DISTRIBUTION OF EVAPORITES AND IMPLICATIONS FOR WATER QUALITY IN THE SAN CARLOS-SAFFORD-DUNCAN NONPOINT-SOURCE MANAGEMENT ZONE

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INTRODUCTION

Much of Arizona, including the San Carlos-Safford-Duncan Nonpoint-Source Management Zone (Figure 1) is characterized by deep, sediment-filled basins separated by narrow mountain ranges. Many basins in Arizona have been found to contain fine-grained lacustrine and evaporite deposits in addition to clastic sediments. Deposits include limestone, gypsum, anhydrite, and salt, some of which are known to be over 5000 feet thick.

The presence of thick or widespread evaporites, especially salt, may have a profound impact on the quality of surface and groundwater. Understanding the distribution of naturally occurring sources of soluble minerals is essential to determine the relative effects on water quality of human activities versus impacts unrelated to human activities.

STRATIGRAPHY OF THE SAFFORD BASIN

The Safford Basin lies between the Pinaleno metamorphic core complex on the southwest and the volcanic Gila Mountains on the northeast. Detachment faulting during mid-Tertiary extension formed the core complex and the structural basin of the present Safford Valley. Seismic reflection profiling (Kruger, 1991; Kruger and others, 1995) has revealed the basin to be a half-graben, with the southwest side of the basin down-faulted along a secondary breakaway fault. The northeast side of the basin is not bounded by a typical Basin and Range major normal fault. The main Safford-San Simon basin is divided into four depositional sub-basins (Houser, 1990). From north to south are the San Carlos, Bylas, 111 Ranch, and San Simon sub-basins.

Basin-fill in the Safford Valley was divided into an upper basin fill and lower basin fill by Harbour (1966). The boundary between the lower and upper basin fill was considered by Harbour to reflect a major climate change at the Pliocene-Pleistocene boundary.

Later workers also tended to follow Harbour's (1966) version of a single "blue clay" layer separating the upper and lower basin fill units, and hydrologists have carried on this tradition by referring to a single upper aquifer and a single lower aquifer, also defined and separated by a single blue clay layer. This overly-simplistic model is not borne out by an examination of logs and cuttings for wells in the valley. First, the assumption of a lower-upper two-aquifer system carries with it an implicit flat-lying, basin-wide stratigraphy, which is not the case in a half-graben. Second, the logs commonly reveal several "blue" (gray) clay layers interbedded with brown, red, yellow or green clay, and even sand and gravel, in many wells. In the Whitlock State #1 well, for example, fresh artesian water is found below six separate zones of salt water. Thus, the notion of a single confining layer between an upper and lower aquifer is not realistic. Third, the identification of a "blue" clay or evaporite facies is somewhat subjective, and some logs refer to blue as well as gray clay in the same hole. Many of the older logs contain such unexplainable terms as "blue granite", "dry water sand" (as well as "water sand"), "serpentine", and red, pink, and blue "soapstone shale". Correlation based on such subjective and logger-dependent criteria is difficult.

Recent work has revealed a more complex stratigraphy in the Safford-San Simon basin. The lateral and vertical changes in the basin-fill sediments reflect a combination of factors, including climate changes, different subsidence rates in different parts of the basins, changing sediment sources as erosion exposed older rocks, and inflow of water and sediment from outside the immediate basins.

Four basin-fill units have been recognized in the 111 Ranch sub-basin of the Safford-San Simon basin (Richter and others, 1983; Houser and others, 1985; Houser, 1990). The oldest unit, the Miocene-Pliocene Midnight Canyon conglomerate, is a proximal fan deposit containing only

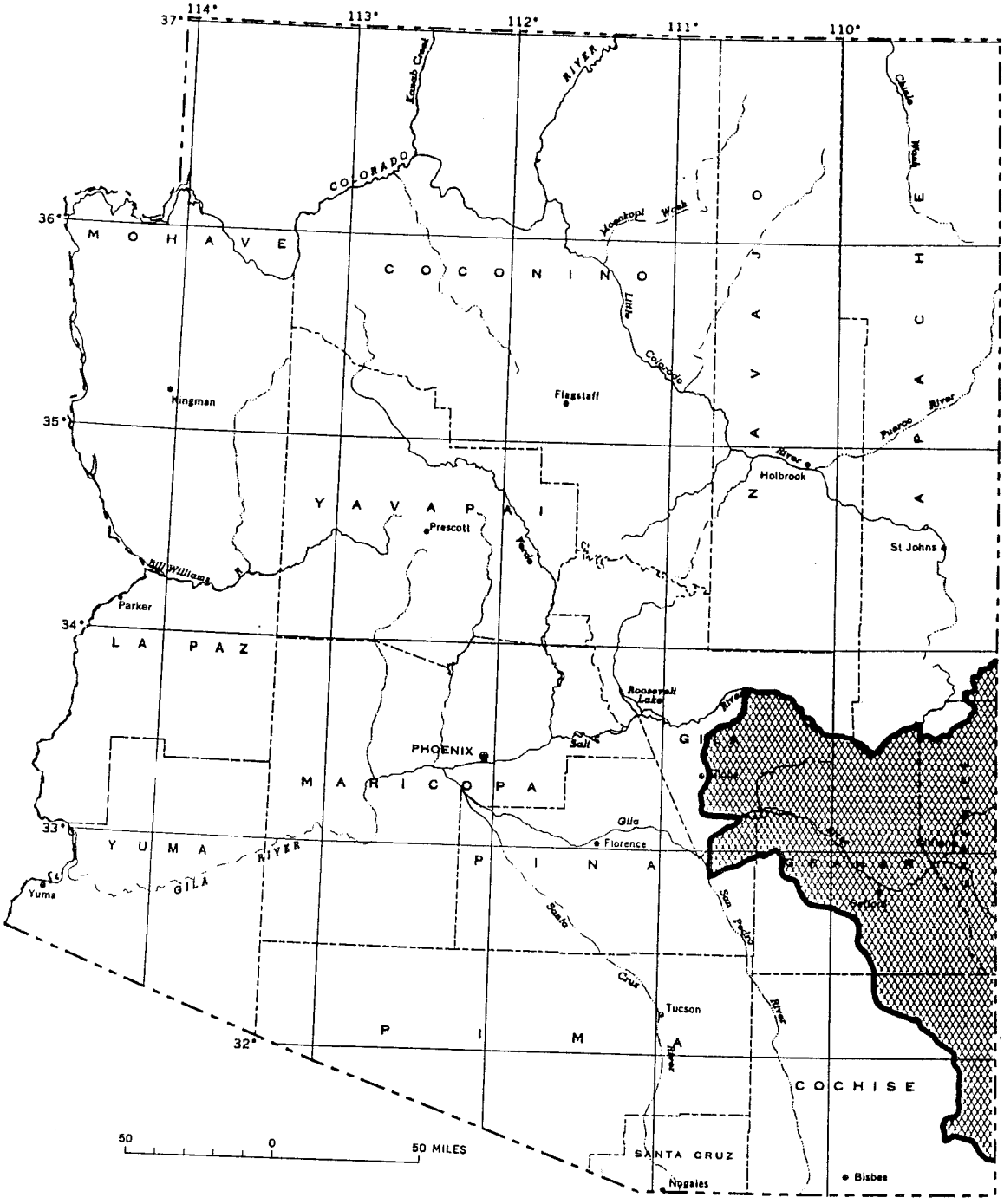


Figure 1. Location of San Carlos-Safford-Duncan Nonpoint-Source Management Zone.

clasts of volcanic rock. The Midnight Canyon unit is inferred to extend across the Safford basin (Houser, 1990) and is equivalent to the basal conglomerate facies of the lower basin fill unit of Harbour (1966).

Conformably overlying the Midnight Canyon conglomerate is the Pliocene Sanchez unit, consisting of silt and conglomerate. The Sanchez beds cover the same area and have the same clast composition as the Midnight Canyon unit, but are finer grained and less indurated. In the center of the Safford basin, the Sanchez beds are 250 m thick and consist of clay, gypsum (or anhydrite), and salt (Houser, 1990). The beds thin and pinch out toward the northeast side of the basin.

Above the Sanchez beds are the Pliocene 111 Ranch beds, which include lacustrine and fluvial facies. The fine-grained lacustrine facies of the unit consists of silt, clay, limestone, marl, and diatomite. The type section of lacustrine sediments at 111 Ranch, 15 miles southeast of Safford, has been studied extensively (Van Horn, 1957; Clay, 1960; Seff, 1962; Galusha and others, 1984) and is known to contain anomalous levels of uranium averaging 12.7 ppm (Harris, 1994), with some outcrops containing up to 566 ppm uranium (O'Neill and Theide, 1982). The fine- to coarse-grained fluvial facies, representing a fan delta from Bonita Creek, interfingers with the lacustrine facies. The 111 Ranch beds attain a thickness of about 520 m near the center of the basin and thin toward the Gila Mountains (Houser and others, 1985; Houser, 1990).

The Bear Springs Wash beds interfinger with the 111 Ranch and Sanchez beds in the southwest part of the Safford basin. This unit consists of fine-grained lacustrine sediments similar to the 111 Ranch beds interbedded with coarse-grained alluvial fan deposits.

Above the Sanchez, 111 Ranch, and Bear Springs Wash beds is Pliocene-Pleistocene alluvium of the ancestral Gila River. The alluvium is similar to modern Gila River sediments, with clasts of volcanic rocks, quartzite, granite, and chalcedony (Houser and others, 1985). Capping the section is a layer of Quaternary alluvium. Along the Gila River are modern alluvial sediments of the flood plain.

At the time of deposition of the basin-fill sediments and evaporites in the Safford-San Simon and Duncan basins, the Gila River did not yet exist, at least in eastern Arizona. Drainage in most of the deep basins of Arizona, and in most of the Basin and Range Province, was internal, except for periods when the regional climate was much wetter and some of the usually internally-drained basins may have overflowed into adjacent basins.

Integration of the drainages of southeastern Arizona into a large regional system - the Gila River- began at the downstream end and gradually worked its way upstream. Drainage in the lower San Pedro Basin was apparently still largely, if not completely, internal at the time of deposition of the Quiburis Formation, dated at 5.35 to 6.43 Ma (Scarborough, 1975). The beginning of through-going drainage in the Safford basin may be constrained by the 3.6 Ma age of Flatiron Mesa basalt flows deposited on the highest terraces and pediments in the area around the San Carlos River (Houser, 1990). However, swampy to playa conditions were still present at the time of deposition of the 111 Ranch beds near Safford, which contain ash layers dated at 2.17 to 2.67 Ma (Dickson and Izett, 1981). Integration of the regional drainage had probably reached the 111 Ranch area and the Duncan Basin by 0.6 Ma, based on ash layers in Gila River gravel deposits (Houser, 1990). The Willcox and Animas Valley playas are testament to the fact that drainage in the upper Gila region is still not completely integrated.

DISTRIBUTION OF EVAPORITES

Arizona's earliest inhabitants discovered and utilized natural occurrences of salt. One need only look at a map to see places in the Management Zone with names such as Salt River, Salt Springs, Salt Mountain, and Salt Creek. Names like Arsenic Tubs, Copper Creek, and Boiling

Springs may reflect other natural features, as well. Appendix A lists place names referring to naturally-occurring salt in the Management Zone.

The most important condition required for evaporites to form in a lake setting is that potential evaporation must greatly exceed the rate of input to the lake. That condition appears to have been met for the Safford and Duncan basins much of the time since the late-Tertiary.

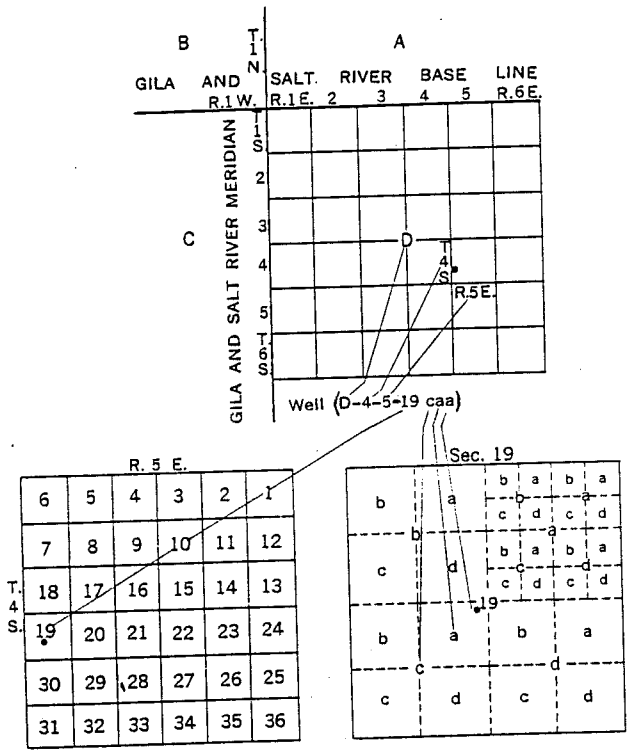
Lacustrine deposits, reflecting periods when the region had little or no through-flowing drainage, are common and widespread in the Safford-San Simon and Duncan basins. Owing to its extremely high solubility, however, salt is rarely obvious in outcrop. Houser (1990) reports salty-tasting clay layers in a gypsiferous lacustrine sequence in Freeman Wash, south of Safford (locations discussed in this report are shown on Plate 1). Soluble salts of calcium and sodium were reportedly found "throughout the upper terraces" in the Safford Valley during a University of Arizona hydrology study (Muller and others, 1973). Harbour (1966) identified salty clay just south of the Safford airport and near Riggs Mesa, northeast of Frye Mesa.

In his study of basin-fill sediments in the San Carlos Indian Reservation, Marlowe (1961), notes that evaporites are common in the clay units throughout the Reservation and that "a saline taste was usually detectable" (p. 49). Four of his descriptions of measured stratigraphic sections specifically refer to salt crystals or salty taste in clay beds. Marlowe's measured section #1, north of Fort Thomas (T4S, R23E, section 8, sw) contains salt and gypsum crystals in vugs in a marly clay. Section #3, also north of Fort Thomas (T4S, R23E, sections 24, 25 and 26) has a salty clay layer near the base of the exposed section. Halite and gypsum crystals in vugs are found in clay beds in measured section #7 near the mouth of Salt Creek (the one in T2S, R20E - there is another Salt Creek nearby in T3S, R22E). Halite and gypsum are again noted in clay beds at Bylas (measured section #15, T3S, R22E, section 31, sw). Another section (#16, T2S, R21E, section 30, sw) contains "abundant evaporites" in a clay layer, but Marlowe does not specify salt versus gypsum in his description. Bromfield and Shride (1956) also document widespread limestone, gypsum, and diatomite on the San Carlos Reservation, and these lacustrine deposits are prominently exposed along Highway 70.

Some well logs contain useful information on salt, gypsum, and limestone encountered during drilling. In addition, the Arizona Geological Survey maintains a well-cuttings repository that has drill cuttings for about 73 wells in the Management Zone. Although the entire management area is not equally covered by deep drill holes, these logs and cuttings provide a glimpse of the extent of lacustrine sediments and evaporites in the study area. Logs from the AZGS files or in published sources for some of the deeper wells are included in Appendix B. Logs of cuttings for selected wells in the AZGS repository are included in Appendix C.

Well logs commonly refer to "salty water" production during drilling. Although the intervals of salt water are noted in some logs, identification of specific layers of salt are rare, owing to the extremely high solubility of salt. As discrete layers of salt or salt-bearing clays are penetrated by drilling, any water present in the sediments, or the drilling fluid itself, will dissolve the salt. Information about the nature of the salt, such as thin lamination versus disseminated crystals in clay, or percentage of salt in the sediment is thus lost. During drilling of many holes, tests were not made of the salinity of the water, so in some cases, salt or salty water may have been encountered, but was not recognized. The well-numbering system used in this report is explained in figure 2.

Salt crusts (presumably halite) formed on dried drill cores from the upper 930 feet of the 1296-foot deep Superior Federal #1 well (D-5-23-15a) west of Ashurst (AZGS oil and gas file 5-16). The sediments to 930 feet were mostly very poorly consolidated sand, silt and clay. Below 930 feet the sediments were lacustrine limestone, silt, and clay, with some gypsum. Although the setting was favorable for borates, none were found.



The well numbers used by the Geological Survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the State into four quadrants. These quadrants are designated counterclockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters also are assigned in a counterclockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (D-4-5-19caa) designates the well as being in the $NE\frac{1}{4}NE\frac{1}{4}SW\frac{1}{4}$ sec. 19, T. 4 S., R. 5 E. Where there is more than one well within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

Figure 2. Well location system used in this report.

One log for the Underwriter's Syndicate No. 1 ("Mary Mack") well (D-6-24-13ab) in the AZGS files indicates an apparently continuous 170-foot thick salt bed from 760 to 930 feet. Another log in the file indicates salt at about 920 feet, but does not say how thick the salt is. Knechtel (1938) does not mention salt or salty water anywhere in his much more detailed log of the same hole. The source of that discrepancy is unknown (perhaps silt was misspelled and became salt?).

Southern Pacific's Safford well (D-7-26-17ba) penetrated a bed of salty clay 820 feet thick at the bottom of the 1820-foot deep hole. According to Knechtel's (1938) log, "all water encountered was salty". Streaks of gypsum were noted from 800-1000 feet.

A clean salt bed six feet thick is reported by Knechtel (1938) in the E.G. Rogers well (D-6-24-5a). Below an unconformity at 82 feet is a 718 foot-thick lacustrine sequence of clay, limestone, and tuff to the bottom of the hole at 800 feet. The salt layer is at about 580 feet.

Three miles northwest of Safford is the Smithville Canal well, also known as the Mt. Graham Mineral Bath well (D6-25-36). Various accounts give different intervals of evaporites in this well. Witcher (1981b) states that mudstone is found to about 312 m (1024 ft), followed by gypsiferous clay-silt and gypsum from 312 to 488 m (1024-1601 ft), with volcanic sand below 488 meters. Houser and others (1985) mention a relatively pure layer of gypsum and salt 30 m (98 ft) thick at a depth of about 300 meters. However, well cuttings in the AZGS repository show a nearly pure sequence of anhydrite with minor gypsum and calcareous silt from 800 to 1600 feet (Appendix C). No salt was detected in the samples, but owing to poor sample recovery, strong artesian flow, and the high solubility of salt, it is possible that any salt in the hole may have been dissolved during drilling.

Salty and gypsiferous clay is present in cuttings (AZGS repository) from an unnamed well (D-7-26-26aaa) a few miles southeast of Safford. Gypsiferous clay-silt occurs from 1080 feet to T.D. at 2240 feet. Salt crusts and scattered crystals are found in the clay below 1895 feet, and pure salt and clayey salt layers are common below 2075 feet. This evaporite sequence is a minimum of 1160 feet thick (the hole bottoms in salty clay, so the true thickness is unknown).

The thickest unequivocal evaporite sequence in the Safford-San Simon Basin is the 2270 feet of anhydrite and salt discovered in the Tenney #3 State well (D-9-27-36cd), in the center of the San Simon Valley half-way between Safford and Bowie. The entire sequence from 1210 feet to the bottom of the hole, at 3480 feet, is anhydrite and salt with minor silt and clay. The hole bottomed in anhydrite, so the true thickness of the evaporite body is unknown, but is a minimum of 2270 feet.

The Tenney #3 hole was logged beginning at a depth of 1210 feet, so no information is available above that depth in the well. (The AZGS cuttings repository contains samples from the Tenney #3 from 1200-3480 feet.) A second set of samples labeled from 280-3480 feet is identified as being from the adjacent Tenney #2 well. However, Tenney #2 was drilled to only 1090 feet, so that set of samples must be a composite from Tenney #2 and #3, at least below 1090 feet. The Tenney #2 samples, if real, are significant because they show anhydrite and gypsum beginning at about 830 feet, adding almost 400 feet to the anhydrite interval known in Tenney #3.

Another nearby well, the Southern Pacific well at Tanque (D-9-27-36) was drilled to 765 feet. The log of that hole (Knechtel, 1938) shows gypsum and clay from 592 feet to the bottom, similar to the stratigraphy in the Tenney wells.

During drilling of the 1837-foot deep Whitlock Oil Co. State #1 oil exploration hole (D-10-28-36aa), salty water was encountered in six intervals between 640 and 1352 feet (AZGS files). At 1363 feet, fresh artesian water was noted.

The log for the Funk Benevolent well at San Simon (D-13-30-27ad) states that salt water was encountered at 5250-5255 and 6650-6651 feet (AZGS files). Although the driller's log for the

well indicates "shale" (clay), "lime" (limestone), and sand for the entire hole, drill cuttings from this well show only purple and gray volcanic rocks from 3700 to 6651 feet (the only interval for which samples are available). The discrepancy between the driller's log and rock samples from the well is unexplained. The source of the salty water is not known.

WATER QUALITY

Gila River

Water quality in the Gila River is directly related to the amount of water flow. At the San Carlos Reservation, TDS varies inversely with flow, ranging from less than 300 mg/l at high flow to more than 4,800 mg/l at low flow (Laney and Hjalmarson, 1977). Water type also changes from a calcium-sodium bicarbonate type at high flows to a sodium chloride type at low flow. Detailed analyses of water quality have been reported in Knechtel (1938), Gatewood and others (1950); Hem (1950), and Muller and others (1973).

Some of the TDS in Gila River water is introduced from the underlying basin-fill sediment. Aquifer tests have indicated that water under artesian pressure is flowing upward from the basin-fill sediments into the valley floor alluvial aquifer (Weist, 1971; Culler and others, 1982). Higher water levels in wells in basin fill versus levels in nearby wells producing from stream alluvium lead Brown (1989) to conclude that water is flowing from the basin fill into the stream aquifer. The magnitude of the vertical flow in the San Carlos Reservation part of the Gila River has been computed at 106,000 cubic feet per day per mile of river length (Hanson and Brown, 1972).

Hot Springs

Several hot springs (shown on Plate 1) occur within the Management Zone which are known to produce salty water. Perhaps the best known is the Clifton Hot Springs (D-4-30-19caa). These springs issue at temperatures up to 49°C (120°F) from Tertiary volcanic rocks. Total dissolved solids (TDS) is 9700 ppm (ppm is used mostly in older literature and is approximately equal to mg/l) and chloride runs 5800 ppm (Eaton and others, 1972) to 6500 mg/l (Witcher, 1981a) in these thermal waters. An estimated average of 54 tons of dissolved solids per day (19,710 tons per year) is discharged from the springs to the San Francisco River (Hem, 1950).

Eagle Creek Hot Springs (D-4-28-35abb) may be on the same fault zone as Clifton Hot Springs (Witcher, 1981a). Eagle Creek springs discharge water at about 42°C (108°F), with TDS of less than 1000 mg/l. The water is of a mixed sodium bicarbonate-chloride type.

Gillard Hot Springs (D-5-29-27aad), along the Gila River where it cuts through the Gila Mountains east of Safford, is reported to be the hottest springs in Arizona, at 80° to 84°C (176 to 183°F) (Witcher, 1981a). The output of hot, saline water from the springs (TDS 1200-1500 mg/l) is sufficient to raise the temperature of Gila River water about 2°C (3.6°F), and raise the chloride content of the river from 25 mg/l upstream from the springs to 30 mg/l below the springs (Hem, 1950; Witcher, 1981a).

Indian Hot Springs (D-5-24-17add), northwest of Safford, produces about 1000 liters per minute of water at 45 to 48°C (113 to 118°F) (Witcher, 1981b). The water is a sodium chloride type and travertine (calcium carbonate) deposits are present at the springs. TDS ranges from 2570 mg/l to 3004 mg/l. A high level of sulfate in the spring water indicates the presence of gypsum in the sediments.

Indian Hot Springs is on an alignment of faults trending NW on the north side of the Gila River flood plain. This zone of faulting extends from Bylas to northwest of Safford and is thought to responsible for an alignment of hot springs and hot wells in that area (Witcher, 1981b). Traces

of fault segments and associated deformation of sedimentary units are exposed at several localities (Houser, 1990; Houser and others, 1985)

Water from hot springs in southeastern Arizona is predominantly a sodium chloride type. This tendency may partly be due not only to the extremely high solubility of salt, but to the *decreasing* solubility of anhydrite, gypsum, and calcium carbonate with increasing temperature. Another factor in the composition of springs water is ion exchange with fine-grained sediments, whereby calcium and magnesium in groundwater are exchanged for sodium in clay.

Other springs

The Salt River, which forms part of the northern boundary of the Management Zone, is named for the several salty springs in the area near the convergence of the White and Black Rivers. White River Salt Springs (A-4 1/2-20-35ad) discharges water with a TDS of 8450 ppm (Feth and Hem, 1963). Sodium and chloride are measured at 2730 and 4420 ppm, respectively. These Springs discharge an estimated 12.25 tons of salt per day, or about 4,500 tons per year to the Salt River (Feth and Hem, 1963).

Bear Springs (D-7-23-1 and -2) are reported to yield water at 12°C (54°F) that is "rather salty" (Knechtel, 1938). However, TDS was measured at 228 ppm, a level much lower than most springs and wells surveyed by Knechtel.

Deep wells

The 3767 foot deep Underwriters Syndicate 1 Mack oil exploration well (D-6-24-13ab; location of wells shown on Plate 1), also known as the Mary Mack well, discharged water similar in chemistry to that of the nearby Indian Hot Springs. (This well is near the fault-controlled alignment of hot springs along the north side of the Gila River.) TDS was measured by Knechtel (1938) at 3351 ppm, and the water temperature was 59°C (138°F). In 1933, the well was flowing at 2250 gpm, but the well is no longer flowing (Witcher 1981b; Stone and Witcher, 1982).

Knechtel (1938) reports that the 2,645-foot deep Gila Oil Syndicate #1 well near Ashurst (D-5-24-30ac) produced substantial artesian flow of hot, mineralized water. Well logs (AZGS oil and gas files; Knechtel, 1938) describe salt water at 590 and 750 feet, but the actual amount was not measured.

Artesian flow of salt water (21 gpm) was noted in a well at Geronimo (D-4-23-19) from the bottom of a 405-foot thick layer of hard clay and lime 90 to 495 feet below surface (Knechtel, 1938). The 28°C (82°F) water had a very high TDS of 14,035 ppm, with a sodium content of 5,076 ppm, chloride content of 6,656 ppm, and sulfate of 1,838 ppm. The well produced fresh water to a depth of 45 feet.

The Smithville Canal well, also known as the Mt. Graham Mineral Bath well (D-6-25-36cbb), produces 601 gpm of sodium chloride type water under artesian flow at 46°C (115°F) (Witcher, 1981b). Witcher reports TDS ranging from 4,431 to 8,292 mg/l, and Muller and others (1973) measured total chloride of 480 to 1504 ppm.

About five miles south of Safford, the Idle Oil-Healy #1 well (D-8-26-6bd) produced what Knechtel (1938) called "scalding hot salty water". This artesian well flowed at 1/2 gpm and the main water-bearing bed was at 1600 feet.

Shallow wells

Generally, salty water is more common in deep holes penetrating hundreds of feet into the basin-fill than in wells in the more recent, shallow alluvial aquifer of the Gila River flood plain, but Knechtel (1938) mentions salty water in several shallow wells. At Fort Thomas, a 16-foot deep

well (D-4-23-26), and a 47 foot well (D-4-23-34a) were drilled into alluvium of the Gila River flood plain and both produced "salty water". These wells are near the fault-controlled trend of hot springs and hot wells north of the Gila River.

Near Sanchez, a 16-foot well (D-6-27-35ad) dug into quaternary alluvium yielded salty water. Another well nearby (D-7-27-8ad) dug 30 feet into alluvium also produced salt water.

Three wells southeast of Safford were also noted to have salty water. An abandoned 68-foot deep well (D-8-27-2), a 65-foot deep well (D-9-27-23), and a 60-foot well all produced "salty water" from Pliocene lake beds similar to those exposed at 111 Ranch.

None of these shallow-aquifer wells have detailed geologic logs or chemical analyses, so the amount and origin of their salt is unknown. Detailed analyses of water quality in wells and springs, and groundwater conditions in the Management Zone include Hassemer and others (1983), Brown (1989), Remick (1989), Barnes (1991), and Black (1991).

Duncan Basin

Drillers' logs for hundreds of wells in the Duncan Valley were examined at the Arizona Department of Water Resources. Water is encountered at depths as shallow as 12 feet, and wells deeper than 200 feet are very rare owing to the shallow water table. Only one well log in the entire valley mentions salty water, and none indicate salt. The Corona well (D-8-32-32cad) produced salty water at 42-65 and 87-95 feet.

Many of the logs refer to blue, gray, or green clay. Also, limestone, marl, and diatomite are common in surface exposures in the Duncan Valley, suggesting that conditions may have been similar to the Safford Basin and that evaporites could be present at depth. Unfortunately, no wells in the valley are deep enough to test that possibility, and the AZGS does not have any cuttings from wells in the Duncan Basin.

CONCLUSIONS

Recent studies (e.g. Kruger and others, 1995) have shown that the structure of the Safford basin is a half-graben, with the southwest side of the basin much deeper than the northeast. Earlier studies (e.g. Harbour, 1966) treated the basin as a more symmetrical graben, and attempts at correlation of units generally assumed that equivalent layers, or facies, should be at approximately the same elevation throughout the valley. However, with a half-graben structure, equivalent layers are deeper and thicker to the southwest, and the difference in elevation between the southwest and northeast parts of equivalent layers is greater with increasing age because the southwestern part of the basin has subsided more since the sediments were deposited. Attempting to correlate across the valley can be very confusing.

Earlier workers also tended to follow Harbour's (1966) version of a single "blue clay" layer separating the upper and lower basin fill units, and a single upper aquifer and a single lower aquifer, also defined and separated by a single blue clay layer. This overly simplistic model is not borne out by an examination of logs and cuttings for wells in the valley. Logs commonly reveal several "blue" (gray) clay layers interbedded with brown, red, yellow or green clay, and even sand and gravel, in many wells. Water is commonly reported from multiple intervals. In many cases, the distinction between lacustrine versus evaporite facies is somewhat subjective, and correlations based on such subjective and logger-dependent criteria can be difficult.

Plate 2 presents the known extent of evaporites and lacustrine sediments in the Management Zone. Sub-basins follow the divisions of Houser (1990). The area indicated as "known extent of evaporites" is a minimum area, and is based on the unequivocal presence of layers of relatively pure gypsum, anhydrite, and salt in wells. The southern extent of the known evaporites, for example, ends near the well where the thickest known evaporite sequence (2270

feet) has been found. A safe assumption is that the body extends some distance to the south, but wells drilled to bedrock near Bowie and San Simon have failed to penetrate similar evaporites. Likewise, the northern extent is placed where it is because of a lack of logs and drill cuttings for any deep wells on the San Carlos Reservation. Fine-grained sediments that have disseminated or scattered gypsum are not included in the unequivocal evaporites, but are considered to be lacustrine.

Lacustrine sediments are widespread in the Management Zone (Plate 2). These sediments consist of clay (commonly gypsiferous), silt, limestone, marl, and diatomite. The distinction between lacustrine sediments and evaporite sequences is somewhat arbitrary.

Logs and cuttings from wells in the Safford Valley reveal extensive evaporite deposits, including salt. Some salt also occurs in exposed sediments near Safford and on the San Carlos Indian Reservation. Hot springs and thermal wells in the Management Zone commonly produce salty water. Together, these evaporites represent an important, *and natural*, source for constituents that affect water quality in the upper Gila River of Arizona.

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APPENDIX A

FEATURE NAMES IN THE MANAGEMENT ZONE REFERRING TO SALT

APPENDIX A

Feature names in the Management Zone referring to salt.

FEATURE	COUNTY	LAT deg-min-sec	LON deg-min-sec	QUADRANGLE
Salt Basin	Greenlee	33 24 28	109 08 32	Dutch Blue Creek
Salt Box Spring	Graham	33 20 43	110 11 25	Branaman Spring
Salt Box Tank	Graham	33 20 43	110 11 02	Branaman Spring
Salt Creek	Graham	33 07 45	110 06 16	Bylas
Salt Creek	Graham	33 12 15	110 19 03	Dewy Flat
Salt Creek Tank	Graham	33 21 15	110 16 48	Mount Triplet
Salt Ground Canyon	Greenlee	33 13 02	109 11 33	Dix Creek
Salt House Creek	Greenlee	33 30 02	109 24 40	Baldy Bill Point
Salt Mountain	Graham	33 15 29	110 19 32	Mount Triplet
Salt Spring	Graham	33 06 09	110 01 49	Geronimo
Salt Spring	Graham	33 18 58	110 18 33	Mount Triplet
Salt Springs	Gila	33 56 44	110 09 50	Cedar Creek

Table does not include Salt River, which forms the northern boundary of the San Carlos-Safford-Duncan Nonpoint-Source Management Zone.

APPENDIX B

LOGS FOR SELECTED WELLS IN THE MANAGEMENT ZONE

FROM AZGS FILES OR PUBLISHED SOURCES

Log of E. G. Rogers well, NE¼ sec. 5, T. 6 S., R. 24 E.

	Thickness	Depth	Remarks
	Feet	*Feet*	
Sand	15	15	
Soft red clay	20	35	
Coarse sand	5	40	Small amount of water.
Red clay	5	45	
Coarse sand	5	50	Considerable water (nonartesian).
Red clay	10	60	
Sand	2	62	Do.
Hard red clay	18	80	
Gravel	2	82	Do.
Unconformity			Contact between lake beds and overlying alluvium.
Clay, with beds of limestone and tuff.	718	800	No sand or gravel and no water. Clean salt 6 feet thick at about 580 feet.

(Knechtel, 1938)

Log of E. W. Black well, NE¼NE¼ sec. 19, T. 4 S., R. 23 E.

	Thickness	Depth	Remarks
	Feet	*Feet*	
Sand and hard clay	27	27	
Sand	3	30	Water.
Hard red clay	24	54	
Quicksand	8	62	Much water, but sand is troublesome.
Sandy clay	13	75	Small amount of water.
Clay	25	100	
Sand	5	105	Large supply of good water.
Unconformity			Contact between lake beds and overlying alluvium.
Clay	20+	125+	Lake beds.

(Knechtel, 1938)

The following section of the flowing well at Geronimo, in sec. 19, T. 4 S., R. 23 E., drilled for oil with cable tools in 1918–19, is furnished from memory by the owner, R. S. Knowles:

Log of flowing well at Geronimo

	Thickness	Depth	Remarks
	Feet	*Feet*	
Clay	28	28	
Sand and clay	17	45	Fresh water at several horizons: cemented off.
Hard clay	43	88	A little water.
Gravel	2	90	
Hard clay and lime	405	495	Artesian flow of salt water.
Sand	30	525	
Shale, lime, and clay	270	795	
Gravel	15	810	Bottom of well; no water was struck below 495 feet.

(Knechtel, 1938)

Log of Gila Oil Syndicate's well in the SW¼NE¼ sec. 30, T. 5 S., R. 24 E., near Ashurst

	Thickness	Depth	Remarks
	Feet	*Feet*	
Alluvium	50	50	Water.
Clay	380	430	
Sand	15	445	Flow of water.
White limestone	145	590	Salt water.
Limy shale	30	620	
Gray sand	80	700	Flow of water.
Limy shale	50	750	Salt water.
Blue shale	55	805	
Gravel	30	835	
Gray shale	200	1,035	
Brown shale	80	1,115	
Blue shale	20	1,135	
Brown shale	15	1,150	
Blue shale	15	1,165	
Brown shale	35	1,200	
Sandy shale	35	1,235	
Blue shale	20	1,255	
Brown shale	80	1,335	
Red shale	60	1,395	
Sandy shale	40	1,435	
Brown shale	80	1,515	
Brown sandstone	480	1,995	Flow of water.
Gravel	10	2,005	
Dark-brown shale	70	2,075	
Black sand	10	2,085	
Brown shale	125	2,210	
Dark-brown sandstone	70	2,280	
Gray shale	15	2,295	
Red shale	110	2,405	
Dark-brown sandstone	80	2,485	
Limestone	80	2,565	
Sandy limestone	30	2,595	
Blue shale	50	2,645	Bottom of well.

Log of Southern Pacific Co.'s well at Tanque, Ariz.

[Pumping yield, 29,000 gallons in 24 hours]

	Thickness	Depth	Remarks
	Feet	*Feet*	
Hardpan	32	32	
Gravel	6	38	
Unconformity			Base of alluvium.
Yellow clay	52	90	
Sand and gravel	34	124	High water, 111 feet. Water level while pumping, 115 feet.
Yellow clay	8	132	
Gravel	12	144	Water.
Blue clay	96	240	Working barrel raised to 155 feet from ground surface, November 1911.
Blue clay and sand	14	254	
Gravel and sand	6	260	
Blue clay	24	284	
Sand	4	288	
Yellow clay	34	322	
Sand and clay	4	326	
Blue clay	70	396	
Sandstone	4	400	
Blue clay	192	592	
Gypsum and clay	143	735	Bottom of casing.
Gypsum	30	765	Bottom of well.

Log of Southern Pacific Co.'s well (dry) 17 feet south of center of main track, 124 feet east of center line of Central Avenue, Safford, Ariz. Sec. 17, T. 7 S., R. 26 E.,

[Drilled January 1906–March 1907. All water encountered was salty]

	Thickness	Depth	Remarks
	Feet	*Feet*	
Soil	8	8	
Gravel and boulders	82	90	
Unconformity			Base of alluvium.
Blue clay	100	190	
Yellow clay	70	260	
Blue clay	40	300	
Yellow stratified clay	400	700	
Yellow clay with streaks of gypsum	100	800	
Yellow clay with strata of hard rock	95	895	
Yellow and brown clay with streaks of gypsum	105	1,000	
Salty clay	820	1,820	Bottom of well.

(Knechtel, 1938)

CORE LOG

Superior-Federal 63-15S
Sec. 15, T5S-R23E, Graham County, Arizona

Depth	Discription
0-5	Recent alluvium. (cutting spls.)
5-16	Clay, brown. (cutting spls.)
16-50	Clay & siltstone, brown, calcareous. (beginning of NX core)
50-52	Siltstone, light brown.
52-60	Clay & siltstone, chocolate brown, calcareous.
60-62	Sandstone, brown, medium grained, arkosic.
62-72	Siltstone & clay, choc. brown.
72-77	No recovery (prob. brown clay).
77-122	Clay, choc. brown.
122-122.2	Sandstone, tan, fine, arkosic.
122.2-141.7	Clay, slightly silty in part, choc. brown.
141.7-157	No recovery.
157-167	Clay, choc. brown (2ft. recovered).
167-172	No recovery (prob. brown clay).
172-202	Clay, choc. brown.
202-205	Sandstone, brown, fine, poorly consolidated.
205-212	Clay, sandy to silty, brown.
212-214	Clay, choc. brown.
214-225	Clay, sl. sandy in part, choc. brown.
225-247	Clay, silty, brown.
247-259	Clay, brown, a few thin sandy stringers.
259-282	No recovery.
282-322	Clay, brown, a few thin sandy stringers.
322-334	Clay, choc. brown.
334-337.5	Clay, slightly sandy to silty, gray brown.
337.5-338.4	Sandstone, fine, silty, gray-brown, iron staining.
338.4-343	Clay, choc. brown, some slightly sandy.
343-353.5	Clay, choc. brown.
353.5-354	Siltstone, tan, crumbly.
354-356	Clay, choc. brown.
356-359	Mudstone, gray-brown to gray-green, sl. micaceous.
359-365	Clay, choc. brown.
365-375	Clay, silty, choc. brown.
375-376	Sandstone & clay, ss. is gray-brown, very fine.
376-389.5	Clay, choc. brown.
389.5-419	Clay, silty to sandy, calcareous.
419-421	Silty sandstone, brown, fine, poorly consolidated; slight salt crust on core.
421-443	Mudstone, choc. brown, calcareous, slightly micaceous.
443-453	No recovery.
453-455	Clay, silty, brown.
455-464	Mudstone, brown, calc., silty at base; slight salt crust on core.
464-473	Siltstone, some clay, choc. brown.
473-493	Clay, sandy & silty in part, brown, calc.
493-494.5	Silty sandstone, fine, calc., poorly consolidated.

Depth	Discription
494.5-496.5	Clay, sandy to silty, calc.
496.5-499.5	Mudstone, brown, calc., slightly micaceous, slight salty taste.
499.5-519	Silty clay, brown, calc.; grades in minor part to fine silty ss.
519-529	Shale, brown, calc.; a few thin silty & sandy stringers; has a greater degree of concolidation than material above.
529-531	Shale, light brown, calc., silty, micaceous.
531-537	Clay, brown, calc.
537-539	Sandy clay, calc., micaceous.
539-541	Silty sandstone, brown, fine, micaceous, calc., soft.
541-544.5	Silty clay, brown calc.
544.5-546	Mudstone, green, calc.
546-548.5	Shale, brown, calc.
548.5-550.5	Sandstone, brown, very fine, silty, calc., poorly consolidated.
550.5-552	Clay, brown, silty, calc.
552-584	Siltstone & shale, brown, calc.; grades in part to fine brown sandstone; slight salt crust on core at 569ft.
584-610	Shale & clay, brown, calc.; a few stringers of siltstone & fine sandstone.
610-617	Siltstone & fine sandstone, brown, calc., cross-bedded; minor shale.
617-620	Clay, brown.
620-622	Sandstone, fine, silty, soft.
622-630	Siltstone, grades to shale, calc.; slight salt crust on core.
630-631.2	Sandstone, very fine, silty, calc., soft.
631.2-641	Clay & shale, brown, calc., some slightly silty.
641-644	Siltstone & sandstone, soft, calc.
644-667	Shale & clay, sandy in part, brown, calc.
667-669	Shale, red-brown, hard, calc.
669-678	Clay & shale, brown, calc.
678-688	Siltstone, brown, calc., soft (only 1 ft. recovered)
688-696.5	Clay, brown, calc.
696.5-700	Siltstone, gray-brown, calc., fairly hard
	(End of NX core; beginning of BX core)
700-700.3	Sandstone, very fine, brown.
700.3-712	Siltstone & silty shale, brown, calc., sl. micaceous (2.5ft. recovered).
712-722	No recovery.
722-762	Shale & siltstone, brown, calc., slightly micaceous, a few inches of fine sandstone at 742.
762-769	Sandstone, brown, fine to silty, slightly, micaceous, calc. (3ft. recovered).
769-781	Shale & siltstone, brown, calc., micaceous.
781-782	Silty to argillaceous sandstone, micaceous.
782-793.5	Shale, brown, calc., micaceous; some silty streaks.
793.5-794	Sandstone, silty & argillaceous, calc., micaceous.
794-799	Shale, brown, calc.
799-807	Siltstone & fine sandstone, gray to brown with black carbonaceous streaks, micaceous, calc. (50% recovery)
807-842	Siltstone & shale, brown, calc., micaceous; includes some thin black carbonaceous laminations; several thin zones of fine ss.
842-852	Silty sandstone & siltstone interbedded with shale; brown, calc., micaceous.

Depth	Discription
852-854.7	Shale, brown, calc.
854.7-862	Silty sandstone & siltstone, brown with black carbonaceous inclusions; cross-bedded, calc., micaceous (3 ft. recovered)
862-872	No recovery.
872-927.5	Shale & minor silty shale, brown, calc., sl. micaceous; a few thin beds (up to 1 ft. thick) of fine brown sandstone & siltstone containing carbonaceous material.
927.5-929.7	Shale, brown to gray, calc.
929.7-932.7	Shale, light gray-green, very calc., contains ostracods(?).
932.7-936.2	Shale, brown, calc., fairly hard.
936.2-942	Shale & clay, brown, calc., brumbled.
942-946.5	Shale, brown, calc., fairly hard, sl. silty.
946.5-951	Shale, brown, calc., inclusions of white limestone increasing in abundance towards base.
951-952	Limestone, white, hard vugular
952-960	Limestone & shale; the ls. is vuggy and occurs as laminations and inclusions in the brown shale.
960-962	Limestone, argillaceous, gray.
962-968	Shale, very calc., gray-brown to brown; contains small inclusions of $CaCO_3$.
968-971.5	Shale, gray, very calc., slightly silty in part.
971.5-985	Shale, brown, abundant small inclusions & thin laminations of white limestone.
985-987	Sandstone, fine, porous, calc; interbedded vuggy white limestone.
987-999.5	Limestone, argillaceous, white, very vugular; contains interbedded brown shale & clay.
999.5-1049	Limestone, white, honeycombed & vugular; vugs contain secondary crystal growth; minor stringers of brown to gray clay; possibly a little intermixed gypsum.
1049-1070	Limestone, white, vugular, intermixed gray clay; a few thin (1/8" to 4") beds of grey, non-calcareous shale.
1070-1072	Argillaceous limestone & very calc. gray clay; contains white powdery $CaCO_3$.
1072-1072.5	Limestone, white, fine crystaline, hard, slightly vuggy.
1072.5-1075.5	Shale, gray to dark gray; a few thin white $CaCO_3$ stringers; small amounts of a green mineral.
1075.5-1078	Limestone, white, vuggular; large admixture of dark gray shale.
1078-1097	Limestone & shale; shale is gray to dark gray, non calc.; limestone occurs in numerous thin stringers beds & inclusions; gypsum noted at 1078' and 1093.5'.
1097-1120	Shale, gray to brown, waxy in part; abundant thin stringers of $CaCO_3$ and some gypsum. Core suggests beds dip 5° ±
1120-1122	Shale, waxy, brown, soft; white $CaCO_3$ & gypsum inclusions.
1122-1127.3	Shale, silty, dark gray, slightly micaceous; occasional thin white calcareous streaks; traces of bright green mineral.
1127.3-1129	Siltstone, gray, porous, sl. micaceous.
1129-1132	Shale, dark brown, sl. micaceous; some thin white limestone stringers.
1132-1134.5	Limestone, white soft, gypsiferous (?); contains dark gray to black shale stringers
1134.5-1141	Shale, dark brown to dark gray, sl. micaceous, numerous irregular white $CaCO_3$ stringers make up 50% of rock in places.

Depth	Discription
1141-1142	Limestone, white, soft, powdery, possibly gypsiferous; contains admixture of dark brown clay.
1142-1144	Limestone, white, numerous irregular stringers of waxy, brown clay.
1144-1149	Shale, dark brown; numerous thin stringers of white limestone. Beds have apparent dip of 5°±.
1149-1154	Shale & limestone, shale is waxy, brown to gray-green; limestone, hard to soft.
1154-1162	Shale with laminations of white limestone; shale is brown to gray, waxy in part; trace of green mineral at 1160' to 62'.
1162-1172	Shale & white limestone; shale is green & gray; ½ inch of red shale at 1168.5'; green mineral in ls. at 1167'.
1172-1182	Shale, green to gray, hard, sl. silty in part; occasional thin white calcareous stringers.
1182-1187	Shale, green, waxy, occasional thin white stringers of vuggy limestone & argillaceous limestone.
1187-1188	Clay, green, waxy.
1188-1189	Shale, green, brown & gray.
1189-1190	Limestone, white, sl. vuggy; minor gray shale.
1190-1198	Shale, brown, gray & gray-green, hard, sl. micaceous; occasional thin calcareous stringers.
1198-1199	Clay, brown, & white limestone.
1199-1205	Shale, dark green, gray, gray-brown; interbedded limestone stringers.
1205-1206	Siltstone & silty shale, gray-green micaceous.
1206-1208	Shale & siltstone green to dark gray; a few calc. stringers.
1208-1212	Shale & clay, green & very dark green; some calc. stringers.
1212-1224	Shale & argillaceous limestone; shale is green to black.
1224-1231.4	Shale, gray, very sl. calc., waxy in part, sl. micaceous in part; occasional light gray calc. bands.
1231.4-1237	Shale, gray, green & brown; interbedded thin limestone stringers.
1237-1246	Shale, brown to olive green; interbedded limestone.
1246-1258	Shale, gray, occasional light gray to white calcareous streaks; 1 inch of vuggy white limestone at 1246'.
1258-1260	Limestone, white, intermixed with green shale; some gypsum.
1260-1270.5	Shale, gray-brown, gray, gray-green; a few light gray calcareous stringers; some gypsum stringers at 1270'.
1270.5-1271.5	Limestone, white, intermixed green shale.
1271.5-1274	Shale, gray, calc., crumbled core.
1274-1281	Shale, green to gray; a few thin calc. streaks.
1281-1285	Shale, black & gray-green.
1285-1287	Shale, gray, slightly micaceous.
1287-1296	Shale or clay, dark gray, slightly micaceous (1 ft. recovered)

Note: The cores were described when wet. Colors exibited by the dry sediments may differ.

The cores from 16 ft. to 936 ft. are stored by the Ground Water Division of the Geological Survey at Tucson, Arizona.

Some of the shales & silts below 950' are tuffaceous. This was not noted until cores were dry. R.M.B.

(from AZGS files)

SAFFORD AND BOWIE AREAS:

5-2 Ashurst No. 1. NE¼ NE¼ Section 30, T. 5 S., R. 24 E., G. & S.R.M. Drilling depth 1,247 feet carrying 10-inch casing. Water not shut off. No evidence of structure. Well visited April 16, 1928.

Log of Ashurst No. 1

0 -	20	Brown clay
20 -	50	Gravel - Water
50 -	450	Brown clay
450 -	465	Red sand - water
465 -	510	White lime
510 -	540	Lime and shale
540 -	620	Light gray sand - water (about 10,000 barrels per day)
620 -	667	Lime and shale
667 -	717	Shale
717 -	757	Gray gravel
757 -	1,197	Gray shale
1,197 -	1,247	Brown shale

Underwriters' Syndicate No. 1. Located in the southeast corner of the NW¼ NE¼ Section 13, T. 6 S., R. 24 E., G. & S.R.M. Operations temporarily suspended at 3,103 feet. Drilling commenced October 7, 1927. Well visited April 16, 1928. No evidence of structure. 5-5

Condensed Log of Well.

0 -	80	Gravel
80 -	760	Red bed - (Cavey shale)
760 -	930	Salt
930 -	1,460	Red beds (shale)
1,460 -	1,463	Sand - showing oil
1,463 -	1,580	Red bed - sand
1,560 -	2,450	Water sand
2,450 -	2,930	Red sandy shale
2,930 -	3,100	Red bed (shale)
3,100 -	3,105	Red sand

Casing Record

24" - 30 feet; 20" - 80 feet; 12½" - 680 feet; 10" - 1,950 feet landed.

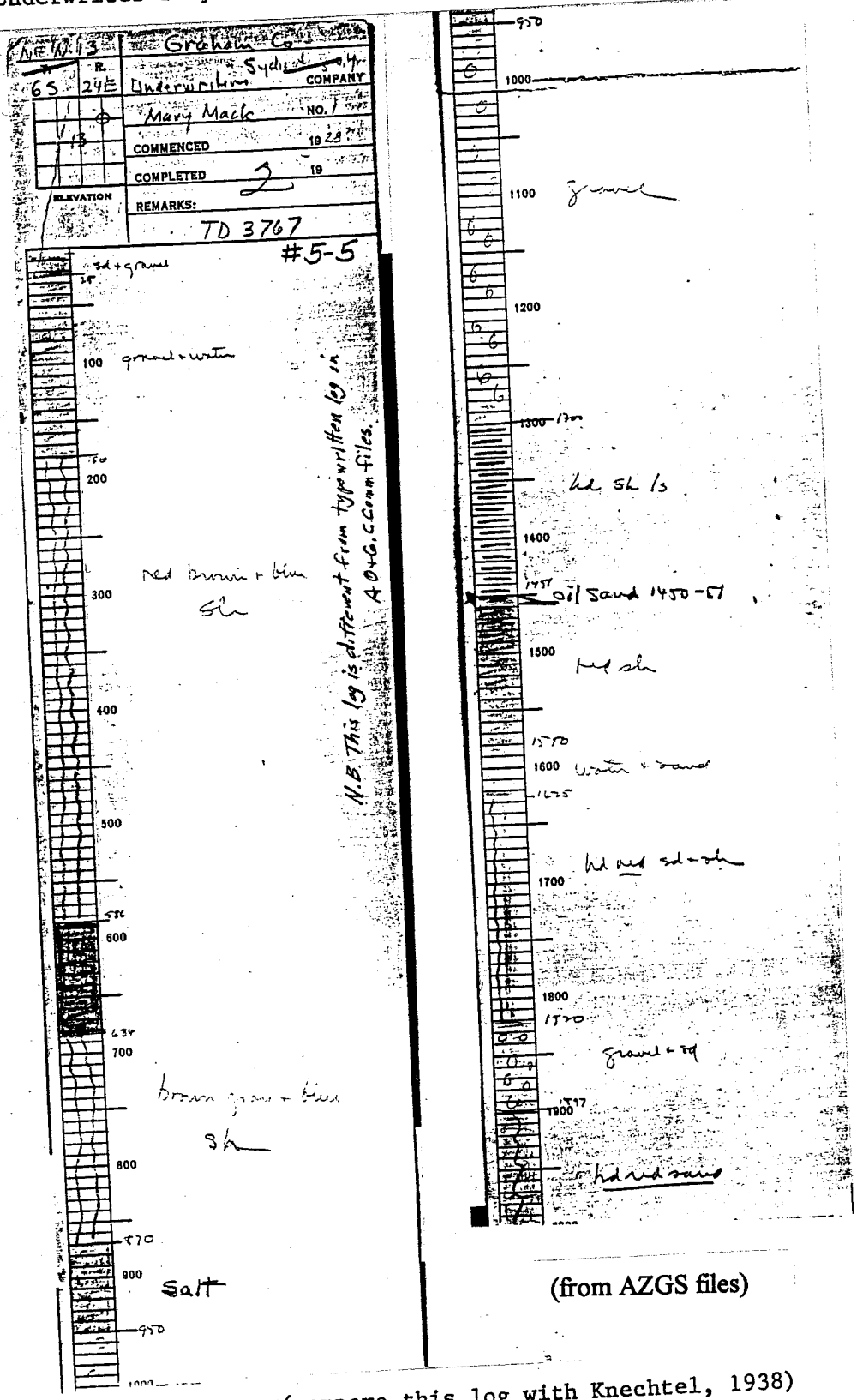
(from AZGS files)

Log of Mary S. Mack well in sec. 13, T. 6 S., R. 24 E., near Pima

	Thickness	Depth	Remarks
	Feet	*Feet*	
Sandy loam	3	3	
Sand	17	20	
Gravel; water	160	180	Base of alluvium; hole full of freshwater.
Unconformity	120	300	
Red sandstone	160	460	
Red sandy shale	40	500	
Brown shale	10	510	
Black shale	50	560	
Brown shale	96	656	
Gray shale	28	684	
Red sandstone	56	740	
Brown shale	95	835	
Gray shale	17	852	
Gypsum and shale	18	870	
Blue shale	80	950	
Hard shale	10	960	
Gray shale	60	1,020	
Blue shale	250	1,270	
Brown shale	30	1,300	
Gravel	90	1,390	
Brown shale	2	1,392	
Limy shale	58	1,450	
Red shale	1	1,451	
Sand	19	1,470	
Gravel	52	1,522	
Red shale	20	1,542	
Red sandstone	38	1,580	
Red shale	45	1,625	Well flowing 12,280 barrels of water in 24 hours.
Red sand	5	1,630	
Gravel	15	1,645	
Red sand	75	1,720	Flow of water increased.
Sand; water	10	1,730	
Gravel	18	1,748	
Red sand	40	1,788	
Sandy shale	15	1,803	
Gravel	17	1,820	
Red shale	10	1,830	
Red gravel	50	1,880	
Red sand	5	1,885	
Red shale	12	1,897	
Gravel	50	1,947	
Hard red sand	5	1,952	
Limy shale	191	2,143	
Red sand	77	2,220	Do.
Sand; water	30	2,250	
Red sand	55	2,305	
Red shale	13	2,318	Do.
Sand; water	81	2,399	
Red sand	76	2,475	
Red shale	5	2,480	
Gravel	18	2,498	
Limy shale	22	2,520	
Gravel	55	2,575	
Red shale	85	2,660	
Red sand	30	2,690	
Red shale	12	2,702	
Broken sand	5	2,707	
Hard lime	63	2,770	
Sandy shale	30	2,800	
Red sandstone	40	2,840	
Red shale	10	2,850	
Pink shale	155	3,005	
Red sandstone	89	3,094	
Red shale	7	3,101	
Hard lime	39	3,140	
Sand	70	3,210	
Red sand; water	2	3,212	
Gray lime	35	3,247	
Red sand	3	3,250	
Gray lime	4	3,254	
Gray sand	4	3,258	
Gray lime	15	3,273	
Gray sand	14	3,287	
Sandy lime	243	3,530	
Red sandstone	10	3,540	Flow of water increased to 50,000 barrels in 24 hours.
Red sand	180	3,720	
Red sandstone	14	3,734	Hole caving very badly.
Red sandy shale	4	3,738	
Gypsum	29	3,767	Bottom of well. Shut down Nov. 4, 1929. Pulled 6¼-inch casing and reamed hole to 10 inches to 3,300 feet and drilled 8¼-inch hole to depth of 3,767 feet.

(Knechtel, 1938)

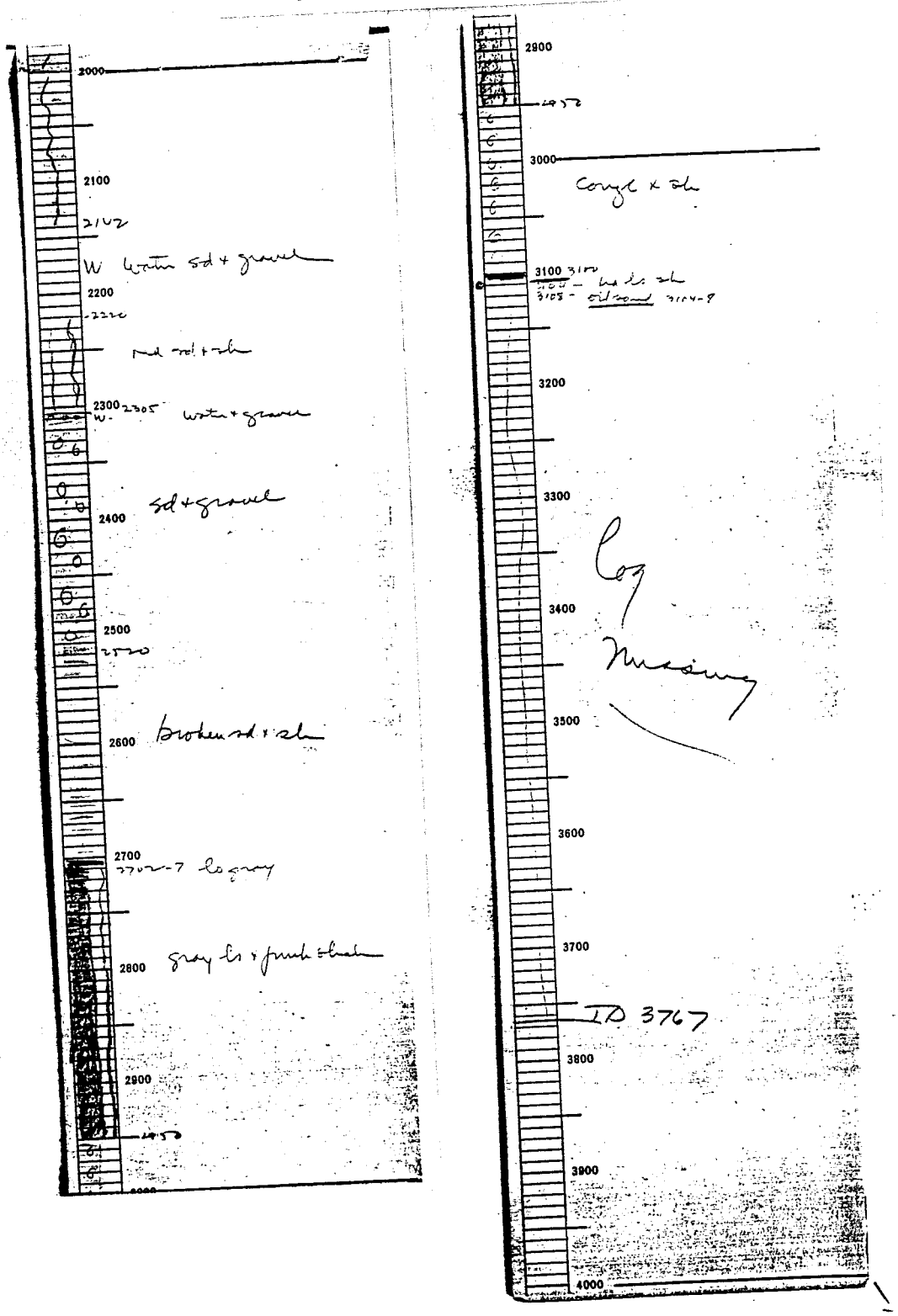
Underwriter's Syndicate "Mary Mack" well (D-6-24-13ab)



(from AZGS files)

(compare this log with Knechtel, 1938)

Mary Mack well, continued



(from AZGS files)

Whitmore #1 State (D-7-25-6cc)

Professional Service

GOULDS Water Systems

JADCO
JIM ALLEN DRILLING CO.
P.O. Box 308 Safford, Arizona 85546 Phone: 428-6993

DRILLING REPORT

Ralph Whitmore
206 College Ave.
Thatcher Az. 85552

WELL LOCATION:
Approx. 3 Mi South of Pima
On the Cluff Ranch Road.

RECEIVED
NOV 16 1977
O & G. CONS. COMM.

0 - 13	Sandy Fill
13 - 16	Sand and Gravel
16 - 25	Sand
25 - 35	Brown Clay
35 - 36	Red Clay
36 - 44	Sand and Gravel.
44 - 55	Brown Clay
55 - 80	Blueish Brown Clay
80 - 82	Brown Clay
82 - 96	Blueish Brown Clay
96 - 105	Brown Clay
105 - 111	Blueish Brown Clay
111 - 1024	Red Clay

There was also found layers of blue clay in the red clay at various places, but they were so small that they were unable to be logged.

(from AZGS files)

AMERICAN STRATIGRAPHIC COMPANY

Log No D-4117 Net Footage 2290 #541

State ARIZONA County GRAHAM

Well Name IVAN TENNEY NO.3 STATE

Spot SE SW Sec 36 T. 9S R 27E

Area (W)

Commenced April 29, 1970

Completed Jan. 29, 1971

Initial Production D & A

Elevation KB GR 3255

Producing Fm

Producing Intervals

Total Depth 3500

Oldest Fm Tertiary Evaporites?

Casing 18" @ 623; 12 3/4" @ 1195; 8 5/8" @ 1450; 7" @ 2095

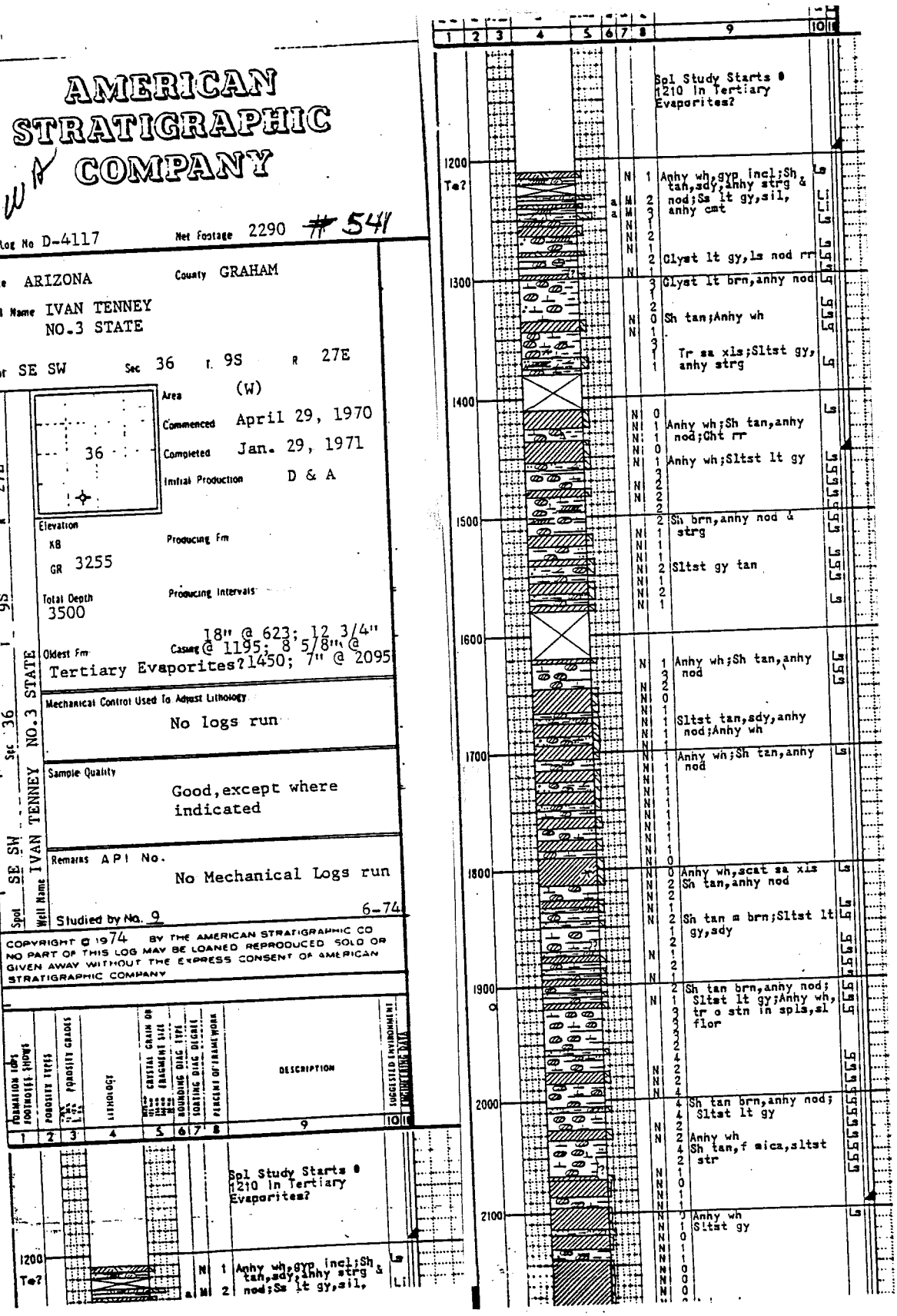
Mechanical Control Used To Adjust Lithology: No logs run

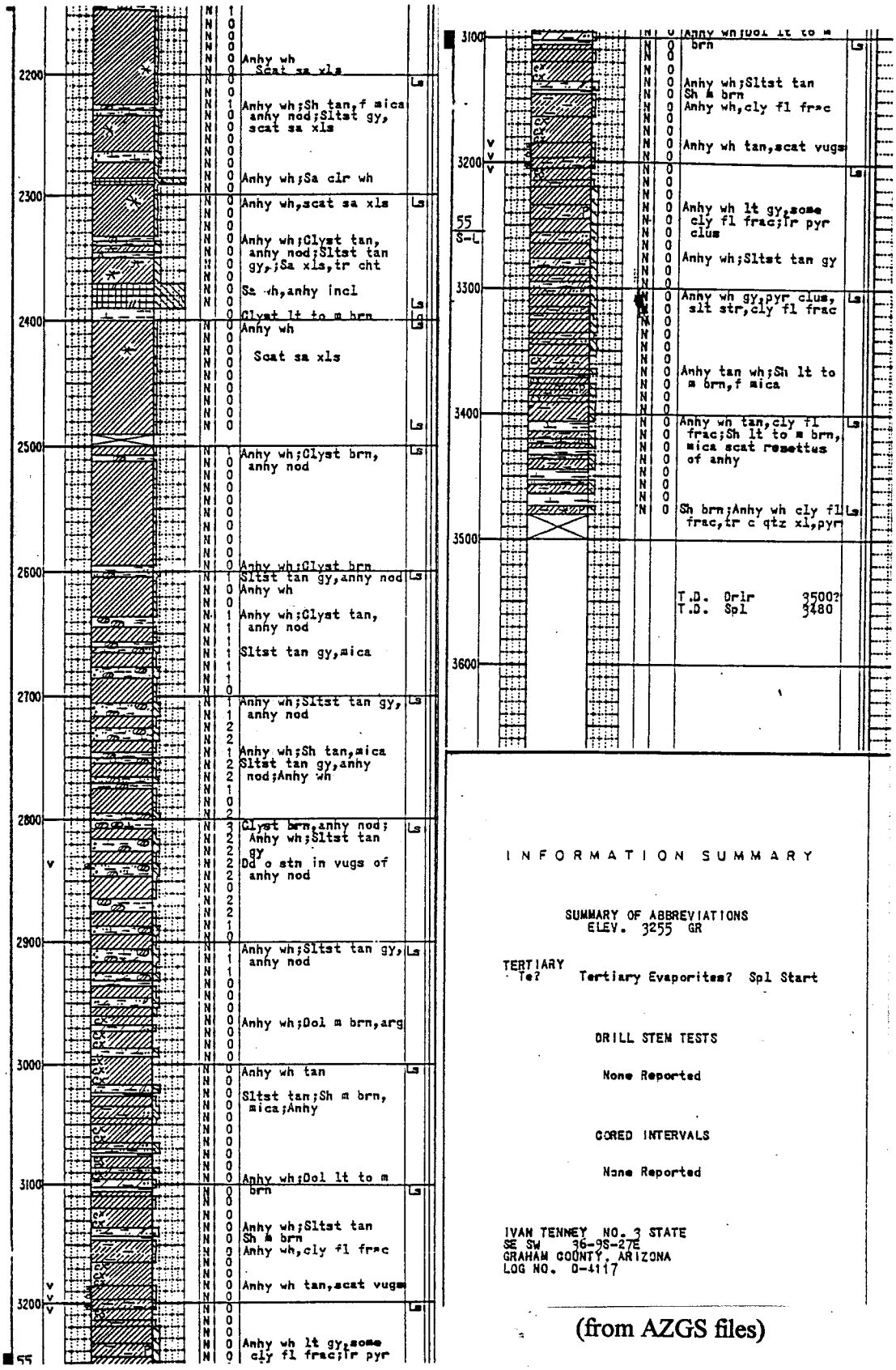
Sample Quality: Good, except where indicated

Remarks API No. No Mechanical Logs run

Studied by No. 9 6-74

Spot SE SW Well Name IVAN TENNEY NO.3 STATE Sec 36 T 9S R 27E





INFORMATION SUMMARY

SUMMARY OF ABBREVIATIONS
ELEV. 3255 GR

TERTIARY
Te? Tertiary Evaporites? Spl Start

DRILL STEM TESTS

None Reported

CORED INTERVALS

None Reported

IVAN TENNEY NO. 3 STATE
SE SW 36-9S-27E
GRAHAM COUNTY, ARIZONA
LOG NO. D-4117

(from AZGS files)

Ivan Tenney #3 State
(driller's log)

DETAIL OF FORMATIONS PENETRATED

Formation	Top	Bottom	Description*
Sandy soil	0	5	
Sand & clay	5	120	surface water. small amount
Sand	120	240	
Clay	240	360	
Brown clay & sand	360	400	
Blue clay	400	1200	
Blue clay & sandy	1200	1300	- small amount of set water at 1240ft
Sandy & Blue clay	1300	1410	
Sandy	1410	1525	
Brown shale & sandy	1525	1635	
Sandy	1635	1660	
Brown shale & sandy	1660	1825	
Brown sticky clay	1825	1895	
Gray shale & sandy	1895	2140	
Sandy & shale	2140	2475	
Sandy	2475	2685	
Sandy & shale	2685	2750	
Lime	2750	2795	
Lime sandy & shale	2795	3150	
Sandy	3150	3200	
Sandy & Brown shale	3200	3500	T.D.

* Show all important zones of porosity, detail of all cores, and all drill-stem tests, including depth interval tested, cushion used, time tool open, flowing and shut-in pressures, and recoveries.

INSTRUCTIONS:
Attach drillers log or other acceptable log of well.
This Well Completion or Recompletion report and well log shall be filed with the State of Arizona Gas Conservation Commission not later than thirty days after project completion.

Form No. 4

(from AZGS files)

Ivan Tenney #2 State

(driller's log)

DETAIL OF FORMATIONS PENETRATED

Formation	Top	Bottom	Description*
Soil	0	5	
sand clay	5	73	
water sand		295	very little water
Rock with streak clay -	78		
Blue sticky clay.	295	1090	

* Show all important zones of porosity, detail of all cores, and all drill-stem tests, including depth interval tested, cushion used, time tool open, flowing and shut-in pressures, and recoveries.

INSTRUCTIONS:

Attach drillers log or other acceptable log of well.

This Well Completion or Recompletion report and well log shall be filed with the State of Arizona Oil & Gas Conservation Commission not later than thirty days after project completion.

Form No. 4

(from AZGS files)

Bear Springs Oil and Gas Company-Allen #1

	Thickness (ft)	Depth (ft)
(D-10-28)25d		
Drift sand	14	14
Adobe	35	49
Hard black sand	4½	53½
Water sand; little water	35	88½
Gumbo and green clay	153	241½
Black water sand; water	4	245½
Gray clay, squeezes	35	280½
Soft sandstone	63	343½
Lime, blue	14	357½
Hard sand	45	402½
Green shale	30	432½
Lime	½	433
Quicksand	35	468
Lime	½	468½
Peat and quicksand	38	506½
Sandstone	4	510½
Black shale and selenite	3	513½
Green shale	51	564½
Blue and white shale	50	614½
Shale and selenite	5	619½
Green and brown shale	18½	638
Light-colored shale and selenite	40	678
Green and brown shale	37	715
Crystallized lime; gypsum	5	720
Brown and green shale	15	735
Green shale	65	800
Brown shale with streaks of gypsum	105	905
Yellow shale, not sandy	25	930
Yellow and brown shale	78	1,008
Alternate layers dark and light brown and yellow shale	22	1,030
Brown shale	5	1,035
Lime or gypsum	7	1,042
Water gravel; some water	27	1,069
Brown shale and sandstone	15	1,084
Alternate layers of brown shale and gypsum	242	1,326
Brown sandy shale	110	1,436
Hard conglomerate	8	1,444
Hard rock	32	1,476
Hard conglomerate	24	1,500
Coarse sand	3	1,503
Conglomerate	13	1,516
Fine sand	3	1,519
Black sandstone	11	1,530
Light sand	2	1,532
Total		1,532

	Thickness (ft)	Depth (ft)
(D-10-29)20		
Cemented gravel	12	12
Quicksand	30	42
Brown clay	6	48
Brown sand	45	93
Sand with sandstone shells	10	103
Brown sand	12	115
Brown clay	15	130
Hard conglomerate	6	136
Fine brown sand	19	155
Brown clay and boulders	18	173
Cemented gravel and boulders	20	193
Sandstone	5	198
Gravel	8	206
Sandy shale and shells	76	282
Blue shale	3	285
Blue and brown shale	11	296
Blue and brown shale with shells	29	325
Soft shale	18	343
Blue shale	30	373
Hard lime shells	9	382
Hard red rock; conglomerate	131	513
Total		513
(D-11-29)26b		
Soil and sand	25	25
Water sand	20	45
Blue clay	5	50
Blue clay, shells gyp-little water	715	765
Hard rock	35	800
Total		800
(D-12-28)23ccc		
Soil	5	5
Caliche	9	14
Clay	56	70
Blue clay	435	505
Red clay	30	535
Gravel	4	539
Clay and gravel	21	560
Sand and gravel	10	570
Sand, gravel with clay strata	30	600
Clay	20	620
Sand and gravel with clay strata	25	645
Sand, gravel	15	660
Sand, gravel with clay	160	820
Cemented gravel	6	826
Gravel cemented with clay	14	840
Sand, gravel with clay strata	34	874
Congl. sand and gravel with clay	126	1,000
Total		1,000

(this page from White, 1963)

Whitlock Oil Co. State #1
State #1, NE¼ NE¼ 36-10S-28E, Log from ABM files
Graham County, Arizona

0 - 40	Sand
40 - 120	sand and shale
120 - 135	sand shale and water
135 - 155	brown and blue shale
155 - 165	blue shale
165 - 180	sand and water (hole full)
180 - 205	brown and blue shale
205 - 215	water sand (hole full)
215 - 230	brown and blue shale
230 - 240	water sand (hole full)
240 - 416	gray shale
416 - 640	brown and light shale
640 - 650	sandy shale (salt water)
650 - 740	brown shale
740 - 1015	blue shale
1015 - 1022	water sand (salt water)
1022 - 1045	brown shale
1045 - 1078	brown sandy shale
1078 - 1094	slight sandy shale
1094 - 1096	shells gypsum (selenite)
1096 - 1104	brown shale
1104 - 1115	light gypsum shale
1115 - 1125	sand (water)
1125 - 1165	brown shale
1165 - 1185	sand (water)
1185 - 1197	brown shale
1197 - 1208	Water sand (salt water)
1208 - 1212	blue shale
1212 - 1260	sand and gravel (salt water)
1260 - 1274	brown and green shale
1274 - 1284	water sand (salt water)
1284 - 1323	brown sandy shale
1323 - 1328	red clay (hot)
1328 - 1350	brown sandy shale
1350 - 1352	water sand (salt water)
1352 - 1363	brown shale
1363 - 1364	coarse water gravel (fresh artesian water at 1080')
1364 - 1369	fine sand (fresh art. water at 1080')
1369 - 1405	coarse water sand
1405 - 1411	conglomerate
1411 - 1422	fine sand
1422 - 1477	sand and gravel
1477 - 1614	red sandstone
1614 - 1627	hard shells
1627 - 1647	brown sandstone
1647 - 1657	hard sand
1657 - 1675	hard sand
1675 - 1695	hard sand, coarse
1695 - 1750	conglomerate
1750 - 1780	hard rock mixed with lime
1780 - 1801	brown sand rock
1801 - 1806	very hard conglomerate
1806 - 1813	conglomerate
1813 - 1814	sandstone
1814 - 1837	sandstone, 6' congl. 18'

(from AZGS files)

Whitlock No. 2. Temple Faust Penrod, permittee. Phoenix 060054. NE¼ NE¼ Section 30, T. 10 S., R. 29 E., G.& S.R.M. Drilled to depth of 513 feet with Okell combination rotary. Propose to rig up with cable tools and resume operations. Well visited April 17, 1928.

Log of Whitlock No. 2.

0	12	Cemented gravel
12	42	Quicksand
42	48	Brown clay
48	93	Brown sand
93	103	Sand with sandstone shells
103	115	Brown sand
115	130	Brown clay
130	155	Fine brown sand
155	173	Brown clay and boulders
173	193	Cemented gravel and boulders
193	198	Sandstone
198	206	Gravel
206	253	Sandy shale and shells
253	282	Sandy shale and shells
282	285	Blue shale
285	296	Blue and brown shale
296	325	Blue and brown shale with shells
325	343	Soft shale
343	373	Blue shale
373	382	Hard lime shells
382	513	Hard red rock (conglomerate)

8¼ inch casing landed at 385 feet.

5-10

(from AZGS files)

Well No. 1 - Bear Springs Oil Co. - Finn - Reed #1 - Whitlock Field

Sec. 28 - 11 S - 28 E., Graham County, Arizona

0	215	Blue Clay
215	265	Coarse gravel
265	300	Blue clay
300	350	Blue cemented gravel
350	400	Blue clay
400	450	Gray-coloured clay
450	480	Sandy blue clay
480	522	Brown clay
522	565	Gray-coloured clay
565	597	Blue shale
597	610	Gravel
610	640	Brown shale
640	660	Blue shale
660	670	Brown shale

(from AZGS files)

Funk Benevolent #1 (D-13-30-27ad)

Log of FUNK WELL, SAN SIMON, ARIZONA
Sec 27 - T-13 S - R 30 E

0 to	95 ft.	Clay and gypsum	95 ft.
95	125	water and gravel	30
125	175	clay and gypsum	50
175	180	water and gravel	5
180	394	blue clay and shale	214
394	400	yellow clay	6
400	630	blue shale and soapstone	230
630	695	brown shale, possibly little water	65
695	700	water and break	5
700	710	water sand	10
710	735	light brown shale	25
735	742	water sand, water filled hole	7
742	767	brown shale	25
767	837	blue soapstone shale	70
837	895	brown shale	58
895	905	light brown shale	10
905	1015	brown shale caved badly	100
1015	1065	water sand artesian flow	50
1065	1105	strictly red shale	40
1105	1128	water sand	23
1128	1200	sticky red shale	72
1200	1260	red sandy shale with traces of oil	60
1260	1290	water sand artesian flow 14,000 B.day	30
1290	1305	red clay	15
1305	1320	water sand, artesian	18
1320	1340	red sandy shale	20
1340	1355	red sticky shale	15
1355	1395	red sandy shale	45
1395	1415	red clay	25
1415	1460	red sandy shale	45
1460	1511	red sticky clay	51
1511	1517	sandy shale	8
1517	1525	brown sandy shale	25
1525	1550	brown shale	25
1550	1598	red shale	48
1598	1618	water sandy, artesian	20
1618	1675	red sandy shale, showing oil	57
1675	1678	water sand	3
1678	1723	red shale	49
1723	1747	red sand, considerable oil & gas	24
1747	1830	brown shale mixed	83
1830	1865	red shale caved badly	35
1865	1980	red shale mixed gravel	115
1980	1996	sand carrying some water	16
1996	2010	red sand oil colors	14
2010	2014	sand	4
2014	2020	red shale	6
2020	2030	red sand heavy oil sand at bottom	10
2030	2033	gravel seemed to carry some water	3
2033	2040	red sandy shale carrying black oil	7
2040	2044	small gravel	4
2044	2052	red shale mixed gravel	8
2052	2068	sand last 11 ft. carrying much black oil	16
2068	2103	tough hard brown and pink shale oil & gas	35

No permit

8 inch casing set formation shut off, all water 2080 ft., some gas and oil flowing continually from well between 10 & 12 inch casing, from 1720 ft. sand. 10 inc. casing cemented at 2026 ft.

****

2103	2130	red shale, some gravel showing some oil and gas	27
2130	2140	red soapstone shale	10
2140	2181	red sandy shale	41
2181	2187	conglomerate shale	6
2187	2232	red sandy shale	45
2232	2244	red snadstone, some shale	12
2244	2284	red shale	40
2284	2285	red sand more oil & gas smell	1
2285	2297	red hard sand, little water traces of oil	12
2297	2310	brown shale oil trace	13
2310	2333	red sticky sandy shale, oil & gas trace	13
2333	2353	red sticky shale, slight water, oil trace	20
2353	2367	red shale sand conglomerate	14
2367	2370	blue soapstone shale	3
2370	2407	red sand, more oil showing, gas smell	37
2407	2414	brownish red shale, oil & gas trace	7
2414	2424	red oil sand showing more oil & gas	10
2424	2430	sand little water apparently trace gas	6
2430	2460	red sand some shale, hard, oil trace	30
2460	2475	red sand some shale, hard, oil trace	15
2475	2494	red sandstone & shale	19
2494	2532	hard red sandstone	38
2532	2550	red sandy shale, oil & gas showing	18
2550	2595	brown shale " " "	45
2595	2650	hard brown sandy lime	55
2650	2664	red sand slight water " "	14
2664	2673	brown sandy lime oil and gas showing	13
2673	2685	brown shale " " "	12
2685	2692	brown lime " " "	7
2692	2698	brown shale " " "	6
2698	2704	brown lime " " "	6
2704	2730	brown shale " " "	26
2730	2754	brown sandstone " " "	24
2754	2766	brown shale	12
2766	2784	brown shale 8 inch casing set at 2772 feet	18
2784	2798	brown shale, sandy lime, oil & gas show	14
2798	2805	lime " " "	7
2805	2812	brown shale " " "	7
2812	2849	brown lime some shale " " "	37
2849	2851	hard shell " " "	2
2851	2857	brown sandy lime more	6
2857	3061	red sandstone, red lime, shale more oil & gas	104
3061	3065	brown lime showing " "	4
3065	3075	hard red sandy shale " "	10
3075	3077	hard red sandy lime " "	2
3077	3082	hard brown lime " "	5
3082	3090	hard red sandy lime " "	8
3090	3098	hard brown lime " "	8
3098	3100	hard brown sandy lime	2

No permit

3100	3104	red sandy lime showing oil & gas	4 ft.
3104	3115	red sandy lime more oil & gas	11
3115	3120	" " " " " "	5
3120	3125	red sandy shale " " "	5
3125	3127	" " " " "	2
3127	3145	" " " " "	18
3145	3158	brown sandy lime " "	13
3158	3165	hard red sandstone " "	7
3165	3195	" " " " "	30
3195	3215	" " " " "	20
3215	3220	hard red sandy lime " "	5
3220	3224	brown lime showing oil & gas, hard	4
3224	3227	hard light sandy brown lime showing oil & gas	3
3227	3232	" " " " " " " "	5
3232	3236	hard brown lime " " "	4
3236	3240	pink soapstone shale " " "	4
3240	3265	pink sandy shale " " "	25
3265	3285	brown lime shale " " "	20
3285	3310	mixed brown & blue shale " " "	25
3310	3370	red sandy shale " " "	60
3370	3392	brown sandy shale " " "	22
3392	3438	hard gray lime " " "	46
3438	3448	red sandstone " " "	10
3448	3460	brown gray shale " " "	12
3460	3471	hard gray sandy lime heavily saturated	11
3471	3477	red sandstone softer "	6
3477	3488	red sandy lime " "	11
3488	3507	hard red sandy lime " "	19
3507	3547	hard red sandstone " "	40
3547	3572	very tough rubbery brown shale "	25
3572	3586	" " " " " "	14
3586	3815	report mislayed, formation brown shale lime	229
3815	3865	reddish brown shale	50
3865	3872	hard brown lime	7
3872	3879	red sandstone little water break	7
3879	3990	red shale	111
3990	4050	red sandy shale	60
4050	4060	red water sand break	10
4060	4102	hard brown grayish sandy lime	42
4102	4106	brown shale	4
4106	4109	red sandstone	3
4109	4130	light brown sandy shale	21
4130	4152	brown sandstone	22
4152	4160	red sandstone some water	8
4160	4170	red sandy shale (6⅝ inch casing set)	10
4170	4195	hard brownish gray sandstone showing oil	25
4195	4207	brown shale	12
4207	4210	hard brown sandstone	3
4210	4325	broken sandstone	115
4325	4500	daily report mislayed	175
4500	4570	light brown sandstone	70
4570	4692	light broken sandstone	122
4692	4700	gray broken sandstone, showing more oil, gas blew slush out of bailer & burned	8

No permit

			27
4700	4727	brown broken sandstone	16
4727	4743	brown sandstone, gas burns, more gas & oil	22
4743	4765	broken brown sandstone, gas burns	33
4765	4798	red sandy shale, more oil & gas	22
4798	4820	brown sandstone " " "	55
4820	4855	hard brown sandy lime, gas burns	35
4855	4890	reddish brown sandstone " "	32
4890	4922	red broken sandstone " "	28
4922	4950	brown mixed shale, caves badly	10
4950	4960	gray sandy lime	26
4960	4986	blue & gray mixed shale gas burns more	4
4986	4990	gray sandy lime broken, some shale, gas burns	26
4990	5016	broken lime shale, mixed, hard to tell, caving in	

CASING RECORD

SIZE	DEPTH
15"	50-60 ft.
12"	650 ft.
10"	2026 ft. cemented
8"	2772 ft.
6"	4170 ft.
4-3/4"	5000 (Out now and drilling with 6")

4-3/4 casing 5187
sluffing place 5483
bottom 5628

Use permit

			14 feet
5016	5030	shale and conglomerate caved badly	50
5030	5080	light brown lime	13
5080	5093	brown shale	3
5093	5096	hard shell	
5096	5110	brown and gray sandy lime shale, carrying oil and live gas	14
5110	5126	hard grey sandy lime, showing heavy oil and live gas burned	16
5126	5210	sandy light brown shale carrying oil and live gas	84
5210	5214	sand, heavy oil and gas and burned all live gas	4
5214	5250	sand and shale mixed oil and live gas	36
5250	5255	lime with salt water that raised about 350 ft. in hole but in a few days it disappeared as they drilled and bailed	5
5255	5374	broken lime shale	19
5374	5400	sandy lime, some oil and gas	26
5400	5410	brown shale " " "	10
5410	5418	gray lime " " "	8
5418	5432	sandy lime " " "	24
5432	5464	brown shale slaked some	32
5464	5480	gray broken lime carrying oil and live gas	16
5480	5608	gray broken lime " " " "	128
5608	5662	gray broken hard lime carrying some oil and live gas	54
5662	5667	hard gray lime carrying oil and live gas	5
5667	5669	reddish gray sand, heavy oil and live gas & burned	2
5669	5680	gray broken lime shale " " " "	11
5680	5695	brown lime and shale slaking some, running in	15
5695	5738	gray lime broken a little	43
5738	5780	gray reddish sand mixed showing some oil	42
5780	5795	hard gray sandy lime	15
5795	5830	broken sandy lime shale	35
5830	5852	light brown, sandy lime. April 21 (some harder)	22
5852	5905	hard sandy lime	53
5905	5908	gray water sand with gas and good oil showing	3
5908	5996	hard sandy lime 18 in a day	88
5996	6000	broken streak of shale	4
6000	6012	hard sandy lime 18 in a day	12
6012	6014	broken streak, soft streak of shale carrying some live gas	2
6014	6040	hard brown sandy lime	26
6040	6042	softer, carrying live gas	2
6042	6050	hard sandy lime, one foot a day	8
6050	6052	softer, carrying little live gas and little oil showing	2
6052	6060	hard sandy lime one ft. a day	8
6060	6062	softer streak carrying a little live gas	2
6062	6066	hard sandy lime	4
6066	6068	softer, carrying little live gas	2
6068	6073	hard sandy lime	5
6073	6075	softer with more gas and oil showing	2
6075	6085½	hard sandy lime	10½
6085½	6087½	softer, gas burned 2 min. out of bailer	2
6087½	6099½	hard sandy lime	12
6099½	6100½	softer streak, live gas	1
6100½	6135	hard sandy lime	34½

1/16 pe mcf

6135	6147	broken formation, shale and lime started coring	12 feet
6147	6184	hard sandy lime and conglomerate	11
6184	6186	hard gray sandy lime, some live gas	2
6186	6197	hard sandy lime and conglomerate	12
6197	6200	brown shale	3
6200	6212	hard sandy lime and conglomerate	12
6212	6214	hard sandy lime, little live gas in core barrel tube	2
6214	6248	hard gray sandy lime, some conglomerate, just started into white fossilized lime with gas increasing	34
6248	6400	hard fossilized sandy lime, showing frequent little leaders of live gas and oil	152
6400	6492	gas would not burn, but more gas foam and more oil showing all hard sandy fossilized sandy lime, and would not blow water out of bailer as before	92
6492	6527	gas again became alive and burned strong out of bailer, and blew 15 to 20 ft. of water out of bailer, as above 6400 ft. hard sandy fossilized lime	35
6527	6585	gas would not burn again nor blow out of bailer, hard fossilized lime	58
6585	6643	hard fossilized sandy lime with more frequent streaks of live gas and oil, heavier or more oil and gas	58
6643	6645	quite hard sandy lime, somewhat fossilized	2
6645	6646	heavy gas and oil bearing gas and oil, interlaid with streaks of hard sandy fossilized lime	over a foot
6646 close to 6650		of very heavy gas and oil in porous sandy lime, oil flowing freely, a little over	3
little over 6651		porous sandy formation carrying salty water	1
6651	6668	very hard fossilized lime capping carrying little gas and oil	17

(from AZGS files)

Vic permit

	Thickness (ft)	Depth (ft)
(D–12–28)35cdc2		
Top soil	4	4
Caliche	4	8
Sandy clay	20	28
Clay	7	35
Sand and gravel, dry	15	50
Clay	20	70
Clay and boulders	5	75
Clay	40	115
Sand and gravel	5	120
Sand and rock, hard	15	135
Clay with sand	31	166
Blue shale, sticky	29	195
Blue clay	38	233
Sand and gravel	22	255
Shale, sticky	13	268
Gravel and boulders	7	275
Shale, sticky	30	305
Clay and shale	60	365
Shale, sticky	110	475
Sand and gravel	20	495
Gravel and sand with clay streaks	10	505
Sand and gravel	89	594
Sand and fine gravel	6	600
Boulders	15	615
Hard sand rock	5	620
Total depth		620
(D–13–28)7dbc		
Surface soil	20	20
Sand and boulders	28	48
Gravel and sand	57	105
Yellow clay	90	195
Clay and boulders	45	240
Sand	17	257
Hard boulders	59	316
Hard boulders and rock	25	341
Rock	35	376
Hard rock	24	400
Total		400
(D–13–29)6cdb		
Clay fill	165	165
Blue shale	120	285
Clay	183	468
Sand and water raised to 100 feet	14	482
Blue clay	10	492
Sand and some water	6	498
Clay and gravel	7	505
Sand and water	7	512
Sand and clay	6	518
Sand and water	8	526
Sand and clay	4	530
Sand	7	537
Sandstone	8	545
Gravel and water	23	568
Clay	10	578
Sand and gravel and clay	14	592
Sand, clay, water raised to 11 feet	36	628
Hard sandstone and clay	77	705
Hard sandstone and clay and water	55	760
Sand, gravel, clay and some water	40	800
Sand	174	974
Sand rock	37	1,011
Conglomeration of r. shale, b. shale, sand	9	1,020
Gray shale and sand	9	1,029
Bed sand with some red shale	22	1,051
Sand, hard streaks of quartz	147	1,198
Sandstone, very hard	27	1,225
Sand soft (some water)	50	1,275
Total		1,275

	Thickness (ft)	Depth (ft)
(D–13–29)28bbc		
Sandy loam	3	3
Red clay	181	184
Blue shale	26	210
Fine sand—a seep of water	1	211
Blue clay	49	260
Coarse water sand and gravel	20	280
Sandy brown clay	87	367
Coarse water sand and gravel	13	380
Sandy brown clay	25	405
Hard sand rock	2	407
Red sandy clay	18	425
Hard sand rock	1	426
Red sandy clay	54	480
Conglomerate-rock and blue clay	50	530
Blue granite rock	17	547
Blue clay	8	555
Blue granite rock	15	570
Coarse water gravel	3	573
Hard conglomerate, rock and blue clay	39	612
Coarse water gravel	3	615
Hard conglomerate, rock and blue clay	40	655
Blue granite rock	5	660
Total		660
(D–13–30)28acc		
Surface soil	4	4
Caliche	24	28
Caliche and boulders	44	72
Sand and small gravel	15	87
Clay and gypsum	113	200
Gypsum	40	240
Blue shale	408	648
Grey shale	113	761
Sand—hard	4	765
Congl. of soapstone, brown shale, little sandy	9	774
Congl. of sand, small gravel, and brown shale	14	788
Sand	2	790
Congl. of sand, quartz and shale streaks	50	840
Sand, soft, with quartz—water	12	852
Sandy quartz, hard streaks	13	865
Sand, soft with some boulders (water sand)	22	887
Sand, hard cemented with some large boulders	4	891
Sand, soft streaks, some water	39	930
Cemented sand, hard	68	998
Hard sand with blue shale streaks very thin	6	1,004
Brown shale, sandy	29	1,033
Sand gravel and granite wash, water	35	1,068
Brown shale	6	1,074
Sand, gravel and boulders	34	1,108
Rock with some broken sand (hard)	30	1,138
Rhyolite (very hard)	82	1,220
Rhyolite, boulders, quartz and some sand (white)	8	1,228
Granite boulders with some mica and brown shale	9	1,237
Shale	28	1,265
Conglomerate sand, boulders, quartz	45	1,310
Shale, red	7	1,317
Red shale and sand	16	1,333
Sand (water)	21	1,354
Total		1,354

(this page from White, 1963)

Bowie Oil Syndicate #1 (D-13-28-16bd)

LOG OF BOWIE OIL WELL NO. 1, Four miles East of Bowie, Arizona, started in 1924. Twelve miles West of San Simon Oil Well #1.

The log down to 2847 was supposed to have been stolen by the two drillers who were fired. Practically, the log was about as follows:

From top to 719 was clay and shale.
From 719 to 1619 - 38 ft. showing oil in brown sand.
2036 to 2042 was 6 ft. showing oil.
2107 to 2237 was 130 ft. of sand showing oil.
2283 to 2434 was 151 ft. of sand showing oil. The formation outside of the sands were some clay, but mostly brown, red and other colors of shale and lime, towards the last.
The first water sand was 90 ft. First artesian water sand was 600 ft. The second artesian water sand was 900 ft. Six more artesian water sands to 1100 ft.
The following is the log given by Walter M. Tuttle:

2847 to 2895 gray sand carrying considerable oil and dead gas
2895 to 2900 hard blue lime
2900 to 2918 blue broken lime - softer
2918 to 2945 green hard serpentine
2945 to 2958 hard black lime
2958 to 2972 sand showing oil and gas (dead)
2972 to 2976 blue shale oil and gas
2976 to 2995 gray sand oil and gas
2995 to 3000 blue shale
3000 to 3018 coarse sand showing oil and dead gas
3018 to 3020 break
3020 to 3048 hard gray lime
3048 to 3054 brown sandy shale
3054 to 3065 fine gray chalkey lime
3065 to 3097 sand showing oil and gas
3097 to 3180 brown lime shale
3180 to 3185 water sand
3185 to 3190 brown shale
3190 to 3210 sandy
3210 to 3276 brown hard lime
8¼ in. casing run Drill stem bent. Shut down Feb. 9, 1926.
3276 to 3285 gray soapstone
3285 to 3292 gray sandy lime
3292 to 3322 pink lime
3322 to 3326 brown lime gas and oil showing
3326 to 3354 brown lime shale
3354 to 3370 brown shale showing gas and oil
3370 to 3398 pink sandy lime
3398 to 3410 fine gray mixed sand
3410 to 3440 pink sandy lime
3440 to 3444 pink shale showing oil and gas
3444 to 3460 gray mixed sand
3460 to 3470 pink, blue, brown shale
3470 to 3480 gray hard mixed sand
3480 to 3495 pink lime shale showing oil and gas
3495 to 3500 pink lime shale
3500 to 3504 blue and pink shale
3504 to 3510 hard sand
3510 to 3520 blue and gray sandy shale
3520 to 3530 blue stickey shale
3530 to 3542 pink mixed sandy lime showing gas and oil
3542 to 3544 tough hard drilling lime
3544 to 3580 sandy lime different colors
3580 to 3585 brown shale - 3585 to 3600 shale all colors showing gas & oil (more)
3600 to 3620 gray sandy lime showing more gas and oil
3620 to 3623 gray lime shale showing more gas and oil
3623 to 3625 brown lime shale showing more gas and oil
3625 to 3682 brown sandy lime shale showing gas and oil considerable
3682 to 3605 brown sandy lime " " " " "
3705 to 3710 shale
3710 to 3713 hard gray lime
3713 to 3740 sandy lime shale showing gas and oil
3740 to 3746 blue and gray soapstone shale showing gas and oil
3746 to 3750 hard gray lime shale
3750 to 3765 blue and gray shell and sandy lime - showing gas and oil
3765 to 3777 blue soapstone shale - showing gas and oil

LOG OF BOWIE OIL WELL NO. 1 (continued)

3777 to 3790 gray sandy lime - Showing gas and oil showing
3790 to 3792 shale - Showing gas and oil
3792 to 3812 all colors sandy shale - showing gas & oil
3812 to 3820 brown shale - showing gas and oil
3820 to 3835 lime shell mixed showing gas and oil
3835 to 3845 green lime shell showing gas and oil
3845 to 3852 green lime shell - showing gas and oil

The following is the only log the Utah Petroleum Corp (Sand to be a subsidiary of all major Co.) would give us, I, S. W. Funk, was at the well every day and they went quite regularly through about 10 of gray lime and then alternating with about 10 to 15 ft. of green 10 to 15 ft of green oil honey combed oil rock heavily saturated with gas and oil.

The artesian water had been standing on the gas and oil for a year or more and the man who ran it would not let Mr. Tuttle shut the water off and test it. The above corp before drilling got a string of 6 inch casing and a control head and set it on the lime at 3852, then drilled about 25 feet into fresh sands and then swabbed the water down 1400 ft. and it begun blowing over the derrick about 20 ft. They shut it off and filled the hole with water and sent for the directors from San Francisco and Salt Lake City and again swabbed it down about 1400 ft and it again started blowing over the top of the derrick about 20 ft. They again shut it off and filled the hole with water and began drilling two shifts night and day. Before starting to drill they again put the swab on and swabbed it down 650 ft, and it again started to foam up several feet, and they shut it off and filled it with water and went to drilling. Tuttle was not on the job from 3852 and on. The log I got was as follows:

3852 to 3857 green sand - heavily saturated with gas and oil
3857 to 3858 green sand heavily saturated with gas and oil
The entire sump hole was always covered with heavy colors like a peacock.
3858 to 3861 green sand porus showing heavy oil and gas.
3861 to 3872 green sand porus showing heavy oil and gas.
3872 to 3877 green sand and little shale - showing heavy oil and gas.
3877 to 3879 green sand and shale " " " " "
3879 to 3884 green sand " " " " "
3884 to 3944 green sand and lime
3944 to 3946 green sand showing gas and oil " " " " "
3946 to 4100 green sandy lime
They stopped in gray lime. Pulled the casing up about 3 ft. and left all the artesian water in the hole again and stopped drilling.
I am positive the log they gave me is not correct for they do not give the lime and green sands alternately as I stated above as I was on the job every day and saw it tested.
This well was south of the apex or where the old gas crack 20 miles long occurred about 50 years ago, about 4 miles towards the fault line which was at that place about 4 miles from the fault line, but being on a slant towards the fault line was shallower than the San Simon Oil Well No. 1 which is close to the gas crack and apex or in the bottom of the basin.
The entire structure, according to our geologist David Gistavison is about 28 miles long and averages 8 miles wide under the great artesian water belt. The Valley is level and San Simon well is close to the center of the unbroken part of the Valley.

s/ S. W. Funk

(from AZGS files)

	Thickness (ft)	Depth (ft)
(D-14-31)16dcc		
Gray clay	61	61
Light brown clay, some pebbles	17	78
Struck first water, 74 feet, raised to 68 feet.		
Brown clay, some gravel	10	88
Gravel showing caliche	10	98
Caliche	4	102
Gray clay	8	110
Blue clay	213	323
Gray clay	49	372
Sand and some water	3	375
Blue clay	9	384
Gray clay	10	394
Brown clay	26	420
Yellow clay showing some gravel	151	571
Sand, second flow to top; bucket test 10 gpm	3	574
Brown sand	10	584
Yellow clay	56	640
Yellow clay showing some sand	10	650
Yellow sticky clay	17	667
Sand showing some black shale	1	668
Yellow clay	15	683
Water sand, small flow	10	693
Yellow clay	5	698
Gray clay	16	714
Dry water sand	2	716
Yellow sticky clay	5	721
Sand, small flow	5	726
Medium hard gray clay	5	731
Yellow sticky clay	16	747
Small flow	5	752
Yellow clay	23	775
Dry water sand	4	779
Yellow clay	17	796
Yellow clay showing brown sand	20	816
Some sand showing gravel	2	818
Yellow clay	15	833
Dry sand, very hard	12	845
Yellow sticky clay	7	852
Yellow clay and sand, no water	5	857
Yellow sticky clay	25	882
Flow to the surface, 8 gpm	3	885
Sand, no water	23	908
Sand	15	923
Sand and gravel	5	928
Very fine sand, some clay and fine gravel, cemented	812	1,740
Cemented sand and gravel up to 3 or 4 inches	25	1,765
Cemented sand and clay	10	1,775
Cemented gravel up to 2 inches	5	1,780
Cemented sand and clay	25	1,805
Cemented sand, clay and gravel up to ¾ of an inch	5	1,810
Cemented sand, clay	20	1,830
Cemented sand and gravel, not much clay	5	1,835
Fine sand and clay cemented together	165	2,000
No water was encountered below 928 feet.		
Total		2,000

	Thickness (ft)	Depth (ft)
(D-14-31)35bcc		
Top soil	108	108
Water gravel	4	112
Caliche and red clay	38	150
Red clay	30	180
Blue clay	220	400
Bentonite clay	118	518
Water gravel	2	520
Conglomerate	105	625
Water gravel	6	631
Conglomerate	47	678
Water gravel	6	684
Conglomerate	24	708
Water gravel and sand	4	712
Conglomerate	11	723
Water gravel and sand	5	728
Conglomerate	4	732
Alternating layers	18	750
Conglomerate	25	775
Gravel	5	780
Conglomerate	20	800
Total		800

	Thickness (ft)	Depth (ft)
(D-14-32)16cab		
Fill	4	4
Sandy clay	21	25
Gravel	3	28
Sandy clay	64	92
White sand	14	106
Sand rock	5	111
Sand with some clay	33	144
Gravel	5	149
Sand with some clay	52	201
Sand and gravel (water)	7	208
Hard, packed sand (some water)	22	230
Sand and gravel (water)	87	317
Sand, gravel and clay	11	328
Hard, packed sand (some water)	7	335
Sand and gravel (water)	77	412
Clay and gravel	8	420
Sand and gravel (water)	40	460
Rhyolite	5	465
Total		465
(D-13-31)21caa		
Red valley fill	55	55
Sandy shale	15	70
Sticky shale	15	85
Sandy—a little water	12	97
Gray soapy gumbo shale	38	135
Green gumbo, apple green	15	150
Gray gumbo shale	85	235
Water sand and water	8	243
Blue sandy shale	17	260
Blue gumbo shale	60	320
Light red shale with fine sand	10	330
White gumbo shale or bentonite	25	355
Light red sandy shale	15	370
Light gray shale	3	373
Light red conglomerate gravel—some sand	47	420
Conglomerate	20	440
Conglomerate, gravel, sand with clay	466	906
Rhyolite	374	1,280
Total		1,280
(D-14-31)3aba		
Soil, clay and gravel	80	80
Sand, gravel and clay layers	80	160
Blue, brown and green clay	240	400
Sand, gravel and clay layers	335	735
Total		735

(this page from White, 1963)

ID 2-14

LOG OF STATE DEEP ARTESIAN TEST WELL — COCHISE COUNTY
8 Miles SE of San Simon Oil Well No. 1 State

SW-SE-16-14S-31E
175 Ft. of stove pipe 16 in.; 1189 ft. of 10 in. casing in the well, 40 lb. weight; 1592 ft. of 8 in. casing

0	61	gray clay
61	68	light brown clay, some pebbles
68	78	light brown clay, some pebbles
78	88	brown clay, some gravel
	Struck first water 74 ft. raised to within 68 ft. of top	
88	98	gravel showing caliche
98	102	caliche
102	110	gray clay
110	323	blue clay
323	372	gray clay
372	375	sand and some water
375	384	blue clay
384	394	gray clay
394	420	brown clay
420	571	yellow clay showing some gravel
571	574	sand, second flow to top; gauge about 4 lbs test. bucket test 10 gal. per min.
574	584	first showing of oil in brown sand
584	591	yellow clay
591	640	yellow clay
640	650	yellow clay showing some sand
650	657	yellow sticky clay
657	667	yellow sticky clay
667	668	sand showing some black shale, light flow to surface
668	683	yellow clay
683	693	water sand, small flow
693	698	yellow clay
698	706	gray clay
706	714	gray clay
714	716	dry water sand
716	721	yellow sticky clay
721	726	sand, small flow
726	731	medium hard gray clay
731	747	yellow sticky clay
747	752	small flow
752	775	yellow clay
775	779	dry water sand
779	796	yellow clay
796	816	yellow clay showing brown sand (oil showing)
816	818	some sand showing gravel
818	833	yellow clay
833	845	dry sand very hard, no water
845	852	yellow sticky clay
852	857	yellow clay and sand, no water
857	882	yellow sticky clay
882	885	flow to the surface, 8 gal. per min.
885	908	sand no water
908	923	sand
923	928	sand and gravel
928	1007	sand
1007	1012	sand, gravel, some red clay and sand
1012	1020	some sand showing blue clay
1020	1034	granite sand
1034	1091	sand
1091	1212	red clay some gravel
1212	1243	dry sand
1243	1253	blue clay and some sand
1253	1293	yellow sticky clay
1293	1307	very fine running sand
1307	1402	very fine running sand
1402	1405	gray clay
1405	1406	white lime
1406	1410	very sticky clay

Log of State Deep Artesian Test Well: COCHISE COUNTY

1410	1425	caliche or white lime
1425	1460	fine running sand
1460	1468	sticky clay
1468	1550	fine sand
1550	1566	yellow clay
1566	1610	sand and clay showing granite and lime pebbles
1610	1645	clay and sand

The log from now on was furnished later in full but does not fully correspond to the above and the following is given:

928	1740	very fine sand, some clay and fine gravel cemented together in places and sand heaved up in casing when casing was moved.
1740	1765	cemented sand and gravel up to 3 or 4 inches, coarse material encountered
1765	1775	cemented sand and clay
1775	1780	cemented gravel up to 2 in.
1780	1805	cemented sand and clay
1805	1810	cemented sand, clay and gravel up to 3/4 of an inch
1810	1830	cemented sand, clay slightly darker than before, and more of a brown color
1830	1835	cemented sand and gravel, not much clay, gravel up to 2"
1835	2000	fine sand and clay cemented together

About 10 different water stratas were encountered, some of these did not flow, coming up to within about to the top of the casing. No water was encountered below 928'. Original samples of formation can be seen by calling at the University of Tucson, Arizona.

P.S. It is believed by oil men that a number of the formations called clay were shale since the driller was not an oil driller previously. The heaving up of the sand was possibly gas pressure, from those who saw it.

According to the Bowie Well, the cementing together of the sand mentioned, possibly might be the same as the porus oil sand found in the Bowie Well. It has been told by local residents that other oil sands were found in this well with good oil showing.

s/S. W. Funk

(from AZGS files)

Artesian well in town of San Simon. Northeast corner W½ NW¼ Section 31, T. 13 S., R. 31 E., G. & S.R.M. Drilled to depth of 860 feet. (Date drilled not available).

2-6

Log of Well.

0	65	Soil and clay
65	70	Clay
70	145	Sand and gravel; water raising to within 65 feet of surface.
145	575	Blue clay and shale foul water
575	576	Fine sand small flow of water to surface
576-	660	Joint clay, gray
660	662	Fine sand small flow of water to surface
662	700	Yellow clay with caliche pebbles.
700	705	Coarse sand
705	770	Caliche and clay
770	778	Coarse sand - no water
~~xx~~778	845	Hard clay and conglomerate
845	860	Coarse sand flowing 125 gal.water per min.

8-5/8 inch casing in hole.

Ryan, et al Well — Notes from Bob Thomas reports

COCHISE COUNTY

SE¼ NW¼ Sec. 34, T. 14 S., R. 30 E. 9 miles S. of San Simon, at mouth of wood canyon

Using Okell "K" Rotary. Has 15 sections of state land under lease and 7,680 acres govt. land. Drilled Sept. 1930 to Feb. 1931.

Log is a rough recapitulation of the Bob Thomas report.

0	404	Valley fill, 8¼" casing set to 404'
460		Drilling in hard sand
520		"Heavy showings of oil and gas". From 360' encountered 23 gas pockets.
650		"Drilling for 6¼" casing"
700		Passed from thick bed of conglomerate into sandy limestone. Gas and "cats eye showings" encountered.
850		In conglomerate, bottom of conglomerate encountered below above ls.
930		In sandy hard limestone with stratas of hard shale
990		In lime conglomerate.

(from AZGS files)

#27

Fitzwater-Thayer #1
San Simon Valley
Sec. 6, T. 14 S., R. 31 E.
By L. A. Heindl

COCHISE COUNTY

Sample - Washed ditch Samples from 200'-1750'	50% under 2 mm. 50% over 2 mm. Under 2 mm: generally well rounded. Sand grains, also some angular fragments, probably broken by drilling. Over 2 mm: No well rounded, some subangular, mostly sharply angular. Occasional pebble fragments with one surface rounded, the rest angular. Material predominantly volcanic, few granitic, few Paleozoic. Alluvial fill - volcanic wash.
Core samples-unknown depth.	
#1	Yellow gray, volcanic tuff, some fragments up to 1". Bedding horizontal?
#2	Yellow gray volcanic tuff.
#3	Pinkish, yellowish volcanic tuff.
#4	Pinkish volcanic tuff-many coarse fragments.
#5	Pink volcanic breccia, some quartzite.
#6	Pink volcanic breccia.
#7	Gray-brown volcanic breccia, much secondary crystalline calcite. 2" max.
#8	Volcanic breccia underlying coarse gray tuff. Contact dip about 10°.
#9	Pink gray breccia.
#10	Pink gray breccia, no calcite.
#11	Pink gray breccia, no calcite.
#12	Pink gray breccia, no calcite.
#13	Tightly cemented gray breccia, some epidotization.
#14	Dark gray vesicular basalt, calcite zeolites.
#15	Dark gray vesicular basalt, calcite zeolites.
#16	Coarsely fractured dark gray felsite with heavy calcite veining along fractures. May be a coarse breccia.
#17	Volcanic breccia, dark gray or coarsely fractured felsite.
#18	Fractured dark gray felsite.
#19	Coarse pale reddish brown breccia. (Fractured rhyolite porphory?).
#20	Pale reddish brown rhyolite porphory.
#21	Pale reddish brown rhyolite porphory.
#22	Pale reddish brown rhyolite porphory.
#23	Sample from 4100+ depth. Fractured dark gray felsite. Some evidence of very high angle. (75-80°) flow lines, if cores vertical.
#24 - 4100+	Same as #23.
Sample from 4100+	Same as #23.

Notes: These samples were checked by "Red" LaMance, of San Simon Petroleum Co., Douglas, who was the driller on the Fitzwater well. From memory, he indicated the following, along with his interpretation of the cores.

Above 2800' ±	Cores 3 and 4	"Valley fill".
2800' ±	Core #8	"Bottom of valley fill".
Between 2800' and 3000'	Core #15	"First solid formation".
About 3100'	Core #19	"Cemented gravel".
3160'+ to 3200'±	Core #18	"Massive shale".
3200-3300	Core #21	"Tight brown shale".
3300 to near bottom	Core #18	"Shales".
Bottom of hole	Core #23	"Shale".

(from AZGS files)

WELL SAMPLE
Lab No. 470 U.S.G.S. - GW
Field or Owner's No. 3-S. Simon
Well Loc. No. (D-14-32)16 cab
Map
General location 10 mi SE San Simon
Cochise County, State of Ariz
NW ¼ NE ¼ SW ¼ sec. 16, T. 14 N, R. 32 E W
Driller
Owner El Paso Gas
Type well: (WW) TH GW, Other
Rotary, (Cable) Dug. Hole diam.
Depth TD 465 WL 200
Water at to Material

Collected by John Allison Date 4-24-57
Partial collection: Yes? No
Missing samples
Number boxes in lot

Procedure and disposition
Wash, Meg analysis, Detailed analysis
Samplex 1 or 2; Envelopes & box
Estimate fines from to
Calculate fines from to

Casing Record
Size from to Length
Size from to Length
Size from to Length

Finish
Perf. size: x from to
Slot size: x from to
Screen size: x from to
Open hole: Diam. from to

REMARKS AND LOG ON REVERSE

Driller's Log

0 - 4' - fill
4 - 25 - sandy clay
25 - 28 - gravel
28 - 92 - sandy clay
92 - 106 - white sand
106 - 111 - sand rock
111 - 144 - sand w/ some clay
144 - 149 - gravel
149 - 201 - sand w/ some clay
201 - 208 - sand & gravel (water)
208 - 230 - hard packed sand (some water)
230 - 317 - sand & gravel (water)
317 - 329 - sand, gravel & clay
329 - 335 - hard packed sand (some water)
335 - 412 - sand & gravel (water)
412 - 420 - clay & gravel
420 - 460 - sand & gravel (water
460 - 465 - red granite

(from AZGS files)

No. 1 TEST WELL - PORTAL DRILLING CORPORATION

Located: Section 9, Township 16 S., R. 31 E., G&SRB&M., Cochise County, Arizona

From:	To:	Formation:
2799	2809	Lime
2809	2816	Lime Sand
2816	2823	Lime
2823	2835	Sandy Lime (White)
2835	2841	Lime
2841	2847	Diatomaceous Clay - Mud Temperature 120°
2847	2868	Sandy lime
2868	2876	Lime Shale, (White)
2876	2893	Lime
2893	2900	White Lime Sand, hard - Mud Temperature 112°
2900	2906	Lime
2906	2912	Lime - Shale
2912	2918	Hard Lime, White - Mud Temperature 120°
2918	2923	Lime
2923	2928	Sandy Lime
2928	2938	White Lime - Hard - Mud Temperature 120°
2938	2953	Lime - Mud Temperature 120°
2953	2962	Shale & Lime (Red Shale at 2962, soft and sticky)
2962	2968	Shale - Lime
2968	2979	Lime & Shale - Mud Temperature 120°
2979	2983	Lime - Sand. Cuttings settle rapidly
2983	2996	Lime - Mud Temperature 120°
2996	3005	Lime and Shale. Hole caving badly at 2996' Mud pumped behind casing.
3005	3010	Sandy lime
3015	3050	Red Sandy Lime (3050, Light Shale)
3050	3059	Red Shale
3059	3070	8-5/8" Casing - Under-reaming
3070	3075	Red Sandy Shale
3075	3082	Red Shale
3082	3090	Shale - Shells
3090	3103	Sandy Shale - Slight rainbow, 3103'. Under-reaming 3103'
3103	3109	Brown Lime, Hard
3109	3141	Sandy Lime
3141	3147	Sand
3147	3152	Sandy lime - hard & sharp
3152	3157	Sand
3157	3159	Shale
3159	3170	Sand
3170	3180	Brown sand
3180	3185	Sandy lime
3185	3191	Sand
3191	3219	Red Sand

(from AZGS files)

LOGS OF DRILL CUTTINGS IN AZGS REPOSITORY

Logged by RCH, 1996

The following are logs of drill cuttings in the Arizona Geological Survey cuttings repository. Although the cuttings can be quite useful, these points need to be kept in mind:

- The cuttings generally reflect an average or composite sample over an interval of anywhere from five to fifty feet. Any bedding or changes in lithology of a finer scale than the sample interval are lost in the mix.
- The samples are commonly washed, or dipped from a container with water present. Thus, some or all of the fines, and soluble minerals like salt, may have been removed, making the samples not truly representative. Information on sampling methods are generally not available, and methods vary widely among drillers.
- Sloughing or caving of a layer can contaminate samples below that layer, especially if the drill stem is raised above the layer or removed as in changing a bit. During drilling, loose material may be dislodged by friction with the drill stem or by circulating fluids and become mixed with cuttings from the current depth.
- There is a physical limit on the size of particle that can make it into the small sample vials, so some coarser material may not be represented.
- Commonly, samples are not taken over the entire depth of a hole, so some intervals are missing.
- Color of the cuttings is largely a judgment call and varies from person to person and with lighting conditions.
- Some cuttings were not logged if detailed logs were already available in AZGS files.

Soto **D-3-22-31c** AZGS file #210; drawer B-10; 62 samples, 230-870 ft.

0 - 230	no samples
230 - 470	clay, silt; light brown; weakly consolidated; mod to strong fizz with acid
480 - 510	1/2 light brown clay, silt; 1/2 white limestone
520 - 550	clay, silt; light red-brown; minor limestone; strong fizz
560 - 870	white limestone, partly recrystallized to clear; minor clay marl; minor gypsum
730'	

Pool at Calva **D-3-21-9d** AZGS file #211; drawer B-10; 17 samples, 70-240 ft.

0 - 70	no samples
70 - 80	gravel
80 - 90	sand and gravel
90 - 130	silt; light brown; strong fizz
130 - 140	medium sand
140 - 200	silt; light brown; strong fizz
200 - 210	sand and gravel
210 - 240	silt; light brown; strong fizz

Safford City Well D-6-28-5bcd AZGS file # 694; drawer C-47; 16 samples, 85-173 ft.

0 - 85	no samples
85- 173	coarse sand to med gravel (volc rocks); no fines

Smithville Canal Co. D-6-25-36cbb AZGS file # 495; drawer C-78; 79 samples, 235-2160 ft.

0 - 235	no samples
235 - 423	silt to fine gravel (mostly volc); dark brown-gray; very poor sample return
450 - 701	silt to fine sand; unconsolidated; strong fizz; very poor sample return
701 - 825	fine to coarse sand; minor fine gravel
850 - 1650	anhydrite/gypsum; minor silt; no fizz with acid; no limestone or salt noted
1650 - 2160	volc rocks

Whitmore #1 State D-7-25-6caa AZGS file # 4298; drawers P-14, 15; 73 samples, 10-760 ft.

0 - 10	silt to fine sand; med-dark brown; strong fizz
20 - 40	med sand, mostly qtz; light brown
40 - 50	silt, minor sand; brown; strong fizz
50 - 60	fine sand, mostly qtz; light brown
60 - 70	silt; light gray; minor sand; very strong fizz
70 - 100	silt to fine sand; brown; very strong fizz
100 - 760	clay, silt; gray-brown, red-brown below 200'; strong fizz; slightly salty (??) 740'

City of Safford D-7-25-27dad AZGS file # 2298; drawer F-12; 88 samples, 130-1396 ft.

0 - 130	no samples
130 - 140	silt to very fine sand; abundant mica; very strong fizz
140 - 160	fine sand (mica +qtz); light gray brown; strong fizz
160 - 230	silt and fine sand, minor clay; light gray; abundant mica +qtz; very strong fizz
230 - 240	silt and sand; gray-brown; weakly consolidated; strong fizz
240 - 270	clay, silt, minor very fine sand; gray-brown; strong fizz
270 - 300	fine sand, some silt; strong fizz
300 - 310	clay-silt; brown; strong fizz
313 - 1206	silt-clay; brown; minor white gypsum slivers throughout ; strong fizz
1206 - 1396	fine sand (qtz + mica); light brown; very poor sample return

No Name D-7-26-26aaa AZGS file # 1580; drawers D-47, 48; 79 samples, 250-2240 ft.

0 - 250	no samples
250 - 260	sand to fine gravel (granitic/gneissic)
260 - 500	no samples
500 - 510	sand, fine to coarse (granitic/gneissic)
510 - 1035	no samples

APPENDIX C

LOGS OF WELLS WITH CUTTINGS
IN THE AZGS CUTTINGS REPOSITORY

1035 - 1080	sand, silt-clay; poor sample return
1080 - 1110	sand, clay-silt with clear and white gypsum; poor sample return
1110 - 1570	gypsum (selenite common); minor clay, silt; minor sand
1570 - 2240	clay-silt; strong fizz; mod consolidated; brown-gray; gypsiferous; very salty - salt crusts and disseminated salt crystals in clay 1895, 1925, 1970, 2015,2060 - pure salt or clayey salt at 2075, 2090, 2105, 2120-2150,2195-2225

Ann Chlarsen D-8-26-6cbc AZGS file # 496; drawer C-78; 58 samples, 10-651 ft.

10 - 96	clay-silt; red-brown; very weak fizz
107 - 160	clay-silt; gray; very strong fizz
160 - 172	silt-clay; brown; very strong fizz
172 - 239	clay-silt; gray, very strong fizz
250 - 282	silt-clay; brown
282 - 651	clay-silt; tannish gray to gray-tan; strong fizz

R R #6 D-8-26-7dda AZGS file #1701; drawer E-19; 80 samples, 19-1382 ft.

0 - 19	no samples
19 - 59	fine silt; light brown; unconsolidated; weak fizz with acid
73 - 133	silt, clay; tuffaceous (?); med gray
133 - 223	quartz sand; gray
223 - 269	silt; light gray-brown; weakly consolidated; mod fizz
269 - 319	quartz sand; gray
319 - 334	clay, silt, minor sand; med brown-gray; tuffaceous (?); strong fizz
349 - 364	quartz sand; gray
364 - 379	silt, abundant mica; tuffaceous (?); med brown-gray; weak fizz
379 - 810	fine to coarse sand
810 - 1331	silt, minor gray tuff; med brown; mod fizz
1331 - 1336	light gray tuff, some brown silt
1336 - 1352	silt; brown
1352 - 1382	sand; brown

Cactus Flat - R R #2 D-8-26-8acc AZGS file #1502; drawer D-20, 54 samples, 0-829 ft.

0 - 122	tan silt-clay; strong fizz
122 - 137	fine to med sand, granitic/gneissic
137 - 182	tan silt-clay; strong fizz
182 - 212	1/2 brown-gray sand; 1/2 tan silt-clay; mod fizz
212 - 287	silt-clay; light brown; mod fizz
287 - 423	silt-clay; gray; very strong fizz
423 - 483	silt-clay; light brown; strong fizz
483 - 498	silt to fine sand; gray-brown; strong fizz
513 - 543	fine sand; gray

543 - 829 clay-silt; brown-gray; strong fizz

R R #5 D-8-26-8bdd AZGS file # 1708; drawer E-18; 46 samples, 0-1399 ft

[note: many intervals not sampled]

0 - 19	fine sand; gray
19 - 61	silt-clay; tan; mod strong fizz
76 - 106	sand; gray to brown
121 - 136	silt; brown; no fizz
136 - 151	med sand; brown-gray
151 - 166	fine sand, minor silt; weak fizz
166 - 181	clay-silt; red-brown; weak fizz
181 - 272	silty clay; gray brown; weak fizz
272 - 287	clay-silt; red-brown; weak fizz
287 - 377	clay-silt; gray-brown; very weak fizz
377 - 392	clay-silt; red-brown
392 - 407	sand to fine gravel; gray
407 - 431	sand, minor clay-silt; gray-brown
482 - 497	clay; gray-brown; strong fizz
497 - 512	sand, med to coarse; gray
542 - 573	silty clay; brown-gray; strong fizz
603 - 618	sand, med to coarse; gray-brown
633 - 678	clay-silt, minor sand; gray; very strong fizz
693 - 708	med sand, granitic/gneissic, mostly qtz; gray
723 - 798	silty clay, some med sand; gray-brown; very strong fizz
798 - 813	med sand, granitic/gneissic, mostly qtz; gray
813 - 1098	silt-clay; gray-brown; strong fizz
1098 - 1113	fine sand to fine gravel; granitic
1248 - 1384	clay-silt; brown; very strong fizz
1369 - 1384	fine to med sand
1384 - 1399	clay-silt; brown; very strong fizz

R.G. Layton D-8-26-33cdcd AZGS file # 2306; drawer F-11; 38 samples, 0-1200 ft.

0 - 50	fine to med sand; light brown
50 - 90	silt to very fine sand; tan
90 - 420	silt; tan-gray; weak fizz
420 - 450	silt to med sand; brown-gray; weak fizz
450 - 475	silt to mod sand, tuffaceous (?); gray; mod fizz
475 - 1060	silt to fine sand, tuffaceous (?); brown-gray; mod fizz
1060 - 1200	silt, minor very fine sand; tan; mod fizz

BLM D-8-28-29dbd AZGS file #2930; drawer I-46; 61 samples, 5-600 ft

0 - 5	very fine sand
10 - 20	med to coarse sand
30 - 60	fine sand
70 - 100	silt-clay; light gray; mod to strong fizz
110 - 120	gravel
130 - 140	silt-clay; gray (tuff?)
140 - 150	gravel, fine sand
160 - 350	silt-clay; light gray to tan-gray; (tuffaceous?)
360 - 600	fine to coarse sand, some gravel; (looks more volcanic than granitic)

El Paso Natrual Gas D-9-26-5b AZGS file #2940; drawer I-43; 20 samples, 20-400 ft.

20 - 400	clean sand, granitic/gneissic; fine to coarse

Phillips #A-1 Safford D-9-26-16ab AZGS file #4207; drawer N28-30; 618 samples, 45-8380 ft.

45 - 8380	sand to fine gravel; granitic/gneissic; remarkably uniform grain size, color, and composition throughout. (samples have been washed, so no fines are present ?)

Tenney #2 State (?) D-9-27-36dc AZGS file #2945; drawer I-45,46; 268 samples, 280-3480 ft.

[Note: samples may be a composite from Tenney #1, #2, and #3 ??]

0 - 280	no samples
280 - 470	sand, fine gravel; gray
470 - 530	clay; gray
530 - 570	clay with abundant gypsum; gray
570 - 830	clay, anhydrite, gypsum; gray [anhydrite starts at 1200' in Tenney #3]
830 - 3470	anhydrite, minor clay and gypsum [T.D. Tenney #1: 630' (supposedly not sampled), Tenney #2: 1090'] [salt not seen in this set of samples as is present in Tenney #3 samples - very suspicious] [samples below 1090' must be from Tenney #3]
3470 - 3480	clay, decreasing anhydrite; gray

No Name D-13-28-14cbd AZGS file #1875; drawer E-22; 18 samples, 815-1000 ft.

0 - 815	no samples
815 - 1000	sand, fine to coarse; poorly sorted, granitic; light brown-gray

Jones Enterprises D-13-28-15dcc AZGS file #1823; drawer E-15; 43 samples, 180-805 ft.

0 - 180	no samples
180	2/3 silt to very fine sand; 1/3 gravel; gray; strong fizz with acid
190 - 250	clay, silt, minor sand; brown-gray; mod wk fizz
250 -260	clay, silt, 1/4 gravel; light gray
260 - 280	clay, silt; tuffaceous; lt gray; strong fizz
280 - 300	clay, silt, some gravel; lt brown-gray; mod strong fizz
300 - 310	clay, silt, minor gravel; med brown
320 - 335	silt to sand; lt gray; caliche cement or calcic paleosol (?)
335 - 360	clay, silt; lt brown-gray
360 - 535	no samples
535 - 555	silt to sand; lt brown; mod fizz
555 - 715	fine to med sand; lt brown; granitic
715 - 765	very fine to med sand, minor silt; weak fizz
775 - 795	fine to coarse sand; granitic
795 - 805	silt to sand; weak fizz

San Simon School D-13-31-30c AZGS file #3972; drawer N-4; 23 samples, 400-625 ft.

0 - 400	no samples
400 - 500	sand, silt; brown
500 - 520	silt, fine sand; lt brown
520 - 540	sand, minor silt; lt brown
540 - 625	clay, silt, sand; brown

Fitzwater #1 D-13-31-31-dca AZGS file #27; drawer A-5; 264 samples, 1733-4100 ft.

0 - 1733	no samples
1733 - 1788	sand and clayey silt; weak to mod fizz
1788	bedrock contact
1788 - 4100	volcanic rock fragments

Arizona Oil and Gas Development #1 State D-14-30-36aad AZGS file 337; drawer A-23; 249 samples, 0-7580 ft.

0 - 7580	Volcanic rock fragments

D.W. Conway **D-14-31-34acc** AZGS file #1029; Drawer D-48; 50 samples, 490-1000 Ft.

0 - 490	no samples
490 - 1000	tan silt-clay; minor sand; strong fizz

Barnes **D-14-32-19daa** AZGS file # 1722; drawer E-20; 61 samples, 0-755 ft.

0 - 170	sang and gravel
170 - 315	silt-clay; brown-gray; some sand; strong fizz
315 - 340	sand and gravel
340 - 380	silt-clay; light brown; weak fizz
380 - 440	sand and gravel
440 - 450	silt-clay; brown; strong fizz
450 - 460	silt-clay; strong fizz
460 - 470	silt-clay; brown; strong fizz
470 - 485	sand, gravel, brown silt
485 - 550	silt-clay; brown; strong fizz
560 - 625	sand and gravel
625 - 660	clay-silt; brown-gray; minor sand; strong fizz
660 - 690	clay-silt; brown; minor sand; strong fizz
690 - 720	sand, fine gravel
720 - 755	clay (tuff?); brown-gray; no fizz

BLM **D-15-32-27dcc** AZGS file #2603; drawer H-20; 20 samples, 0-200 ft.

0 - 20	fine sand; lt brown
30 - 50	sand to gravel; dark brown
50 - 60	white tuffaceous marl
70 - 200	sand to gravel