Geology and mineral resources in the Cornudas Mountains, Otero County, New Mexico and Hudspeth County, Texas

Virginia T. McLemore and James R. Guilinger

1993, pp. 145-153. https://doi.org/10.56577/FFC-44.145

in:

Carlsbad Region (New Mexico and West Texas), Love, D. W.; Hawley, J. W.; Kues, B. S.; Austin, G. S.; Lucas, S. G.; [eds.], New Mexico Geological Society 44th Annual Fall Field Conference Guidebook, 357 p. https://doi.org/10.56577/FFC-44

This page is intentionally left blank to maintain order of facing pages.

GEOLOGY AND MINERAL RESOURCES OF THE CORNUDAS MOUNTAINS, OTERO COUNTY, NEW MEXICO AND HUDSPETH COUNTY, TEXAS

VIRGINIA T. McLEMORE[1] and JAMES R. GUILINGER[2]
[1]New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801; [2]Addwest Minerals, Inc, 5460 Ward Rd., Suite 370, Arvada, Colorado 80002

Abstract—The Cornudas Mountains form the northern part of the Trans-Pecos magmatic province in southern New Mexico and northern Texas. Ten larger intrusive bodies and numerous dikes, sills and smaller plugs have intruded Permian and Cretaceous limestones and other sedimentary rocks. The intrusives range in age from 33 to 36 Ma. The Cornudas Mountains have been examined for potential economic deposits of gold, silver, beryllium, rare-earth elements, niobium and uranium but no economic deposits have been found. However, Addwest Minerals, Inc. recently began exploration and development of the Wind Mountain nepheline syenite for use in amber-colored beverage containers and ceramics. Production is expected within a few years. The Cornudas Mountains alkalic igneous rocks form the eastern limit of a progressive change from alkalic-igneous rocks in the eastern Trans-Pecos magmatic province to less alkalic and calc-alkalic igneous rocks in western Trans-Pecos Texas, Mexico and southwestern New Mexico. This change in magmatism corresponds in time to the transitional interval between Laramide compressional tectonics and younger Basin and Range extensional tectonics. Great Plains Margin gold-silver deposits (i.e., alkalic-related gold deposits), including those elsewhere in New Mexico and along the North American Cordilleran alkalic-igneous belt, appear to be related to back-arc extension, hot spots and complex, multiple cycles of magmatic differentiation resulting in both alkalic and calc-alkalic igneous rocks. If these constraints are required to form Great Plains Margin gold-silver deposits, the Cornudas Mountains may be unfavorable for such deposits.

INTRODUCTION

The Cornudas Mountains are a cluster of Tertiary intrusive bodies that stand above the Otero and Diablo platforms as tall, rounded peaks (Fig. 1). The Otero and Diablo platforms are part of the Basin and Range physiographic province in Otero and Hudspeth Counties (Fig. 2; King and Harder, 1985). The Cornudas Mountains have been examined for potential economic deposits of gold, silver, beryllium, rare-earth elements, niobium and uranium. There has been no production to date. Recently, Addwest Minerals, Inc. began exploration and development of the nepheline syenite at Wind Mountain for use in amber-colored beverage bottles and ceramics. Production of nepheline syenite by open-pit methods is expected to occur within the next few years.

The Cornudas Mountains form part of the northern portion of the Trans-Pecos magmatic province, a regional belt of igneous rocks that lie within an area defined by the Rio Grande on the west and south, the Pecos River on the east and an east-west line approximately 12 km north of the boundary between New Mexico and Texas (Fig. 2). This province contains more than 200 intrusive bodies, each with an outcrop area exceeding 1 km' (Barker, 1977, 1987).

The Cornudas Mountains and the Trans-Pecos magmatic province are part of a diffuse belt of Cenozoic alkalic-igneous rocks that extends along the eastern margin of the North American Cordillera and Basin and Range provinces (Fig. 3). This belt extends from southeast Alaska and British Columbia southward into Trans-Pecos Texas (Mutschler et al., 1991a; Woolley, 1987) and continues southward for approximately 200 km into eastern Mexico (Barker, 1977; Woolley, 1987). The southern part of the North American Cordilleran alkalic igneous belt overlaps the gradational boundary between the Cordillera (including the Basin and Range) and the Great Plains provinces.

FIGURE 1. Wind Mountain (right) and Deer Mountain (left) of the Cornudas Mountains, looking north.

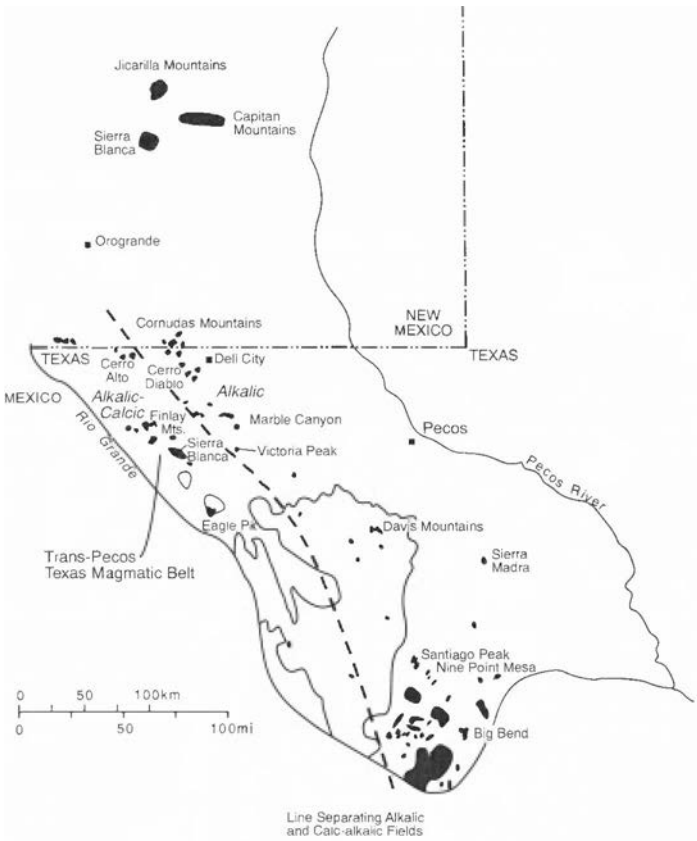


FIGURE 2. Trans-Pecos magmatic province, New Mexico and Texas (modified from Barker, 1987; Price et al., 1987).

FIGURE 3. North American Cordilleran belt of alkalic igneous rocks (Woolley, 1987; Mutschler et al., 1991a).

The purposes of this paper are to (1) summarize the geology and known mineral deposits of the Cornudas Mountains, (2) speculate on the mineral resource potential, (3) speculate on the origin of the igneous rocks and associated mineral deposits, and (4) briefly compare the geology and petrogenesis of the Cornudas Mountains alkalic igneous rocks with those elsewhere in the North American Cordilleran alkalic igneous belt, especially the nearby Lincoln County porphyry belt in New Mexico.

Much of this paper relies heavily on previous studies in the Cornudas Mountains and the Trans-Pecos magmatic province. The earliest geologic mapping and petrographic studies were by Zapp (1941), Timm (1941) and Clabaugh (1941, 1950). Warner et al. (1959) examined the Wind Mountain area looking for beryllium resources and refined the earlier geologic maps. The most extensive petrographic, geochemical and isotopic studies of the Cornudas Mountains and Trans-Pecos magmatic province have been conducted by Barker (1977, 1979, 1987), Barker et al. 1977), Barker and Hodges (1977), Price et al. (1987) and Henry et al. (1988, 1991). The mineral resources were examined by Warner et al. (1959), Collins (1958), McLemore (1983), McLemore et al. (1988a, b), McLemore and Chenoweth (1989), and North and McLemore (1986, 1988).

Several private companies have also examined the Cornudas Mountains for various commodities, without much success. In 1986, U.S. Borax drilled three holes in the Chess Draw area, northeast of Wind Mountain. More recently in 1989-1990, Addwest Minerals, Inc. initiated a sampling program in the area looking for nepheline syenite suitable for glass and ceramics. Several areas were identified and the nepheline syenite at Wind Mountain was chosen for additional tests. In 1992, eight holes were drilled which confirmed earlier tests.

REGIONAL SETTING

Lindgren (1915) first noted that a belt of alkalic igneous rocks extends from Canada into eastern Mexico and that these rocks contain relatively large quantities of chlorine, fluorine, strontium, zirconium and rare-earth elements. Since then, the North American Cordilleran alkalic igneous belt has been explored and exploited for numerous types of mineral deposits, especially gold and silver (Fig. 3; North and McLemore, 1986, 1988; Clark, 1989; Mutschler et al., 1991a, b; Thompson, 1991, 1992), fluorite (van Alstine, 1976), rare-earth elements (Woolley, 1987) and uranium.

The Trans-Pecos magmatic province forms part of the southern portion of the North American Cordilleran alkalic igneous belt. This southern area is now recognized as the eastern limit of a Tertiary "magmatic sweep" of decreasing age of magmatic activity from the California coastline eastward to the Great Plains Margin. This "magmatic sweep" is linked to the progressive shallowing of the subduction of the Farallon plate beneath the North American plate with time (Coney, 1972; Sillitoe, 1972; Barker, 1977, 1987; Damon et al., 1981; Clark et al., 1982; Campa and Coney, 1983; Clark, 1989; Henry et al., 1989). However, the northern portion of the belt (including Colorado and northward) may be related to back-arc extension rather than subduction (Thompson, 1991, 1992; Mutschler et al., 1991a; Eggler and Furlong, 1991). Some areas of alkalic magmatism in this belt may be a result of deep-seated asthenospheric mantle plumes or hot spots (Mutschler et al., 1991b).

The Cornudas Mountains and Trans-Pecos Texas are critical areas for understanding the tectonic and magmatic evolution of western North America (Henry et al., 1991). This region is the eastern limit of Cenozoic magmatic activity, which has occurred in this area nearly continuously from 48 to 17 Ma and overlaps the change in tectonic style from Laramide compression to Basin and Range extension. Compositions of igneous rocks are alkalic in the eastern portions of the Trans-Pecos belt, including the Cornudas Mountains, and become progressively less alkaline and more calc-alkalic westward into Mexico (Fig. 2; Barker, 1977, 1987; Price and Henry, 1984; Cameron and Cameron, 1985; Price et al., 1987; Clark, 1989).

Earlier interpretations by Barker (1977) suggested an analogy between the Trans-Pecos magmatic province and the Kenya portion of the East African rift. However, subsequent work has shown that much of the Cenozoic faulting in Trans-Pecos Texas thought to be associated with rifting postdates most igneous activity (Barker, 1987; Henry et al., 1991). Trans-Pecos magmatism began during the Laramide compressional period, prior to igneous activity associated with the Rio Grande rift. The magmatism in Trans-Pecos Texas and adjacent New Mexico appears to be related to subduction rather than continental rifting (Barker, 1987; Henry et al., 1991).

GEOLOGY

The Cornudas Mountains are a group of Late Eocene to Oligocene laccoliths, sills, plugs and dikes of predominantly nepheline syenite, phonolite and trachyte (Fig. 4; Table **1).** Ten larger intrusive bodies and numerous dikes, sills and smaller plugs have intruded the relatively flat-lying limestones and other sedimentary rocks of Permian and Early Cretaceous age (see Kues and Lucas, this volume). Most of the Permian sedimentary rocks belong to the Hueco Limestone and Bone Springs Limestone. Undoubtedly, numerous sills, dikes and plugs remained buried by the sedimentary cover and are inferred or detected by subsurface drilling (King and Harder, 1985), geophysical surveys and perhaps by structural anomalies (i.e., folds, synclines, faults) in the overlying sedimentary rocks.

The larger laccoliths and sills, except for the Cornudas Mountain laccolith, are composed predominantly of dark gray to pink, fine- to coarse-grained to porphyritic nepheline syenites, syenites and phonolites (Table 1). Cornudas Mountain is a deeply weathered and eroded laccolith or plug consisting of light gray to pink gray quartz syenite to syenite and trachyte (Table 1; Zapp, 1941).

The laccoliths are texturally and compositionally zoned. Extremely diverse compositions and textures of varying grain size are found within single intrusive bodies. Detailed geologic mapping of possible textural and compositional zones within the laccoliths is hampered by steep terrain, talus-covered slopes and locally poor exposure. Wind Mountain displays excellent zoning. A medium-grained nepheline syenite porphyry forms a rim surrounding a coarse-grained nepheline syenite porphyry, which surrounds a central core of fine-grained syenite porphyry

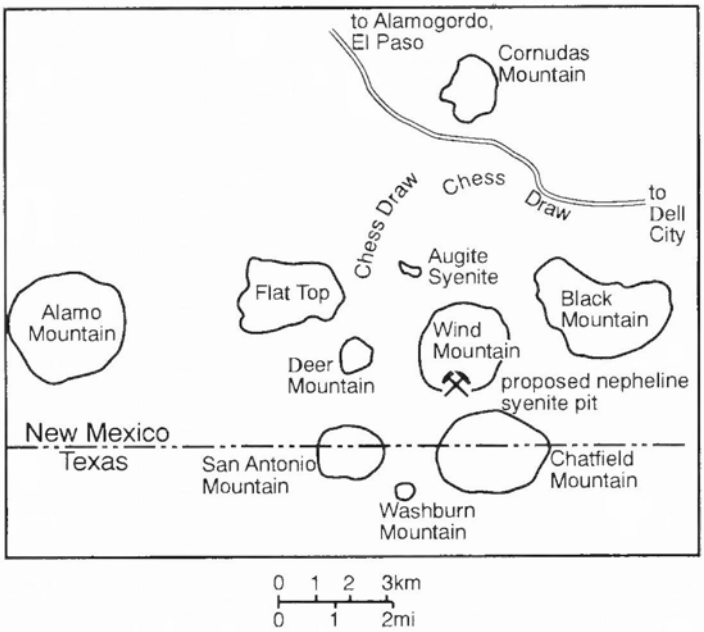


FIGURE 4. Reference map of Cornudas Mountains.

(Fig. 5; Table 2). Younger dikes, some pegmatitic, others aphanitic, intruded many of the laccoliths. Mapping of other laccoliths is needed to determine if they too are zoned.

Numerous dikes, sills and small plugs of varying textures and lithologies intrude the sedimentary rocks throughout the Cornudas Mountains. Some smaller intrusives can be traced into major laccoliths, where they either remain as discrete dikes or become gradational zones within

147

the laccolith. Silicification and brecciation of some dikes and plugs occur in the Chess Draw area.

Barker et al. (1977) divided the lithologies found in the Trans-Pecos magmatic province into nine types based on mineralogy and texture: (1) nepheline-bearing augite syenite, (2) nepheline-bearing trachyte, (3) syenite, (4) nepheline syenite, (5) porphyritic nepheline syenite, (6) phonolite, (7) foliated porphyritic nepheline syenite, (8) quartz-bearing syenite and (9) quartz-bearing trachyte. All nine types are found in the Cornudas Mountains. The Cornudas Mountains also contain less common minerals that are typically found in alkalic-igneous rocks throughout the world (Table 3). Several of these minerals (georgechaoite, parakeldyshite, catapleiite; Boggs and Ghose, 1985; Barker and Hodges, 1977) are extremely rare and found elsewhere in only a few localities in the world.

Chemical analyses of igneous rocks from the Cornudas Mountains (Table 4) show that they are similar in composition to other alkalic-igneous rocks in the Trans-Pecos magmatic province (Figs. 6, 7; Barker et al., 1977; Barker, 1987). Skarns adjacent to some intrusions are present in the Cornudas Mountains. Small dikes and plugs intrude the adjacent limestone and have produced a mineral assemblage of calcite, grossularite, idocrase, apophyllite and wollastonite, with local prehnite and chondrodite (Barker et al., 1977). Zones of marble and diopside-bearing hornfels are also locally common (Figs. 8, 9).

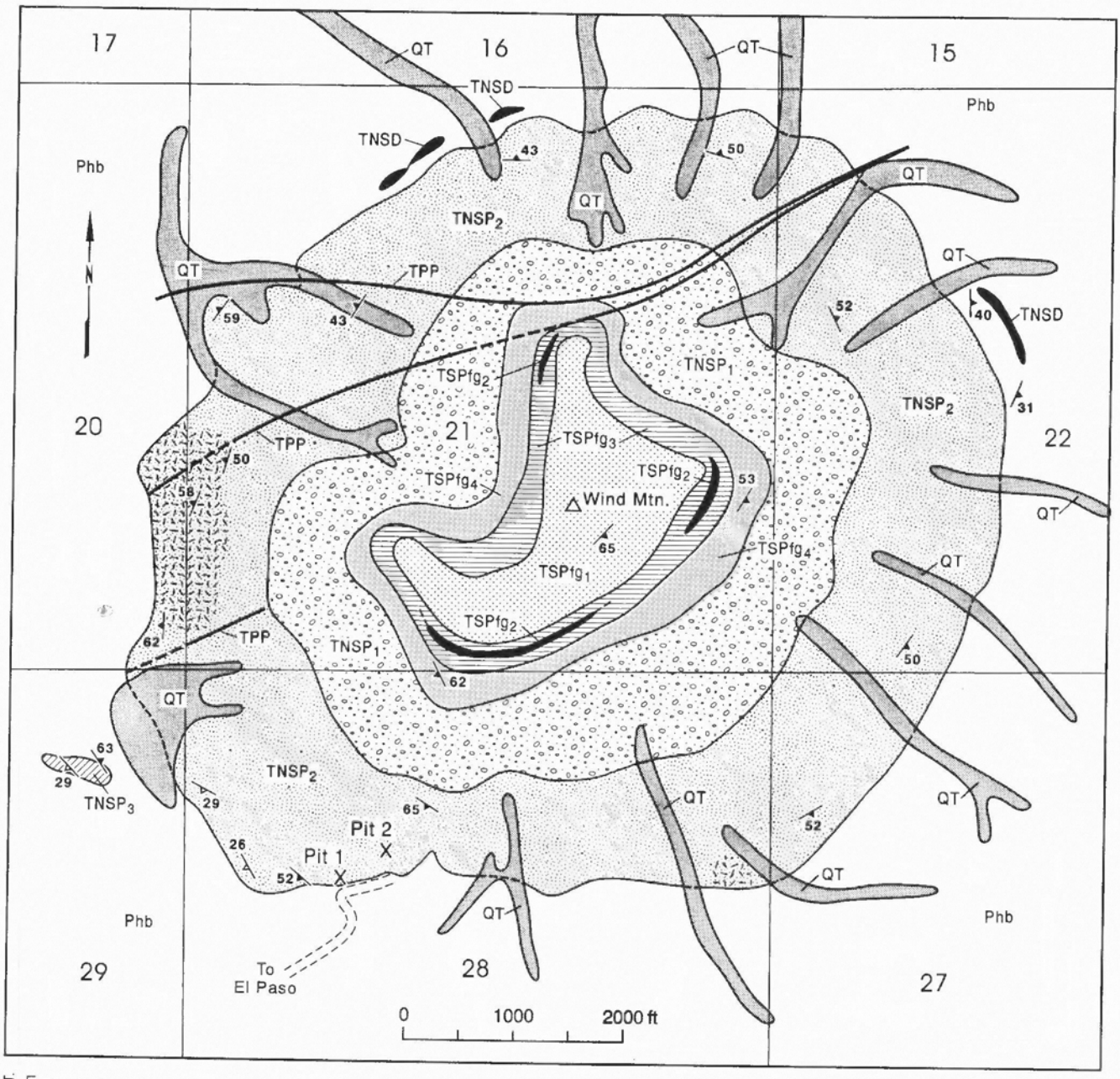
MINERAL DEPOSITS

Uranium

In the 1950s, prospectors located several areas of anomalously high radioactivity in the Cornudas Mountains and attributed it to the presence of uranium. Shallow prospect pits were dug on many of the claims in the area, but assay results were very low and the claims were dropped with no production. In 1956, the U.S. Atomic Energy Commission examined the area to evaluate the potential for uranium (Collins, 1958).

TABLE 1. Description of igneous intrusive bodies within the Cornudas Mountains. Bodies shown in Fig. 4.

Name	Predominant lithology	Form	Age	References
Alamo Mountain	phonolite, foliated porphyritic nepheline syenite	discordant sheet or sill	36.8 ± 0.6 (K/Ar on biotite)	Barker et al. (1977); Clabaugh (1941); Henry et al. (1986)
Flat Top Mountain	phonolite, augite syenite dike	sill		Barker et al. (1977); Clabaugh (1941)
Cornudas Mountain	quartz-bearing syenite, syenite, trachyte	plug or laccolith	34.6 ± 1.5 (K/Ar on biotite)	Barker et al (1977); Zapp (1941); Henry et al. (1986)
Wind Mountain	nepheline syenite, phonolite, porphyritic nepheline syenite	laccolith		Barker et al. (1977); Warner et al. (1959); This report (Fig. 5)
San Antonio Mountain	nepheline syenite	laccolith		Timm (1941); Barker et al. (1977)
Deer Mountain (Little Wind Mountain)	nepheline syenite	plug or laccolith	33.0 ± 1.4 (K/Ar on biotite)	Barker et al. (1977); Clabaugh (1941, 1950); Henry et al. (1986)
Chattfield Mountain	phonolite	sill		Timm (1941); Barker et al. (1977)
Black Mountain	porphyritic nepheline syenite	sill		Barker et al. (1977)
Washburn Mountain	porphyritic nepheline syenite	sill		Timm (1941); Barker et al. (1977)
Unnamed hill	nepheline-bearing augite syenite	plug	36.8 ± 0.6 (K/Ar on biotite)	Barker et al. (1977); Clabaugh (1941); Henry et al. (1986)



QUAT.

QT — Talus and fan deposits

TERTIARY

TPP — **Phonolite Dike**—Porphyritic

$TSPfg_1$ — **Syenite Porphyry**—fine grained, contains minor interstitial analcite plus accessory aegerite-soda amphibole-biotite and magnetite in a plagioclase rich groundmass.

$TSPfg_2$ — **Syenite Porphyry**—fine grained, contains dominant plagioclase enclosing aegerite-soda amphibole-biotite.

$TSPfg_3$ — **Syenite Porphyry**—fine grained, contains dominant plagioclase enclosing aegerite-soda amphibole-biotite. The zone is more mafic than $TSPfg_1$.

$TSPfg_4$ — **Syenite Porphyry**—fine grained, contains moderate interstitial analcite plus accessory aegerite-soda amphibole-biotite and magnetite in a plagioclase rich groundmass.

$TNSP_1$ — **Nepheline Syenite Porphyry**—coarse grained K-feldspar phenocrysts in a matrix of dominant plagioclase with moderate interstitial nepheline and analcite plus accessory aegerite-soda-amphibole and minor magnetite.

$TNSP_2$ — **Nepheline Syenite Porphyry**—medium grained K-feldspar phenocrysts in a matrix of dominant plagioclase with moderate interstitial nepheline and minor analcite plus accessory aegerite-soda amphibole-biotite and minor magnetite.

Mafic zonation/lamination

$TNSP_3$ — **Nepheline Syenite Porphyry**—medium grained K-feldspar is present as subhedral blocky prisms. Intersitial nepheline plus accessory arfedsonite-aegerite and minor magnetite are present in a plagioclase rich groundmass. The orientation of the feldspar crystals are vertical rather than flat (as in the main intrusive mass), suggesting a different intrusive phase.

TNSD — **Nepheline Syenite Dikes**—fine grained massive crystalline dike-like bodies outcrop around the stock in the hornfels facies of the limestone.

PERMIAN

Phb — **Limestone**—Hueco Fm. and Bone Spring Fm. limestone undifferentiated. Near the contact with the stock, the limestone is altered to a hornfels facies by contact metamorphism.

X — Prospect

FIGURE 5. Geologic map of Wind Mountain (P. Gruaseah, field mapping, July 1992).

TABLE 2. Mineralogical analyses of the Wind Mountain nepheline syenite (Addwest Minerals, Inc. data).

Unit	Albite	K-feldspar	Nepheline	Amphibole	Pyroxene	Zeolite	Magnetite	Mica	FeO and clay
Knob Tnsp3	50	32	6	8	2	1	2		11
Pit 2 Tnsp2	64	15	10	2	4	2	2	1	8
Coarse Tnsp1	42	30	8	2	6	10	2		7
Upper Tspfg4	65	18		3	7	2	3	1	12
Upper Tspfg3	55	20		4	5	14	3	1	12
Top Tspfg1	60	20		3	5	6	4	2	4

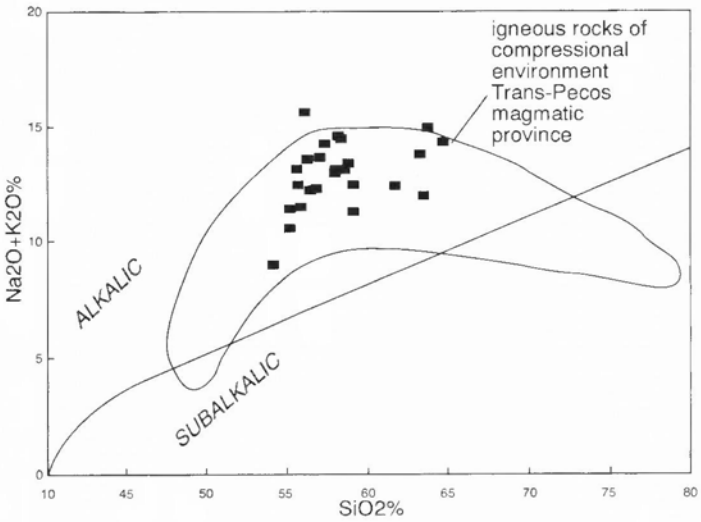


FIGURE 6. $Na_2O + K_2O$–SiO_2 diagram, showing the similarity in composition of igneous rock samples from Cornudas Mountains and Trans-Pecos magmatic province (Price et al., 1987; Barker et al., 1977). Squares represent samples from Cornudas Mountains. Line separating alkalic and subalkalic fields from Irvine and Baragar (1971).

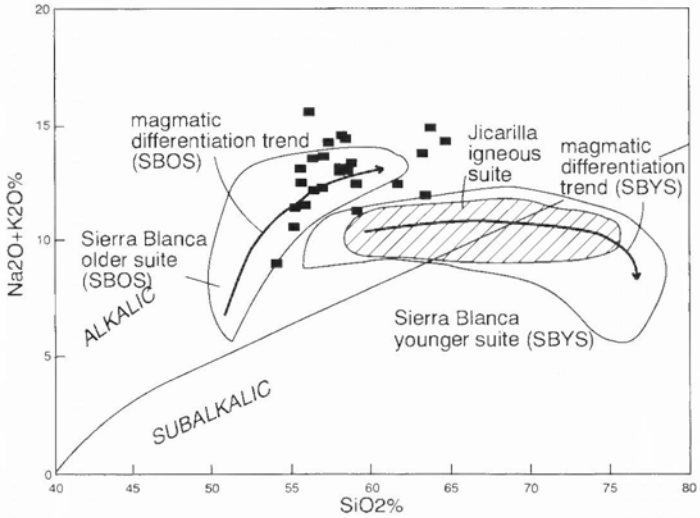


FIGURE 7. $Na_2O + K_2O$–SiO_2 diagram, showing the similarity in composition of igneous samples from Cornudas Mountains and Sierra Blanca older suite (SBOS) in the Lincoln County porphyry belt (Allen and Foord, 1991; Moore et al., 1991; McLemore et al., 1991). Note the difference in composition of samples from the Cornudas Mountains and Sierra Blanca younger suite (SBYS). Squares represent samples from Cornudas Mountains. Line separating alkalic and subalkalic fields from Irvine and Baragar (1971).

TABLE 3. Selected less common minerals reported from the Cornudas Mountains.

Mineral	Chemical formula	Occurrence	Reference
analcime	$NaAl\ Si_2O_6 \cdot H_2O$	replaces nepheline, lines vugs, vesicles and miarolitic cavities	Barker and Hodges (1977); Boggs (1985)
natrolite	$Na_2Al_2Si_3O_{10} \cdot 2H_2O$	replaces nepheline and feldspars	Barker and Hodges (1977)
olivine	$(Mg,Fe)_2SiO_4$	mineral aggregates of ferromagnesium minerals and magnetite	Barker and Hodges (1977)
aenigmatite	$Na_2Fe_5{}^{+2}TiSi_6O_{20}$	in nepheline syenite	Barker and Hodges (1977)
eudialyte	$Na_4(Ca,Ce)_2(Fe^{+2},Mn^{+2}),Y\ ZrSi_8O_{22}(OH,Cl)_2$	in dikes, sills, and laccoliths and in miarolitic cavities	Barker and Hodges (1977); Clabaugh (1950); Boggs (1985, 1987)
catapleiite	$Na_2ZrSi_3O_9 \cdot 2H_2O$	miarolitic cavities	Boggs (1985)
georgechaoite	$NaKZrSi_3O_9 \cdot 2H_2O$	miarolitic cavities	Boggs (1985); Boggs and Ghose (1985)
aegirine (acmite)	$NaFe^{+3}Si_2O_6$	miarolitic cavities	Boggs (1985, 1987)
monazite	$(Ce,La,Th,Nd)PO_4$	miarolitic cavities	Boggs (1985)
thomsonite	$NaCa_2Al_5Si_5O_{20} \cdot 6H_2O$	miarolitic cavities	Zapp (1941); Boggs (1985)
chabazite	$Ca(Al_2Si_4O_{12}) \cdot 6H_2O$	miarolitic cavities	Boggs (1985)
parakeldyshite	$Na_2ZrSi_2O_7$	nepheline syenite, Wind Mountain	This report

TABLE 4. Chemical analyses of the alkalic rocks in the Cornudas Mountains. AS, CH, De, SA, WS, Z, AL, CO and WN from Barker et al. (1977) and Barker (1987). CORN, F2TSPFG2 and FSTNSD samples collected by V. T. McLemore and analyzed by C. McKee (NMBMMR, x-ray laboratory). $TSPN_2$, PIT 1 and PIT 2 from Addwest Minerals, Inc. (analyses by The Mineral Lab., Inc.). PIT 1 and PIT 2 are analyses of the nonmagnetic fraction only. Fe_2O_3* is total iron calculated as Fe_2O_3. Description of samples in Appendix.

	AS-2	AS-5	DE-1	DE-5	DE-4	DE-12	CH-1	SA-1	SA-12	WN-11	Z-2	WS-1	AL-11	AL-10	CO-1	CO-4
SiO_2	54.10	55.15	56.90	57.05	55.60	55.60	56.10	56.40	55.20	58.60	57.35	55.90	58.40	58.10	59.10	63.45
TiO_2	1.81	1.28	0.51	0.44	0.43	0.3	0.18	0.21	0.44	0.11	0.22	0.21	0.21	0.14	0.05	0.05
Al_2O_3	18.60	18.41	19.80	20.17	17.95	17.35	19.57	18.10	17.56	18.54	18.64	18.10	18.80	18.55	16.60	18.25
Fe_2O_3	3.46	3.24	1.99	2.00	2.76	7.06	2.87	4.52	2.01	3.70	2.43	4.24	2.95	3.64	1.42	2.33
FeO	3.28	3.28	4.06	2.38	3.80	1.10	1.86	2.03	4.73	2.08	3.44	2.32	1.60	1.10	1.13	0.92
MgO	2.56	1.78	0.50	0.45	0.38	0.25	0.13	0.37	0.54	0.30	0.23	0.45	0.14	0.18	0.81	0.07
CaO	5.46	3.75	1.65	1.63	1.50	1.30	0.90	1.90	1.75	1.62	1.25	2.78	0.81	1.09	4.97	1.20
K_2O	3.67	4.71	5.55	6.12	5.37	4.20	4.90	5.27	3.50	5.47	5.08	5.31	4.98	4.84	5.30	5.30
Na_2O	5.33	5.86	6.76	7.58	7.15	8.95	10.77	6.96	7.92	7.65	9.22	6.22	9.51	8.32	5.99	6.70
MnO	0.17	0.17	0.16	0.14	0.23	0.38	0.29	0.24	0.27	0.31	0.39	0.21	0.26	0.24	0.12	0.14
P_2O_5	0.81	0.62	0.20	0.19	0.19	0.11	0.04	0.16	0.21	0.11	0.09	0.14	0.07	0.06	0.16	0.18
LOI	1.14	0.76	1.85	1.64	4.90	2.88	2.42	3.37	4.96	1.90	1.82	3.10	1.35	2.51	1.04	0.72
CO_2	0.26	0.22	0.44	0.48	0.05	0.13	0.08	0.60	0.03	0.26	0.12	0.00	0.05	0.21	3.15	0.65
TOTAL	100.39	99.01	99.93	99.79	100.26	99.48	100.03	99.53	99.09	100.39	100.16	98.98	99.08	98.77	97.14	99.76
Rb		85					260			142						
Sr		970					85			123						
Y		29					56			52						
Zr		520					2549			1640						
Nb		59					260			154						
Zn		90					154			118						
Ni		<3					4			<3						
Na_2O+K_2O	9	10.57	12.31	13.7	12.52	13.15	15.67	12.23	11.42	13.12	14.30	11.53	14.49	13.16	11.29	12

	CORN10	CORN11	CORN12	CORN14	CORN13	CORN18	CORN15	F2TSPFG2	FSTNSD	TNSP2	PIT 1	PIT 2
SiO_2	59.10	60.00	53.10	61.70	52.00	58.20	58.00	58.80	56.30	63.30	64.70	63.80
TiO_2	0.14	0.27	0.25	0.25	0.32	0.26	0.44	0.12	0.08	0.03	<0.01	<0.01
Al_2O_3	17.60	4.72	4.39	18.90	2.87	17.90	19.90	18.20	18.70	20.80	20.50	20.90
Fe_2O_3*	5.61	5.34	4.84	4.70	4.17	4.68	4.16	6.24	6.43	1.54	0.52	0.40
MgO	0.48	2.19	2.41	1.80	2.61	0.44	1.04	0.81	0.47	0.07	<0.05	<0.05
CaO	1.10	16.20	25.50	1.64	29.60	1.37	1.92	1.35	1.40	0.68	0.23	0.20
K_2O	5.06	1.40	1.97	5.27	1.96	4.86	5.74	5.30	4.80	6.32	6.74	6.73
Na_2O	7.44	6.05	3.66	7.20	0.72	9.76	7.29	8.12	8.80	7.53	7.62	8.23
MnO	0.28	0.08	0.06	0.24	0.08	0.35	0.13	0.35	0.33	0.14	<0.01	<0.01
P_2O_5	0.11	0.39	0.50	0.16	0.19	0.10	0.15	0.10	0.04	<0.05	<0.05	<0.05
LOI	1.75	1.37	0.72	1.51	0.72	2.08	2.11	2.80	2.91			
TOTAL	98.67	98.01	97.40	103.37	95.24	100.00	100.88	102.19	100.26	100.41	100.31	100.26
Pb		17	12			50		50	40	45	23	25
Th		21	17			78		63	41	46	43	41
Rb		48	77			258		185	235	176	180	168
U		5	3			11		14	11	25	26	23
Sr		292	332			111		59	230	46	37	36
Y		42	55			103		67	150	55	34	39
Zr		313	228			2155		2296	3965	645	338	322
Nb		8	2			448		310	45	89	57	67
Mo						11		11	10	<10	16	13
Ga	39	6	6	28	2	44		38	49			
Zn	264	61	36	73	38	334		285	277	105	60	78
Cu	5	5	3	4	2	3		7	11	<10	<10	<10
Ni	10	18	30	8	35	10		182	173	<10	<10	<10
Na_2O+K_2O	12.50	7.45	5.63	12.47	2.68	14.62	13.03	13.42	13.60	13.85	14.36	14.96

FIGURE 8. Nepheline syenite sill and dike intruding Permian limestone at Wind Mountain.

FIGURE 9. Closeup of the nepheline syenite dike in Fig. 8 with adjacent zones of hornfels. Sample locations shown for analyses in Table 4.

Subsequent assays ranged from 0 to 0.08% U,08 (Collins, 1958). No further work was recommended.

Alkalic rocks are typically enriched in uranium relative to other igneous rocks, and a few alkalic igneous complexes in the world have been exploited for their uranium deposits (Ilimaussaq, Greenland; Pocos de Caldas, Brazil: Murphy et al., 1978). However, the potential for economic uranium deposits in the Cornudas Mountains appears low because of low assays in areas of anomalously high radioactivity and a depressed uranium market (McLemore and Chenoweth, 1989).

Beryllium

Beryllium is a strategic mineral used as an alloy and oxide in electronic components, with aerospace and defense applications and other uses (U.S. Bureau of Mines, 1991). A large beryllium deposit occurs near Sierra Blanca, Texas, south of the Cornudas Mountains (Fig. 2), where Cyprus Minerals Inc. announced resources totaling 25 million lbs of beryllium oxide grading greater than 2% Be0 (Price et al., 1990; Henry, 1992). Beryllium occurs with fluorite at the contact between Tertiary rhyolite and Cretaceous limestone.

Beryllium was first reported from the Cornudas Mountains during the 1940s, and a few assayed samples contained as much as 0.2% Be0 (Warner et al., 1959). Beryllium occurs in feldspar, nepheline, aegirine and eudialite within dikes, sills and laccoliths, but no beryllium minerals have been identified. In the Chess Draw area, northwest of Wind Mountain, only one sample contained 150 ppm Be, whereas the remaining samples from that area contained less than 100 ppm Be (U.S. Borax, written commun. January 1986).

The resource potential for beryllium is moderate to high. Exploration should concentrate along the intrusive contacts between the Tertiary intrusives and Permian limestones for the potential discovery of a beryllium deposit similar to that found at Sierra Blanca, Texas.

Gold and silver deposits

A variety of deposits containing gold and silver are associated with alkalic igneous rocks in New Mexico (Great Plains Margin deposits of North and McLemore, 1986, 1988; McLemore, 1991) and elsewhere along the North American Cordilleran belt (Mutschler et al., 1991a; Thompson, 1991, 1992). These deposits have produced nearly 13% of the total lode gold production in the United States and Canada (Mutschler et al., 1991a). Consequently, numerous private companies have examined the Cornudas Mountains for similar gold-silver deposits, but without success.

Four samples of altered areas in the Chess Draw area, northwest of Wind Mountain, were assayed for gold and silver (Table 5). Only one sample contained a trace of gold (<0.02 oz/ton, 0.7 ppm) and 0.78 oz/ton (27 ppm) of silver. U.S. Borax also sampled and drilled in the Chess Draw area and assayed for gold and silver but their samples contained only trace amounts.

Additional studies are required to locate any potential gold-silver deposits. There is little evidence for a major hydrothermal system around the intrusives that would concentrate gold and silver. Skarn deposits are possible, but those near Wind Mountain appear to be small and are barren of metal mineralization. The potential for gold and silver deposits in the Cornudas Mountains is probably low for these and additional reasons discussed in the conclusions.

Rare-earth elements and niobium

Alkalic igneous rocks may contain high concentrations of rare-earth elements, niobium, zirconium and titanium. Economic deposits are rare but do occur associated with alkalic igneous complexes (Woolley, 1987). A few companies have examined the Cornudas Mountains unsuccessfully for similar deposits. U.S. Borax sampled and drilled in the Chess Draw area, but their assays were low (up to 0.06% total rare-earth oxides; 10-1400 ppm Nb; 10-3000 ppm Zr; 230-13,000 ppm F). An analysis reported by McLemore et al. (1988a, b) contained 1235 ppm Ce, 700 ppm La, 270 ppm Nd and 242 ppm Y. Zirconium silicates are common in the area (Table 2).

The resource potential for economic deposits of rare-earth elements, niobium, zirconium and titanium is unknown in the Cornudas Mountains. Additional geologic, geochemical, geophysical and other exploration techniques are required to properly evaluate this area, especially in dikes and along intrusive contacts with the limestones.

Nepheline syenite

Nepheline syenite is a critical ingredient in manufacturing glass and ceramics and also is utilized in filler applications and as roofing granules. There are only two commercial deposits of nepheline syenite in the world, located in Canada and Norway (Potter, 1991), and they average greater than 60% SiO_2, 20-24% Al_2O_3 and less than 0.1% Fe_2O_3. The Soviet Union has produced nepheline syenite in the past (Lofty et al., 1991). Because a small amount of iron results in colored glass or ceramics, the product sold from a commercial deposit usually

TABLE 5. Chemical assays of samples from the Chess Draw area (collected by V. T. McLemore and analyzed by L. Brandvold and associates, NMBMMR Chemical Laboratory).

	7368	CORN 16	CORN 17	CORN 19
Au	tr	0	0	0
Ag	0.78	0	0	0
Cu		10	122	27
Pb		15	195	22
Zn		62	122	34
Hg		0.05	0.17	0.02

must contain small amounts of iron-bearing minerals. Nepheline syenite also imparts the unique quality of toughness to the glass which is more resistant to breakage.

Addwest Minerals, Inc. has discovered that nepheline syenite from Wind Mountain is suitable for dark-colored beverage bottles, ceramics and several other possible uses. The Wind Mountain nepheline syenite is a zoned pluton that ranges from syenite porphyry to nepheline syenite porphyry (Fig. 5; Table 2). Analcime also is present locally as an alteration of nepheline and feldspar, but must be avoided in commercial deposits because it inhibits the fusion required to produce glass and ceramics. Chemically, the deposit consists of 56-63% SiO_2, 17-21% Al_2O_3 and 0.4-5% Fe_2O_3 (Table 3). Although iron is initially high, when the crushed rock is passed through a specialized rare-earth elements magnetic separator, the iron content drops below commercial maximum standards of less than 0.5% Fe_2O_3 (Table 4). The Wind Mountain nepheline syenite is currently under exploration and testing to determine marketability of the deposit. Production is expected within the next few years. Preliminary examination of other intrusives within the Cornudas Mountains failed to locate any additional nepheline syenite deposits suitable for glass and ceramic use. Additional studies are under way.

DISCUSSION AND PRELIMINARY CONCLUSIONS

The alkalic-igneous rocks in the Cornudas Mountains are similar in composition to other alkalic igneous rocks in Trans-Pecos Texas and in the Lincoln County porphyry belt (Figs. 6, 7; Barker et al., 1977; Barker, 1987; Allen and Foord, 1991; Moore et al., 1991). However, the alkalic igneous rocks in the Lincoln County porphyry belt and in other areas of the North American Cordilleran alkalic belt are spatially and, locally, genetically related to less alkaline and calc-alkalic igneous rocks (North and McLemore, 1986, 1988; Mutschler et al., 1991a, b; Thompson, 1991, 1992). Calc-alkalic igneous rocks are not exposed in the Cornudas Mountains.

The progressive change in composition of igneous rocks from alkalic in the eastern Trans-Pecos magmatic province to less alkalic to calc-alkalic in the western Trans-Pecos, Mexico and southwestern New Mexico (Fig. 2; Barker, 1977, 1987; Henry and Price, 1984; North and McLemore, 1986, 1988; Price et al., 1987; Clark, 1989; Henry et al., 1991) is consistent with an origin related to subduction of the Farallon plate beneath the North American plate with time. The resulting igneous rocks in the Cornudas Mountains and the Trans-Pecos magmatic province correspond to the eastern limit of the "magmatic sweep" that occurred during the transition between Laramide compressional tectonics and Basin and Range extensional tectonics (Price et al., 1987; Henry' et al., 1991). These alkalic-igneous rocks are a result of partial melting and magmatic differentiation of lower crustal and evolved mantle-derived sources (Barker, 1987; Price et al., 1987; Henry et al., 1991). Once the descending slab becomes dehydrated with depth, generation of calc-alkalic magmas decreases, but there is enough heat to cause melting of the overlying asthenosphere that can result in generation of alkalic magmas from mantle sources (Fitton and Upton, 1987). Magmatic differentiation was greater during the Laramide and the transitional period than during the Basin and Range extensional period in the Trans-Pecos magmatic province (Price et al., 1987).

Alkalic-igneous rocks are typically associated with deposits or high concentrations of beryllium, rare-earth elements, niobium and uranium. Economic deposits of these commodities are less common but can occur near or within alkalic-igneous complexes. Geologic mapping, geophysical and geochemical surveys and other exploration techniques are required to locate and delineate any potential deposits in the Cornudas Mountains.

Deposits of nepheline syenite suitable for glass and ceramic use are rare because of high concentrations of iron. In addition, alteration of nepheline and feldspar to analcime is undesirable. Petrographic and geochemical studies are required to locate such deposits. Only the Wind Mountain nepheline syenite in the Cornudas Mountains has thus far proven to be suitable for amber-colored beverage containers and ceramics. Additional studies are under way.

Gold and silver are likewise associated with alkalic igneous complexes, especially along the eastern margin of the North American Cordillera. Gold and silver occur in several types of deposits that have been classified together as Great Plains Margin deposits (North and McLemore, 1986, 1988; McLemore, 1991) and alkalic-related gold deposits (Thompson, 1991, 1992; Mutschler et al. , 1991a, b; Woodward and Fulp, 1991). However, in many areas of the North American Cordillera where gold-silver deposits are related to alkalic-igneous rocks, the gold-silver deposits are also associated with less alkalic to calc-alkalic igneous rocks (North and McLemore, 1986, 1988; Mutschler et al., 1991a, b; Thompson, 1991, 1992). The igneous rock assemblages in these mineralized areas appear to be related to complex and multiple intrusive cycles of partial melting and differentiation of lower crustal or mantle-deep crustal sources (Thompson, 1991; Mutschler et al., 1991a, b). Hot spots may also be involved. Their tectonic setting appears to be related to back-arc extension rather than to subduction (Eggler and Furlong, 1991; Thompson, 1991).

A combination of tectonic setting (back-arc extension) and complex, multiple intrusive cycles of magmatic differentiation resulting in both alkalic and calc-alkalic igneous rocks may provide constraints on the genesis of alkalic-related gold deposits. If these constraints do apply, the Cornudas Mountains and the Trans-Pecos magmatic province may be unfavorable for the occurrence of Great Plains Margin gold-silver deposits. This theory needs to be investigated further.

ACKNOWLEDGMENTS

Special thanks are to P. Gruaseah for his geologic map of Wind Mountain. George Austin, Mark Ouimette and Robert Guilinger reviewed this manuscript and their comments are appreciated. Figures were drafted by the NMBMMR Cartography Department and the manuscript was typed by Lynne Hemenway. This work was supported by NMBMMR (Charles E. Chapin, Director and State Geologist) and Addwest Minerals, Inc. (James R. Guilinger, project supervisor).

REFERENCES

Allen, M. S. and Foord, E. E., 1991, Geological, geochemical and isotopic characteristics of the Lincoln County porphyry belt, New Mexico: implications for regional tectonics and mineral deposits: New Mexico Geological Society, Guidebook 42, p. 97-113.

Barker, D. S., 1977, Northern Trans-Pecos magmatic province: introduction and comparison with the Kenya rift: Geological Society of America Bulletin, v. 88, p. 1421.1427.

Barker, D. S., 1979, Cenozoic magmatism in the Trans-Pecos province: relation to Rio Grande rift; *in* Riecker, R. E., ed., Rio Grande rift: tectonics and magmatism: American Geophysical Union, p. 382-392.

Barker, D. S., 1987, Tertiary alkaline magmatism in Trans-Pecos Texas; *in* Fitton, J. G. and Upton, B. G. J., eds., Alkaline igneous rocks: Geological Society of America, Special Publication 30, p. 415-431.

Barker, D. S. and Hodges, F. N., 1977, Mineralogy of intrusions in the Diablo Plateau, northern Trans-Pecos magmatic province, Texas and New Mexico: Geological Society of America Bulletin, v. 88, p. 1428-1436.

Barker, D. S., Long, L. E., Hoops, C. K. and Hodges, F. N., 1977, Petrology and Rb-Sr isotope geochemistry of intrusions in the Diablo Plateau, northern Trans-Pecos magmatic province, Texas and New Mexico: Geological Society of America Bulletin, v. 88, p. 1437-1446.

Boggs, R. C., 1985, Mineralogy of the Wind Mountain laccolith, Otero County, New Mexico: New Mexico Geology, v. 7, p. 41-42.

Boggs, R. C., 1987, Mineralogy and textures of a eudialyte bearing dike, Wind Mountain, Otero County, New Mexico: New Mexico Geology, v. 9, p. 22.

Boggs, R. C. and Ghose, S., 1985, Georgechaoite NaKZrSi3O9.2H20, a new species from Wind Mountain, New Mexico: Canadian Mineralogist, v. 23, p. 1-4.

Cameron, K. L. and Cameron, M., 1985, Rare-earth elements, $Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ compositions of Cenozoic orogenic dacites from Baja California, north-western Mexico and adjacent west Texas: evidence for the predominance of a subcrustal component: Contributions to Mineralogy and Petrology, v. 91, p. 1-11.

Campa, M. F. and Coney, P. J., 1983, Tectono-stratigraphic terranes and mineral resource distributions in Mexico: Canadian Journal of Earth Sciences, v. 20, p. 1040-1051.

Clabaugh, S. E., 1941, Geology of the northwestern portion of the Cornudas Mountains, New Mexico [M.S. thesis]: Austin, University of Texas, 66 p.

Clabaugh, S. E., 1950, Eudialyte and eucolite from southem New Mexico: American Mineralogist, v. 35, p. 279-280.

Clark, K. F., 1989, Metallogenic provinces and epochs in Mexico: 28th International Geological Congress, Abstracts, v. 1, p. 300.

Clark, K. F., Foster, C. T. and Damon, P. E., 1982, Cenozoic mineral deposits and subduction related magmatic arcs in Mexico: Geological Society of America Bulletin, v. 93, p. 533-544.

Collins, G. E., 1958, Preliminary reconnaissance for uranium in the Cornudas Mountains, Otero County, New Mexico and Hudspeth County, Texas: U.S. Atomic Energy Commission, Report DBO-4-TM5, 16 p.

Coney, P. J., 1972, Cordilleran tectonics and North American plate motions: American Journal of Science, v. 272, p. 603-628.

Damon, P. E., Shafiqullah, M. and Clark, K. F., 1981, Age trends of igneous activity in relation to metallogenesis in the southern Cordillera: Arizona Geological Society Digest, v. 14, p. 137-154.

Eggler, D. H. and Furlong, K. P., 1991, Petrochemical and geophysical evidence for old mantle lithosphere beneath Montana; *in* Baker, P. W. and Berg, R. B., eds., Guidebook of the central Montana alkalic province: Montana Bureau of Mines and Geology, Special Publication 100, p. 87-91.

Fitton, J. G. and Upton, B. G. J., 1987, Introduction; *in* Fitton, J. G. and Upton, B. G. J., eds., Alkaline igneous rocks: Geological Society of America, Special Publication 30, p. 415-531.

Henry, C. D., 1992, Beryllium and other rare metals in Trans-Pecos Texas: West Texas Geological Society Bulletin, v. 31, p. 15.

Henry, C. D., McDowell, F. W., Price, J. G. and Smyth, R. C., 1986, Compilation of potassium-argon ages of Tertiary igneous rocks, Trans-Pecos Texas: Texas Bureau of Economic Geology, Geological Circular 86-2, p. 6-7.

Henry, C. D. and Price, J. G., 1984, Variations in caldera development in the Tertiary volcanic field of Trans-Pecos Texas: Journal of Geophysical Research, v. 89, p. 8765-8786.

Henry, C. D., Price, J. G. and James, E. W., 1991, Mid-Cenozoic stress evolution and magmatism in the southern Cordillera, Texas and Mexico: transition from continental arc to intraplate extention: Journal of Geophysical Research, v. 96, no. B8, p. 13,545-13,560.

Henry, C. D., Price, J. G., Parker, D. F. and Wolff, J. A., 1989, Excursions 9A: Mid-Tertiary silicic alkalic magmatism of Trans-Pecos Texas rheomorphic tuffs and extensive silic lavas: New Mexico Bureau of Mines and Mineral Resources, Memoir 46, p. 231-274.

Irvine, T. N. and Baragar, W. R. A., 1971, A guide to the chemical classification of the common volcanic rocks: Canadian Journal of Earth Sciences, v. 8, p. 523-548.

King, W. E. and Harder, V. M., 1985, Oil and gas potential of the Tularosa Basin-Otero platform-Salt Basin graben area, New Mexico and Texas: New Mexico Bureau of Mines and Mineral Resources, Circular 198, 36 p.

Lindgren, W., 1915, The igneous history of the Cordillera and its problems: Yale University, p. 284-286.

Lofty, G. J., Hillier, J. A., Sooke, S. A., Hale, P. **I.,** Linley, K. A. and Singh, H. R., comps., 1991, World mineral statistics 1985-89: British Geological Survey, Keyworth, Nottingham, p. 307.

McLemore, V. T., 1983, Uranium and thorium occurrences in New Mexico: distribution, geology, production and resources: New Mexico Bureau of Mines and Mineral Resources, Open-file Report OF-182, 250 p.

McLemore, V. T., 1991, Base- and precious-metals deposits in Lincoln and Otero Counties, New Mexico: New Mexico Geological Society, Guidebook 42, p. 305-310.

McLemore, V. T. and Chenoweth, W. L., 1989, Uranium resources in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Resource Map 18, 36 p.

McLemore, V. T., North, R. M. and Leppert, S., I988a, REE, niobium and thorium districts and occurrences in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 324, 27 p.

McLemore, V. T., North, R. M. and Leppert, S., 1988b, Rare-earth elements (REE) in New Mexico: New Mexico Geology, v. 10, p. 33-38.

McLemore, V. T., Ouimette, M. and Eveleth, R. W., 1991, Preliminary observations on the mining history, geology and mineralization of the Jicarilla mining district, Lincoln County, New Mexico: New Mexico Geological Society, Guidebook 42, p. 311-316.

Moore, S. L., Thompson, T. B. and Foord, E. E., 1991, Structure and igneous rocks of the Ruidoso region, New Mexico: New Mexico Geological Society, Guidebook 42, p. 137-145.

Murphy, M., Wollenburg, H., Strisower, B., Bowman, H., Flexser, S. and Carmichael, I., 1978, Uranium in alkaline rocks: U.S. Department of Energy, Open-file Report GJBX-78(78), 185 p.

Mutschler, F. E., Mooney, T. C. and Johnson, D. C., 1991a, Precious metal deposits related to alkaline igneous rocks-a space-time trip through the Cordillera: Mining Engineering, v. 43, p. 304-309.

Mutschler, F. E., Johnson, C. and Mooney, T. C., 1991b, A speculative plate kinematic model for the central Montana alkalic province and related gold deposits; *in* Baker, D. W. and Berg, R. B., eds., Guidebook of the central Montana alkalic province: Montana Bureau of Mines, Special Publication 100, p. 121-124.

North, R. M. and McLemore, V. T., 1986, Silver and gold occurrences in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Resource Map 15, 35 p.

North, R. M. and McLemore, V. T., 1988, A classification of the precious metal deposits of New Mexico; *in* Bulk minable precious metal deposits of the western United States: Geological Society of Nevada, Symposium Proceedings, p. 625-659.

Potter, M. J., 1990, Annual report of feldspar, nepheline syenite and aplite: U.S. Bureau of Mines, 6 p.

Price, J. G. and Henry, C. D., 1984, Stress orientations during Oligocene volcanism in Trans-Pecos Texas: timing the transition from Laramide compression to Basin and Range tension: Geology, v. 12, p. 238-241.

Price, J. G., Henry, C. D., Barker, D. S. and Parker, D. F., 1987, Alkalic rocks of contrasting tectonic settings in Trans-Pecos Texas: Geological Society of America, Special Paper 215, p. 335-346.

Price, J. G., Rubin, J. N., Henry, C. D., Pinkston, T. L., Tweedy, S. W. and Koppenaal, D. W., 1990, Rare-metal enriched peraluminous rhyolites in a continental arc, Sierra Blanca area, Trans-Pecos Texas: chemical modification by vapor-phase crystallization: Geological Society of America, Special Paper 246, p. 103-120.

Sillitoe, R. **H.,** 1972, Relation of metal provinces in western American to subduction of oceanic lithosphere: Geological Society of America, Abstracts with Programs, South-central Section, p. 14.

Thompson, T. B., 1991, Genesis of gold associated with alkaline igneous rocks: Geological Society of America, Abstracts with Programs, v. 23, p. 99-100.

Thompson, T. B., 1992, Mineral deposits of the Cripple Creek district, Colorado: Mining Engineering, v. 44, p. 135-143.

Timm, B. C., 1941, The geology of the southern Cornudas Mountains, Texas and New Mexico [M.S. thesis]: Austin, University of Texas, 55 p.

U.S. Bureau of Mines, 1991, Mineral commodity summaries 1992: U.S. Bureau of Mines, 196 p.

Van Alstine, R. E., 1976, Continental rifts and lineaments associated with major fluorspar districts: Economic Geology, v. 71, p. 977-987.

Warner, L. A., Holser, W. T., Wilmarth, V. R. and Cameron, E. N., 1959, Occurrence of nonpegmatite beryllium in the United States: U.S. Geological Survey, Professional Paper 318, 198 p.

Woodward, L. A. and Fulp, M. S., 1991, Gold mineralization associated with alkali trachyte breccia in the Gallinas mining district, Lincoln County, New Mexico: New Mexico Geological Society, Guidebook 42, p. 323-326.

Woolley, A. R., 1987, Alkaline rocks and carbonatites of the world, part 1: North and South America: University of Texas Press, Austin and British Museum of Natural History, Cambridge, England, 216 p.

Zapp, A. D., 1941, Geology of the northeastern Cornudas Mountains, New Mexico [M.S. thesis]: Austin, University of Texas, 63 p.

APPENDIX—DESCRIPTION OF SAMPLES

AS-2	chilled selvage, nepheline-bearing augite syenite
AS-5	nepheline-bearing augite syenite
DE-1	nepheline syenite, Deer Mountain
DE-5	nepheline syenite, Deer Mountain
DE-4	devitrified glass dike in nepheline syenite, Deer Mountain
DE-12	groundmass of phonolite dike, 1 km WSW Deer Mountain
CH-1	phonolite, Chatfield Mountain
SA-1	nepheline syenite, San Antonio Mountain
SA-12	porphyritic pitchstone, SE flank San Antonio Mountain
WN-11	nepheline syenite, Wind Mountain
Z-2	phonolite plug, 3.7 km west of Wind Mountain
WS-1	nepheline syenite, Washburn Mountain
AL-11	phonolite, Alamo Mountain
AL-10	foliated porphyritic nepheline syenite, Alamo Mountain
CORN-10	nepheline syenite, TSNP, Wind Mountain
CORN-11	hornfels zone, Wind Mountain (Fig. 9)
CORN-12	chilled margin, nepheline syenite dike, Wind Mountain (Fig. 9)
CORN-13	nepheline syenite sill with limestone zenoliths, $TSNP_2$, Wind Mountain
CORN-14	nepheline syenite, $TSNP_2$, Wind Mountain
CORN-15	altered nepheline syenite, $TSNP_2$, Wind Mountain
CORN-18	phonolite dike, NW Wind Mountain
F2TSPF62	core sample nepheline syenite $TSNP_2$, Wind Mountain
FSTNSD	core sample nepheline syenite $TSNP_2$, Wind Mountain
$TSNP_2$	nepheline syenite, Wind Mountain
PIT 1	nonmagnetic separate
PIT 2	nonmagnetic separate

West Dog Canyon in southern Brokeoff Mountains. View is upstream, S82°E. The canyon is about 150–240 m deep. Cliffs and ridges are Grayburg Formation. Lower slopes are San Andres/Cherry Canyon tongue. Creosote bush (medium to dark gray shrub) is confined mainly to the alluvial terrace at right and the alluvial fan at base of canyon wall just above center of photograph. Rugged ground on flood plain at left of center is bouldery mudflow or streamflood deposit. The deposit is overgrown with grass and shrubs. The present channel has been diverted south around the deposit. Camera station is in NW1/4 sec. 17, T26S, R20E, about 9.5 km southwest of El Paso Gap. Altitude is approximately 1524 m. W. Lambert photograph No. 85L113. November 16, 1985, 12:25 p.m. MST.