Tertiary geology of Hidalgo County, New Mexico. Guide to metals, industrial minerals, petroleum, and geothermal resources

W. E. Elston, Edward E. Erbe, and E. G. Deal

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Tertiary geology of Hidalgo County, New Mexico

Guide to metals, industrial minerals, petroleum, and geothermal resources

Wolfgang E. Elston and Edward E. Erb, University of New Mexico, and Edmond G. Deal, Eastern Kentucky University

Introduction

In Hidalgo County, New Mexico, Laramide deformation was accompanied by andesitic and basaltic volcanism and intrusion of stocks of intermediate composition. Later, in Oligocene time, large-scale volcanism resulted in formation of at least nine major ash-flow tuff cauldrons (fig. 1). In at least three of them (fig. 1, Nos. 2, 3, 6), porphyry bodies were emplaced during a resurgent magma pulse. Subsequently, in Miocene to Holocene time the region was broken into Basin and Range fault blocks. The ranges were eroded, the basins filled with sedimentary rocks, and basalt erupted locally from small cones. The structural and stratigraphic evidence and radiometric dates on which these interpretations are based have been summarized elsewhere (Deal and others, 1978); this paper deals only with economic geology. Stratigraphic terminology and ages of mid-Tertiary volcanic rocks are shown in fig. 2.

Economic geology

Metals and fluorspar

Over 90 percent of the metallic mineral production of Hidalgo County has come from the Lordsburg mining district, where copper and lesser amounts of gold, silver, lead, and zinc have been mined from northeast-trending veins (Emerald, Bonney, Miser's Chest) associated with a Laramide (56.5 ± 1.2 m.y.) granodiorite porphyry stock intruded into late Cretaceous or early Tertiary basalt and andesite. Total production has been over $60 million (all values given are those at the time of production). Dates have not yet been published for the stocks of the Little Hatchet Mountain (Eureka and Sylvanite mining districts) but all other known porphyry bodies in Hidalgo County are mid-Tertiary in age, coeval with mid-Tertiary volcanic rocks (fig. 1).

Numerous shows of mineralization, prospects, and small mines are controlled by mid-Tertiary ash-flow tuff cauldrons. Details of individual mines were given by Elston (1963) and estimates of production of districts by Elston (1965a). The San Simon and Granite Gap districts between them have yielded about $1,900,000; production of all other districts has been between a few thousand and a few hundred thousand dollars each.

In the Apache No. 2 mining district (Apache Hills), copper-bearing skarns are associated with monzonite and rhyolite dikes, probably part of a resurgent magma pulse of the Apache cauldron. Alteration is widespread. The rhyolite bodies are later than, but probably related to, the main mass of the Apache Hills quartz monzonite porphyry stock, which seems to be barren (Peterson, 1976). Similar rhyolite bodies, skarn mineralization, and thermal metamorphism exist in the Fremont district (Sierra Rica) but no porphyry body is exposed. Possibly, porphyry exists in the subsurface. In the Gillespie (Red Hill) district in the Animas Mountains, veins of fluorite, silver, or lead are in the ring-fracture zone of the Juniper cauldron. Drilling has shown the existence of a buried quartz monzonite body under part of the district, probably a ring-fracture intrusion emplaced as part of a resurgent magma pulse (Elston and Erb, 1977). The exposed porphyries of the Juniper cauldron, the Animas and Walnut Wells stocks of Zeller and Alper (1965), appear to be barren.

The composite stock emplaced in the northwestern end of the Muir cauldron in the Pyramid Mountains (fig. 1, No. 2) is not known to be mineralized but the rocks in which it is emplaced (mainly rhyolite of Jose Placencia Canyon and tuff of Woodhaul Canyon) are intensely argillized. Pyrite is widespread. Galena and stibnite have been sought, respectively, in the Silver Tree and Allen prospects, both in sec. 7 (unsurveyed), T. 25 S., R. 18 W. In the southern Peloncillo Mountains, there is widespread alteration and a silver-bearing vein in the Silver Tip district, on the Arizona-New Mexico boundary. The district is near the northeastern margin of the Geronimo Trail cauldron. Altered andesite and Cretaceous shale have been quarried for fire clay south of Pratt, in the margin of the Rodeo cauldron.

The central part of the Peloncillo Mountains has yielded copper, lead, zinc,

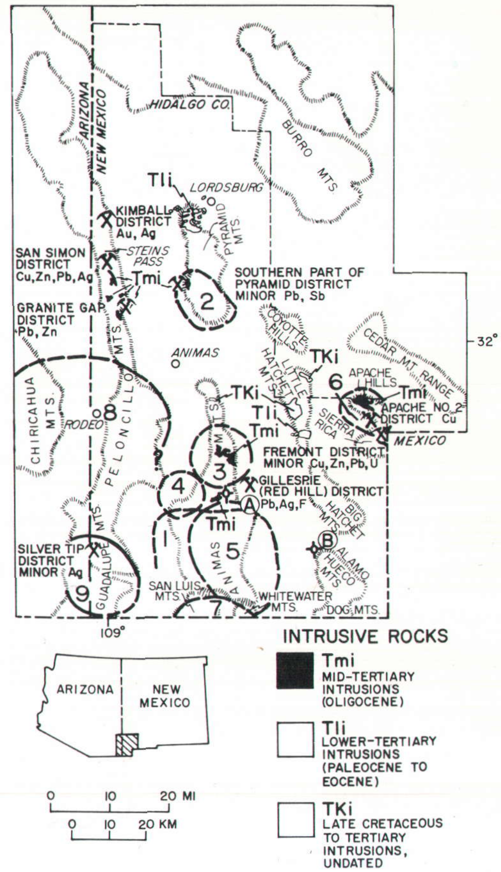

FIGURE 1—ASH-FLOW TUFF CAULDRONS, IGNEOUS INTRUSIONS, MINING DISTRICTS THAT WERE MINERALIZED IN OLIGOCENE TIME, AND PRINCIPAL PETROLEUM EXPLORATION WELLS. Names of cauldrons: 1-Tullous, 2-Muir, 3-Juniper, 4-Animas Peak, 5-Cowboy Rim, 6-Apache, 7-San Luis, 8-Rodeo, 9-Geronimo Trail. For details of cauldrons, see Deal and others (1978) and Elston (1978). Exploration wells: A-KCM No. 1 Forest Federal, B-Humble No. 1 Stage "BA." For complete listing of wells, see Thompson and others (1978).

(continued on page 3)

Tertiary geology of Hidalgo County *(continued from page 1)*

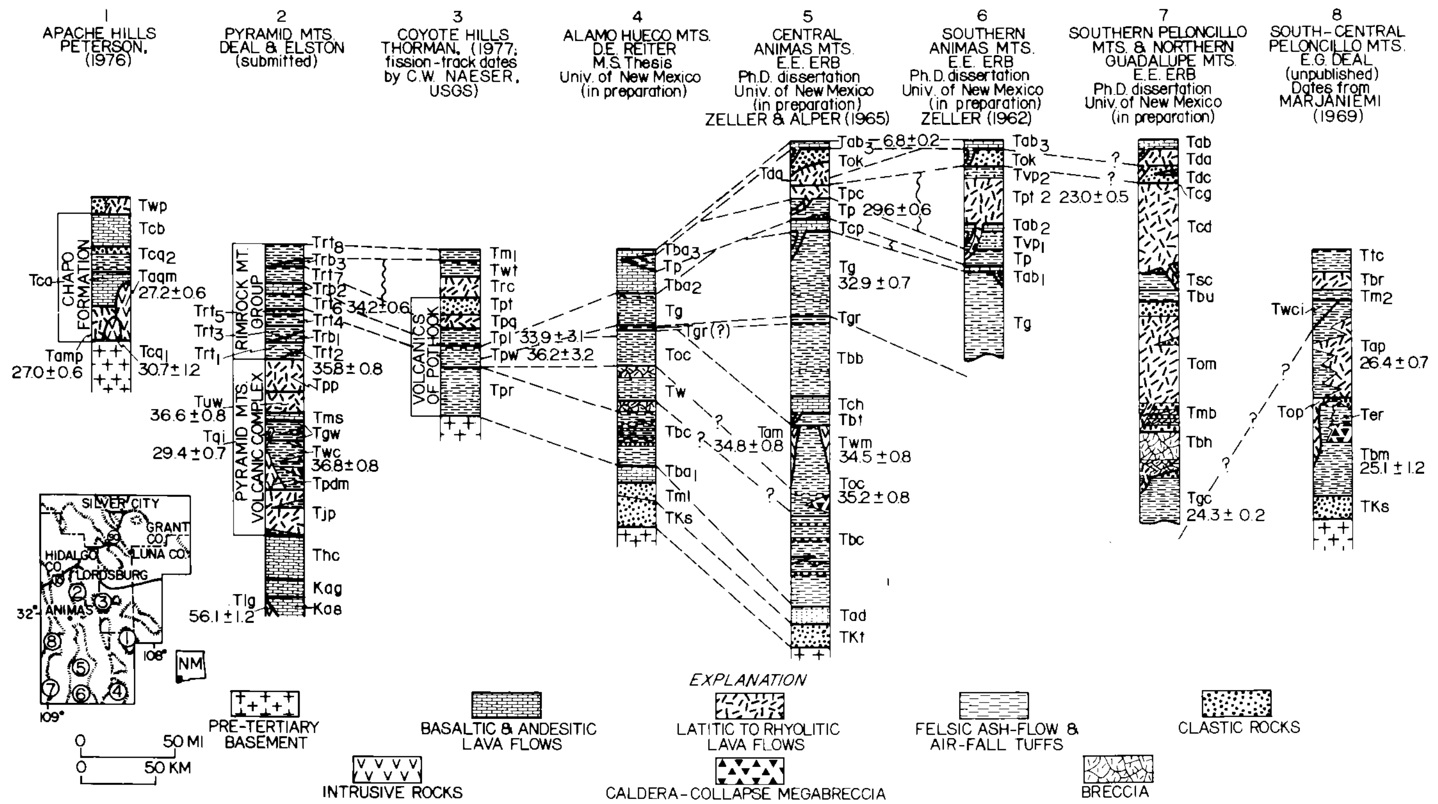

FIGURE 2—CORRELATION CHART OF CENOZOIC IGNEOUS ROCKS OF HIDALGO COUNTY, NEW MEXICO, modified from Deal and others (1978). Symbols are explained in stratigraphic order within each column.

COLUMN 1—APACHE HILLS. Chapo Formation, including Tcq₁—lower quartz latite member; Tca—andesite member; Tcq₂—upper quartz latite member; Tcb—basalt and andesite member. Taqm—quartz monzonite prophyry; Tamp—monzonite porphyry; Twp—rhyolite of Wamel's Pond.

COLUMN 2—PYRAMID MOUNTAINS. Kas—andesite of Shakespeare; Kag—andesite of Gore Canyon; Tlg—granodiorite porphyry stock of Lordsburg mining district, Thc—andesite of Holtkamp Canyon. Pyramid Mountains volcanic complex: Tjp—rhyolite of Jose Placencia Canyon; Twc—tuff of Woodhaul Canyon; Tgw—tuff of Graham Well; Tms—andesite of Mansfield Seep; Tuw—latite of Uhl Well; Tpp—rhyolite of Pyramid Peak. Tpdm—diorite and monzonite composite stock; Tai—intrusive andesite. Rimrock Mountain Group: Trt₁ through Trt₈—tuff members; Trb₁ through Trb₃—basaltic-andesite members.

COLUMN 3—COYOTE HILLS. VOLCANICS OF POTHOOK: Tpr—rhyolitic tuffs member; Tpw—quartz latite member; Tpl—lithic tuff member; Tpq—quartz latite lava member; Tpf—clastic tuffaceous member. Trc—rhyolite lava of Coyote Peak; Twt—rhyolite welded tuff; Tm₁—moonstone-bearing rhyolite ash-flow tuff 1.

COLUMN 4—ALAMO HUECO MOUNTAINS. TKs—conglomerate and sandstone, late Cretaceous or early Tertiary; Tml—volcaniclastic mudflows and lakebeds; Tba₁—basaltic andesite 1; Tbc—Bluff Creek Formation; Tw—tuff of Wood Canyon; Toc—Oak Creek Tuff; Tgr—tuff of Gray Ranch; Tg—Gillespie Tuff; Tba₂—basaltic andesite 2, Tp—Park Tuff; Tba₃—basaltic andesite.

COLUMN 5—CENTRAL ANIMAS MOUNTAINS. TKt—Timberlake fanglomerate; Tad—andesite of Taylor Draw; Tbc—Bluff Creek Formation; Toc—Oak Creek Tuff; Tam—Animas quartz monzonite; Twm—Walnut Wells monzonite; Tbc—Basin Creek Tuff; Tbb—tuff of Black Bill Canyon; Tch—Center Peak Andesite; Tgr—tuff of Gray Ranch; Tg—Gillespie Tuff; Tcp—Center Peak Andesite; Tp—Park Tuff; Tpc—Pine Canyon Rhyolite; Tda—Double Adobe Latite; Tok—O.K. Bar Conglomerate; Tab₃—alkali basalt 3.

COLUMN 6—SOUTHERN ANIMAS MOUNTAINS. Tg—Gillespie Tuff; Tab₁—alkali basalt 1; Tp—Park Tuff; Tvp₁—volcaniclastic and pyroclastic rocks 1; Tab₂—alkali basalt 2; Tpt—rhyolite of Packer's Trail; Tvp₂—volcaniclastic and pyroclastic rocks 2; Tok—O.K. Bar Conglomerate; Tab₃—alkali basalt 3.

COLUMN 7—SOUTHERN PELONCILLO AND NORTHERN GUADALUPE MOUNTAINS. Tgc—tuff of Guadalupe Canyon; Tbh—breccia of Hog Canyon; Tmb—sedimentary breccia and mudflows; Tom—quartz latite of Outlaw Mountain; Tbu—biotite-rich ash-flow tuff, unnamed; Tsc—tuff of Skeleton Canyon; Tcd—rhyolite of Clanton Draw; Tcg—conglomerate, unnamed; Tda—Double Adobe Latite; Tab—alkali basalt.

COLUMN 8—SOUTH-CENTRAL PELONCILLO MOUNTAINS. TKs—conglomerate and sandstone, late Cretaceous or early Tertiary; Tbm—tuff of Black Mountain; Ter—tuff of Evans Ranch; Top—Porphyritic latite of Owl Canyon; Tap—unit of Antelope Pass; Twci—Weatherby Canyon ignimbrite; Tm₂—moonstone-bearing rhyolite ashflow tuff 2, unnamed; Tbr—flow-banded rhyolite, unnamed; Ttc—tuff of Trail Creek.

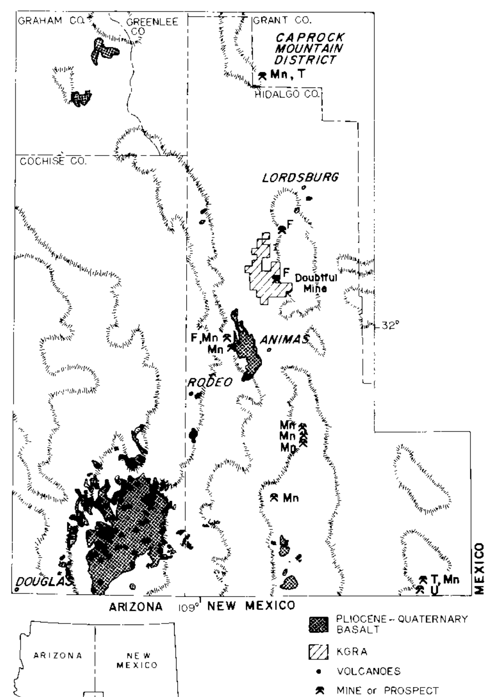

FIGURE 3—LOCATION OF MINES AND PROSPECTS IN WHICH VEINS ARE PRESUMED TO BE MIOCENE AND YOUNGER, THE LIGHTNING DOCK KGRA, AND OCCURRENCES OF BASALT DATED OR PRESUMED TO BE 7 M.Y. OR YOUNGER.

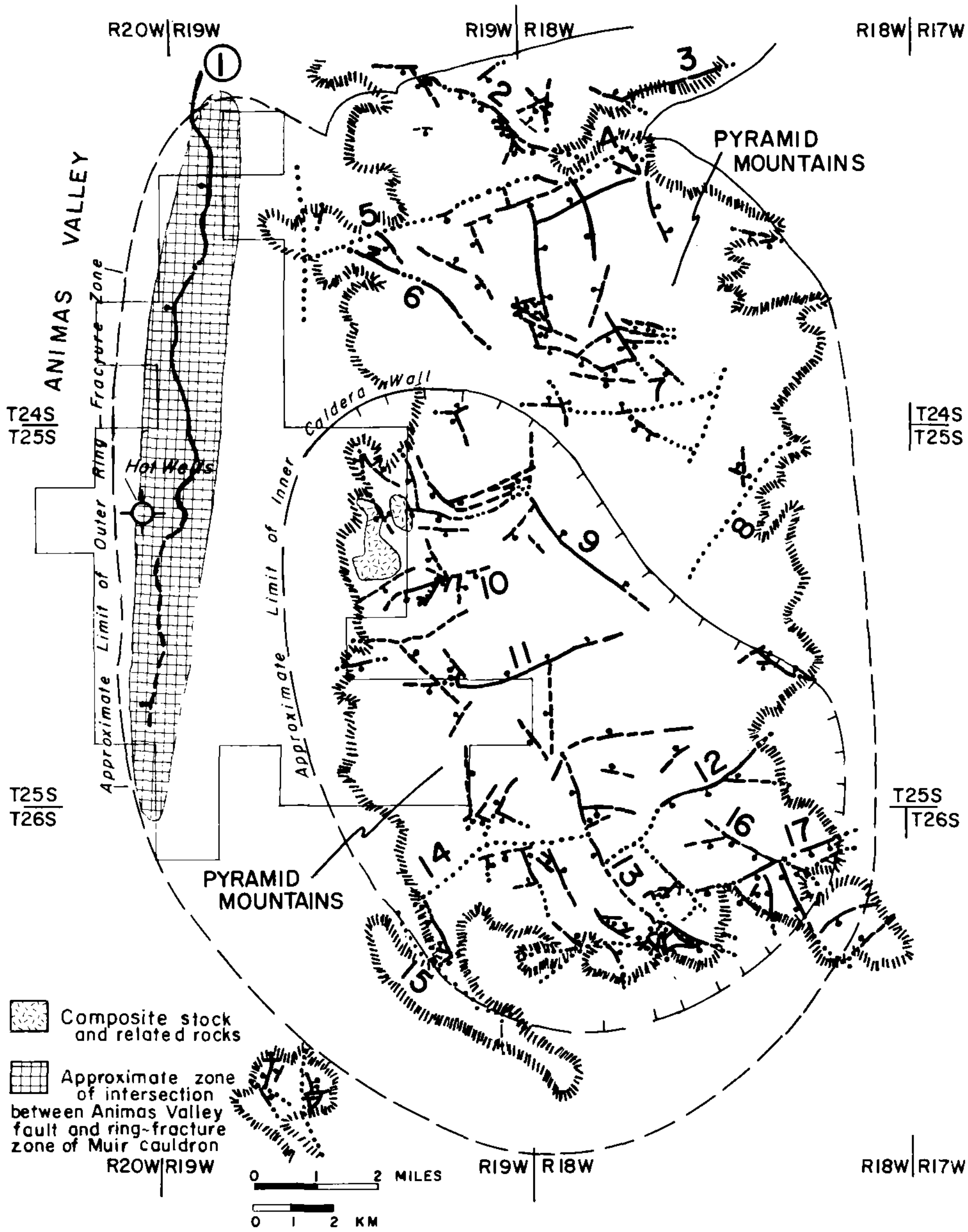

FIGURE 4—TECTONIC SKETCH MAP OF THE MUIR CAULDRON AND THE LIGHTNING DOCK KGRA.

gold, silver, and tungsten worth more than $2 million (Granite Gap, San Simon, Kimball districts). Instrusions of mid-Tertiary age seem to control metal deposits. These districts lie on a faulted arch in which mid-Tertiary volcanic rocks flank pre-Tertiary rocks. Possibly the arch is the deeply eroded resurgent dome of a cauldron from which the Steins Mountain and/or Weatherby Canyon tuffs of Gillerman (1958) erupted, but this relationship has not yet been documented. In the Granite Gap district, galena and oxidized lead-silver ores replace Paleozoic limestone near quartz monzonite porphyry dikes of mid-Tertiary age (30 to 31 m.y.) and tungsten-bearing skarns are associated with a 32 m.y. granite (dates from Hoggatt and others, 1977). In the west part of the San Simon district, skarn deposits show a zonal pattern around a major northwest-trending fault, the Johnny Bull fault of Gillerman (1958). Near the fault, copper mineralization predominates (Johnny Bull mine), away from the fault there are zones of zinc-lead (Silver Hill mine) and lead-silver (Elston, 1963; Carten and others, 1974). The skarns are localized in Paleozoic limestone next to small felsite dikes related to larger bodies of quartz monzonite porphyry (30 to 31 m.y.). The zoning pattern suggests a magma source at depth in the vicinity of the Johnny Bull fault. On the east side of the district, lead-zinc skarn has been mined in the Carbonate Hill mine next to an altered monzonite body. South of Steins Pass, quartz monzonite porphyry is intensely altered and pyritized; surrounding andesite is altered and mineralized with silver-bearing galena veins near rhyolite intrusions (Mineral Mountain mine). North of Steins Pass, in the Kimball district, gold and silver, respectively, have been mined from veins in the Beck and Volcano mines. Both mines are controlled by elongated domes of flow-banded rhyolite, possibly ring-fracture domes of a source cauldron of the Weatherby Canyon-Steins Mountain tuffs.

The recognition of many porphyry bodies as mid-Tertiary rather than Laramide, and as related to cauldrons, has been an important result of current work. In Hidalgo County, the cumulative production of metals associated with mid-Tertiary cauldrons and intrusions is insignificant, even when compared to the modest production from deposits associated with local Laramide porphyry bodies. It remains to be seen whether our growing knowledge of cauldrons will lead to new discoveries of ore deposits or whether the mid-Tertiary igneous rocks are inherently less favorable for exploration than Laramide igneous rocks (Elston and others, 1976a; Elston, 1978).

On the eastern side of the Animas Valley, young faults belonging to the Basin and Range episode control low-temperature vein deposits of psilomelane (Caprock Mountain and Animas districts) and of fluorspar (Lordsburg and Animas districts). At the Cliffroy mine (Caprock Mountain district) and the Doubtful or Animas mine (Animas district) some of these veins grade into near-surface deposits of travertine or banded calcite and are closely related to former hot springs (fig. 3). In the Dog Mountains, uranium showings in chalcedony-opal veins in ash-flow tuff outflow sheets are controlled by faults (SE¼ sec. 15, T. 34 S., R. 15 W.). In and around the northeastern part of the same township, layers of banded travertine with local manganese oxide mineralization appear in outflow sheets of the Bluff Creek Formation.

Geothermal potential

Hot or warm water has been reported from wells in the San Simon, Animas, Lordsburg, and Playas Valleys. The chief geothermal prospect is on the McCants farm in the Animas Valley, where boiling water and hot rhyolite were encountered at 26.5 m (87 ft) in a well drilled in 1948 in NE¼ sec. 7, T. 25 S., R. 19 W. (Kintzinger, 1956). The area is now part of the Lightning Dock Known Geothermal Resources Area (KGRA). It is the only known place in southwestern New Mexico in which indicated subsurface tempera-

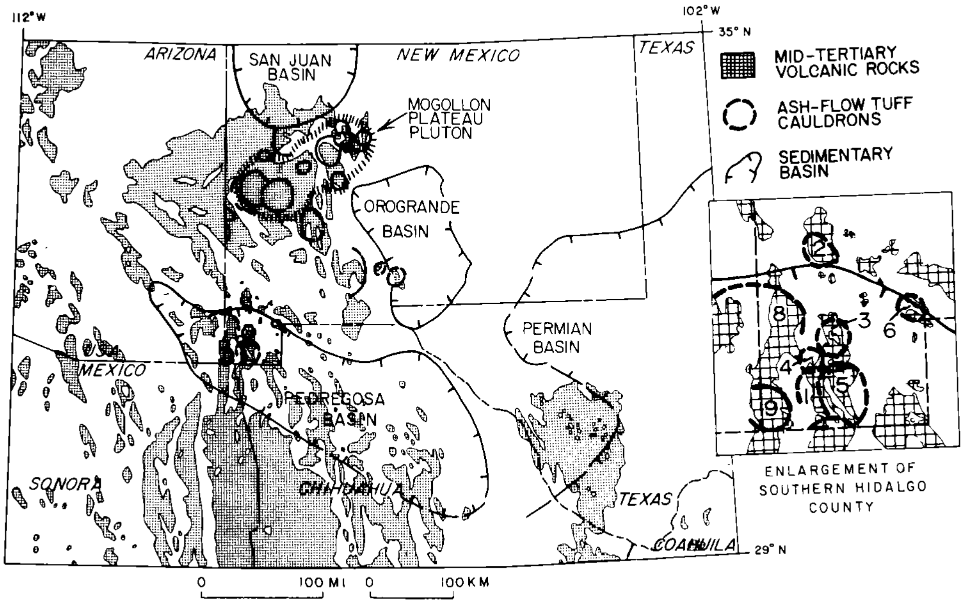

FIGURE 5—MAJOR SEDIMENTARY BASINS OF SOUTHERN NEW MEXICO AND SURROUNDING REGIONS, from Greenwood and others (1977), and outcrop areas of mid-Tertiary volcanic rocks. The outline of the Pedregosa Basin is drawn on the 2,000-ft isopach for Pennsylvanian rocks. The inset shows details for southern Hidalgo County; numbers of cauldrons are the same as for fig. 1.

tures exceed 300° F (Renner and others, 1975; Smith, 1978).

The hot wells of the Lightning Dock KGRA seem to be structurally controlled by the intersection of the ring-fracture zone of the Muir cauldron and a recently active fault on the east side of the Animas Valley (Deal and Elston, submitted; Smith, 1978). The Oligocene Muir cauldron is not suggested as a modern heat source. Rather, the broken ground of its ring-fracture zone could have provided conduits for thermal waters (fig. 4). If the Weatherby Canyon and Steins Mountain Tuffs came from a source in the Peloncillo Mountains, the ring-fracture zone of that cauldron could also pass through the Lightning Dock KGRA.

The widespread occurrence of Miocene or younger low-temperature fluorite and psilomelane veins and related hot-spring deposits (fig. 3) suggests that the hot wells of the Lightning Dock KGRA may be the relict of a geothermal system that once was much more widespread. Specifically, the largest known fluorite-calcite vein set in Hidalgo County is at the foot of Lightning Dock Mountain, near the Doubtful (Animas) mine in sec. 15, T. 25 S., R. 19 W. Some vein zones are 60 m (197 ft) wide. They are separated from the fluorine-bearing hot wells by about 5 km (3 mi) of valley fill without outcrops.

The ultimate heat source for the Lightning Dock KGRA is uncertain. The rhyolite breccia or conglomerate penetrated by the hot wells is not likely to be modern. More likely, it is early Miocene consolidated valley fill. Material of this type is exposed further south, at Tabletop Mountain. All postulated occurrences of supposedly Pliocene or younger rhyolitic rocks in southwestern New Mexico (Flege, 1959; Ballman, 1960; Elston, 1965b) have now been found to be Oligocene. Also, widespread hydrothermal alteration in the Pyramid Mountains, east of the hot wells, is now attributed to activity of the Oligocene Muir cauldron, not the modern geothermal system; most of it is older than the tuff of Graham Well (fig. 2, column 2). On the other hand, several sites of basaltic activity younger than 7 m.y. have now been found (fig. 3). A combination of deep-seated basaltic activity, extensional faulting, and deeply convecting meteoric water could account for the observed geothermal system.

In conclusion, a volcanogenic high-temperature, vapor-dominated geothermal system probably is not present in the Lightning Dock KGRA or elsewhere in Hidalgo County. If sufficient hot water and steam are present in the Lightning Dock KGRA, they could be applied to local agricultural uses, for drying crops or heating greenhouses. Whether the supply of hot water is sufficient to do so on a large scale depends on local hydrologic conditions, especially on how much hot water circulated from deep bedrock fractures into shallow cold-water aquifers within the late Cenozoic valley fill. This is unknown at present. The hydrologic conditions that prevail in the Lightning Dock KGRA may well be repeated elsewhere in the Animas, Playas, San Simon, and Lordsburg Valleys.

Petroleum potential

The part of Hidalgo County north of Lordsburg lies on the southern flank of the Burro uplift (Elston, 1958) and is not likely to have petroleum potential. The southern part of Hidalgo County lies within the late Paleozoic Pedregosa Basin and a Lower Cretaceous basin. The Pedregosa Basin has many similarities with the highly productive Permian Basin of southeastern New Mexico and west Texas. Greenwood and others (1977) gave an optimistic appraisal of its petroleum potential. Thompson and others (1978) have summarized drilling results.

The discovery of numerous ash-flow cauldrons and other volcanic centers in the Pedregosa Basin should introduce a note of caution. Elsewhere, in the San Juan Mountains of Colorado and the Mogollon Plateau of New Mexico, clusters of cauldrons have been interpreted as the surface expressions of major batholiths (Steven and Lipman, 1976; Elston and others, 1976b). The clustering of cauldrons in the Animas, southern Peloncillo, and Pyramid Mountains suggests the same interpretation for parts of the Pedregosa Basin (fig. 5). The KCM No. 1 Forest Federal wildcat, drilled on the Winkler anticline in sec. 3, T. 31 S., R. 18 W. (fig. 1), in fact, encountered quartz monzonite below 1,254 m (4,113 ft). The quartz monzonite appears to be a ring-fracture intrusion of the Juniper cauldron and the Winkler anticline was probably domed as a result of its emplacement (Elston and Erb, 1977).

Only the southeastern part of Hidalgo County is not known to have major volcanic centers. There, the Little Hatchet Mountains are intruded by monzonitic and granitic stocks of unknown age. The Big Hatchet Mountains and parts of the Sierra Rica are free of known intrusions other than minor dikes. The Alamo Hueco Mountains are covered with ash-flow tuff outflow sheets but show no sign of major non-basaltic volcanic centers.

The limits of the shallow plutons postulated as lying beneath cauldrons are unknown and so is the extent of thermal and hydrothermal effects. In the central part of the Peloncillo Mountains, where a cauldron is possible but has not yet been demonstrated and where mid-Tertiary intrusions are pervasive, Precambrian granite yielded a 34 m.y. K-Ar age. This suggests argon loss because of mid-Tertiary heating (Hoggatt and others, 1977). Evidence of widespread late Tertiary hot-spring and hydrothermal activity, mainly in the Animas Valley and controlled by Basin and Range faults, places another constraint on petroleum possibilities. On the other hand, in the KCM well, severe thermal effects were limited to about 700 m (2,296 ft) from the igneous contact. At greater distances, Pennsylvanian-Permian marine sedimentary rocks retained some of their petroleum source-rock characteristics (Thompson, 1977). The Humble No. 1 State BA well, drilled to a depth of 5,190 m (17,023 ft) in NE¼ sec. 25, T. 32 S., R. 16 W., off the northwest side of the Alamo Hueco Mountains, encountered a show of gas in Epitaph Dolomite (Permian) and a show of oil in El Paso Limestone (Ordovician); no thermal metamorphism was reported (Greenwood and others, 1977). Evidently, mid-Tertiary thermal gradients were high in Hidalgo County. Areas of destructively high temperatures may have been limited to the immediate vicinity of cauldrons. More distant areas may have been unaffected or may even have had their petroleum possibilities enhanced. Under favorable circumstances, moderate heating may provide energy for generation, maturation, and migration of hydrocarbons.

Discussion

This project is still in progress, therefore this report is preliminary. Final interpretations must await the completion of mapping, petrographic work, and chemical analyses. The reader may be skeptical about the proliferation of ash-flow tuff cauldrons and of interpretations that hinge on cauldrons. The recognition that virtually all regional ash-flow tuff sheets have their sources in collapsed central volcanoes has come slowly since the publication of Smith (1960). Criteria for recognizing these central volcanoes have also been accumulating slowly; Smith and Bailey (1968) remains the best summary.

The stratigraphic framework forms the basis of our interpretations. Complicated as our interpretations are, they still represent a simplification of reality. Many of the regional ash-flow tuff sheets shown on fig. 2 are without known sources, so that the number of cauldrons is likely to increase as work progresses. We regard the cauldrons as keys to understanding mid-Tertiary events, geologic structures, and mineral resources. They are the most prominent geologic features in Hidalgo County.

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