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GEOCHRONOLOGY OF BASEMENT AND RECENT INTRUSIVE ROCKS FROM THE CUERVO AREA, EAST-CENTRAL NEW MEXICO

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INTRODUCTION

The basement and intrusive rocks of the Cuervo area received scant geologic attention until 1982–83, when wildcat drilling by Yates Petroleum Corporation and Trans-Pecos Resources resulted in the first significant hydrocarbon discoveries in the Tucumcari basin (Fig. 1). Detailed geologic investigations of the basement lithologies, tectonics and kinematics were deemed vital for any future commercial hydrocarbon exploitation of the Tucumcari basin. We present eight new potassium–argon radiometric-age determinations, together with several representative whole-rock chemical analyses. Although our interpretations of the basement of the Cuervo area are largely empirical and based almost exclusively on proprietary data, we seek to stimulate more long-term research in the geology of the Tucumcari basin.

PREVIOUS WORK

Several discussions on the nature and age of the Precambrian basement terrain of east-central New Mexico are given by Flawn (1956), Muehlberger et al. (1966), Denison and Hetherington (1969), Foster et al. (1972) and Mukhopadhyay et al. (1975). Rubidium–strontium radiometric-age determinations by Mukhopadhyay et al. (1975) on the Precambrian rocks of the Pedernal Hills of Torrance County are significant because they are from the exposed Precambrian terrain nearest to the Cuervo area. Loring and Armstrong (1980) also reported several new radiometric ages from the Pedernal Hills, although these were reported as Cambrian–Ordovician. The significance of these ages is discussed later. Condie and Budding (1979) include most of these studies in a comprehensive summary of the Precambrian rocks of central and south-central New Mexico. Callender et al. (1976) were the first to address the detailed Precambrian geology and geochronology of northeastern New Mexico. Their study included three radiometric-age determinations by Muehlberger et al. (1966) from wells drilled to Precambrian basement adjacent to the Cuervo area of this report.

The general regional geology of the Cuervo area is given in Kelley (1972) as well as the guidebook of the New Mexico Geological Society 23rd Field Conference on east-central New Mexico (Kelley and Trauger, 1972). Recent comprehensive reviews of the subsurface petroleum geology of the Cuervo area are given by Broadhead (1984) and McKallip (1984).

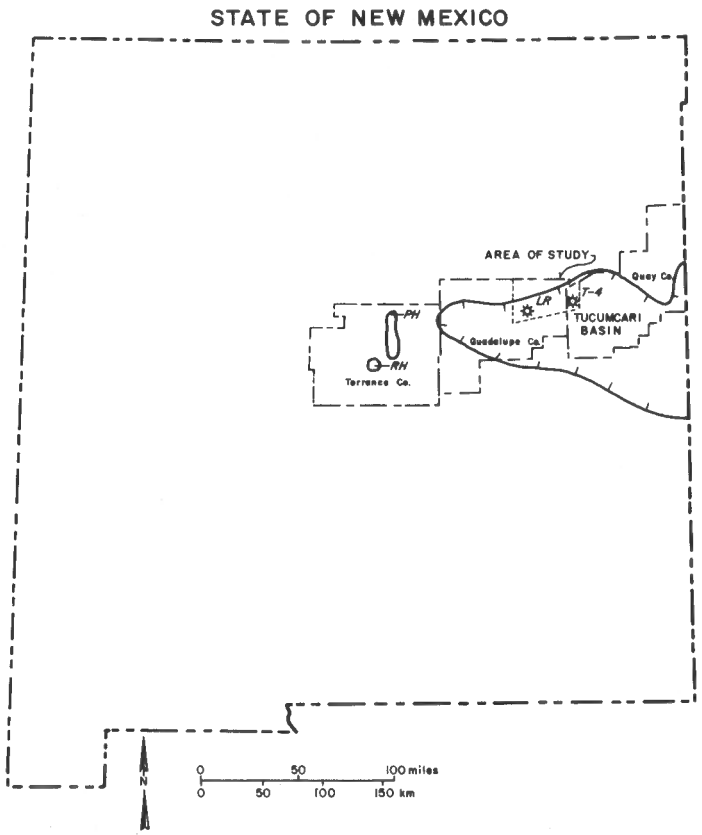

FIGURE 1. Location map. LR = Latigo Ranch wells, T-4 = T-4 Cattle Company wells, PH = Pedernal Hills, RH = Rattlesnake Hills.

GEOCHRONOLOGY

Eight new basement ages are described, with seven ages from the Cuervo area and one age from the nearest exposed Precambrian rocks in Torrance County included for comparison. The age determinations were done by the potassium–argon-dating technique on fresh, whole-rock igneous material by Teledyne Isotopes. Details of the analytical procedures used are given at the end of this paper. Five basement samples from four wells were selected for dating, along with three outcrop samples (Table 1). Two of the basement samples are from the Gila Exploration Latigo Ranch wells, and the three other basement samples are from the Yates Petroleum T-4 Cattle Company wells (Fig. 1).

The ages recorded for the basement samples range from 766 m.y. to 376 m.y. (Table 1). The 376-m.y. age for the T-4 Cattle Company #1 is clearly anomalous, the sample being recovered at over 7000 feet depth, underneath a Pennsylvanian sedimentary section. We consider this mid-Devonian age to represent thermal "resetting," and subsequent argon loss, of a Precambrian granite.

Although there may be some limitations in the sole use of whole-rock potassium–argon age determinations, we feel that these ages indicate a basement terrain at least 250 m.y. younger than previously reported by Muehlberger et al. (1966) for two wells drilled to basement in Guadalupe County (Table 1). With our knowledge of the complex basement configuration shown from drilling records and a high-resolution, airborne magnetic survey and over 440 miles of reflection seismic surveys, we conjecture that there is a late Precambrian basement of very heterogeneous lithologies having a considerable subsurface relief pattern. Lithologies range from sericitic quartzites and argillites, granites and amphibolites, to quartz-feldspathic gneisses and quartz–feldspar porphyries. These varied lithologies could represent more than one tectono-stratigraphic assemblage present in the Cuervo area. Partial evidence for this is suggested from many aspects of mineralogy and petrology which are akin to the exposed Precambrian terrain of the Pedernal Hills. Setter (1985) reported, from fabric mapping, at least two different tectono-stratigraphic assemblages present between the Pedernal Hills and the adjacent Rattlesnake Hills (Fig. 1). In the Rattlesnake Hills, a fresh, unsheared basalt (Table 2) was dated by Setter at 848 m.y. (Table 1). This age is older than the basement rocks of the Cuervo area by about 100 m.y., although it is younger than the 1.4

TABLE 1. Radiometric dates for Precambrian rocks from east-central New Mexico. *Muehlberger et al. (1966).

Rock Type	Location	Isotopic Age (m.y.)	Method
Qtz-Feldspathic Gneiss	Trans-Pecos Resources Latigo Ranch #1-A Guadalupe County Sec. 2, T9N, R23E (7200' depth)	720 ± 36	K/Ar
Qtz-Feldspar Porphyry	Trans-Pecos Resources Latigo Ranch #1-D Guadalupe County Sec. 26, T10N, R23E (7800' depth)	604 ± 30	K/Ar
Hornblende Granite	Yates Petroleum T-4 Cattle Company #1 Quay County Sec. 5, T10N, R27E (7230-7235' depth)	376 ± 19	K/Ar
Hornblende Granite	Yates Petroleum T-4 Cattle Company #2 Quay County Sec. 32, T11N, R27E (5900-5920' depth) (a) (6610-6860' depth) (b)	664 ± 35 (a) 766 ± 38 (b)	K/Ar K/Ar
Basalt	Rattlesnake Hills Torrance County Sec. 21, T4N, R11E	848 ± 42	K/Ar
Diabase	Prospect Hill Guadalupe County Sec. 32, T11N, R23E	12.6 ± 1	K/Ar
Basalt	Spires Ranch Guadalupe County Sec. 29, T10N, R22E	12.5 ± 0.6	K/Ar
Granite (c) Biotite (d)	Cities Services Driggers #1 Guadalupe County Sec. 22, T11N, R21E	1667 (c) 1350 (d)	Rb/Sr* K/Ar*
Granite	Husky-General Crude Hanthett State #1 Guadalupe County Sec. 16, T8N, R24E	1040	Rb/Sr*

TABLE 2. Representative chemical analyses of Precambrian and recent rocks from east-central New Mexico. 1 – basalt, Rattlesnake Hills, 2 – basalt, Spires Ranch, 3 – diabase, Prospect Hill, 4 – specular hematite-mineralized calcareous breccia, Prospect Hill, 5 – Precambrian argillite, Trans-Pecos Resources, Latigo Ranch #1-C Well, 7000′ depth, sec. 4, T9N, R23E. All analyses were done by Barringer Resources, Inc., Golden, Colorado.

	1.	2.	3.	4.	5.
Major Elements (wt%)					
SiO2	54.0	48.8	52.4	46.0	77.0
TiO2	0.6	2.3	1.6	0.6	1.4
Al203	12.6	11.3	14.2	9.5	10.8
Fe203[T]	10.3	11.7	10.0	15.0	2.7
MnO	0.2	0.2	0.2	0.2	0.1
MgO	11.0	9.6	4.6	3.6	1.0
CaO	10.0	9.6	7.5	13.2	0.1
Na20	1.5	4.4	5.1	1.0	0.1
K20	0.3	1.5	3.3	1.9	2.2
P205	0.0	0.6	0.6	0.1	0.0
L.O.I.	0.4	0.0	2.9	8.5	6.0
Trace Elements (ppm)					
As	-	-	10	10	10
Ag	-	-	-	-	1
Ba	-	1100	1840	1120	-
Be	-	-	2	-	-
Bi	22	90	50	50	10
Cu	150	51	50	180	10
Co	56	35	20	23	44
Cr	750	295	15	55	140
F	50	400	310	190	730
Li	15	18	25	25	150
Mo	-	10	5	5	-
Ni	160	148	66	26	56
Pb	-	-	25	-	14
Rb	30	40	60	110	100
Sn	1	3	-	-	1
Sr	200	900	1160	190	100
V	220	245	250	210	110
Zn	78	125	170	53	30
U	-	1.6	1.0	0.8	2.6

b.y. given for the Precambrian rocks of the Pedernal Hills by Mukhopadhyay et al. (1975).

The sample of quartz–feldspar porphyry, dated at 604 m.y., from the Latigo Ranch #1-D (Table 1), showed very similar textural and mineralogical characteristics to llanite, a Precambrian porphyry rock from the Llano uplift in central Texas. In particular, glomero-porphyritic quartz displays a deep blue iridescence that is typical of llanite from Texas. A similar quartz–feldspar porphyry was recovered in 1984 from 6100 feet at the total depth of the McClellan Oil Burner Fee #3 in sec. 31, T11N, R22E.

A medium-grained amphibolite is present immediately beneath 300–400 feet of quartz–feldspar porphyry in the Latigo Ranch #1-D well. This amphibolite was not a candidate for radiometric-age dating because of relict mineral textures suggestive of intense deuteric- and/or hydrothermal-alteration effects from the emplacement of the quartz–feldspar porphyry.

Two recent mafic dikes were sampled in the Cuervo area, one sample (SR-83-01) from the old Spires Ranch and the other sample (PH-008) from Prospect Hill on the Latigo Ranch. Both dikes form resistant, upstanding outcrops that are recognizable on a 7½-minute topographic quadrangle map. At Prospect Hill, the dike connects with a small volcanic neck, having minor welded tuffs and vent agglomerates on its flanks, and also a specular hematite-mineralized calcareous breccia (Table 2). These dikes have almost identical ages of 12.6 m.y. and 12.5 m.y. for Prospect Hill and Spires Ranch, respectively, and also display similar chemical compositions (Table 2). The juxtaposition of the Prospect Hill dike with the NNE–SSW-trending, down to the west, Garita fault that is immediately west of Cuervo Hill indicates a least principal horizontal stress direction of N20°E at the time of dike emplacement. The petrology of the Prospect Hill dike is that of a holocrystalline diabase, whereas the Spires Ranch dike is a weakly porphyritic olivine basalt.

TECTONICS

Based on our studies, the basement of the Cuervo area has undergone at least three periods of tectonic activity. The first event was a period of extensive plutonism and volcanism that began in late Proterozoic times, less than 900 m.y. ago. This event might be related to an episode of late Proterozoic rifting of the Cordilleran miogeocline as described by Armin and Mayer (1983). Conceivably, this period of rifting may have set the stage for early Paleozoic basin development in the Cuervo portion of the Tucumcari basin. It is uncertain whether the Cuervo Precambrian rocks could possibly represent a separate deep-basement-fracture system, or were generated during the continental-scale suturing with the development of the Anadarko aulacogen (700–550 m.y.) and the Keweenawan aulacogen (mid-continent rift system approximately 1.05 b.y. old).

Recent discoveries of hydrogen gas along the mid-continent rift were originally thought to be the only example of its kind in the world. However, Gila Exploration in February 1985 recovered anomalous amounts of hydrogen and helium gas from one of the wells they operate on the Latigo Ranch. The detection of these gases lends support to the idea of some form of late Proterozoic rifting in the Cuervo area.

The second basement tectonic event in the Cuervo area is best shown by a proprietary, high-resolution, airborne magnetic survey flown by Applied Geophysics in 1983. The observed magnetic map that was generated captures many major Paleozoic tectonic events that formed the structural grain of the area. Most notable is the prominent E–NE-trending structural axis beneath the Latigo Ranch wells and a deep low to the northwest of these wells offset by right-lateral faulting. There is reasonable agreement between the features shown on the magnetic map and those interpreted on the proprietary Pennsylvanian (P-6 marker) seismic-structure map.

The age of the second tectonic event can be partially constrained by east-trending Ordovician syenite dikes in the Pedernal Hills to the southwest. These dikes were dated by Loring and Armstrong (1980) using the rubidium–strontium method, yielding a whole-rock age of about 470 m.y. Of particular interest is their estimation of a maximum possible age of one of the dikes at 604 m.y., comparable to the age given by us for the quartz–feldspar porphyry from the Latigo Ranch #1-D well. It is evident that alkalic igneous activity affected portions of central New Mexico in early Paleozoic time, suggesting a least principal horizontal-stress direction that parallels the interpreted right-lateral faulting shown on the observed magnetic map of the Cuervo basement. Additional evidence for the age of this right-lateral faulting may be indicated by the anomalous 376-m.y. age for a basement sample from the T-4 Cattle Company #1 well. This second period of tectonism in the Cuervo area could have reset the potassium–argon "clock" for this sample at or near the age of deformation.

The last tectonic event is recognized from the recent ages of the mafic dikes near Cuervo. Their ages of 12.5 m.y. are important for the Cuervo area, since they help to constrain the timing of crustal extension at the eastern margin of the southern Basin and Range province (Eaton, 1979). In the Cuervo area, this crustal extension has produced a variety of faults at the surface, such as the Garita fault with over 500 m of displacement, to the more subtle, listric normal faults which are apparent on several seismic profiles.

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APPENDIX

The constants used for the age calculations are those given by the Subcommission on Geochronology, 25th International Geological Congress, 1976. The indicated precision of the reported ages is calculated using the method of Cox, A. and Dalrymple, G. B., 1967, Statistical analysis of geomagnetic reversal data and the precision of potassium–argon dating: Journal of Geophysical Research, v. 72, pp. 2603–2614.

Ute Creek looking southeast from Punta de Gallegos (photo: S. G. Lucas).