FIELDNOTES

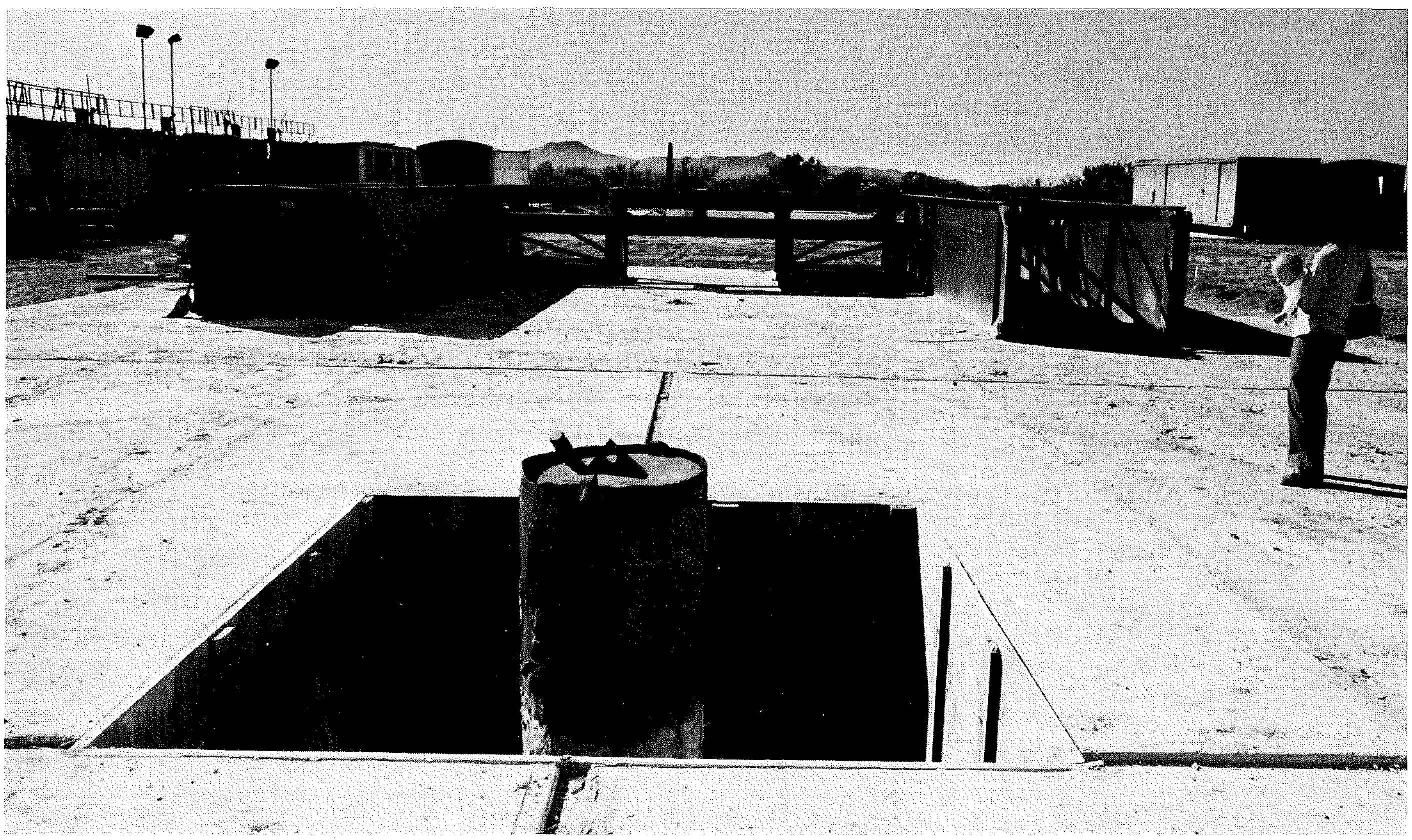
From The State Of Arizona
Bureau Of Geology And Mineral Technology

Vol.. 10, No. 1 | Earth Sciences and Mineral Resources in Arizona | March 1980

THE GREAT SOUTHWESTERN ARIZONA OVERTHRUST OIL AND GAS PLAY

Drilling Commences

by Stanley B. Keith



Anschutz-Texoma drill site as of February 23, 1980. View west toward northern Picacho Mountains. In the foreground is the previously-drilled three-foot diameter pilot hole with casing. **Photo: S.B. Keith**

Fifteen miles south of Florence, Arizona, preparations for a unique drillhole were completed in late February. The drillhole is unprecedented in its physical dimensions. It will likely smash the Arizona depth record of 12,500 feet set in 1972 by Exxon, 15 miles southeast of Tucson. The geologic reasoning behind the placement of the well is also unprecedented in its vision of a thrust fault complex of heretofore undreamed-of size and displacement that hides oil-bearing rocks under a veneer of barren crystalline granite and metamorphic rocks.

In late February, 1980, Anschutz Corporation of Denver, in conjunction with its partner, Texoma Production Co., an exploration subsidiary of Peoples Gas Company of Chicago, began drilling their historic and long-awaited oil test. After two years of exploration, Anschutz-Texoma have located their wildcat well in Section 2 T. 7 S, R. 10 E. of Pinal County, between Tucson and Florence (Figure 1). In January, over 100 truckloads of equipment were scheduled to arrive at the Anschutz-operated site from a former drilling site in Wyoming. A smaller hole has been drilled on the site to supply water for the parent rig. In order to reach the drilling depths expected to be favorable for oil and/or gas, the initial hole diameter at the surface is about three feet in diameter. The initial three foot penetration was drilled by a smaller rig. This "pilot" rig has now been replaced by a much larger rig from Wyoming owned by Parker Drilling Company and capable of a 25,000 foot test if needed. Anschutz-Texoma officials expect to reach favorable rocks in 8-10,000 feet and are prepared to drill to 20,000 feet, and spend twelve million dollars if necessary. Anschutz officials have indicated that a second hole will be started (spudded) while the first drillhole is still in progress. The first hole will take 240 to 300 days to drill. In drillers' parlance, the drillhole is "well engineered" to handle almost any eventuality, such as blow-outs, and corrosive agents, like salt and hydrogen sulfide.

Of particular interest to geologists is a provision for spot-coring which will allow collection of solid rock core samples at short intervals, greatly facilitating rock identification and interpretation. Certainly, some of these rock cores will be the most expensive and most scrutinized rock samples ever collected in Arizona.

The final location of the site came after two years of intense seismic exploration within Arizona. To date about 3,000 line miles of seismic cross section have been completed. Anschutz-Peoples Gas have spent about 6.2 million dollars and are currently spending about $500,000 a month mostly obtaining seismic lines. Figure 1 shows the approximate location of one of these lines (AZ-18), which was used in conjunction with other nearby seismic data to locate the Anschutz-Texoma Hole, named Anschutz-Texoma State No. 1-10-2. The upper part of Figure 3 shows an uninterpreted 35-mile long "raw data" segment of AZ-18 in the vicinity of Anschutz-Texoma State No. 1-10-2. Until line AZ-18 became available in June of 1979, the Anschutz-Texoma oil and gas quest was without a largescale prospect or play. The lower part of Figure 2 shows the Anschutz interpretation of AZ-18 that led to their decision to drill Arizona's potentially deepest oil test.

The Anschutz interpretation of AZ-18 is consistent with their regional geologic concept that central Pinal County is part of a vast regional overthrust belt that runs from the northwest to southeast corner of Arizona. More regionally, this belt is interpreted by Anschutz to extend the length of the Cordillera from Northeastern British Columbia, Canada to south of Vera Cruz, Mexico (see Keith, 1979, and Anschutz, 1980, for overviews of the overthrust belt). Some idealized styles of overthrust faulting known to be present in the Cordilleran overthrust belt were described by Keith, 1979 (see Fieldnotes v. 9, no. 1, p. 11). More specifically, the Anschutz interpretation of AZ-18 bears a resemblance to their interpretation of seismic reflection profiles of similar appearance at Anschutz Ranch, Utah (compare Figure 3 with Figure 2), a known natural gas producer. The gas field at Anschutz Ranch, like many other such occurrences in the Idaho-Wyoming-Utah segment of the Cordilleran overthrust belt, consists of an accumulation of gas within the Twin Creek-Nugget sandstone horizon of Figure 3. Furthermore, this gas accumulation occurs in the Twin Creek-Nugget sandstone horizon where it crosses the crest of an anticlinal fold (archlike flexure in figure 3). The Jurassic age (190-180 m.y. old) Twin Creek-Nugget sandstone horizon is a reservoir for petroleum fluids that migrated there from hydrocarbon-rich source rocks of Cretaceous age (110 m.y. to 80 m.y. old), thought to be below and to the right of the Twin Creek-Navajo horizon in Figure 3. These source rocks are separated from the reservoir rocks by the Tunp and Absaroka thrust faults.

One interpretation is that petroleum formation began when the leading edge of the Tunp and Absaroka thrusts came to rest (following their arrival from the west) on the hydrocarbon-bearing Cretaceous rocks. During the emplacement of these thrusts, hydrocarbon materials in the Cretaceous rocks were converted or matured into a petroleum condensate by increased heat and pressure associated with burial of the Cretaceous rocks underneath the Absaroka and Tunp thrusts. The petroleum condensate then migrated from the high pressure regions to structural traps in areas of lower pressure. In the overthrust belt, petroleum "traps" (as they are called in the trade) are classically associated with the hinges of anticlines (refer again to the arch-like structures in Figure 3 and Figure 2). The interested reader may refer to Ver Ploeg (1979) and Anschutz (1980) for a summary of the geologic setting and review of the recently discovered oil and gas fields in the Utah-Wyoming sector of the Cordilleran overthrust belt.

By comparing Figures 2 and 3, it is apparent that the Anschutz interpretation of seismic line AZ-18 is similar to the proven petroleum-productive analog in Wyoming. Anschutz believes that the prominent sub-horizontal seismic layering or 'reflectors', conspicuous in the lower two-thirds of AZ-18, represents sedimentary rocks of Mesozoic and Paleozoic age. The

EXPLANATION

ROCKS

Late Miocene valley fill alluvium; includes minor intercalations and cones of basalt.

Middle Oligocene through middle Miocene volcanic and sedimentary rocks. 'V' pattern shows volcanic-dominant facies. Stipple pattern shows clastic-sedimentary dominant facies.

Middle Oligocene through early Miocene intrusions.

Late Cretaceous through Paleocene (Laramide) intrusions.

Late Cretaceous volcanic and sedimentary rocks.

Mid-to-late Mesozoic (post-160 m.y. and pre-90 m.y. B.P.) clastic sedimentary rocks.

Younger Precambrian (1.4 to 1.2 b.y. B.P.) clastic-dominant sedimentary rocks, 1.2 to 1.1 b.y. B.P. diabase. Paleozoic sedimentary rocks.

Older Precambrian granitic rocks. Predominantly 1.45 to 1.4 b.y. porphyritic granitic rocks; includes a minor amount of older 1.7 b.y. (?) granodiorite rocks and a minor amount of younger muscovite granites.

Pinal Schist (1.7 b.y. +). Predominantly green schist grade metasedimentary rocks; includes a minor amount metavolcanics.

STRUCTURE

High angle fault; bar and ball on downthrown side; dashed or dotted where hidden or concealed

Low-angle normal fault; hashures on downthrown side; dashed or dotted where hidden or concealed.

Low-angle reverse fault (thrust); barbs in upper plate; dashed or dotted where concealed.

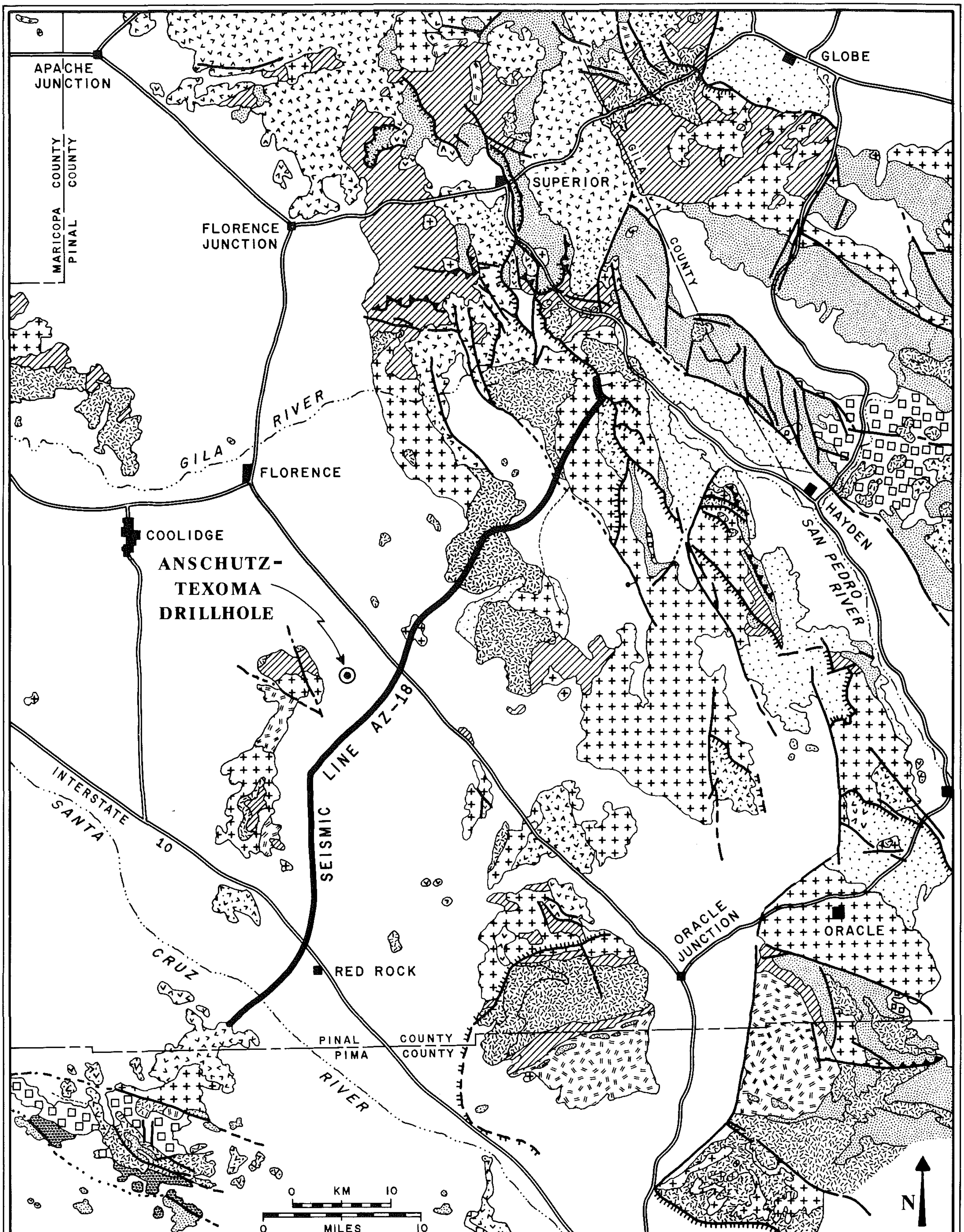


Figure 1: Geologic map of a portion of central Arizona showing location of seismic time cross-section AZ 18 and Anschutz-Texoma drillhole. Geology is modified from Wilson and others (1969).

continued on p. 6

Oil & Gas continued

sedimentary rocks occur beneath an upper plate of Pre-Cambrian age metasedimentary rocks which are represented by an area that contains few seismic reflectors in the upper third of the seismic section. For Anschutz, all of the Precambrian crystalline rocks shown on the geologic map in figure 1 are part of the upper plate. Anschutz would also suggest that the late Cretaceous-early Tertiary igneous rocks are part of the upper plate. Further, this entire upper plate package of crystalline rocks has been transported to the central portion of Pinal County from an original position some 60 to 120 miles to the SW, according to Anschutz. In a broad sense, then, many of the southern Arizona Laramide porphyry copper deposits which have yielded the great proportion of Arizona's copper production are, for Anschutz, structurally rootless.

Anschutz has located the Anschutz-Texoma wildcat well near the hinge of a broad arch-like seismic structure, toward the left of Figure 3a. The model is based on the assumption (similar to the Utah-Wyoming presumed analog), that petroleum condensate might have migrated to structural traps in this arch from possible source regions in nearby Mesozoic and Paleozoic sediments buried underneath the thrust. Anschutz expects to drill through a veneer of about 3,000 feet of late Cenozoic valley fill sedimentary rock 0 to 15 m.y. old, penetrate Precambrian metasedimentary rocks in the upper plate, and encounter potential petroleum resources at 8 to 10,000 feet in structural traps near the hinge of the arch-like structure. In oil industry parlance, Anschutz is hoping to encounter the top of a petroleum column or pay zone at depths of 8 to 10,000 feet.

The seismic work commissioned by Anschutz et al during the great southwestern Arizona oil and gas play has excited the imagination of every geologist-geophysicist who has seen the data. Naturally, the data have provoked interpretations other than the Anschutz model previously outlined. Some would suggest that the prominent seismic reflectors represent buried, layered crystalline gneisses of the kind found in the forerange of the Santa Catalina Mountains, in canyons like Sabino Canyon. The conventional view would be that the seismic reflectors mirror slight changes in seismic velocities and densities of an otherwise entirely Precambrian crystalline basement, like the one exposed at the surface in central Pinal County. An outrageous speculation tossed in with a big grain of salt by myself is that the seismic reflectors represent sedimentary rocks of Franciscan vintage normally present along the western coast of California. The proposition is that these rocks have been shoved some 300 miles eastward underneath Arizona's Precambrian crust (underthrust rather than overthrust from the southwest) during low-angle subduction beneath North America 55 to 45 million years ago. In any case, discovery of the enigmatic reflectors represents a totally new, unexpected and provocative twist for Arizona-based geologists. The reflected anomalies may mean petroleum. They may not. But Anschutz should be credited for its determination to take a crack at what they do mean.

In closing, it is interesting to note that one of the deepest of the few wildcat oil tests in southern Arizona was drilled in 1953, eight miles northwest of the Anschutz-Texoma site. It is said that the well was promoted after a Texas oilman's wife's arthritis flared-up when the couple were driving through Pinal County, like it had when she was near several producing well fields in Texas. Western Oil Fields #1 Federal bottomed at 5,142 feet in what was interpreted to be a dry Precambrian granite. Wouldn't it be something if they didn't drill deep enough. We can't wait to find out.

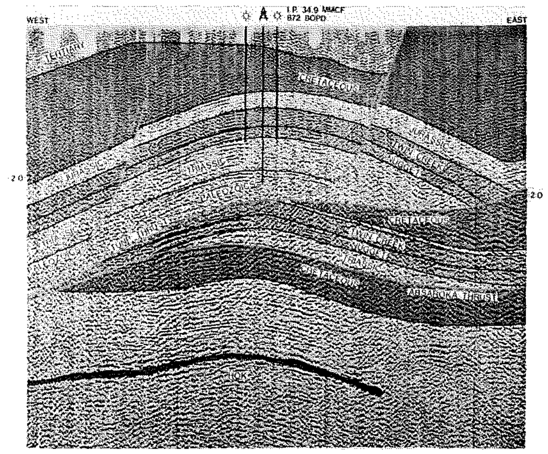


Figure 3: Seismic time cross section through Anschutz Ranch Field, North Pineview area, Wyoming.

SELECTED REFERENCES:

Anschutz, P.F., 1980, The overthrust belt: will it double U.S. gas reserves: *World Oil.* v. 190, no. 1, p. 111-116

Keith, S. B., 1979, The great southwestern Arizona overthrust oil and gas play: *Fieldnotes,* v. 9, no. 1, p. 10-14.

Ver Ploeg, A.J., 1979, The overthrust belt: an overview of an important new oil and gas province: *Geological Survey of Wyoming Public Information Circular,* no. 11, 15 p.

Wilson, E.D., Moore, R.T., and Cooper, J.R., 1969, *Geologic map of Arizona. U.S. Geological Survey and Arizona Bureau of Mines*

THE WILLCOX "OIL FIELD"

By Edgar B. Heylmun

The Southern Pacific Railroad drilled a 650-foot water well across the tracks from the Willcox depot in the late 1800's. The well produced clear, cool water until the 1920's, when the well started to produce 42.3° A.P.I. (American Petroleum Institute) high gravity, low-sulfur oil along with water. The ice plant water well, two blocks to the north, also started to produce oil, and a portion of the town's water supply became contaminated with oil. Fourteen hand-dug postholes in the chicken yard of the Lundquist residence, near the railroad, produced over 10,000 gallons of oil, and several additional wells drilled within two or three blocks of the Southern Pacific well encountered oil. The U.S. Bureau of Mines tested the oil in 1937 and reported it to be "natural crude".

Several hundred barrels of high-gravity oil were produced from the Willcox "oil field" in the 1920's and 1930's, and were sold locally, unprocessed, for 10-12 cents a gallon, for use in stoves, lanterns, farm machinery, and even in automobiles. The occurrence of oil in the town of Willcox brought on a flurry of promotional activity by speculators, and a number of wells were drilled for oil and gas in southeastern Arizona between 1930 and 1963. Some of the reported oil and gas shows were probably legitimate, but a number of the reported oil shows cannot be confirmed by a study of well-cuttings kept on file by the State of Arizona.

How can the "oil field" at Willcox be explained? Did an oil field suddenly migrate into the area and cause high-gravity oil to seep into wells that had been producing clear, clean water? The writer went to Willcox to get at the heart of the matter. Old records and town plats were examined and longtime residents were quizzed. The answer to the problem appears to be obvious. Following World War I, storage tanks for oil were constructed along the railroad. Some of the tanks were masonry cisterns which apparently leaked like a sieve, and some of the