

Petrogenesis, emplacement, and alteration

The carbonatite dikes were formed by multiple forceful injections of carbonatite magma. Part of the melt solidified and was brecciated

TABLE 3—Whole-rock geochemistry in percent. Assays were done by commercial laboratories. * Standard whole-rock geochemistry. § After Gold, 1966. † Quantitative x-ray fluorescence. ** Total iron expressed as Fe_2O_3.

Oxide	Samples from the Chupadera Mountains				"Typical" carbonatite§
	45h*	45h†	47b†	53c†	
SiO_2	10.2%	7.7%	8.9%	13.0%	5.67%
CO_2	31.1	—	—	—	32.16
TiO_2	0.91	1.11	1.73	3.65	0.50
Al_2O_3	1.31	1.9	1.9	4.1	1.77
Fe_2O_3**	4.64	5.48	9.17	14.85	8.00
MnO	0.89	0.82	0.45	0.81	0.78
MgO	3.42	3.70	3.55	7.00	6.10
CaO	43.3	43.49	43.91	35.28	37.06
Na_2O	0.046	<0.01	<0.03	<0.03	1.09
K_2O	0.070	0.07	0.25	0.19	0.81
P_2O_5	3.51	2.27	3.78	2.73	1.73
Total	99.4%	—	—	—	95.73%

TABLE 4—Abundance of minor and heavy elements in representative samples. Values are in ppm unless otherwise noted. Assays were done by commercial laboratories. * Arithmetic mean and range based on 43 semiquantitative XRF analyses and 39 quantitative assays for F, Cu, Zn, Pb, and U. Values below detection limits were considered to be 0 for calculation of the mean. † Weighted average of 200 analyses from 55 localities (Gold, 1966). § Total rare-earth-element oxides.

	Samples from the Chupadera Mountains*		"Typical" carbonatite† weighted average
Element	Mean	Range	
F	1,221	350–1,800	3,800
Ti	1,818	660–3,900	2,998
Mn	2,449	1,000–4,100	6,040
Fe	3.16%	0.46–8.50%	5.61%
Ni	155	20–490	32
Cu	41	12–80	88
Zn	172	26–571	160
Rb	62	<10–250	52
Sr	720	220–2,600	7,526
Y	247	46–700	114
Zr	1,011	190–7,700	461
Nb	384	110–650	—
Nb+Ta	—	—	560
Ba	1,272	<30–13,000	4,030
Ce	737	<80–4,900	—
La	296	<80–1,700	—
REO§	—	—	5,900
Pb	56	24–208	27
Th	191	<20–1,100	694
U	50	3–1,094	57

at least once before final emplacement. The intrusive breccia texture and apparent composite nature of certain dikes indicate several periods of magmatic activity.

Experimental evidence indicates that apatite is the first mineral to crystallize from a carbonatite melt (Wyllie and Biggar, 1966). Magnetite, the second-formed mineral within carbonatites of the Chupadera Mountains, encases apatite. Biotite followed magnetite and was altered before final emplacement. However, biotite within carbonatite fragments was isolated from late magmatic fluids and remains relatively fresh. Probable calzirtite or zirkelite crystallized early and was replaced completely by calcite, zircon, and ilmenite before final solidification of the carbonatite. Plagioclase, which is completely replaced by carbonate and clay, may have originated as phenocrysts from a precursor magma.

Le Bas (1977) and numerous other researchers suggest that a carbonate melt is formed as an immiscible phase of a volatile-rich, alkaline, ultramafic magma. Unlike many carbonatites, those in the Chupadera Moun-

tains are distal to possible alkalic intrusives. A related alkaline intrusive complex may occur at depth or may be concealed by adjacent Paleozoic and Cenozoic rocks.

Minor wall-rock assimilation, potassium fenitization, and hematization accompanied emplacement, but they appear to have had only minor effects on final carbonatite composition. Fenite forms a rind up to 0.02 mm thick along dike margins, on adjacent host-rock fractures, and around wall-rock xenoliths within the carbonatite. The fenite is a light-gray to brown replacement, which is composed predominantly of potassium feldspar. The feldspar is replaced locally by irregular patches of carbonate, chlorite, goethite, and hematite.

Brick-red hematite extends up to 5 cm beyond fenitized wall rock as minute grains along host-rock grain boundaries. Fractures in Precambrian rocks distal to the carbonatite dikes are coated locally with hematite. Some of these fracture zones are in the trend of nearby carbonatite dikes. Sparse hematite is evenly dispersed throughout primary potassium feldspar in the Precambrian rocks. The

TABLE 5—Linear correlation coefficients (r values) of selected minor and heavy elements, listed in order of abundance. These were based on up to 43 element pairs calculated from analyses summarized in Table 4. Element pairs were discarded when there was a value below detection limits. Elements with no detections were Ba (4), Ce+La (4), Th (16), and Rb (14).

Element	Fe	Mn	Ti	Ba	F	Ce+La	Zr	Sr	Nb	Y	Th	Zn	Ni	Rb	U	Pb	Cu
Cu	0.42	0.17	0.53	−0.25	0.23	0.01	0.38	0.11	−0.04	−0.36	−0.19	0.06	0.26	0.05	−0.32	−0.19	1.00
Pb	0.09	−0.31	−0.03	0.30	0.02	0.52	0.34	0.58	0.22	−0.20	−0.15	0.68	−0.24	−0.08	0.14	1.00	
U	−0.50	0.03	−0.41	0.25	−0.04	0.10	−0.14	−0.01	0.03	0.70	0.39	−0.28	0.12	−0.21	1.00		
Rb	−0.06	0.28	−0.03	0.16	−0.28	0.36	0.35	−0.03	0.17	0.14	0.36	0.07	0.11	1.00			
Ni	0.58	0.36	0.50	−0.07	0.25	0.43	0.45	0.24	0.28	0.25	0.10	−0.15	1.00				
Zn	0.41	−0.29	0.37	0.07	−0.03	0.33	0.28	0.30	0.05	−0.51	−0.27	1.00					
Th	−0.31	0.32	−0.33	0.04	−0.25	0.39	0.20	−0.17	0.09	0.56	1.00						
Y	−0.42	0.23	−0.42	−0.01	−0.02	0.26	−0.05	−0.26	0.27	1.00							
Nb	0.10	0.10	−0.03	0.02	0.37	0.47	0.37	0.25	1.00								
Sr	0.42	−0.11	0.32	0.20	0.27	0.45	0.55	1.00									
Zr	0.48	0.40	0.41	0.04	0.40	0.75	1.00										
Ce+La	0.31	0.25	0.06	0.10	0.38	1.00											
F	0.35	0.29	0.26	−0.02	1.00												
Ba	−0.15	0.03	−0.21	1.00													
Ti	0.79	0.04	1.00														
Mn	0.17	1.00															
Fe	1.00																

disseminated hematite may be related to widespread mild fenitization, but more likely it formed during deuteric or metamorphic processes before carbonatite magmatic activity.

Carbonate replacements and minor veinlets of secondary calcite within the carbonatites represent minor recrystallization after dike emplacement. The recrystallization appears to have been predominantly isochemical. Subsequent partial weathering altered select orthoclase and chlorite to clay and altered minor amounts of titaniferous magnetite to hematite, goethite, and leucoxene.

Some porphyritic dikes may be texturally similar to select carbonate rocks in the Wet Mountains of Colorado (Armbrustmacher, pers. comm. 1985), which are interpreted to be replacements of lamprophyre dikes. These rocks are named "replacement carbonatites" by Armbrustmacher (1979). However, it is improbable that the carbonatites of the Chupadera Mountains formed in this manner. More likely the petrography reflects variable instability of phenocrysts and inclusions during magmatic emplacement. All phenocrysts, carbonatite fragments, and, to a minimal extent, wall-rock inclusions display partial resorption by carbonate, and most phenocryst minerals are chemically altered.

Thorium-bearing jasperoid and quartz veins

The Caloso Formation (Mississippian) contains jasperoid that can be traced in continuous outcrop for up to 0.5 mi along strike. The jasperoid extensively replaced the formation near the Paleozoic–Precambrian unconformity. Basal mineralization is dark reddish brown (because of disseminated hematite), fine grained, and commonly radioactive (because of thorium). Portions of the jasperoid contain minor calcite, iron- and manganese-oxide joint coatings, and concentrations of barite. The silicification has enclosed fine detrital grains of quartz, feldspar (which is partly corroded), and trace muscovite. Carbonate inclusions are abundant where jasperoid grades into unreplaced

host rock. Semiquantitative x-ray fluorescence (XRF) analyses of seven jasperoid samples reveal maximum concentrations in individual samples of 31% Ba, 2% Fe, 0.25% Zr, 0.14% Mn, 560 ppm Th, 560 ppm Cu, 360 ppm Y, and 56 ppm U. Rare-earth elements were not detected.

Three radioactive, hematitic, quartz veins were found in Precambrian rocks. One similar vein occurs within a carbonatite dike. The veins are less than 1 ft in maximum width and are of short strike length. Semiquantitative XRF analyses of three vein samples contain up to 3.9% Fe, 0.46% Zr, 400 ppm Y, 340 ppm U, and 270 ppm Th. The veins contain no barite or detectable rare-earth elements.

The hematitic jasperoid and quartz veins are of uncertain origin. Somewhat similar hematitic quartz–microcline–barite–carbonate veins with thorium, yttrium, and rare-earth elements occur in other carbonatite districts such as the Wet Mountains and Powderhorn areas of Colorado and the Lemhi Pass area of Idaho and Montana (Phair and Fisher, 1961).

Age and regional significance

Carbonatites of the Chupadera Mountains have a mineralogical, geochemical, and geological setting comparable to the late Ordovician carbonatites in the Lemitar Mountains (McLemore, 1983). These carbonatites lie in a regional belt of Late Precambrian to Late Silurian carbonatites and alkalic rocks, which extends from southern New Mexico to central Colorado (Fig. 1). The intrusives probably formed during a period of extension within a zone that approximates the Cenozoic Rio Grande rift and possibly a Precambrian rift system.

Thorium-bearing quartz occurs spatially, but probably not temporally, related to carbonatites of the Chupadera Mountains. The Mississippian or younger thorium-rich jasperoid appears younger in age than the carbonatites. Additional research on the genesis of the thorium occurrences is warranted.

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cordingly. Generally, only the very best gas prospects, or those gas prospects required to hold leases, were drilled in 1985. However, existing gas pools in the San Juan Basin continued to be developed.

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Association for Women Geoscientists field trip

Kate Johnson of the USGS, a noted expert on the Salmon River area of west-central Idaho, will lead a three-day trip on the Salmon River on July 4–6, 1986. The lower canyons of the Salmon River cut through some of the most spectacular country anywhere in the U.S. Johnson will discuss the local outcrops of Tertiary and Cretaceous rocks exposed in the canyon and the regional geology and tectonic setting of the area. In addition, we will have ample time to study the modern point-bar deposits of the Salmon River, which are exposed as white sand beaches that make some of the best campsites in the west. The cost of $300 for members and $350 for nonmembers includes all expenses on the river and round-trip transportation between Grangeville, Idaho, and the river. The trip is limited to 24 people. For information call Marcia Knadle at (206) 593–6510 or Jeanne Harris at (303) 694–6076, or write to: Association for Women Geoscientists, National Field Trip, Box 1005, Menlo Park, California 94024.

Editor's note: Because several articles in this issue include both conventional (American and British) and metric units, I have reprinted below the current policy on use of measurements in *New Mexico Geology*. Comments are invited.

The general policy is that measurements should be given in the units *originally* used and conversions will not be given in parentheses unless specifically requested by the author. This means:

1) Geographic distances or elevations in the U.S. should be given in conventional units (miles, yards, feet) regardless of the kind of measurements used elsewhere in the paper.

2) Field, section, fossil, or other measurements made *originally* in metric units should be reported that way even if this means that some measurements in the paper are reported in standard units (. . . the study area is 10 miles north of Socorro . . .) and some are reported in metric units (. . . the 6-m-thick section . . .; . . . we used a 2-mm mesh screen to . . .).

3) Any quoted material must, of course, be identical to the original published text. Conversion of meters to feet within a quote (. . . "the 6-m-[19.7-ft-] thick section . . .") is unnecessary even if in the rest of the paper only standard units are used.

4) An exception is made on figures where we require one scale bar that has *both* metric and conventional units delineated.

Society of Economic Paleontologists and Mineralogists courses

May 30, 1986 SEPM short course "Glacial sedimentary environments," in Champaign, Illinois.

June 14–15, 1986 SEPM short course "Structures and sequences in clastic rocks," in Atlanta, Georgia.

June 14–15, 1986 SEPM short course "Modern and ancient deep sea fan sedimentation," in Atlanta, Georgia.

June 15, 1986 SPEM short course "Paleoclimatology and economic geology," in Atlanta, Georgia.

June 15, 1986 SEPM core workshop "Modern and ancient shelf clastics," in Atlanta, Georgia.

August 1–2, 1986 SEPM field seminar, "Paleozoic and Mesozoic rocks of the Golden–Boulder area and Denver Basin, Colorado," in Golden, Colorado.

For more information or to register for any of the above courses, contact: Joni C. Merkel, Society of Economic Paleontologists and Mineralogists, P.O. Box 4756, Tulsa, Oklahoma 74159–0756, (918) 743-2498.