DOE/MC/31063 -- 5692
(DE97005417)

Greater Green River Basin Production Improvement Project Phase I: Site Characterization Report

Topical Report
May 1996

By
B. Blakeney DeJarnett
L.F. Krystinik
R.H. Mead
S.C. Poe

Work Performed Under Contract No.: DE-AC21-95MC31063

For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
Morgantown Site
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
Union Pacific Resources Company
P. O. Box 7
Fort Worth, Texas 76101-0007

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Greater Green River Basin Production Improvement Project
Stratos Site Characterization Report

Abstract

Several tight, naturally-fractured, gas-productive formations in the Greater Green River Basin (GGRB) in Wyoming have been exploited using conventional vertical well technology. Typically, hydraulic fracture treatments must be performed in completing these wells to increase gas production rates to economic levels. However, with the maturation of horizontal drilling technology hydraulic fracture treatments may not be the most effective method for improving gas production from these tight reservoirs. Horizontal drilling technology may be particularly well suited to reservoirs where hydraulic fracturing is inefficient either because hydraulic fractures are parallel to natural fracture strike and/or because these natural fractures are poor stress barriers to limit excessive hydraulic fracture height growth.

Two of the most prolific tight gas reservoirs in the Green River Basin, the Frontier and the Mesaverde, are candidates for the application of horizontal well completion technology. Several horizontal completions have already been implemented in the Wamsutter Arch area as an alternative to vertical, hydraulically-fractured wells (e.g., Amoco Champlin 254-B2-H in T20N-R93W, completed in January 1994). It is estimated that 5 to 10 additional horizontal wells will be drilled for the Mesaverde within the next several years. The objective of the proposed project, however, is to apply the DOE's technical concept to the Second Frontier Formation on the western flank of the Rock Springs Uplift. This area has not been tested with alternative completion technology (i.e., horizontal drilling) and the marine blanket and fluvial lenticular reservoirs characteristic of the Second Frontier represent a prime candidate for a DOE demonstration project that would compare production improvements by drilling, completing and testing vertical, horizontal and directionally-drilled wells.

Previous industry attempts to produce in commercial quantities from the Second Frontier Formation west of the Rock Springs Uplift have been hampered by lack of understanding of both the in-situ natural fracture system and lack of adequate stimulation treatments. Developing techniques to more efficiently improve exploitation efficiencies in the Second Frontier has potentially high rewards because the potential recoverable gas resource in the Deep Frontier is large, with gas-in-place ranging from 10 to 25 BCF per 640-acre section. A successful demonstration of the economic feasibility of multiple lateral drilling will accomplish the principal objective established by the DOE for the proposed project: to reduce the technical risks and economic uncertainty standing in the way of increased efficient industry development of the low permeability (tight) gas resource of the GGRB, Wyoming.

The proposed technical approach involves drilling a vertical characterization well to the Second Frontier Formation at a depth of approximately 16,000 ft. from a site located about 18 miles northwest of Rock Springs, Wyoming. Logging, coring, and well testing information from the vertical well will be used to design a hydraulic fracturing treatment and to assess the resulting production performance. Data from the vertical drilling phase will be used to design a 2,500 to 3,00-ft. lateral wellbore which will be kicked off from the vertical hole and extend into the blanket marine sandstone bench of the Second Frontier Formation. The trajectory of this wellbore will be designed to intersect the maximum number of natural fractures to maximize production rates. Production testing of the resulting completion will provide an assessment of reserve potential related to horizontal lateral completions.

In a potential additional phase of the project, a high-angle wellbore will be kicked off from the vertical well to intersect compartmentalized lenticular fluvial sandstones in the upper sandstone bench of the Second Frontier Formation. Production testing of this wellbore will provide an assessment of reserve potential related to high-angle wellbore completions in somewhat discontinuous sandstone reservoirs.

A final report will be issued documenting the relative economic merits, including costs and recoveries, for each drilling scenario. The economic benefits of multiple lateral drilling will also be compared to the costs of drilling vertical wells to accomplish similar production rates in the deep Second Frontier Formation.

Acknowledgments

Many Union Pacific Resources personnel have been involved in this project since its inception, and we would like to acknowledge their efforts. These individuals include Stan Lewis (geology), Keith Nosich (engineering), Craig Cipolla (engineering), Dave Kyte (engineering), Frank Lim (contract administration and engineering), Mark Podell (geology), Nathan Meehan (engineering), and Mark Schoomaker (geophysics).

Tireless technical support was provided by Barbara Richardson (geology, petrography), Tad Taylor (SEM photomicrographs, geology), and Steve Walker (geology). Dave Kinkel and James Vasquez of Union Pacific Resources' Graphics Department enthusiastically created or enhanced all of the figures for this report, and Patti Dougharty and Angel Renteria of Union Pacific Resources' Graphic Reproduction Department cheerfully compiled the report.

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1. Introduction

The Greater Green River Basin (GGRB) of Wyoming has produced abundant oil and gas out of multiple reservoirs for over 60 years, and large quantities of gas remain untapped in tight gas sandstone reservoirs. Recent gas resource estimates for low permeability Cretaceous and Tertiary reservoirs in the GGRB range from 1,968 TCF in place (the Scotia Group) to 5,064 TCF in place (U. S. Geological Survey) (DOE Topical Report by the Scotia Group, 1993). Current activity, including the Greater Green River Basin Production Improvement Project, is focusing on ways to convert this vast resource into economically recoverable gas.

Even though GGRB production has been established in formations from the Paleozoic to the Tertiary, recent activity has focused on several Cretaceous reservoirs. Two of these formations, the Almond and the Frontier Formations, have been classified as tight sands (permeabilities <0.1 millidarcy) and are prolific gas producers in the GGRB. The formations are typically naturally fractured and have been exploited using conventional vertical well technology. In most cases, hydraulic fracture treatments must be performed when completing these wells to increase gas production rates to economic levels. However, hydraulic fracture treatments may not be the most effective method for improving gas production from these tight reservoirs. With the maturation of horizontal drilling technology it has become apparent that horizontal drilling may be particularly well suited to reservoirs where hydraulic fracturing is inefficient either because hydraulic fractures are parallel to natural fracture strike and/or because encasing shales are poor stress barriers to limit excessive hydraulic fracture height growth.

Several horizontal completions have been made in the Almond Formation in the Wamsutter Arch area (i.e. Amoco Champlin 254-B2-H in T20N-R93W), and several more horizontal completions are planned as alternatives to vertical, hydraulically-fractured wells. The purpose of this project is to apply alternative completions technology (i.e. horizontal drilling) to the Second Frontier Formation on the western flank of the Rock Springs Uplift (Fig. 1), and to compare production improvements by drilling, completing, and testing vertical, horizontal and directionally-drilled wellbores at a common site.

1.1 Objectives of the project and technical approach

The objective of the Greater Green River Basin (GGRB) production improvement project is to assess the technical and economic feasibility of multiple lateral completion technology in the fluvial and marine sandstones of the deep Second Frontier Formation located in the GGRB, Sweetwater County, Wyoming.

The technical approach involves the drilling of a vertical characterization well to the Second Frontier Formation in the deep basin located between the Rock Springs Uplift and the Moxa Arch in southwest Wyoming. Following complete characterization, stimulation and testing of the Second Frontier marine sandstone bench and the overlying fluvial sandstone bench from the vertical wellbore, a horizontal wellbore will be initiated from the characterization well in the marine bench of the Second Frontier. Following evaluation of the lateral wellbore, a slant wellbore will be initiated in the fluvial sandstone.

The project is subdivided into several phases. Optional phase 3 will be performed subject to mutual agreement between DOE and UPR regarding final technical design and feasibility. Each phase is described as follows:

Phase 1: The objective of Phase 1 is to complete the permitting process, geologic characterization and NEPA reporting for a wellsite location in Section 24, T22N-R107W, Sweetwater County, Wyoming.

Phase 2: The objective of Phase 2 is to drill, complete and test a vertical wellbore in the Second Frontier Formation. With appropriate approval, a road and well location will be constructed in early 1995. Drilling of this well is anticipated to begin in August 1995. The wellbore will be designed with a 12.5 " casing string to total depth to facilitate the kickoff of the directionally-drilled lateral to be emplaced in the Second Frontier in subsequent optional phases. The information from the vertical well will be used to further characterize the site geology, rock quality, natural fractures, stress directions and gas productivity in support of the subsequent phases of the project. The results of Phase 2 will be documented in a topical report and presented at appropriate technology transfer workshops.

Phase 3a: The objective of Phase 3a is to design, drill, test and evaluate the effectiveness of a horizontal lateral which will be directionally kicked-off from the existing vertical well in the marine sandstone bench of the Second Frontier. The lateral will be normal to the strike of the prevailing natural fracture trend. A comparison of the completion effectiveness of the horizontal lateral and the vertical, hydraulically-fractured well will be made and documented in a topical report. Project results will be presented at an appropriate technology transfer workshop.

Phase 3b: The objective of Phase 3b is to design, drill, test and evaluate the effectiveness of a high-angle lateral which will be drilled in the lenticular reservoirs of the fluvial bench of the Second Frontier at a separate location. The high-angle wellbore will be normal to strike of the prevailing fracture trend and will intersect several discrete sandstone bodies. Phase 3b results will be documented in a topical report and a cumulative comparison of the completion effectiveness of the vertical, dual-horizontal laterals, and the high-angle completions will be made an documented in a final report. If warranted, project results will be presented at an appropriate technology transfer workshop.

1.2 Location of the selected site for the project

The site has been designated the Stratos site and is located in Section 24, T22N-R107W, Sweetwater County, Wyoming. The location of the well is shown in figure 1, and is located in the central part of the GGRB, approximately 18 miles west of the west flank of the Rock Springs Uplift and 25 miles east of the Moxa Arch. Subsurface mineral rights are owned 100 percent by Union Pacific Resources, and the surface owner is the U. S. Bureau of Land Management. The Second Frontier is the target formation at approximately 16,000 ft., and the primary objectives are fluvial sandstones and marine shoreface sandstones within the Second Frontier.

The Second Frontier at the selected wellsite should contain both marine shoreface sandstones and fluvial channel-fill sandstones. The presence of the fluvial and marine sandstones in wells adjacent to the proposed location provide the basis for significant production potential. Based on offsetting log and core information a combined net pay of over 40 ft. is anticipated, with an average porosity of 9 percent and an average water saturation of 40 to 45 percent. Seismic information, well log and core analysis, and field examination all support the likelihood of natural fractures occurring in the proposed well. The proposed location is adjacent to two previous Frontier completions (one of which was the Blue Rim Federal 1-31) which produced gas at rates of 250 to 1,800 MCFD. The probability of encountering gas is very high; however there are risks associated with recoverable reserve levels and the payout potential for the combined drilling, completion, and testing costs associated with the proposed project.

2. Regional Geology

2.1 General overview of the structural framework of the GGRB and the depositional setting for the Cretaceous of western Wyoming

The Greater Green River Basin is a composite of several smaller foreland basins, and covers an area of approximately 19,700 square miles. The GGRB is bounded by the Wyoming Overthrust Belt on the west, the Wind River Mountains on the north, the Rawlins Uplift and the Park Range Uplift on the east, and the Uinta Mountains and Axial Basin Arch on the south (Figures 2a and 2b). Although the GGRB is bounded on the west by the thin-skinned deformation of the Overthrust Belt, the uplifts within the GGRB and their adjacent sub-basins are basement-involved. Most of the structural features within the basin are the result of compressional deformation associated with the Laramide orogeny (Campanian through Maastrichtian). There is evidence that there was earlier movement along the Moxa Arch, perhaps as early as Frontier time (Wach, 1977). Isopach maps and stratigraphic relationships within the Frontier Formation indicate that parts of southwestern Wyoming and northeast Utah were slightly positive elements during Frontier time.

The Greater Green River Basin of Wyoming is located along the western margin of the Cretaceous Western Interior Seaway which extended from Alaska to Mexico during the Upper Cretaceous (Fig. 3). Over 17,000 feet of Upper Cretaceous rocks were deposited during several cycles of relative sea level rises and falls. The sediments that fed the Upper Cretaceous shorelines in southwest Wyoming were derived from the west and northwest as uplifts resulting from the Sevier and Laramide orogenies were eroded.

Isopach maps of the Upper Cretaceous sediments in southwesternmost Wyoming and easternmost Utah show a north-south trending feature in which tens of thousands of feet of Upper Cretaceous sediments accumulated (Fig. 4). This geographic area characterized by the remarkably thick package of sediments is interpreted to represent a foredeep. This foredeep apparently formed in response to the loading of the crust caused by the multiple episodes of thrusting associated with the Sevier Orogeny to the west. The foredeep acted as a sediment sink for many of the Upper Cretaceous rocks, and trapped most of the coarse-grained sediment that was being shed off the Sevier Orogeny. The Greater Green River Basin is situated on the easternmost edge of the foredeep, and contains a relatively thin package of Upper Cretaceous rocks compared to the foredeep directly to the west.

2.2 Frontier Formation regional depositional setting

The Frontier Formation in the Greater Green River Basin of Wyoming, Colorado, and Utah consists primarily of sandstone, siltstone, and shale, with minor amounts of coal and conglomerate. These marine and non-marine sediments were deposited along the western margin of the Western Interior Cretaceous Seaway, and record sedimentation into and across a foredeep that was subsiding during Frontier time (Figures 3 and 4). Previous studies have described the Frontier sediments as fluvial/deltaic deposits associated with wave-dominated deltaic complexes that fed sediments from the rising Sevier highlands in the west to the Cretaceous seaway to the east (Cobban and Reeside, 1952; Reeside, 1955; Hale, 1962; DeChadènades, 1975; Ryer, 1977; Myers, 1977; Winn et al., 1984; Moslow and Tillman, 1986; Moslow and Tillman, 1989; Hamlin, 1992). Molluscan fossils from the marine units indicate that the Frontier was deposited during early Late Cretaceous time (Merewether and Cobban, 1983; Merewether, et al., 1984; Merewether, 1983).

The Frontier Formation ranges from several thousand feet thick near Coalville, Utah (Ryer, 1977) to less that 200 feet thick near the northern flank of the Uinta Mountains (Reeside, 1955; Merewether, et al., 1984). The dramatic thickness changes in the Frontier are related to the presence of a foredeep that allowed several thousand feet of Frontier sediments to accumulate due to increased accommodation space. In contrast, the area along the north flank of the Uinta Mountains was a positive element during Frontier deposition, where a relatively thin Frontier package is present. The thin accumulation of Frontier may be because this was an area of sediment by-pass and sediments were never deposited, or it may be the result of erosion of previously deposited sediments during subsequent periods of subaerial exposure and/or marine transgressions, common in areas of low accommodation. At outcrops along the eastern edge of the Overthrust Belt, the Frontier Formation is of Cenomanian, Turonian and early Coniacian age, and is approximately 610 m (2000 ft) thick. The Frontier in that area apparently conformably overlies the Lower Cretaceous Aspen (Mowry) Shale and is divided into the following members, in ascending order: Chalk Creek, Coalville, Allen Hollow, Oyster Ridge, and Dry Hollow (Fig. 5). At outcrops on the northern flank of the Uinta Mountains in northern Utah, the Frontier is middle and late Turonian in age, and is only about 60 m (200 ft) thick. In this area, the Frontier disconformably overlies the Lower Cretaceous Mowry Shale. Along the Moxa Arch, the upper part of the Frontier is middle Turonian to early Coniacian in age and unconformably overlies the lower part of the formation. The lower part of the Frontier Formation along the Moxa Arch is early Cenomanian at the southern end of the arch and probably Cenomanian to early Turonian at the northern end of the arch. The Frontier Formation on the Moxa Arch thickens northward from approximately 100m (328 ft) to more that 300 m (984 ft), and the formation apparently overlies the Mowry Shale. The Frontier Formation is overlain by the extensive Upper Cretaceous Hilliard Shale in all of the Greater Green River Basin.

The Frontier Formation consists primarily of sandstones, siltstones and shales that were deposited on the western flank of the Cretaceous Western Interior Seaway. The sediments were deposited as several wave-dominated deltaic complexes prograded seaward during Frontier time. The Frontier deltas were sourced from the Sevier orogenic belt to the west in Utah and the Idaho Batholith to the northwest in Idaho. Sediments in the lower part of the Frontier Formation generally prograded to the east-southeast while sediments in the upper part of the Frontier (First Frontier and some of the Second Frontier) prograded to the east-southeast as well as to the south in the northern part of the Greater Green Basin. Figures 6 through 9 (early Frontier to late Frontier, respectively) show the positions of the Frontier shorelines as they shifted though time.

The Stratos well will target the part of the Frontier Formation known throughout the subsurface as the Second Frontier sandstone. Correlations from outcrops on the eastern edge of the Overthrust Belt into the subsurface indicate that the Second Frontier is equivalent to the Oyster Ridge and Dry Hollow members of the Frontier (Merewether and Cobban, 1983; Merewether, et al., 1984; Merewether, 1983) (Fig. 5). The Second Frontier is further subdivided in the subsurface into two benches (Fig. 10). The second bench (the older of the two benches) of the Second Frontier consists of a coarsening-upward shoreface succession of mudstone, siltstone and sandstone. It is unconformably overlain by the first bench of the Second Frontier which consists of fluvial and estuarine channel-fill sandstones and associated coastal plain mudstones and siltstones. Both sandstone benches are expected in the Stratos proposed location.

2.3 Region of Overpressure in the GGRB

The Upper Cretaceous sedimentary rocks in the GGRB are commonly overpressured, beginning at depths of 8,000 to 12,000 ft. (2438 to 3658 m) (Law and Dickinson, 1985). These rocks can have pressure gradients exceeding 0.9 psi/ft (Law and Spencer, 1091; Spencer and Law, 1981), exhibit low porosities and low permeabilities (<0.1 md), and always contain gas. The overpressured, gas-bearing rocks occur in the deeper parts of the Green River Basin, downdip from the normally pressured, gas and water-bearing rocks (Fig. 11). There is no apparent lithologic seal for the gas accumulations; the top of the overpressuring cuts across structural and stratigraphic boundaries (Fig. 12). This relationship should reduce the importance of conventional structural and stratigraphic trapping configurations within the zone of overpressuring.

Overpressuring in the Green River Basin was first recognized by Rathbun (1968) and Rathbun and Dickey (1969). Their study was confined to the northern part of the Green River Basin, and they concluded that the overpressuring was caused by tectonism. Later work by Law et al. (1979, 1980), McPeek (1981), Law (1984), Law and Dickinson (1985), Law et al. (1986), Spencer, 1987, and Law et al. (1989) attributed the origin of the anomalously high pressures to the accumulation of gas in low permeability reservoirs, at rates greater than it is lost. The position of the top of the overpressuring in the GGRB is related to the level of thermal maturity, organic richness of the gas source rocks, and present-day temperature (Law, 1984). The top of overpressuring occurs at an uncorrected bottom hole temperature of approximately 180 F. (82 C) and a vitrinite reflectance of around 0.8% (ranges from 0.74 to 0.94%). An organic carbon content of at least 0.5% is required to be considered a favorable source for economic hydrocarbon accumulations. The average organic carbon content for Cretaceous Mesaverde through Tertiary Fort Union sediments is 2.04%. The Cretaceous Baxter Shale overlies the Frontier Formation and exhibits total organic carbon content ranging from 0.2% to 2.71%. The Cretaceous Mowry Shale underlies the Frontier Formation, and its total organic carbon content ranges from 1.5% to 2.5%. Thermal maturity maps have been prepared for the GGRB by Pawlewicz et al. (1986) and Merewether et al. (1987), and show the Cretaceous and lower Tertiary rocks to be thermally mature throughout most of the basin.

The proposed Stratos well is located well within the zone in which the Frontier Formation is overpressured. The Frontier Formation is overlain by the Baxter Shale is and underlain by the Mowry Formation, both of which are considered two favorable source bed units. Bottom hole temperatures in the two closest offsets to the Stratos location (the ERG Blue Rim Federal 1-30 and the ERG Blue Rim Federal 1-31) ranged from 270 to 295 F. The Frontier Formation typically exhibits permeabilities of less than 0.1 millidarcy, and it has been classified as a tight gas sand throughout this part of the Green River Basin. Both of the Blue Rim wells tested significant amounts of gas and no water from perforations in the Second Frontier. All of these factors make the Frontier Formation a prime candidate for testing new technologies in a potentially basin-wide, unconventional gas accumulation within a low permeability reservoir.

2.4 Natural fracturing

Regional fracture orientations were obtained through numerous measurements taken from Frontier outcrops that surround the Green River Basin. The locations of the outcrops are shown on Figure 13 and include outcrops from the Oyster Ridge in the Wyoming/Utah Overthrust Belt, the north flank of the Uinta Mountains near Manila, Utah, and Frontier outcrops near Sinclair, Wyoming. The most prominent fracture orientations from the Frontier Formation along the Oyster Ridge outcrop are east, east-northeast, and north; the east-trending fractures are the most numerous. There is more variability in fracture orientations from the north flank of the Uinta Mountains, and there seem to be several common fracture orientations. These include east (75-95 degrees), southeast (110-120 degrees), and northeast (35-55 degrees). There are also scattered north to northeast-trending fractures along the outcrop. Measurements from the east flank of the Greater Green River Basin (Sinclair, WY) are predominantly south-southeast (334 degrees) and east-northeast (70 degrees).

Fracture trends and patterns from the Oyster Ridge outcrop along the eastern margin of the Overthrust Belt were considered to be most analogous to the fracture patterns predicted for the Stratos location for several reasons. The Oyster Ridge outcrop is approximately 50 miles west of the proposed Stratos location and is therefore the closest outcrop to the proposed location. Fractures are known to behave differently between units with differing rock properties, and therefore it is more accurate to compare fractures between rocks with similar lithologic characteristics. The Oyster

Ridge and Dry Hollow members of the Frontier are the units that make up the resistant Oyster Ridge Hogback topographic feature, and these two members of the Frontier are equivalent to the Second Frontier sandstones targeted in the Stratos well. Therefore, natural fractures with east, east-northeast, and north-south trends, the most prominent trends in the Oyster Ridge Overthrust outcrop, are predicted for the Second Frontier target in the Stratos well. Fracture orientations derived from other deep basin wells (some previously drilled and one well currently being drilled) will also be analyzed and incorporated into the predictions for the natural fractures in the proposed location. The dominant trend of regional lineaments in the area is to the northeast, and the Stratos well will be deviated to the north north-west in hopes of crossing fractures oriented southwest to northeast.

3. Stratos site selection

3.1 Summary of previously drilled wells in the deep Green River Basin

The study area included in analysis of the Stratos wellsite selection encompasses primarily the deep Green River Basin between the Rock Springs Uplift and the Moxa Arch. However, data from many wells along the crests of both the Moxa Arch and Rock Springs Uplift were incorporated into the study and aided in the interpretation of sequence stratigraphy, depositional architecture and facies analysis, diagenesis, and reservoir characterization of the Frontier Formation. The study focuses on the twenty-three deep wells that were drilled between the two uplifts (includes Townships 14 North to 25 North and Ranges 104 West to 109 West). These twenty-three wells represent every Frontier penetration in that geographic area. Table 1 summarizes the drilling histories, hydrocarbon shows, production tests, actual production, and Frontier marine and fluvial net pay values for each of these deep wells. Electric logs for the Frontier section of each of the wells are provided in Appendix 1.

The net pay values were calculated by Union Pacific Resources personnel and are based on the following log parameters. Net pay was defined as any part of the Frontier sandstones that exhibited 6% or greater porosity, 60% or less water saturation, and 40% or less Vshale. The vast majority of the porosity values were calculated from sonic logs while the remainder were calculated from density logs. Water saturations were also calculated from sonic logs, and values for Vshale were calculated from the gamma ray curves. Once the net feet of pay for each well that penetrated the Frontier was calculated, regional and site-specific isopach maps for net feet of pay in the First, Second, Third, and Fourth Frontier marine sandstones, as well as the Second Frontier fluvial sandstone, were constructed (Figs. 28 through 31).

Core analyses from several deep basin wells confirm the fact that the Frontier typically exhibits permeabilities of less than 0.1 millidarcy. For example, horizontal unstressed permeabilities in the Second Frontier fluvial sandstone of the ERG Blue Rim 1-30 (Sec. 30-T22N-R106W) range from less than 0.01 md. to 0.18 md., with an average of 0.05 md. Twenty-seven out of forty-four marine sandstone samples from the Blue Rim 1-30 exhibited permeabilities of less than 0.01 md. The highest permeability value measured for the marine sandstone in this well was 0.09, with the majority of the samples having much lower permeabilities. Despite these low permeability values, this well tested 1.3 MMCFD from the Second Frontier sandstones during a pre-acid, pre-frac. production test. This relatively high flow rate from these very low permeability rocks probably reflects the presence of natural fractures in the Second Frontier reservoir. The Frontier sandstones in the Stratos well are expected to be similar in reservoir quality to the Frontier in the two Blue Rim wells, and as discussed above, should also be naturally fractured.

The specific location of the Stratos site was determined after careful examination of all of the data that the previously drilled wells provided. The proposed site is considered to be optimal for several reasons, one of which being its proximity to two significant production tests from the Second Frontier. The Stratos well will be drilled in close proximity to two relatively recent Frontier wells (the ERG Blue Rim Federal #1-30 and #31-1, Sections 30 and 31 of T22N-R106W, drilled in the late 1970's). These two wells had the best production tests out of the Frontier sandstones of any of the deep basin wells. Both of these wells tested gas at rates of over one million cubic feet of gas per day, and one well (the #1-31) actually produced and sold gas to a pipeline at monthly average rates in excess of 500 MCFD. The well had a cumulative production of 145.5 MMCF after nineteen months out of the Second Frontier sandstones. This production was established in a well with a hydraulic fracture treatment considered to be well below optimal and relatively ineffective when compared to current stimulation technology.

3.2 Detailed geological and geophysical analysis of the Stratos Site

3.2.1 Seismic description and interpretation

The seismic coverage for the area of interest is shown in figure 14 and extends from the west flank of the Rock Springs Uplift to the Moxa Arch, encompassing 170 townships. There are several hundred seismic lines of various vintages, sources, and shooting geometries. Seismic acquisition represented on the base map dates back to 1966 and includes data acquired through 1992. The dominant source is dynamite, although several lines have been acquired with vibroseis. The far offset for these lines ranges from as little as six to a high of sixty, while most are on the order of 12 fold. The majority of seismic lines have been reprocessed in the last five years. The key line across the Stratos prospect is also shown on figure 14 as Line A-A'. It is line GRB1A and was acquired in 1991 for First Seismic.

Several synthetics and a VSP from wells that penetrated the Frontier were used to establish phase and formation ties to the seismic data. The synthetic shown in figure 15 is taken from the ERG Blue Rim #31-1 well in Sec. 31-T22N-R106W. Three formation tops were chosen to carry across the basin: a Tertiary coal marker, the Mesaverde, and the Frontier. The Tertiary coal is 15-25 ft. thick and is below the tuning thickness of approximately 60 ft. thick. Therefore, the thin-bed response of the coal appears as a 90 degree phase wavelet with a leading trough. Since this coal marker exists everywhere in the area of interest, it is a very good indicator of the phase of the seismic data. This seismic marker was also used to calculate relative bulk shifts between seismic lines. The synthetic projects onto line GRB1A (Fig.16) at shotpoint 940 from 300 ft. to the southwest. This is approximately 1 1/4 miles from the Stratos location. The checkshot acquired from a VSP shot in the UPRC Mountaineer #1 well in Sec. 35-T21N-R106W was applied to the synthetic, resulting in a reasonably good tie.

The resulting time structure map of the Frontier is shown in figure 17. The south plunging anticline of the Moxa Arch is evident to the west while the west flank of the Rock Springs Uplift is evident to the east. The Stratos Unit (red outline on Figure 17) is shown to be almost in the center of the south plunging syncline between the bounding structures to the east and west. The Stratos location is shown as it projects onto line GRB1A in figure 16 from 200 ft. to the northeast. This seismic line shows the relative position of the Stratos location to the west flank of the Rock Springs Uplift.

The velocity gradient map shown in figure 18 was derived using the available subsurface data and the interpreted seismic data. There is considerable control over the Moxa Arch while the subsurface control is sparse over the balance of deep Green River Basin. This velocity map was used to convert the time structure map in figure 17 to depth. The resulting depth structure map is shown in figure 19 and will be discussed below.

3.2.2 Structural position

The Stratos prospect is based on finding gas-charged, naturally fractured Second Frontier reservoir sandstones in an overpressured position. Wells closest to the structural axis of the Green River Basin are the deepest and exhibit reservoir temperatures that are more than adequate for natural gas generation. In fact, in deep-basin wells that tested the Frontier, the formation always gives up some gas. Where pressure data are available, all of the deep-basin Frontier wells exhibit indications of overpressuring. Many workers have postulated that the overpressuring in the deeper parts of the Greater Green River Basin is due to the continuous generation of natural gas at depth, and its migration into the low-permeability sandstone reservoirs at rates greater than the rate at which the gas can leak out of the reservoir (Law et al. 1979, 1980; McPeek, 1981; Law, 1984; Law and Dickinson, 1985; Law et al., 1986; Spencer, 1987; Law et al., 1989). Data from the two Blue Rim wells, both of which are located less than one mile from the proposed location, indicate that the Frontier is overpressured and is gas-productive. The two Blue Rim wells are situated near the structural axis of the Green River Basin (Fig. 19), and rest on a structural saddle within the basin known to operators as the Blue Rim Arch. The structural position of the Frontier Formation at the proposed Stratos site (proposed subsea elevation = -9280 ft.) will be similar to the two Blue Rim wells, and the Second Frontier at Stratos should therefore exhibit abnormally high reservoir pressures and produce gas.

Even though the deep-basin Frontier Formation can contain tens of feet of porosity greater that 8%, the presence of open natural fractures is expected to further improve reservoir permeability. Enhancement of any regional, through-going natural fractures by more local fractures would be ideal for the prospect. The regional set of natural fractures in the sandstone reservoirs expected in the Stratos well may certainly be enhanced by local fracturing developed as a result of deformation associated with the Blue Rim Arch (Fig. 19).

3.2.3 Depositional Setting of the Frontier sandstones at the Stratos Location

The Frontier Formation of southwest Wyoming consists of mudstones, sandstones, siltstones and thin coals that were deposited as fluvial systems fed wave-dominated delta along the western margin of the Cretaceous Western Interior Seaway. Regional studies of the Frontier Formation indicate that the marine units of the Frontier Formation consist of shallowing-upward successions of sediments, beginning with offshore marine mudstones that grade up into lower shoreface and upper shoreface sandstones. (Cobban and Reeside, 1952; Reeside, 1955; Hale, 1962; DeChadenades, 1975; Ryer, 1977; Myers, 1977; Merewether, 1983; Merewether and Cobban, 1983; Merewether, et al., 1984; Winn et al., 1984; Moslow and Tillman, 1986; Moslow and Tillman, 1989; Hamlin, 1992). Foreshore sediments are rarely preserved because they have been planed off by subsequent transgressions.

Along the Moxa Arch, fluvial sediments unconformably overlie the marine units of both the Second and Third Frontier sandstone members. Depending on the location of the well, the fluvial channels can scour into upper shoreface or more rarely preserved foreshore deposits, or they can completely remove all of the shoreface sandstones, resulting in fluvial deposits sitting directly on top of marine mudstones of the offshore transition.

Based on careful electric log correlations and calibrations to over 100 cores and extensive outcrop descriptions, the unconformities at the bases of the fluvial units can be traced across the entire Greater Green River Basin. Based on ammonite ages, several million years may be missing at these surfaces (Cobban and Reeside, 1952; Reeside, 1955; Merewether, 1983; Merewether and Cobban, 1983; Merewether, et al., 1984;). Integrated basin analysis incorporating biostratigraphic data, the depth of fluvial scour into and through previously deposited shoreface successions, and the areal extent of fluvial scour which can be traced regionally over 200 miles, the fluvial erosion surface is interpreted to represent a sequence boundary or regional unconformity.

Over 100 Frontier cores from the Moxa Arch, the Rock Springs Uplift, and the deep basin have been described and calibrated to electric log responses to allow for regional correlation of depositional packages. Five cores were particularly useful in tying the Frontier Formation at the proposed location to the regional depositional setting of the Frontier. The detailed core descriptions of the Energy Reserves Group #1-30 Blue Rim Federal (Sec. 30-T22N-R106W), the American Hunter Faraway #1 (Sec. 17-T25N-R108W), and the American Hunter A-1 Enterprise (Sec. 30-T25N-R107W), the Davis Oil Dines #1 (Sec. 7-T20N-R105W), and the Davis Oil Dines #2 (Sec. 18-T20N-

R105W) are shown in figures 20 through 24. The Energy Reserves Group #1-30 Blue Rim is located only one-half mile to the south of the proposed Stratos location, and therefore the Frontier encountered in that core should be very similar to what is discovered at Stratos. In the #1-30 Blue Rim well, the fluvial section is composed of sharp-based, fine to medium-grained sandstone that is trough cross-stratified (Fig. 20). The ten foot thick sandstone contains abundant mudstone laminations as well as several soft-sediment deformation structures. No burrows were observed, and there were abundant mudstone rip-up clasts at the base of the sandstone. The sandstone contains several internal scours with abundant mudstone rip-up clasts. This sandstone body is interpreted to be a fluvial channel deposit. This channel sandstone is overlain by approximately eight feet of interbedded mudstone and fine to very fine-grained sandstone. Mudstone clasts are still common, but burrowing is also present. This unit is interpreted to represent a marine-influenced fluvial deposit (estuarine).

The marine section in the #1-30 Blue Rim well is composed of several coarsening and sanding-upwards shoreface successions. Only the upper two of these were cored, and the uppermost succession is the primary marine target of the Stratos well. The reservoir within the marine section consists of approximately twenty-eight feet of very fine to fine-grained bioturbated sandstone with some minor mudstone laminae. Mudstone content decreases upward, and the sandstone becomes cleaner and coarser-grained. Burrowers that were still distinct enough to be identified include *Ophiomorpha* and *Planolites*. This sandstone is interpreted to represent deposition within the lower shoreface of wave-dominated delta/shoreline complex.

After calibration of the core depositional lithofacies to their corresponding electric log responses, it is apparent that the marine and fluvial lithofacies can be distinguished on logs (See Appendix 1 for the ERG Blue Rim #1-30 composite log). The core depths are approximately four feet high to log depths, and with that depth correction in mind, the contact between the fluvial section and the marine section occurs at 16,078 feet in the core. Note the funnel-shaped curves characteristic of the coarsening and sanding-upward shoreface successions below the contact. Note that the fluvial section exhibits a bell-shaped electric log response, indicating that the fluvial sediments in this well generally fine upward.

<u>Reginal stratigraphic analysis through cross-sections</u>

Calibration of many cores to their corresponding electric logs facilitated the stratigraphic correlation of the deep-basin Frontier Formation lithofacies over a large area. This regional stratigraphic analysis of the Frontier Formation was performed to determine the most likely occurrence of widespread reservoir sandstone, and to understand the mechanisms controlling sand distribution. Several regional stratigraphic cross-sections were generated by Union Pacific personnel in order to tie the Frontier expected at the proposed location into the regional depositional setting of the Frontier and to establish the sequence stratigraphic relationships of the major units within the

Frontier Formation.. Three of those cross-sections are included in this report and are shown in figures 25, 26, and 27.

The methodology used for this stratigraphic analysis is that of Van Wagoner (1993); key stratigraphic surfaces are identified from outcrop and core data and then calibrated to subsurface log data for regional correlation of these surfaces. Although the available well data is sparse, reasonable extrapolations could be made because of the availability of cores in critical wells, as well as extensive data bases along the Moxa Arch and Rock Springs Uplift which bracket the study area.

Unconformities: This work documents at least two regionally extensive unconformities, or sequence boundaries, which can be traced over much or all of the study area. Each of these surfaces places incisive fluvial channels and flood-plain/overbank deposits on top of open marine mudstone and nearshore deposits. In areas with less accommodation (generally in the southern part of the study area), the sediment between these surfaces is truncated, and the unconformities merge into a master surface which divides the overlying fluvial rocks of the Dry Hollow/Upper bench Second Frontier from the underlying, pre-Oyster Ridge/Lower bench Second Frontier or older deposits.

Lowstand Shorelines: In the southern part of the study area, it is possible that the lower unconformity locally feeds a lowstand shoreline, prior to truncation by the upper (Dry Hollow) unconformity; see cross section B-B' (Massacre 11-5,3-26, and Currant Creek wells) (Fig. 26). Further to the south and east this deposit is largely truncated beneath the Dry Hollow Unconformity. No lowstand shoreline is observed for the Dry Hollow unconformity within the study area, although outcrops east of Sinclair, Wyoming can be used to document that the Dry Hollow fluvially-sourced conglomerates have been transgressively reworked into a marine deposit. This may indicate that the lowstand shoreline equivalent to the Dry Hollow unconformity and associated fluvial deposits occurs east of this point.

Highstand Shorelines: The areal extent of the Second bench and Third bench shorelines is shown in each of the cross sections. For the most part, the vast percentage of reservoir-quality sandstone resides within the lower (marine) bench of the Second Frontier/Oyster Ridge Member. Sandstone thickness and reservoir quality generally decrease from north to south. This is a proximal to distal trend, and is also a function of erosional truncation in areas of low accommodation to the south. The shoreline trends appear to rotate across the study area. In the southwest part of the study area the shorelines appear to be oriented north-northeast to south-southwest, but rotate in the northern and eastern parts of the study area to become east-west, and finally trend northwest to southeast in the eastern and southeastern part of the study area.

Anomalously Thick Fluvial Sections: Deeply incised and sandstone-filled fluvial sections exist in the east central part of the study area, just west of the Rock Springs Uplift. The White Mountain 1-C-19 well (Sec. 19-T19N-R105W) and cross section

B-B' (Poitevent Federal and Sue Federal wells) (Fig. 26) document this unusually thick fluvial succession which fully truncates the underlying marine sandstone and may have been a major sand transport conduit out of the study area.

Isopach maps

Based on detailed core descriptions, subsequent calibration to electric logs, and log correlation of the Frontier Formation from the Moxa Arch, the western flank of the Rock Springs Uplift, and the intervening deep Green River Basin, a series of isopach maps of net feet of pay were constructed for the Second Frontier fluvial sandstones as well as for any sandstone encountered in the First, Second, Third and Fourth Frontier marine benches. These isopach maps cover an area that includes the Moxa Arch, the Rock Springs Uplift, and the deep Green River Basin in between (Figs. 28 and 29).

The fluvial isopach map is shown in figure 28 and shows the net feet of pay encountered within the Second Frontier fluvial interval. As previously discussed, net pay was defined as sandstone that exhibited 6% or greater porosity, 60% or less water saturation, and 40% or less Vshale. The vast majority of the porosity values were calculated from sonic logs while the remainder were calculated from density logs. Water saturations were also calculated from sonic logs, and values for Vshale were calculated from the gamma ray curves.

The fluvial isopach map is somewhat difficult to interpret because there appears to be some thickness of fluvial sand almost everywhere. Some of this is a function of the sparse drilling in the deep basin, and some of it is actually representative of the Frontier fluvial section. Where drilling is closely spaced on the Moxa Arch and Rock Springs Uplfit, the well control indicates considerable variability in the thickness of the fluvial sandstones. The unconformity, or sequence boundary, at the base of the Second Frontier fluvial section, can be traced over all of the mapped area and even one hundred miles to the east of the mapped area. In almost all wells in the study area, there is fluvial sandstone sitting on top of the sequence boundary. The Second Frontier fluvial system apparently was deposited as an irregular sheet of wandering river channels, perhaps due to very low accommodation space during the lowstand. In areas where there is more closely spaced well control, such as the Moxa Arch and the Rock Springs Uplift, correlations of channels within the Second Frontier yield a transport direction of east to southeast. These trends are consistent with paleocurrent measurements taken from outcrops of the Dry Hollow member of the Frontier (equivalent to the subsurface Second Frontier) along the Oyster Ridge at the eastern edge of the Overthrust Belt.

The marine isopach map (Fig. 19) does not differentiate between the different benches of the Frontier Formation. The map shows total thickness of net feet of pay for the entire Frontier Formation and includes not only the Second Frontier, but the First, Third and Fourth Frontier marine sandstones as well. However, the map does illustrate the gross overall trends of the Frontier shorelines. Paleocurrent measurements from outcrops along the Overthrust Belt and the north flank of the Uintas indicate north-south to northeast-southwest-trending shorelines. Detailed correlation of individual shoreface successions along the Moxa Arch also indicate approximately north-south or northeast-southwest trends for the Frontier shorelines along almost the length of the Moxa Arch. However, as discussed above, the trends of the shorelines begin to shift around to an east-west trend on the northern part of the Moxa Arch. In fact the shorelines appear to wrap around what is now the deep Green River Basin (Fig. 29). This indicates that the present-day deep Green River Basin was also an embayment of some sort during the time that some of the Frontier shorelines were being deposited. This is also illustrated on the regional maps of McGookey, et al., 1972 (Figs. 6 through 9).

Based on integration of detailed core descriptions, calibration of core to logs, log correlation, and mapping, the Stratos proposed location should encounter significant thicknesses of both the fluvial and the marine sandstone reservoirs (Figs. 30 and 31). Specifically, the Frontier at the Stratos proposed location is predicted to find 15-20 feet of fluvial sandstone with 6% or greater porosity and approximately 15 feet of marine sandstone with 6% or greater porosity.

3.2.4 Petrography and Diagenesis of the Frontier sandstones

Frontier sandstones in the Green River Basin have undergone a complex diagenetic history, with the diagenesis being related primarily to original framework grain composition, depositional processes affecting the sandstones, and burial history. Several workers have documented the petrography and diagenesis of the Frontier Formation on the Moxa Arch (Stonecipher, et al., 1984; Winn, et al., 1984; Dutton, 1993), and those readers interested in a more detailed discussion are referred to those studies. Petrographic analyses of the deep-basin Frontier have also been performed at Union Pacific Resources Co., and the results indicate that the deep-basin Frontier sandstones possess similar original framework grain compositions as, and have similar diagenetic histories to, the Frontier sandstones on the Moxa Arch.

The Frontier sandstones on the Moxa Arch are litharenites to sublitharenites and have an average composition of 64% quartz, 6% feldspar, and 30% rock fragments; however, these values vary with original depositional setting and stratigraphic position of the sandstone (Dutton, 1993). For example, fluvial sandstones on the Moxa Arch contain less quartz than do the marine sandstones. The marine sandstones are more quartzose because of better sorting and winnowing occurring in the shoreface environment (Stonecipher, 1984). Fluvial sandstones on the Moxa Arch have an average framework-grain composition of 59% quartz, 6% feldspar, and 36% rock fragments while shoreface sandstones have an average composition of 66% quartz, 5% feldspar, and 29% rock fragments (Dutton, 1993). The feldspar present in Frontier samples is almost exclusively plagioclase; potassium feldspar occurs only rarely. Feldspar content was also greater when the sands were deposited than it is now. Some feldspar has been partially to completely dissolved, while other feldspar has been replaced by calcite cement.

The most common lithic grains in the Frontier sandstones are sedimentary rock fragments. Chert is the most important of these sedimentary rock fragments, but chalcedony, sandstone, and mudstone fragments are also common. Metamorphic rock fragments, most typically slightly metamorphosed sandstones and mudstones, are common in some samples. Volcanic rock fragments can also be common in some samples.

Authigenic clay, quartz, calcite and other cements are common in Frontier sandstones. Dutton's study on the Moxa Arch (1993) reported that these components make up between 0 and 38% of the sandstone volume in the Frontier. The most common authigenic clays in the Moxa Arch Frontier samples and in the deep basin Frontier samples are mixed-layer illite-smectite and illite.

Based on detailed petrographic analysis, the relative sequence of events in the diagenesis of Frontier sandstones on the Moxa Arch is 1) mechanical compaction of grains, including deformation of ductile grains, 2) formation of illite and mixed-layer illite-smectite rims, 3) precipitation of quartz overgrowths, 4) precipitation of pore-filling and grain-replacing calcite cement, 5) dissolution of feldspar, chert, mica, mudstone grains, and calcite cement, 6) precipitation of kaolinite in primary and secondary pores, and 7) pressure solution and stylolitization and additional precipitation of quartz cement (Dutton, 1993). There is some overlap between events as well as some variability in certain samples. For example, a few samples contain very early calcite cement which predates quartz overgrowths. The diagenetic history of the deep basin Frontier is similar to that of the Moxa Arch, except that kaolinite and smectite are absent from the deep-basin samples. The clays in the deep-basin Frontier samples are almost exclusively illite and illite mixed-layer clay.

Porosity in the Frontier Formation is a combination of primary intergranular porosity and secondary porosity generated by the dissolution of feldspars, cherts, mudstone grains, and calcite cement. The two factors most detrimental to porosity in Frontier sandstones are quartz overgrowths and authigenic clays. There is a slight increase in quartz cement content with depth, but there is still significant secondary porosity that has been preserved in most of the deep-basin Frontier wells.

3.3 Selection of the Stratos site

The location for the Stratos well was determined by Union Pacific geotechnical personnel after careful integration of all available data, including electric logs, cores, production tests, pressure data, and seismic data. The location was based primarily on the probability of favorable reservoir sandstone thickness, the location's proximity to two offset wells with known Frontier gas production and good reservoir quality, and structural position within the zone of overpressured Frontier. Although the probability of encountering overpressured gas in the proposed well is high, the risks of this project involve finding adequate reservoir quality and implementing a successful stimulation technology.

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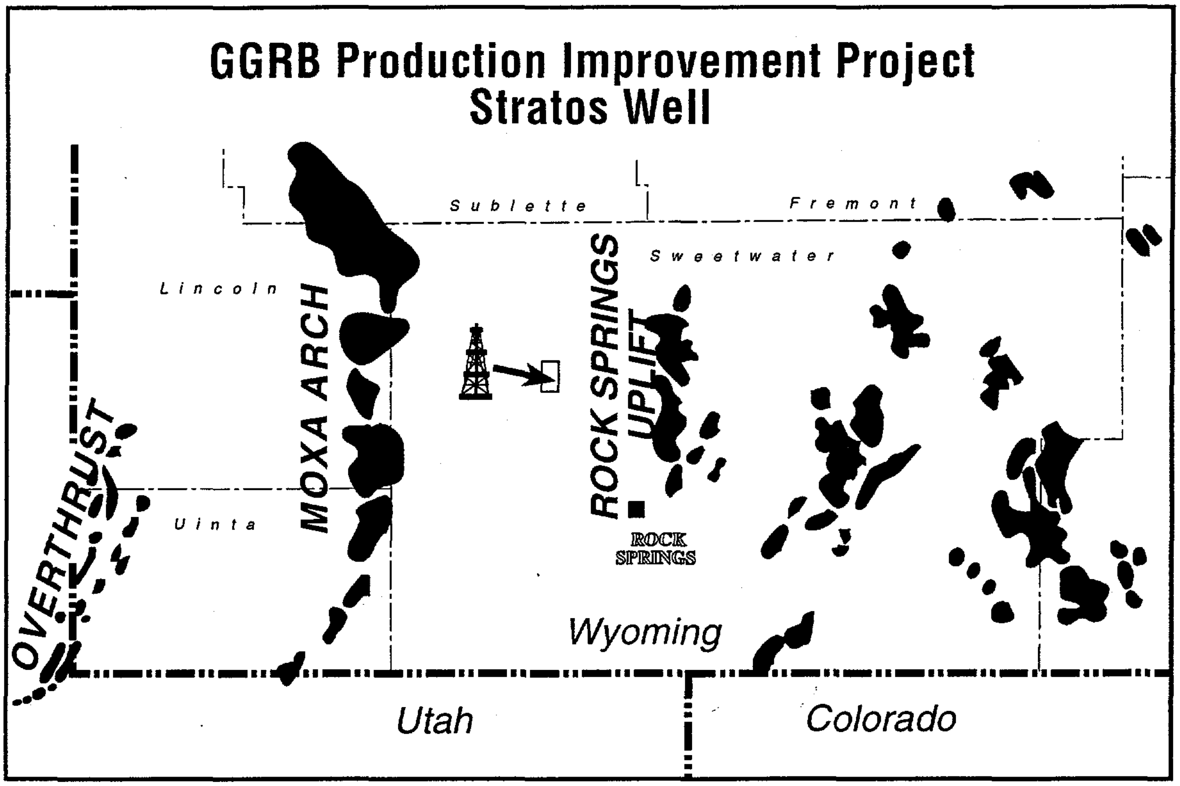
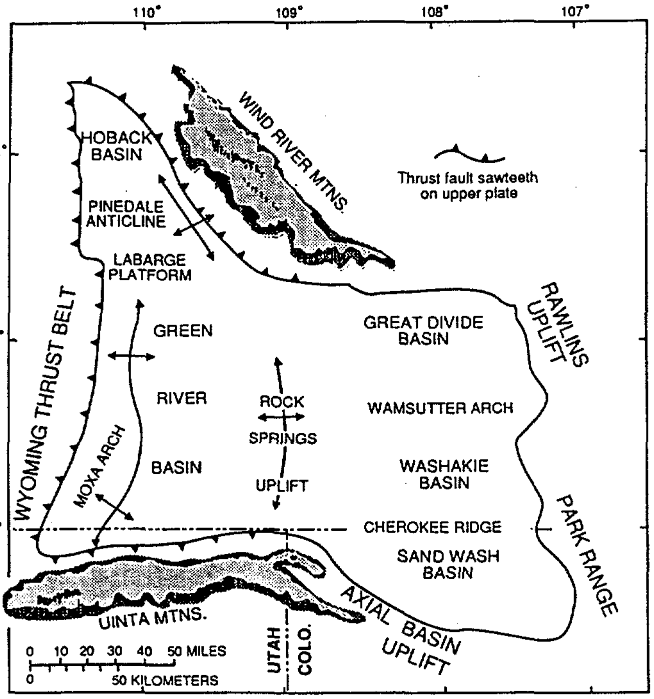
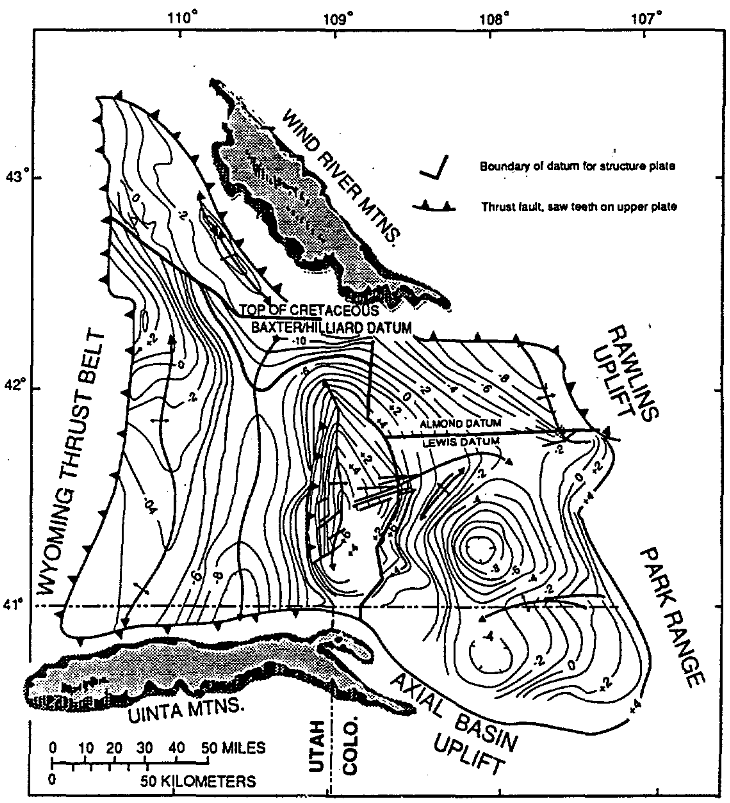


Figure 1. Index map of major oil and gas fields in the Greater Green River Basin, Wyoming with respect to the location of the proposed Stratos wellsite in Sweetwater County.



A



B

Figure 2. Index maps of the Greater Green River Basin and surrounding uplifts; (A) index map showing the names of the structural features within the Greater Green River Basin; (B) structure map of the Greater Green River Basin (from Law, et al., 1989).

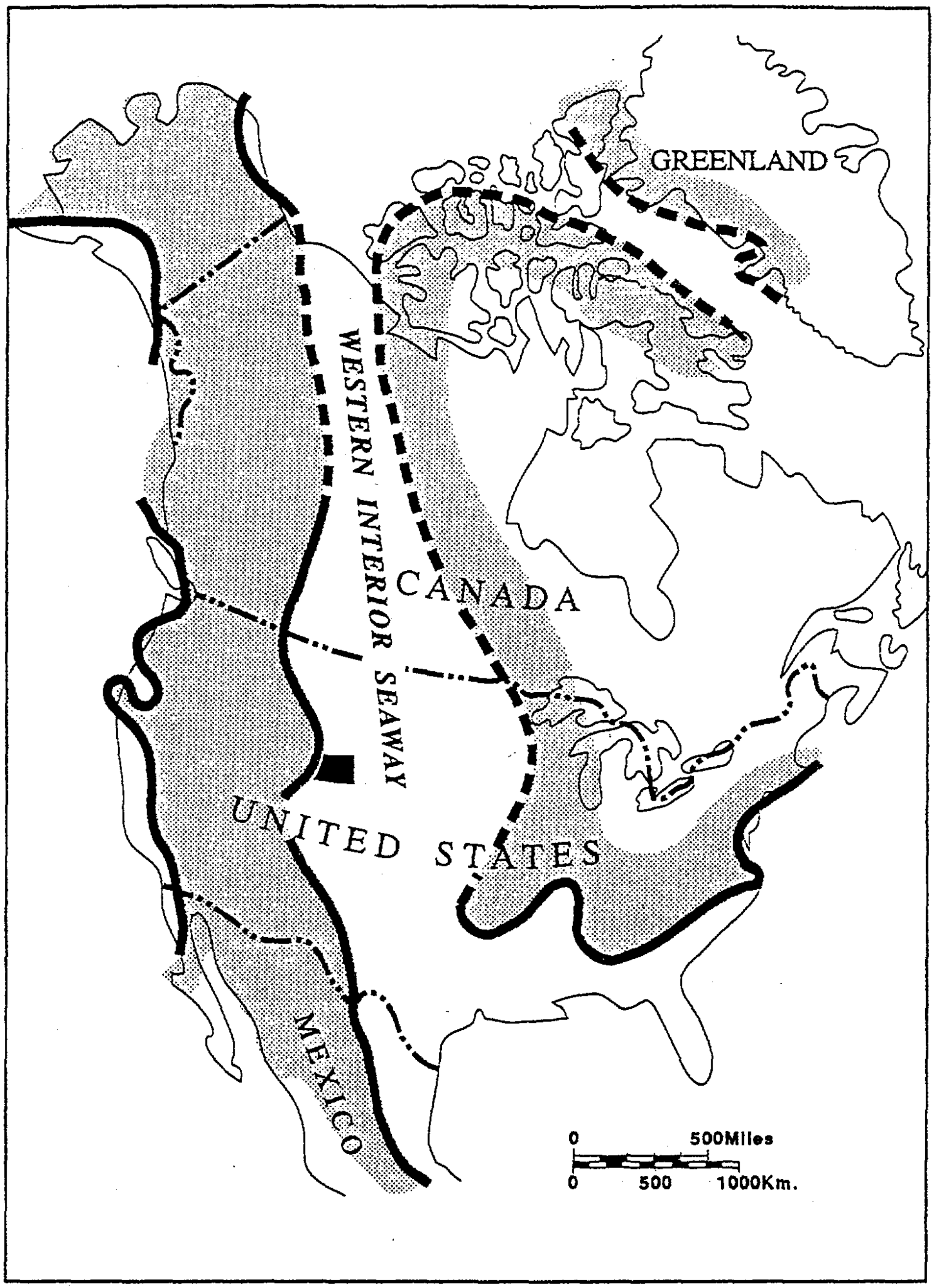


Figure 3. Geographic extent of the Cretaceous Interior Seaway with Green River Basin highlighted.

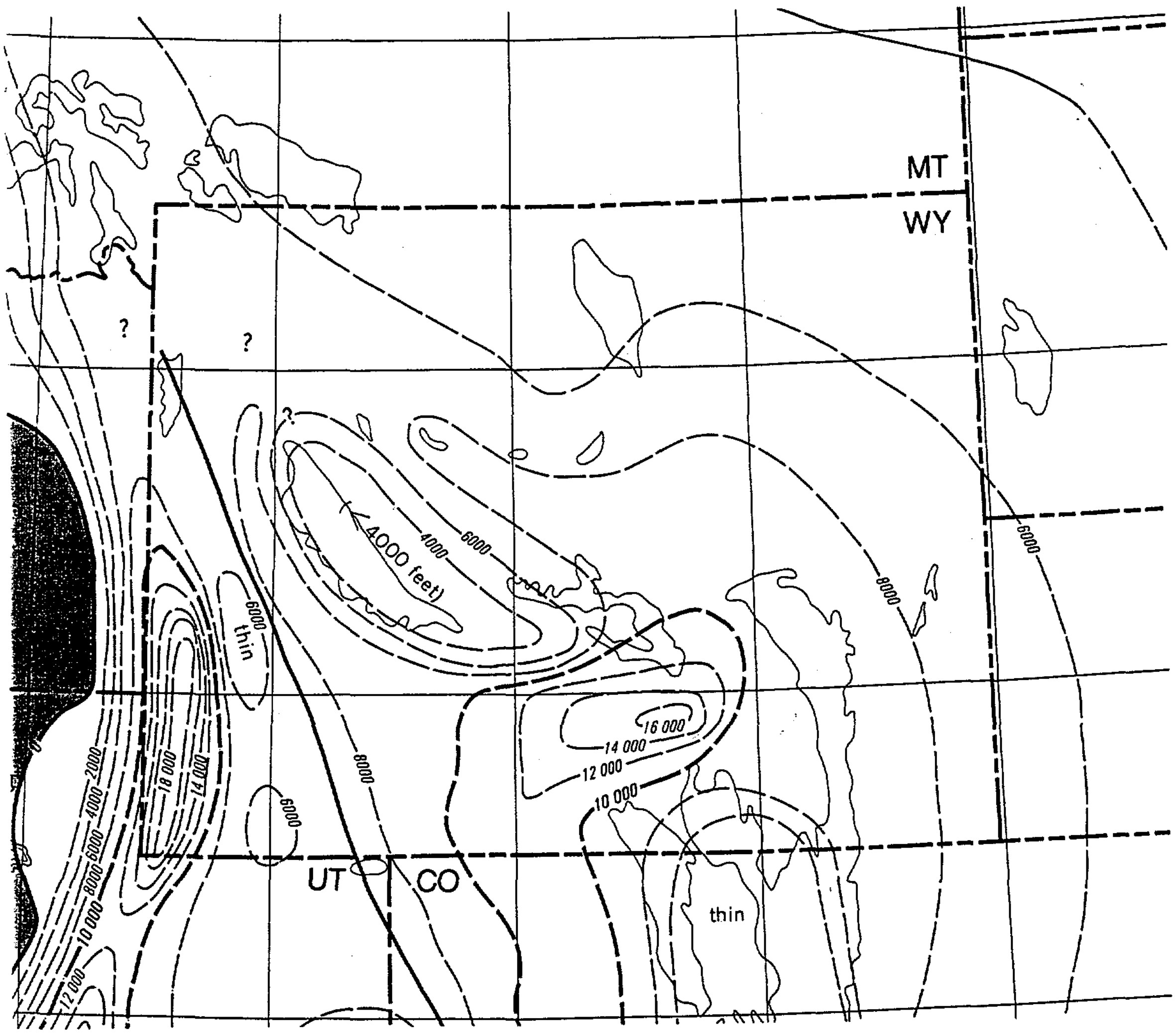


Figure 4. Isopach map of Upper Cretaceous sediments, southwest Wyoming and eastern Utah (from McGookey, 1972)

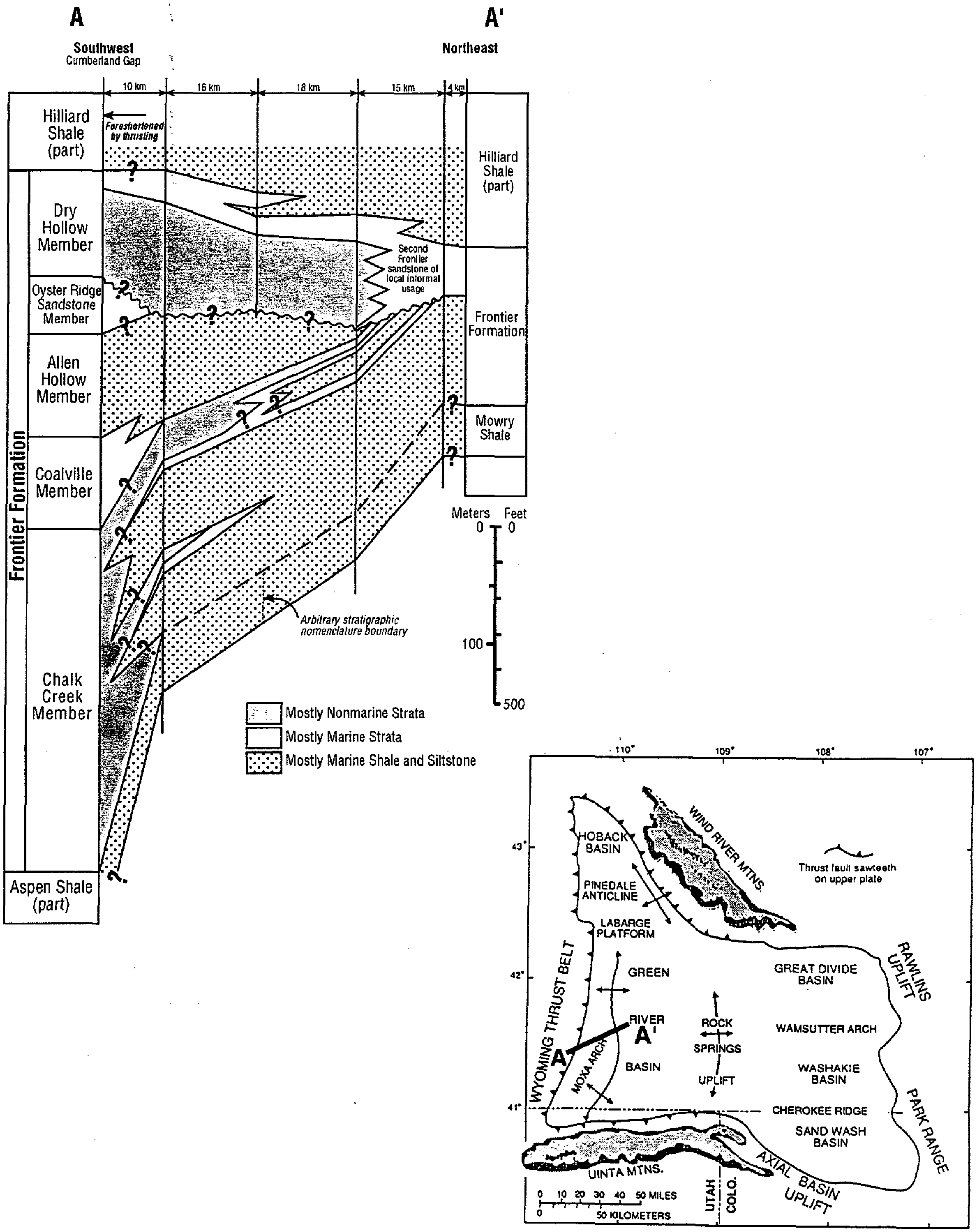


Figure 5. West to east stratigraphic cross-section of the Frontier Formation, Wyoming Overthrust Belt to the Moxa Arch (modified from Merewether, et al., 1984).

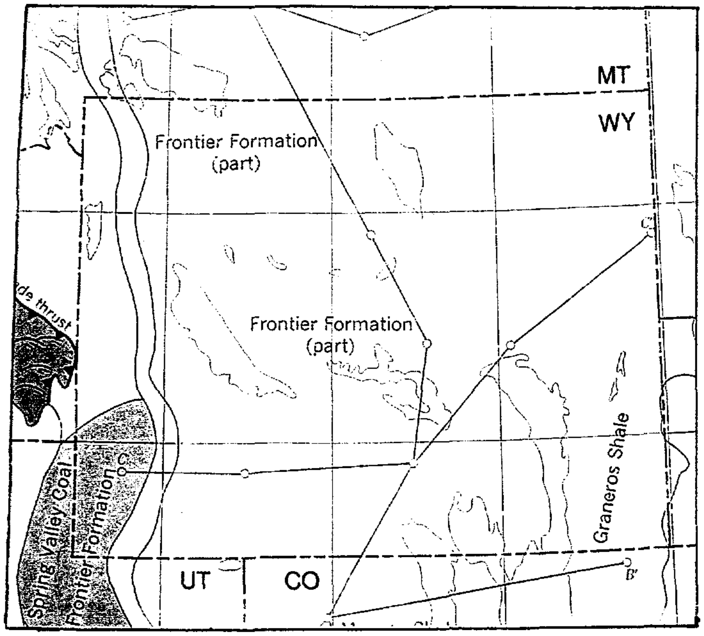


Figure 6

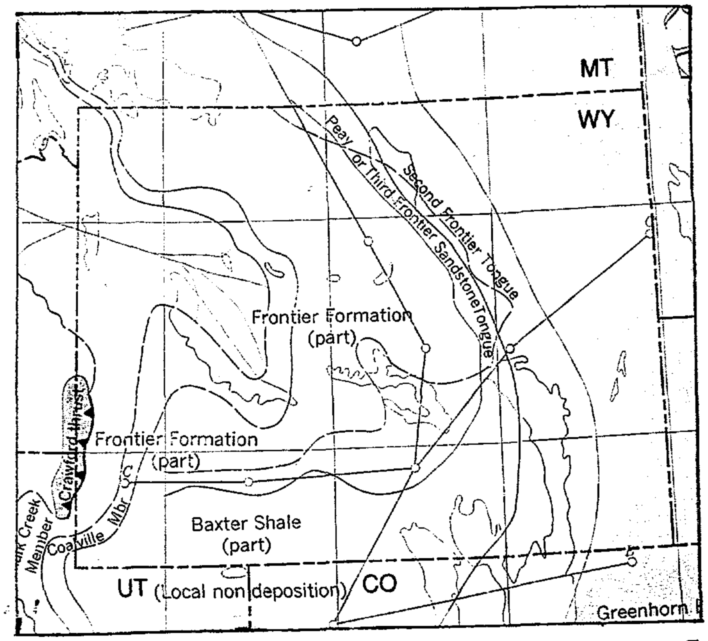


Figure 7

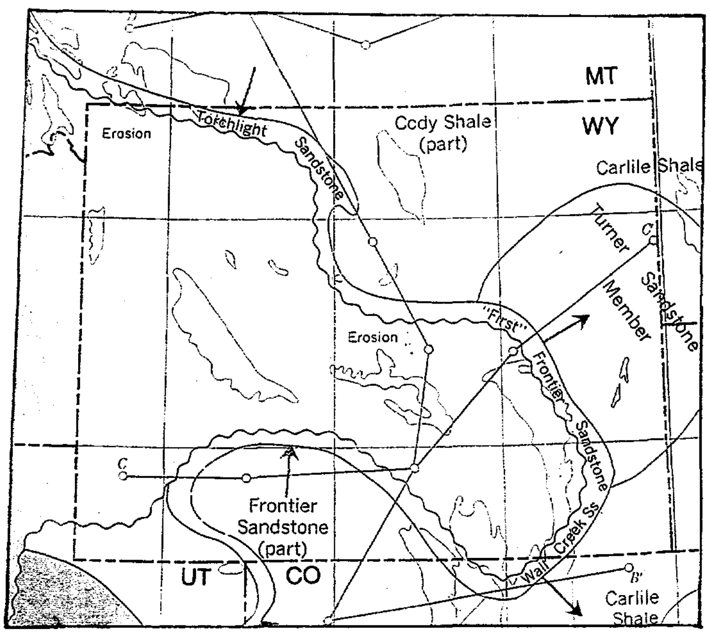


Figure 8

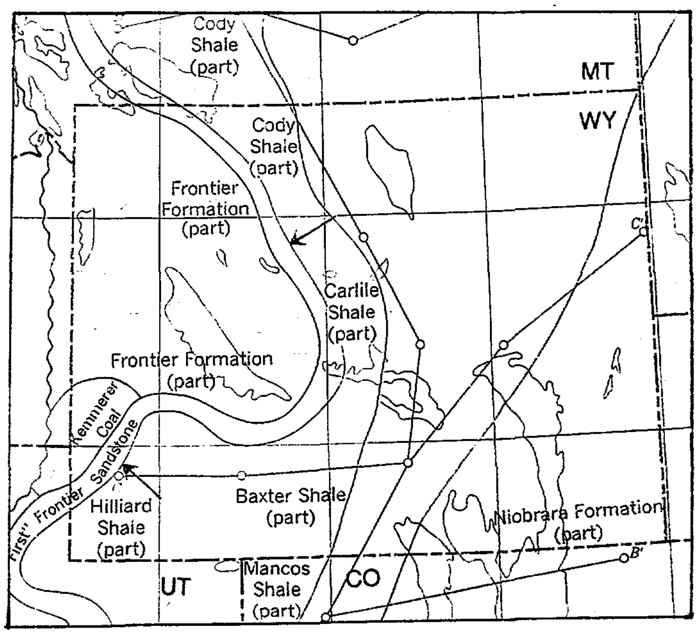


Figure 9

Figures 6 through 9. Series of isopach maps showing the evolution of Frontier shorelines through time (modified from McGookey, 1972)

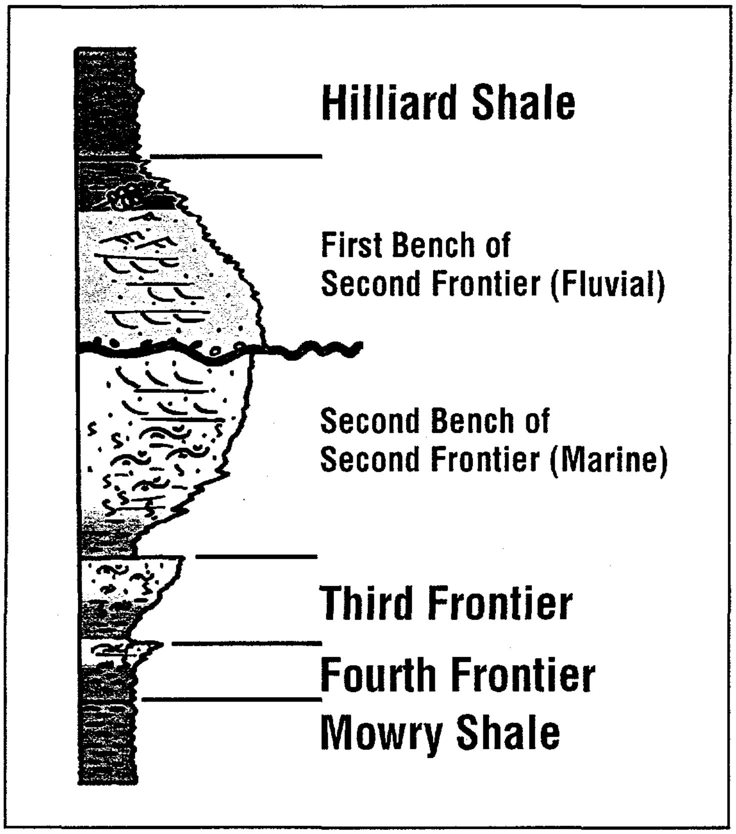


Figure 10. Schematic vertical profile of the Second Frontier Formation near the proposed Stratos location, Sweetwater County, Wyoming.

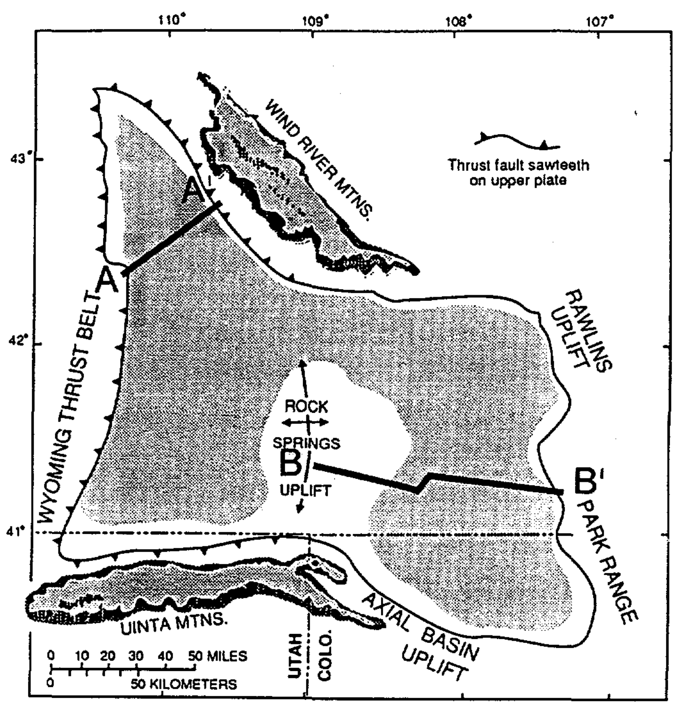


Figure 11. Region of overpressuring in the Greater Green River Basin, Wyoming (modified from Law, et al., 1989)

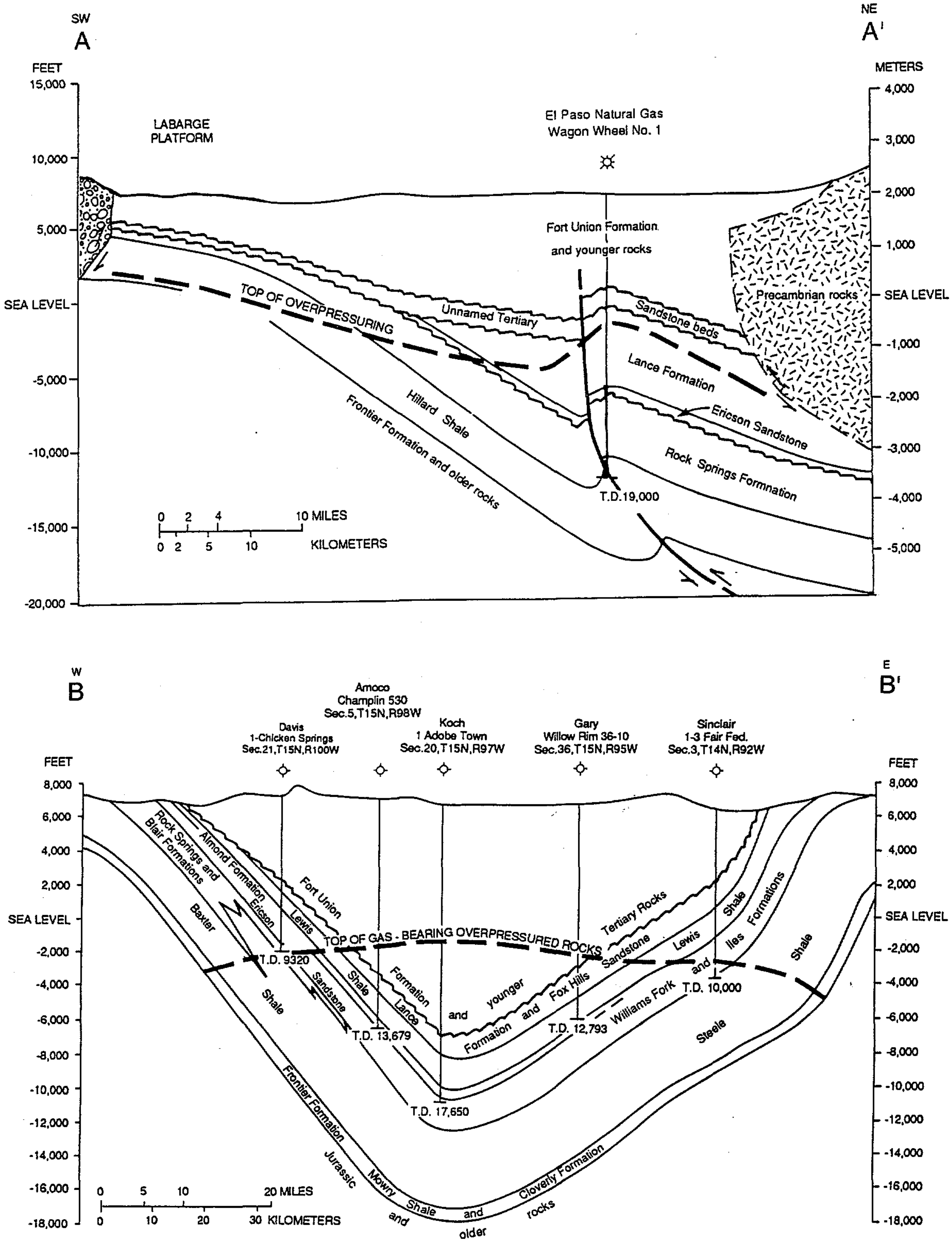


Figure 12. Structural cross-sections across the Green River Basin showing how the top of the overpressuring cuts across stratigraphic boundaries (modified from Law, et al., 1989). Location of cross-sections is shown in figure 11.

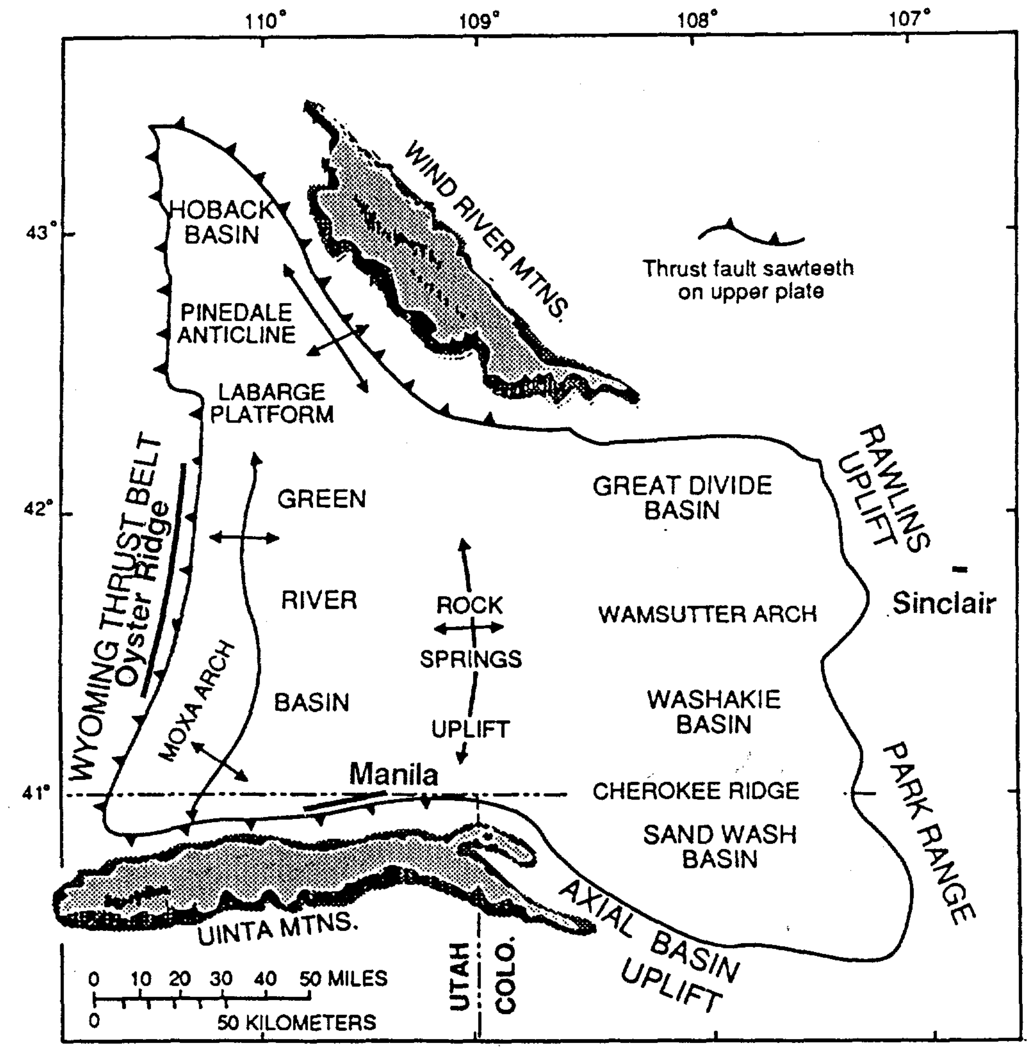


Figure 13. Index map showing the location of Frontier outcrops from which measurements of natural fractures were taken.

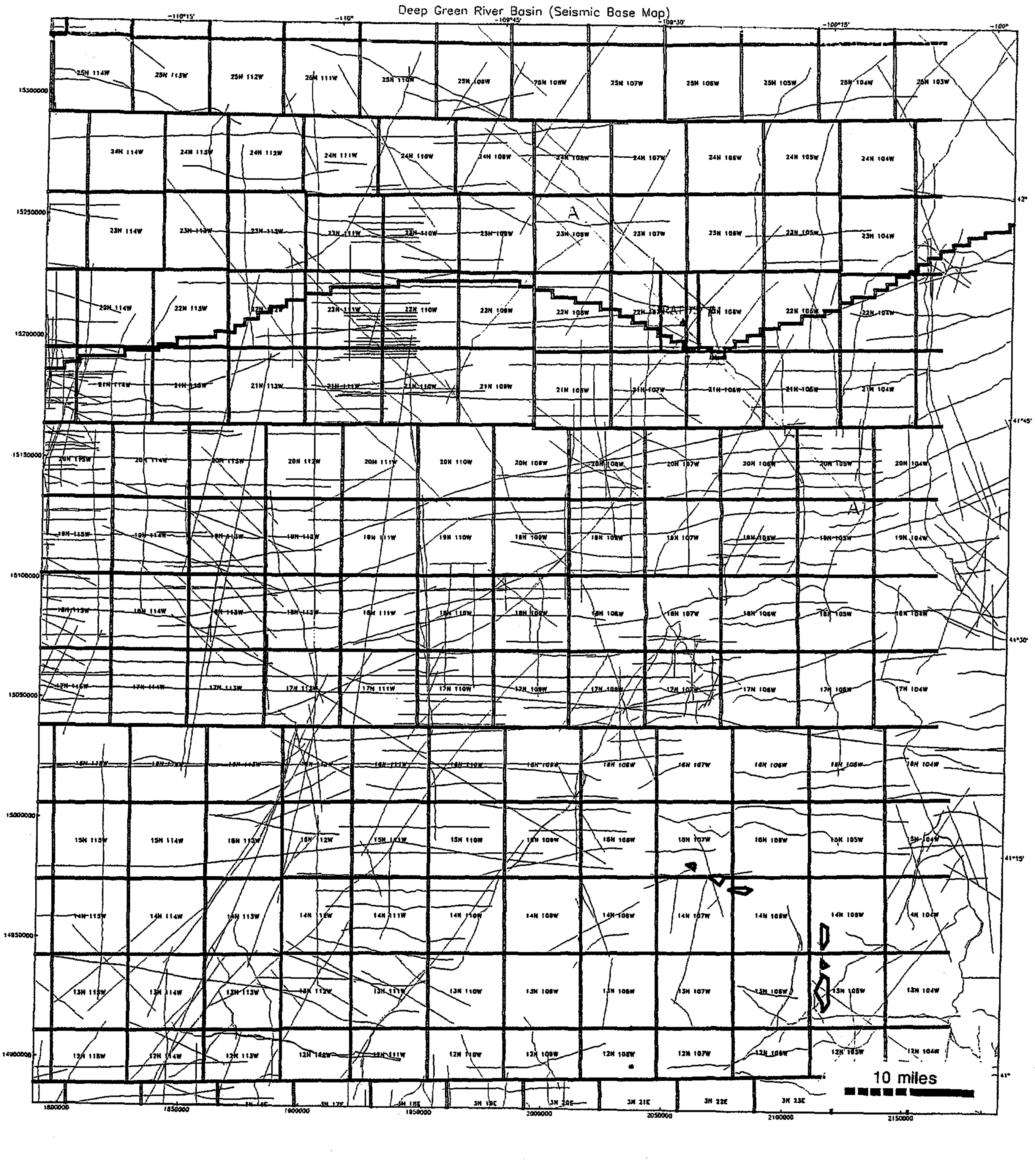


Figure 14. Seismic coverage index map, Greater Green River Basin, Wyoming. The locations of seismic line A-A' and the Stratos Federal Unit are highlighted.

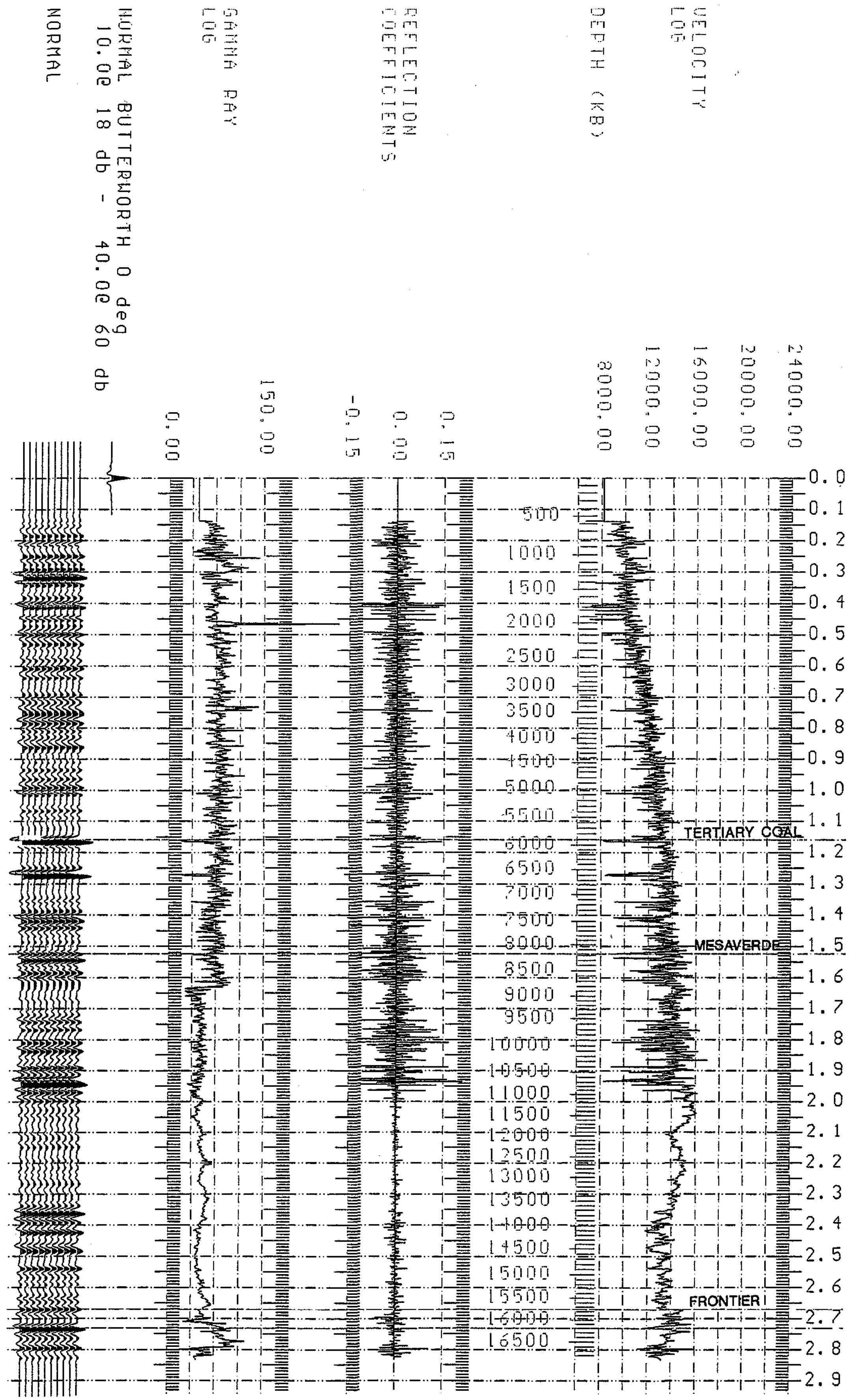


Figure 15. Synthetic from the ERG Blue Rim #31-1, Sec. 31-T22N-R106W, Sweetwater County, Wyoming.

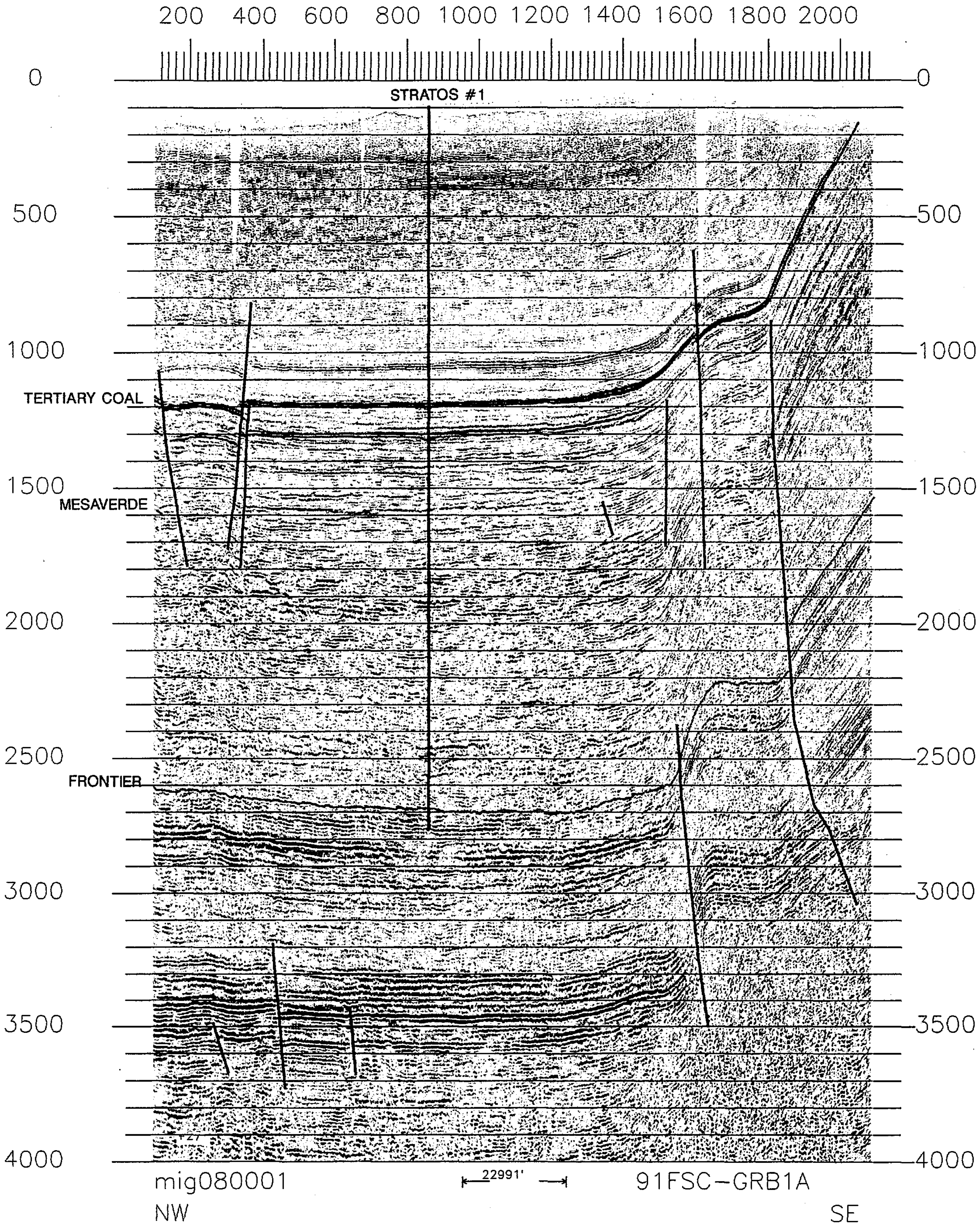


Figure 16. Northwest - southeast seismic line A-A' across the Stratos prospect. Location of seismic line is shown on Figure 14.

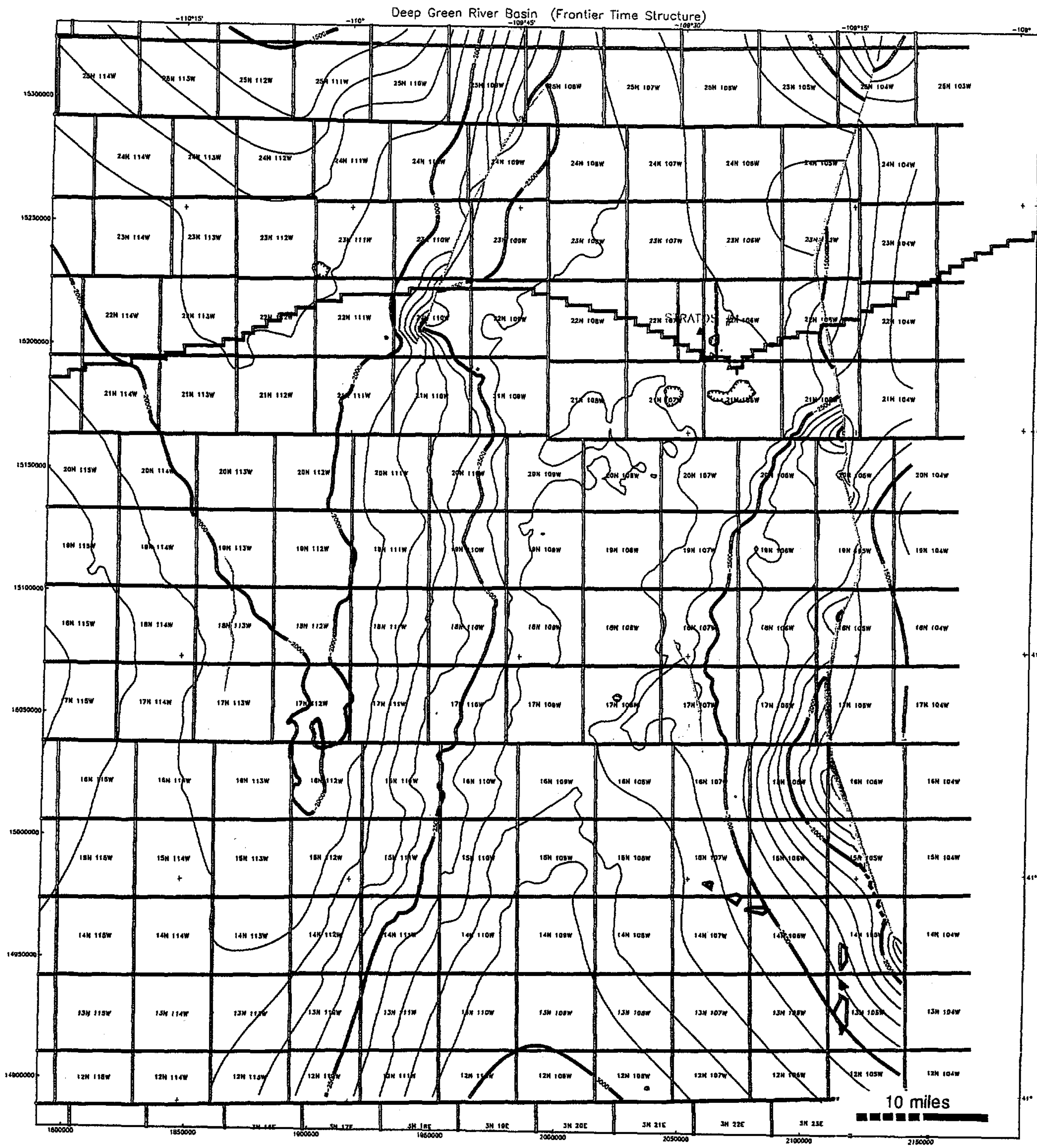


Figure 17. Time structure map on top of the Frontier Formation, Greater Green River Basin.

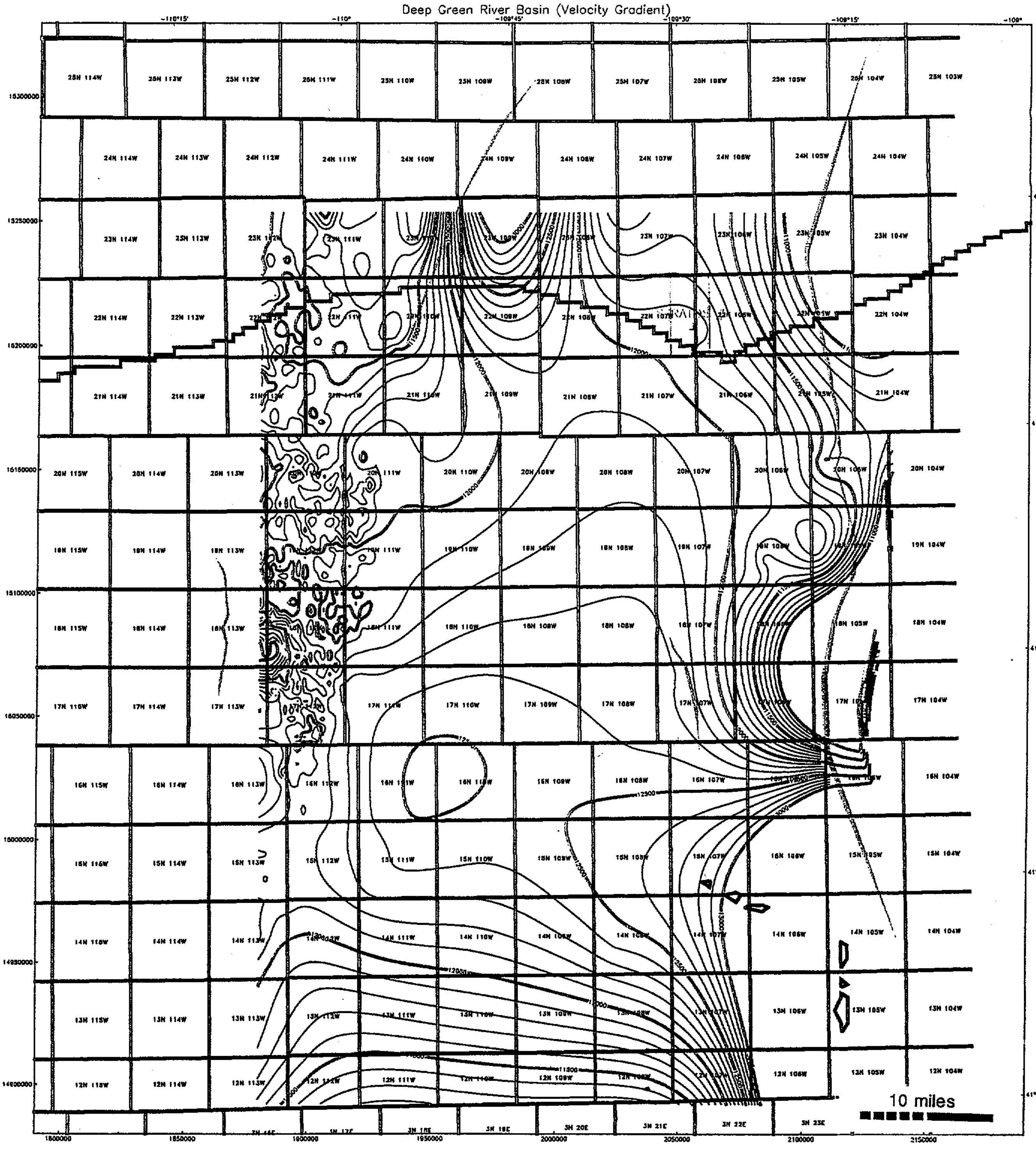


Figure 18. Velocity gradient map, Greater Green River Basin.

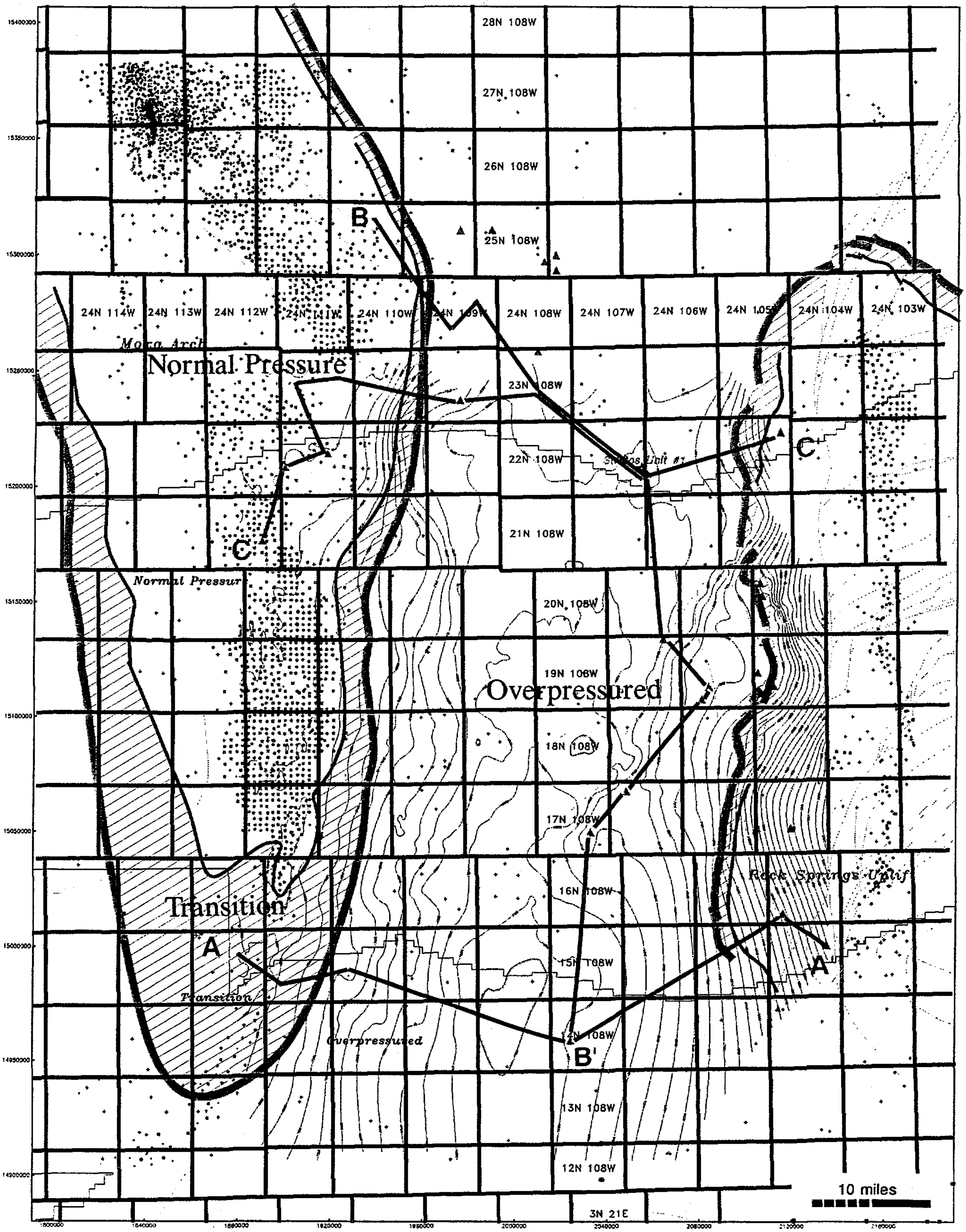


Figure 19. Depth structure map on top of the Frontier Formation showing the distribution of normally pressured, marginally overpressured (transition zone), and overpressured Frontier rocks.

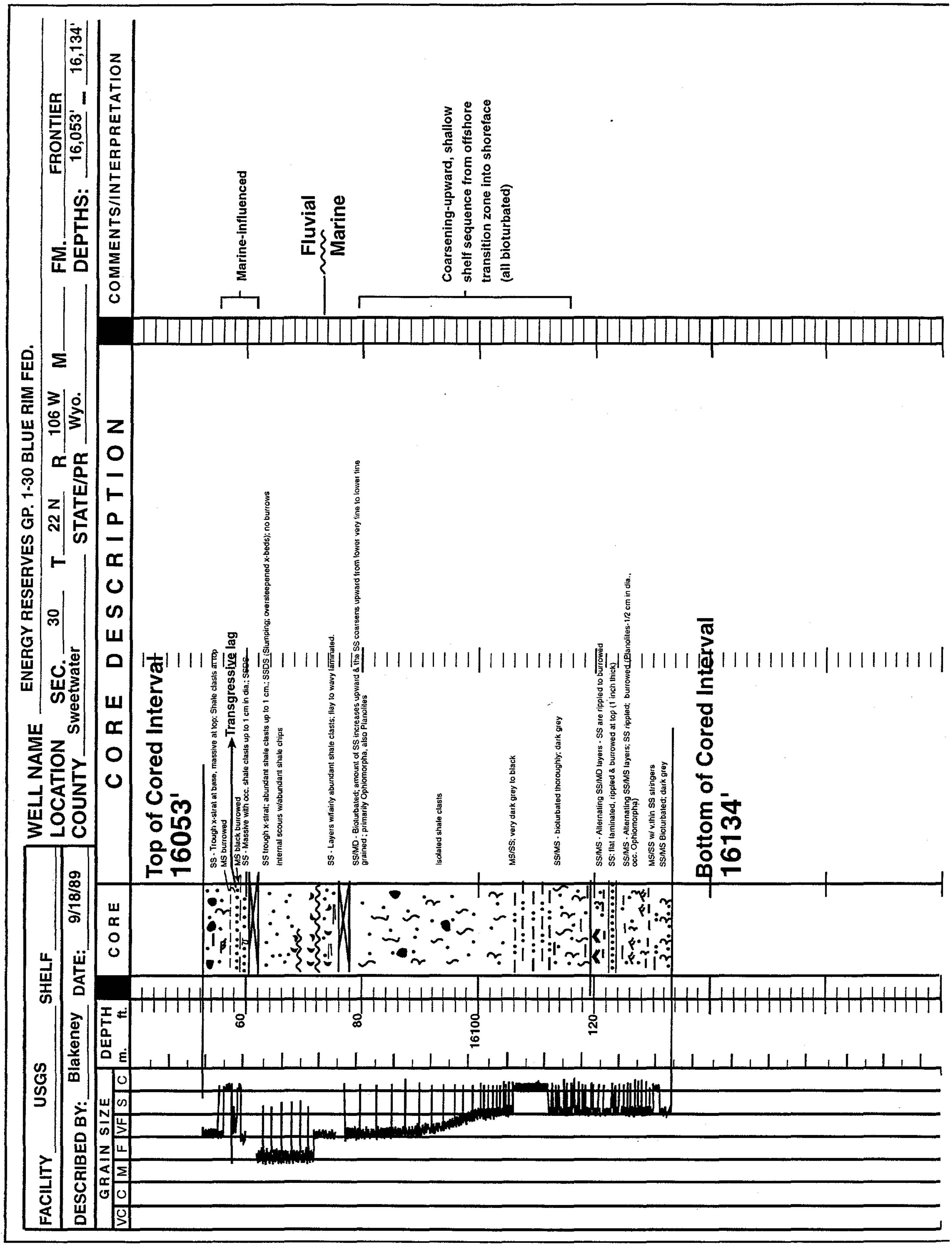


Figure 20. Core description for the ERG Blue Rim Federal #1-30, Sec. 30-T22N-R106W

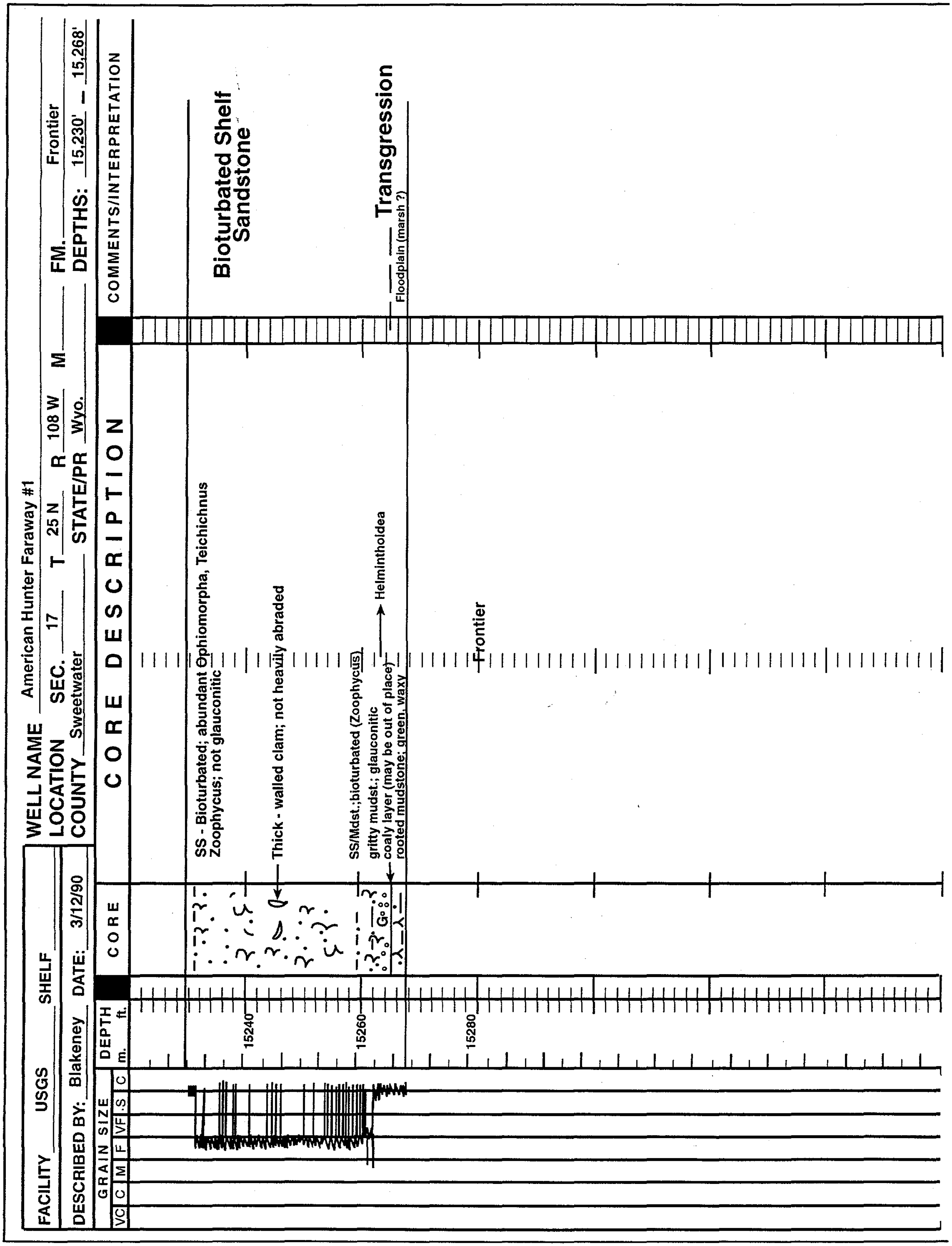


Figure 21. Core description for the American Hunter Faraway #1, Sec. 17-T25N-R108W

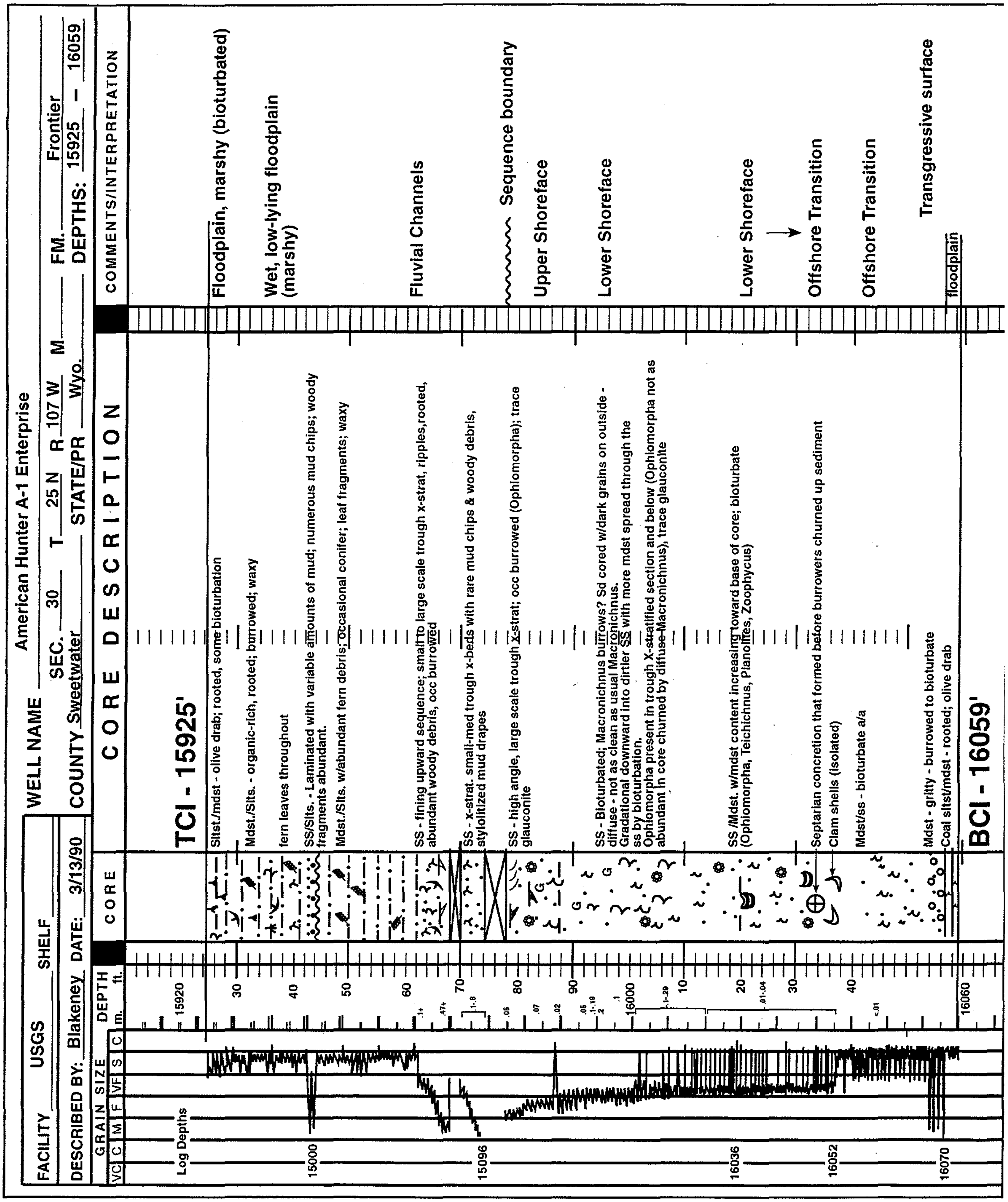


Figure 22. Core description for the American Hunter #A-1 Enterprise, Sec. 30-T25N-R107W.

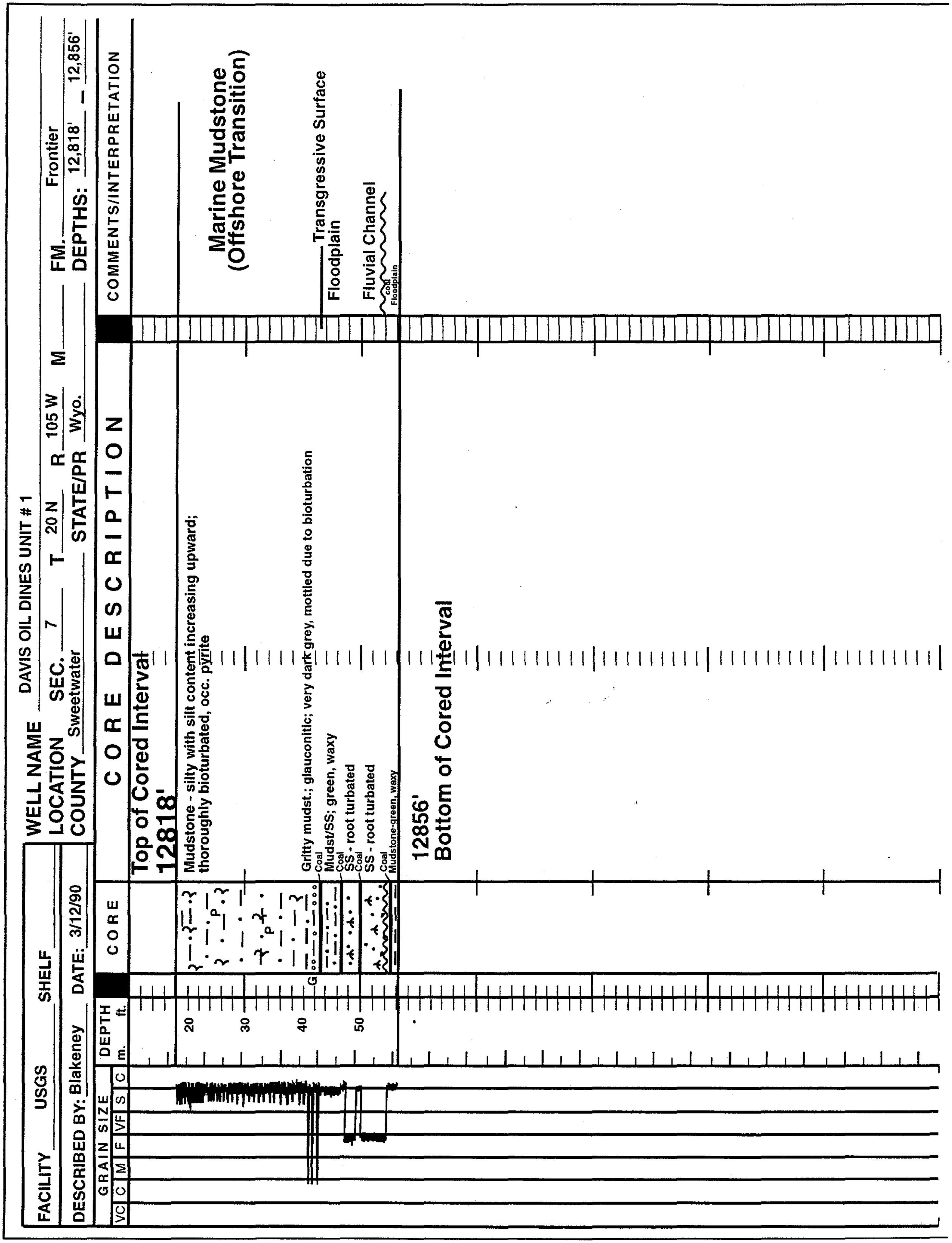


Figure 23. Core description for the Davis Oil Dines Unit #1, Sec. 7-T20N-R105W

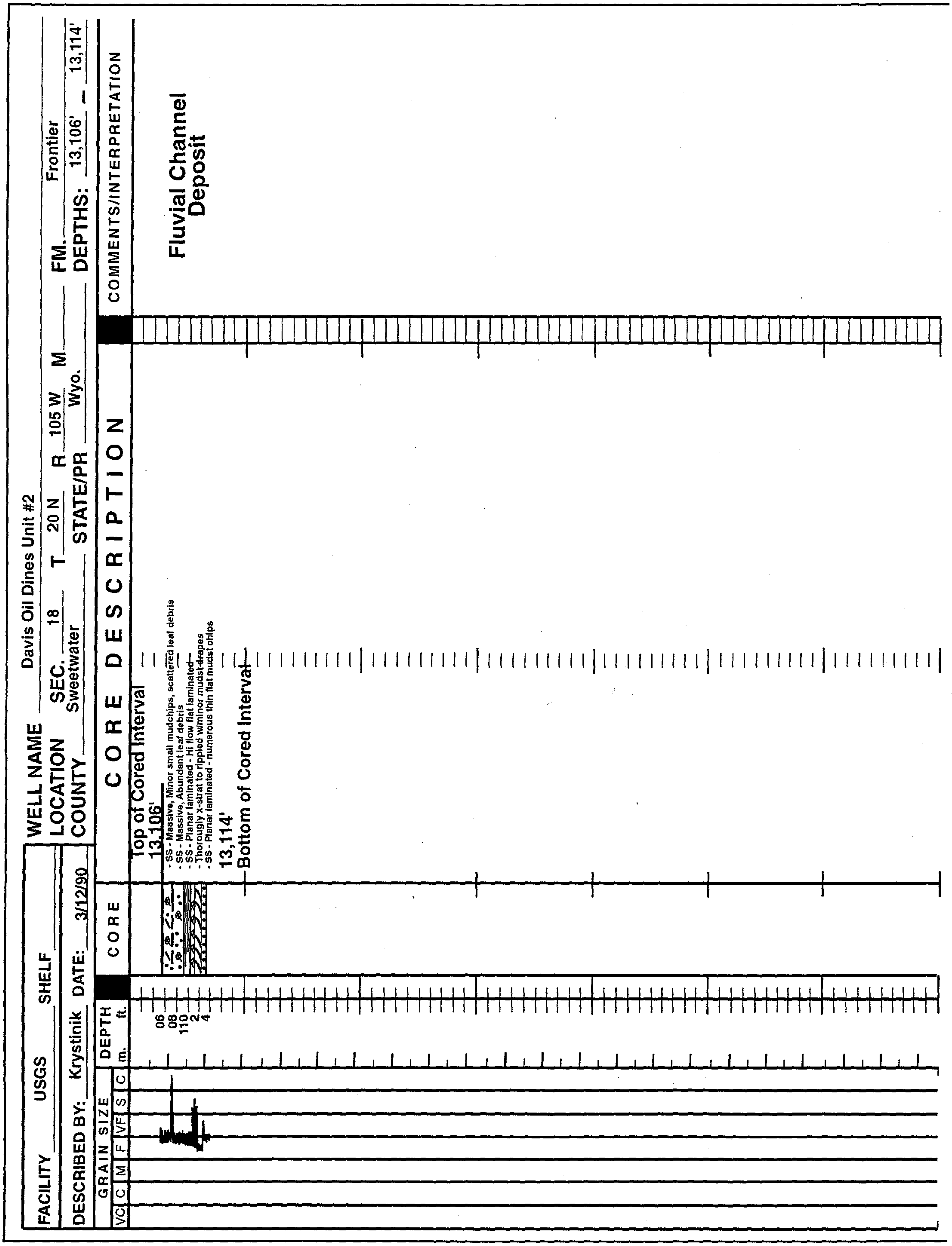


Figure 24. Core description for the Davis Oil Dines Unit #2, Sec. 18-T20N-R105W.

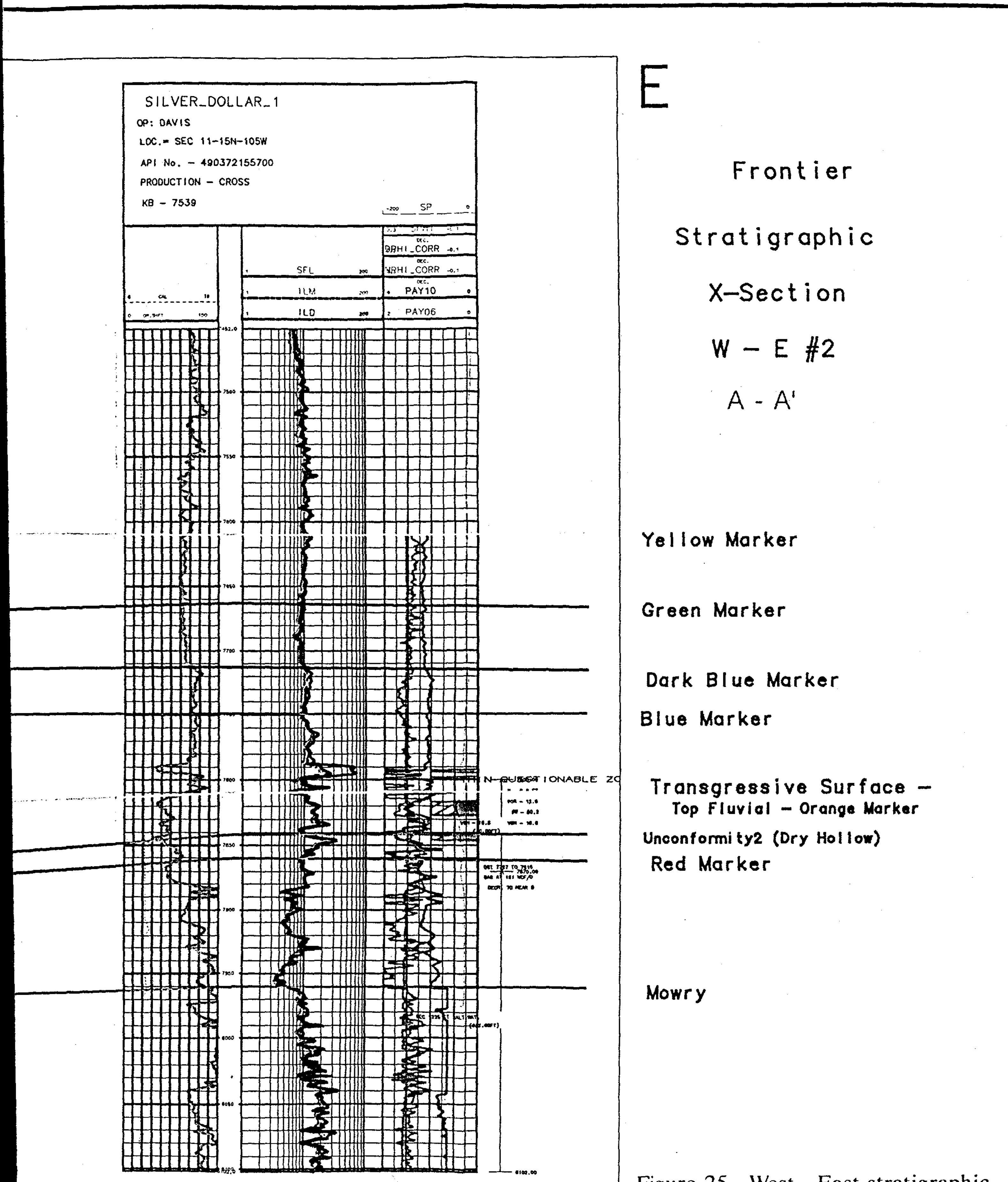
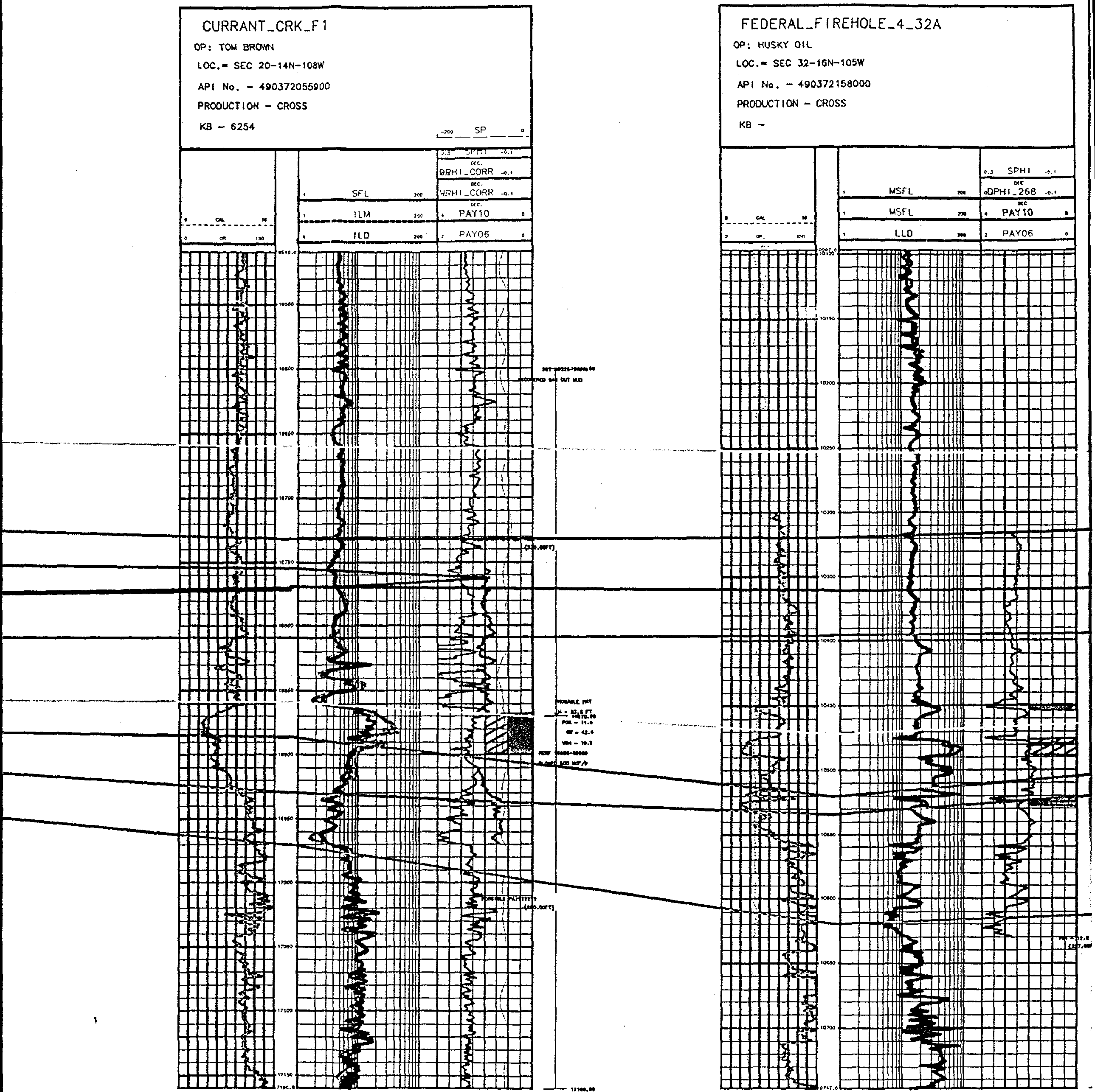
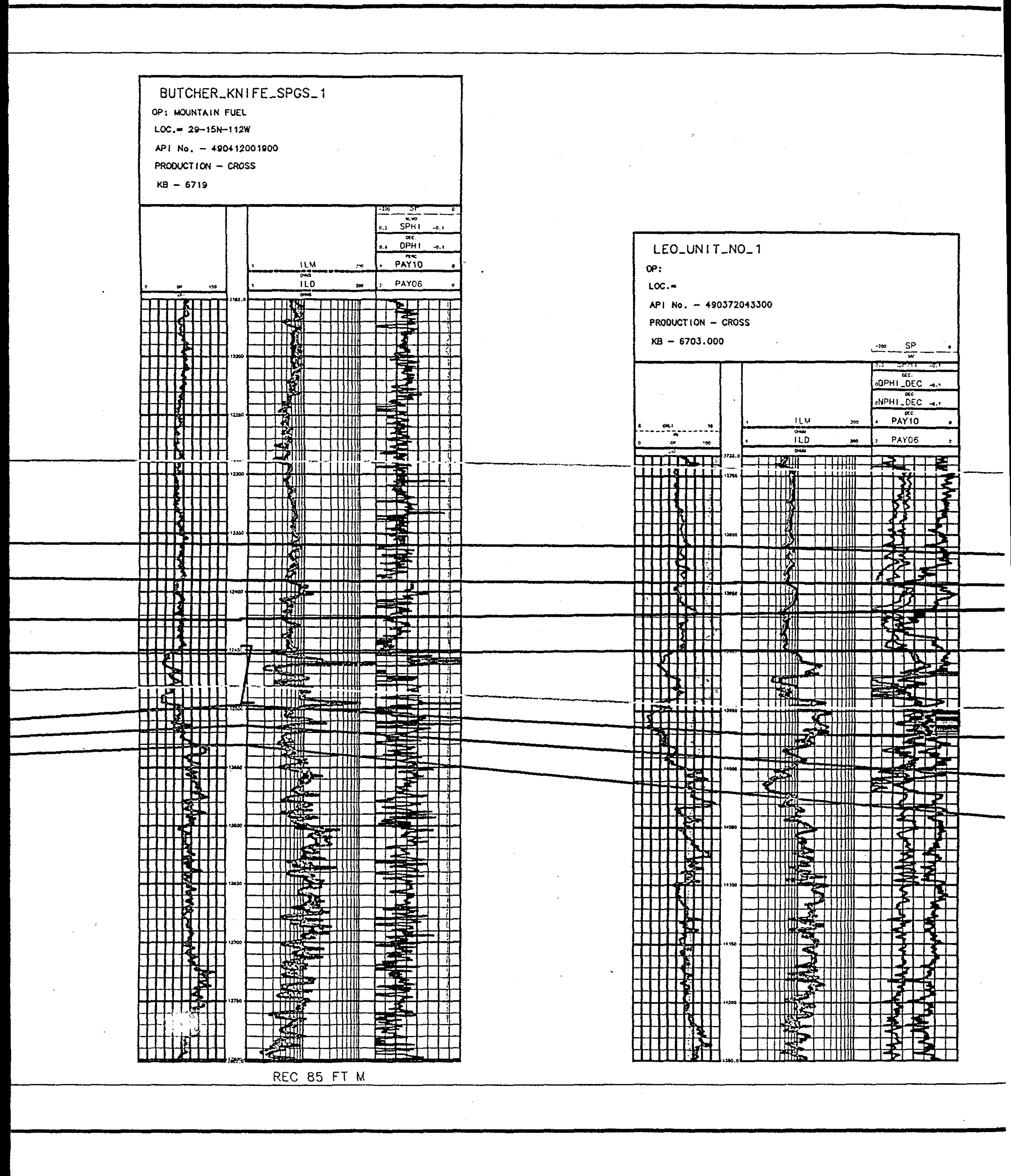


Figure 25. West - East stratigraphic cross-section of the Frontier Frontier. Location of cross-section shown on Figure 19.

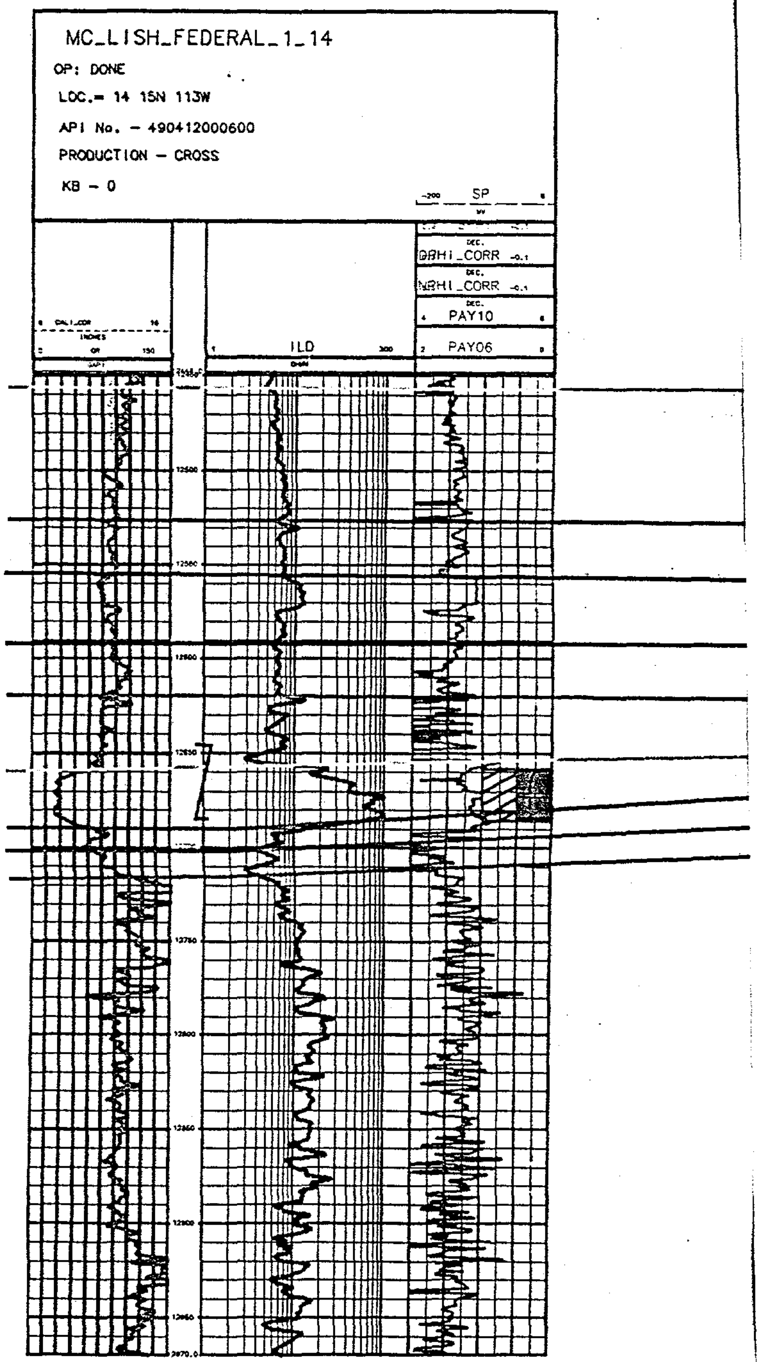

CURRANT_CRK_F1
OP: TOM BROWN
LOC.= SEC 20-14N-108W
API No. - 490372055900
PRODUCTION - CROSS
KB - 6254
SP
DRHI_CORR
SFL
WRHI_CORR
ILM
PAY10
ILD
PAY06
CAL
GR
PROBABLE PAY
FEDERAL_FIREHOLE_4_32A
OP: HUSKY OIL
LOC.= SEC 32-16N-105W
API No. - 490372158000
PRODUCTION - CROSS
KB -
SPHI
MSFL
DPHI_268
MSFL
PAY10
LLD
PAY06
CAL
GR

1



BUTCHER_KNIFE_SPGS_1
OP: MOUNTAIN FUEL
LOC.= 29-15N-112W
API No. - 490412001900
PRODUCTION - CROSS
KB - 6719
SP
SPHI
DPHI
ILM
PAY10
ILD
PAY06
REC 85 FT M
LEO_UNIT_NO_1
OP:
LOC.=
API No. - 490372043300
PRODUCTION - CROSS
KB - 6703.000
SP
SPHI
DPHI_DEC
NPHI_DEC
ILM
PAY10
ILD
PAY06

W



REC 2 BBL O 2600 FT O&GCW

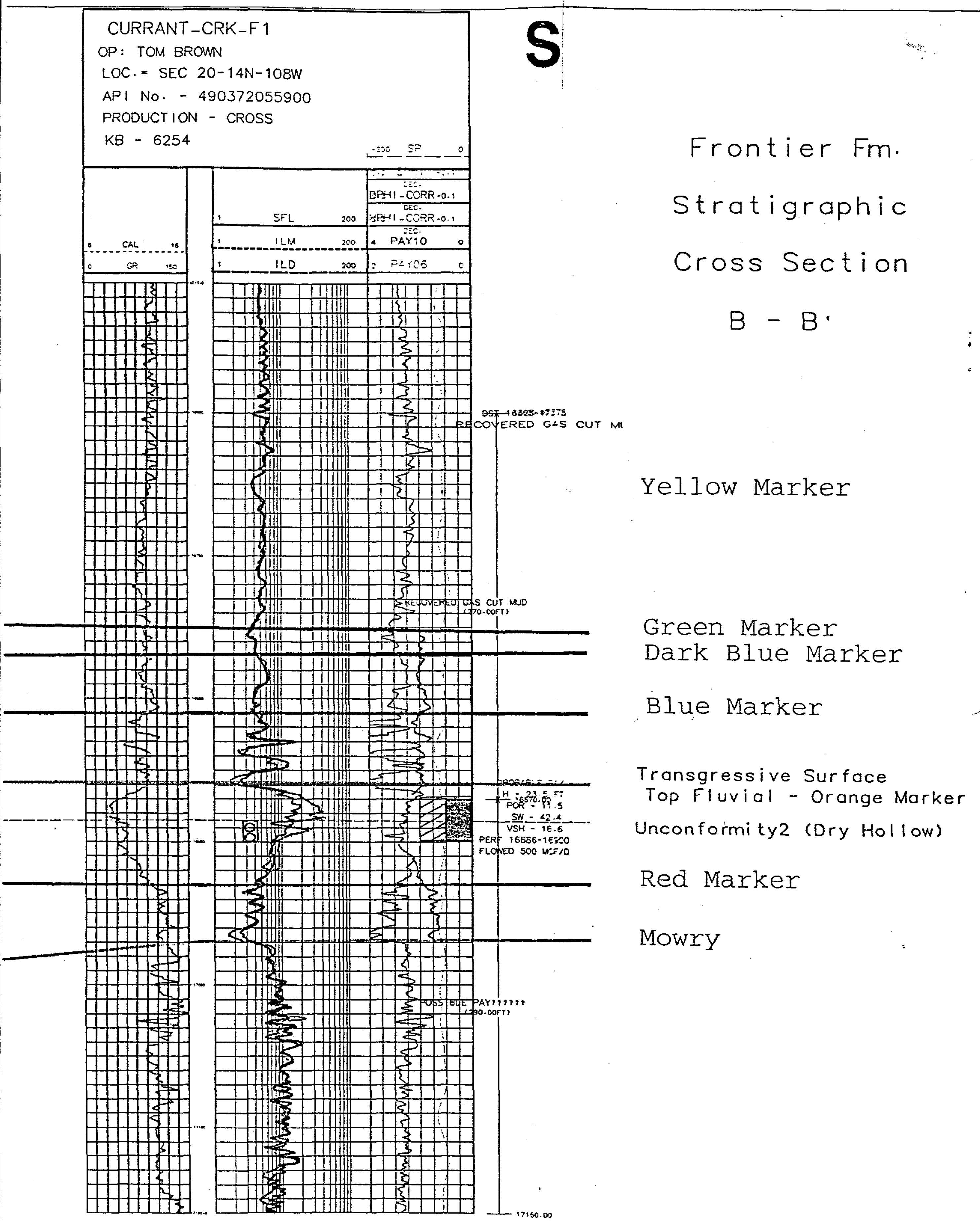
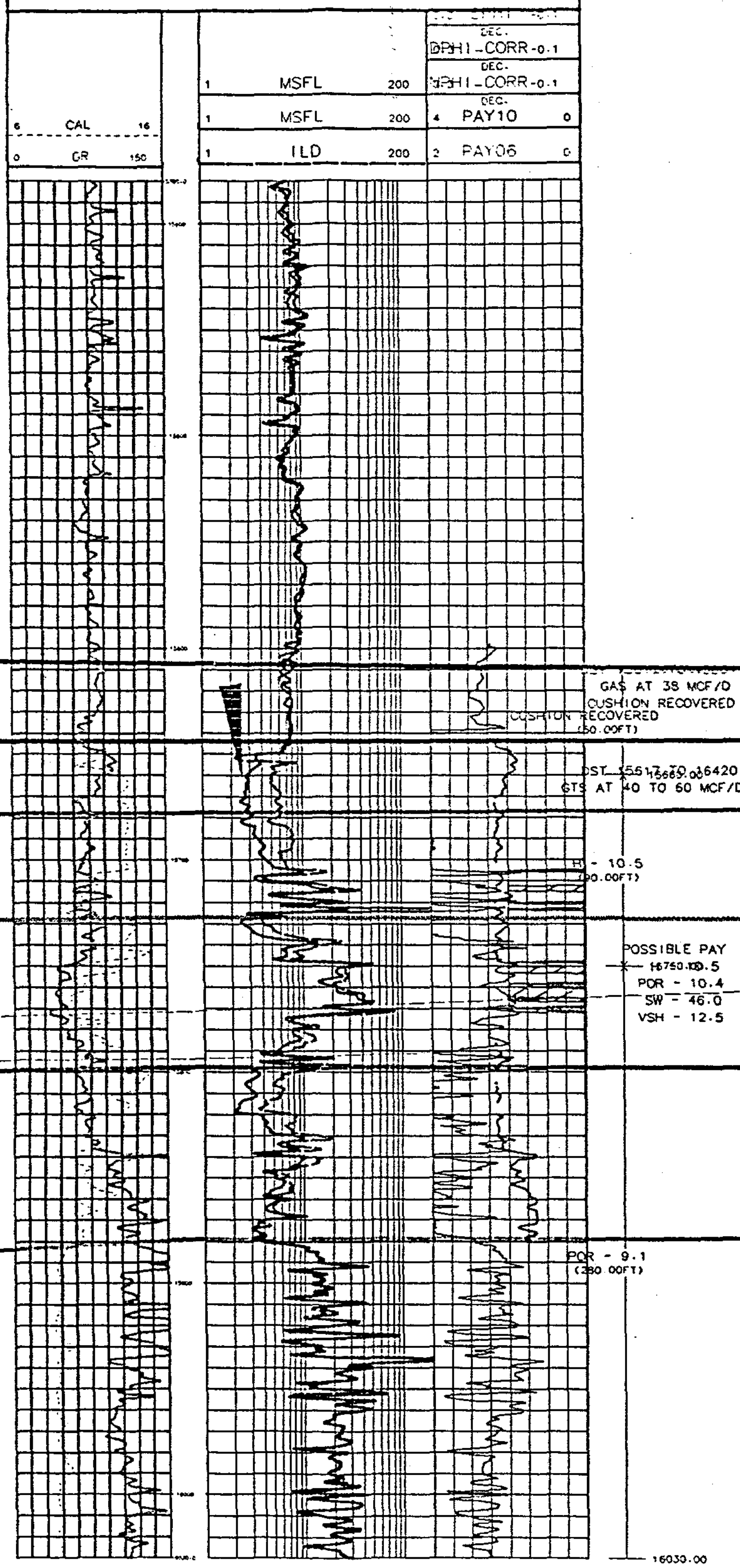
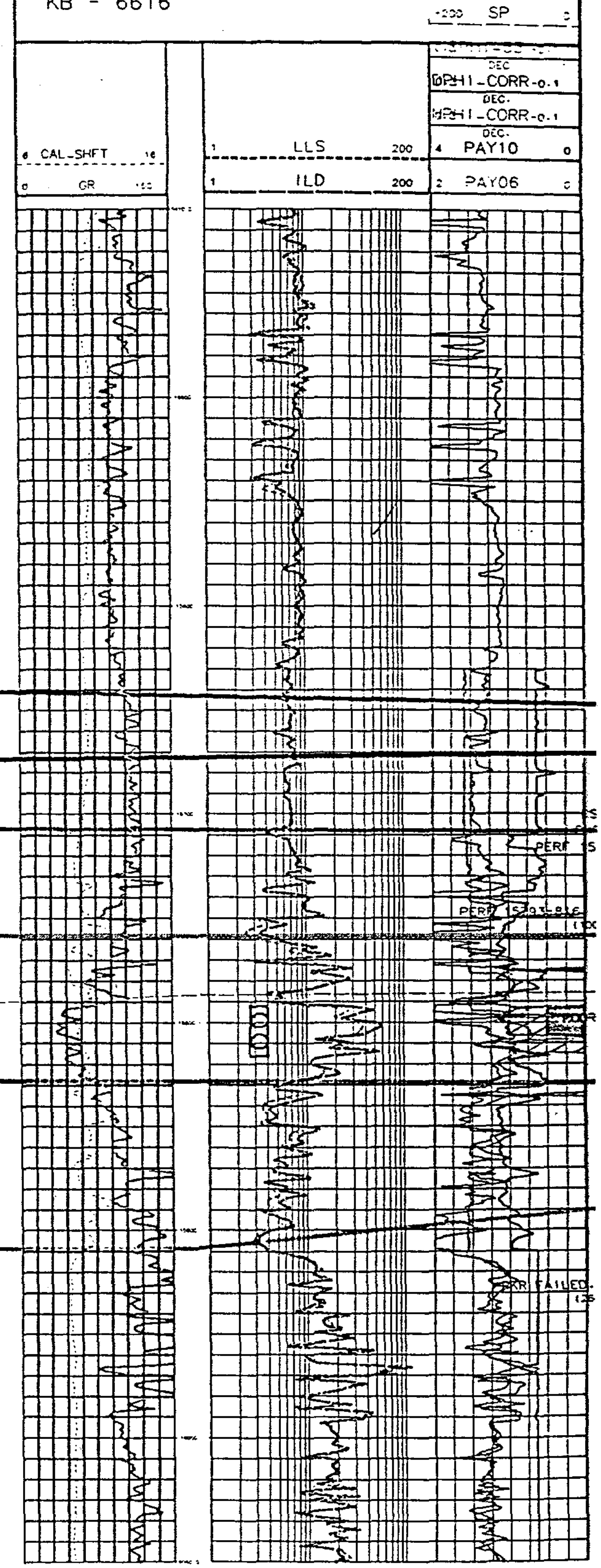


Figure 26. North - South stratigraphic cross-section of the Frontier Formation. Location of cross-section shown on Figure 19.

MASSACRE-11-5
OP: HUSKY OIL
LOC.= SEC 5-17N-107W
API No. - 490372109200
PRODUCTION - CROSS
KB - 6801

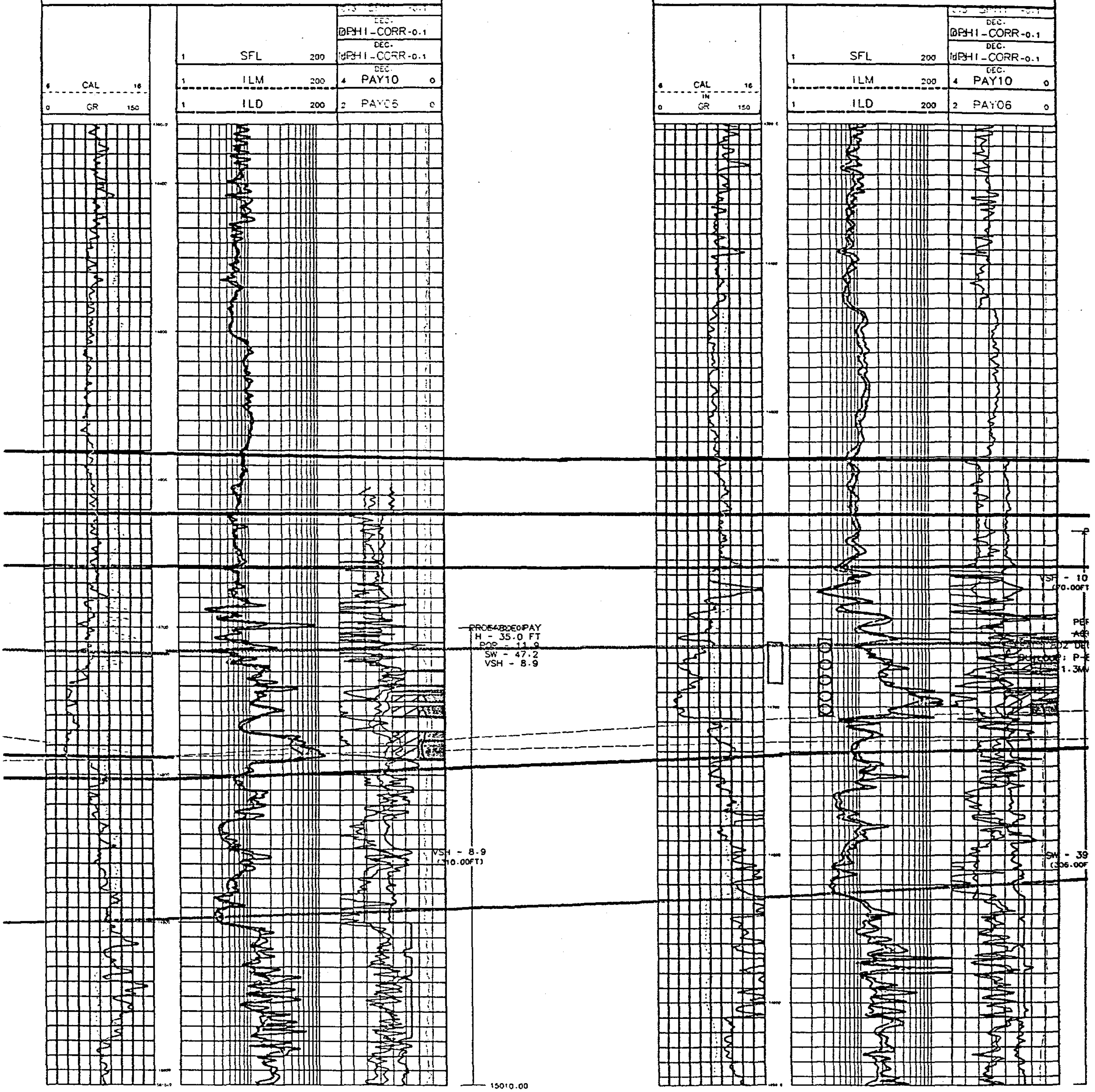


MASSACRE-3-26
OP: HUSKY OIL
LOC.= SEC 26-17N-108W
API No. - 490372106600
PRODUCTION - CROSS
KB - 6616

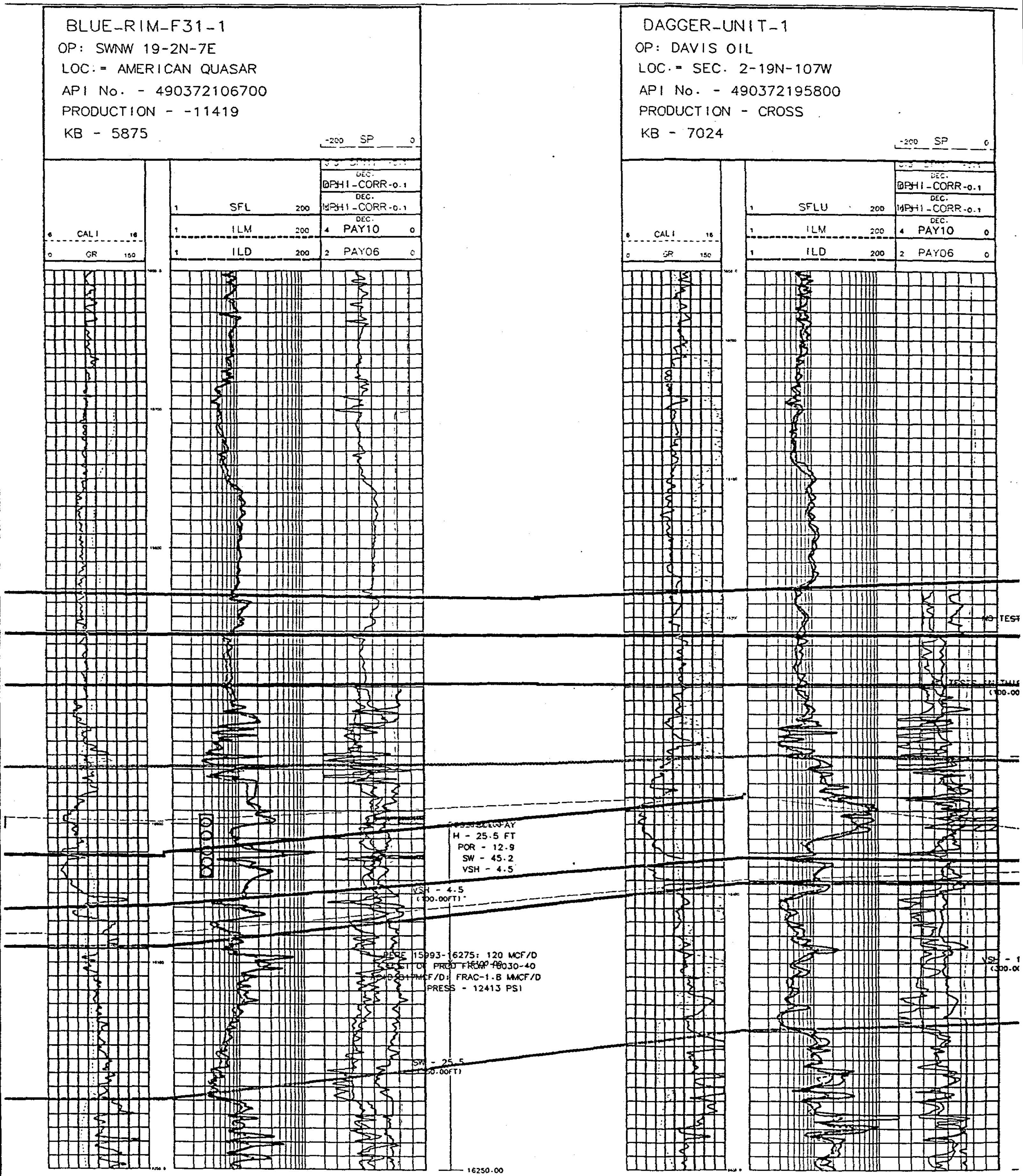


POITEVENT-FED-1
OP: DAVIS OIL
LOC.= SEC 28-19N-106W
API No. - 490372112800
PRODUCTION - CROSS
KB - 7368

SUE-FED-1
OP: DAVIS
LOC.= SEC 32-19N-106W
API No. - 490372120600
PRODUCTION - CROSS
KB - 7150



IP: 332 MCFD
frac: 147 Kgal
179 K # sand



IP= 1797 MCFD
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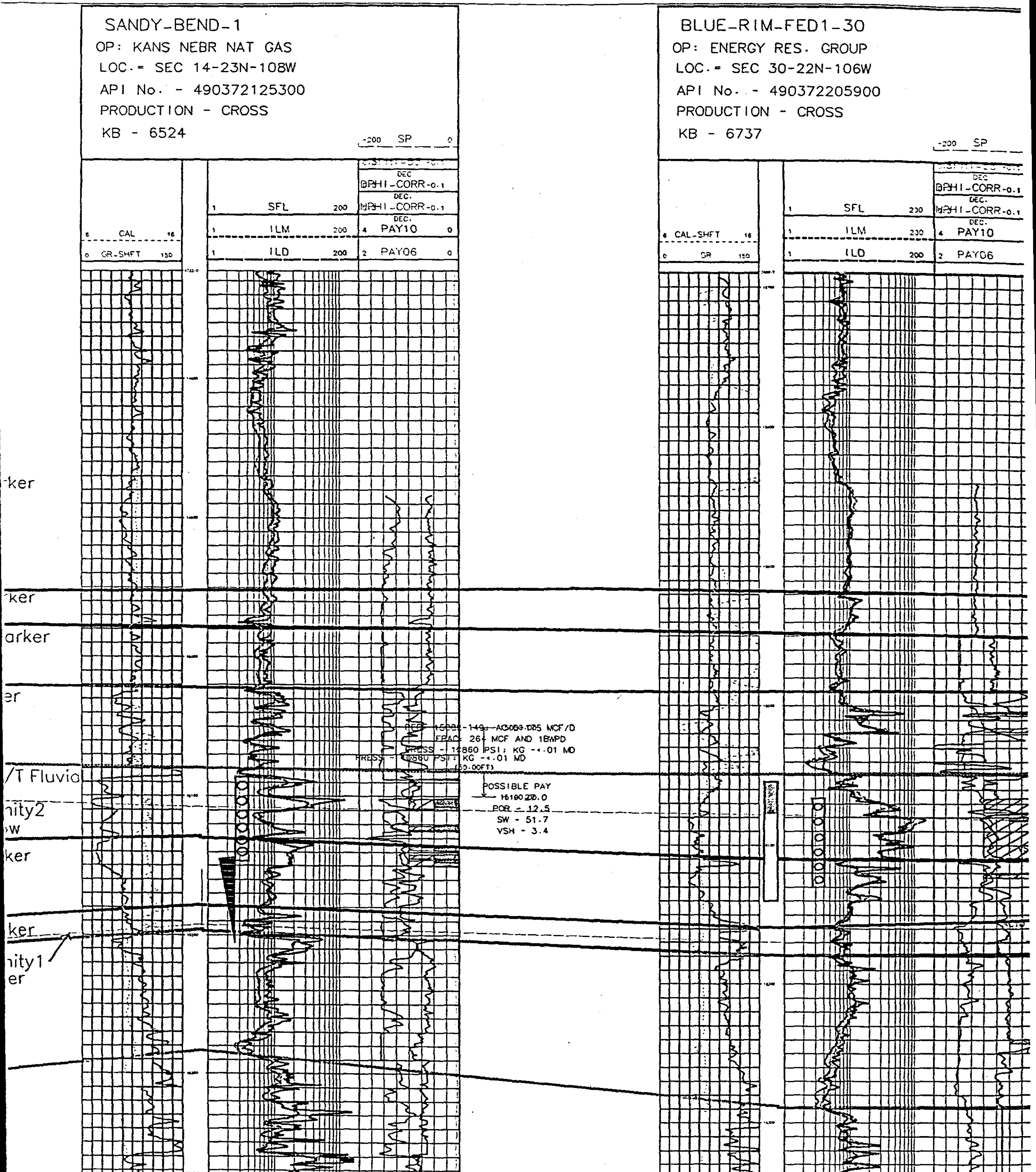
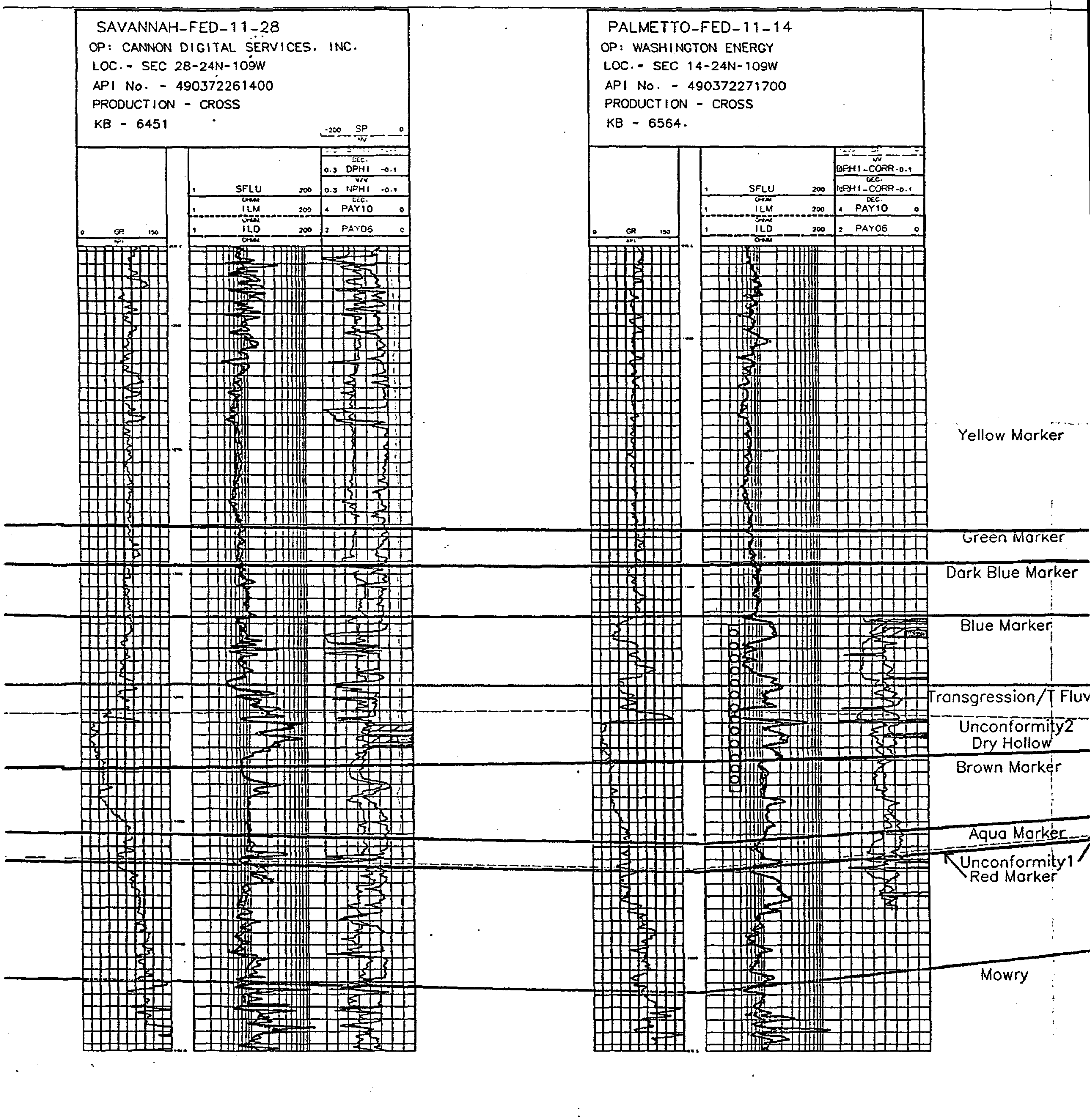
77 K # sand



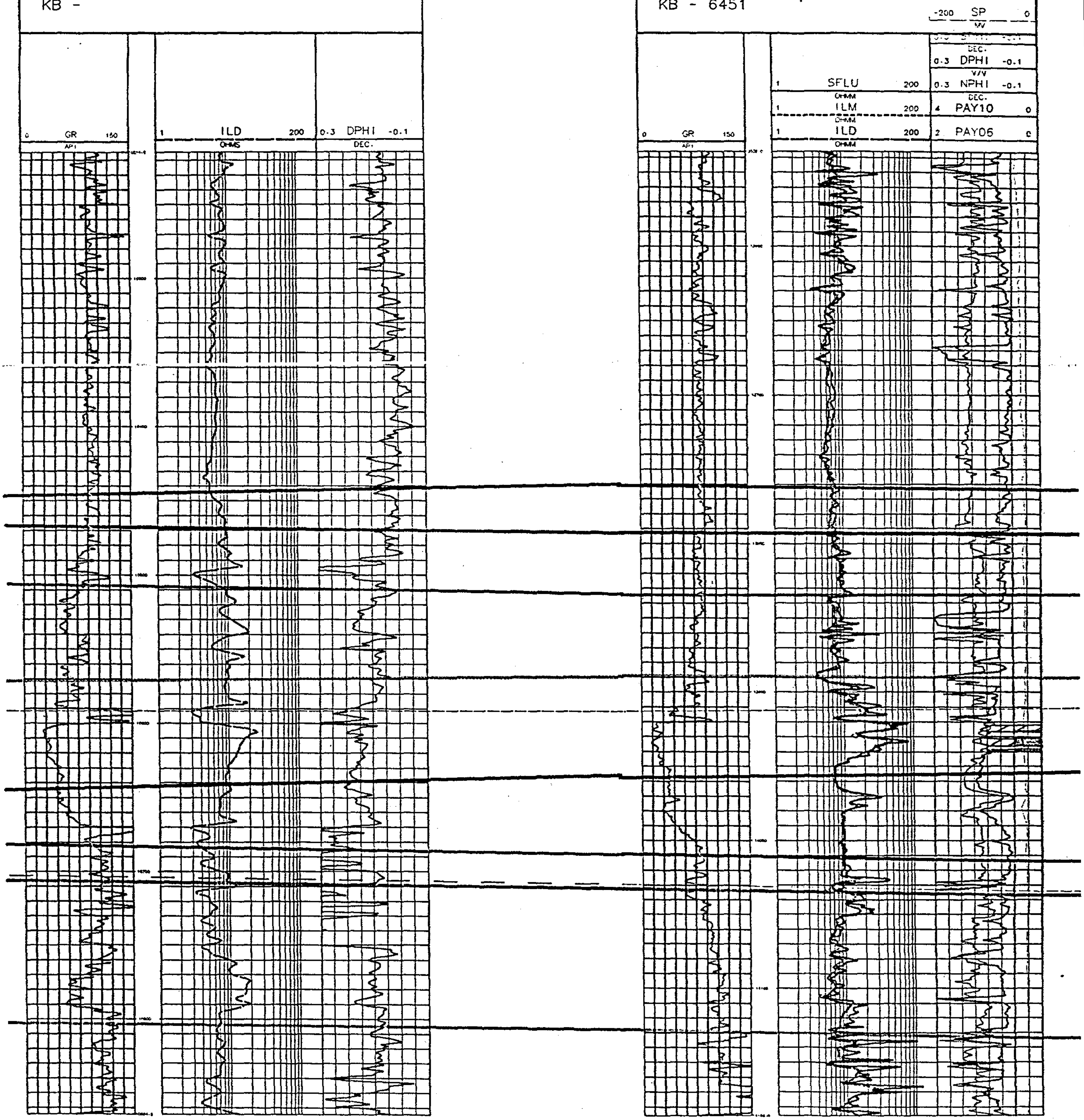
IP= 264 MCFD
frac: 316 Kgal
579 K # sand

IP= 1316 MCFD
frac: 52 Kgal
75 K # sand


SAVANNAH-FED-11-28
OP: CANNON DIGITAL SERVICES, INC.
LOC.- SEC 28-24N-109W
API No. - 490372261400
PRODUCTION - CROSS
KB - 6451
GR
SFLU
ILM
ILD
SP
DPHI
NPHI
PAY10
PAY06
PALMETTO-FED-11-14
OP: WASHINGTON ENERGY
LOC.- SEC 14-24N-109W
API No. - 490372271700
PRODUCTION - CROSS
KB - 6564.
GR
SFLU
ILM
ILD
DPHI-CORR
NPHI-CORR
PAY10
PAY06
Yellow Marker
Green Marker
Dark Blue Marker
Blue Marker
Transgression/T Fluv
Unconformity2
Dry Hollow
Brown Marker
Aqua Marker
Unconformity1
Red Marker
Mowry

FEDERAL-31-3
OP: ENERGETICS
LOC.= SEC 3-25N-110W
API No. - 490372207900
PRODUCTION - CROSS
KB -

SAVANNAH-FED-11-28
OP: CANNON DIGITAL SERVICES, INC.
LOC.= SEC 28-24N-109W
API No. - 490372261400
PRODUCTION - CROSS
KB - 6451



N

FEDERAL-31-3

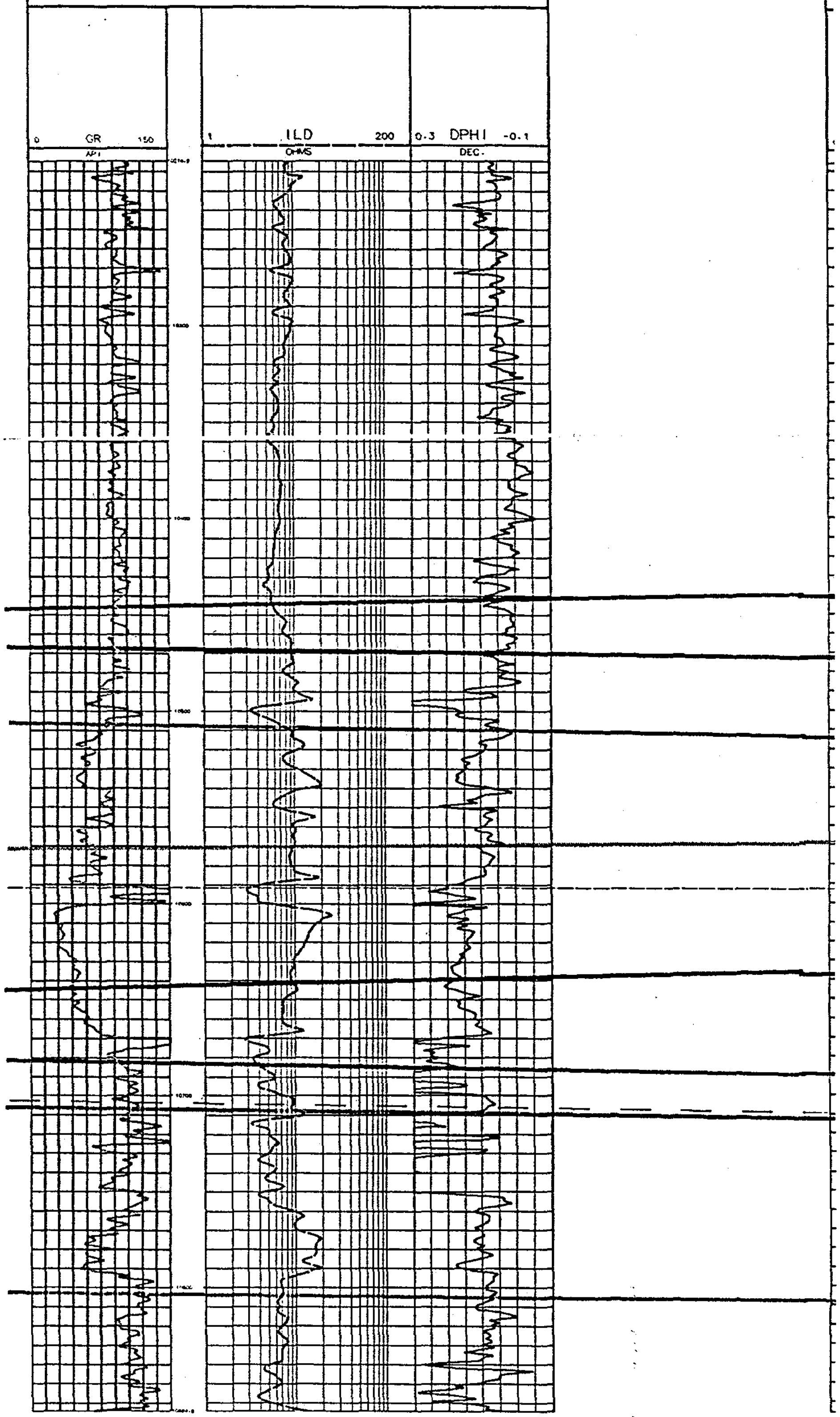
OP: ENERGETICS

LOC.= SEC 3-25N-110W

API No. - 490372207900

PRODUCTION - CROSS

KB -



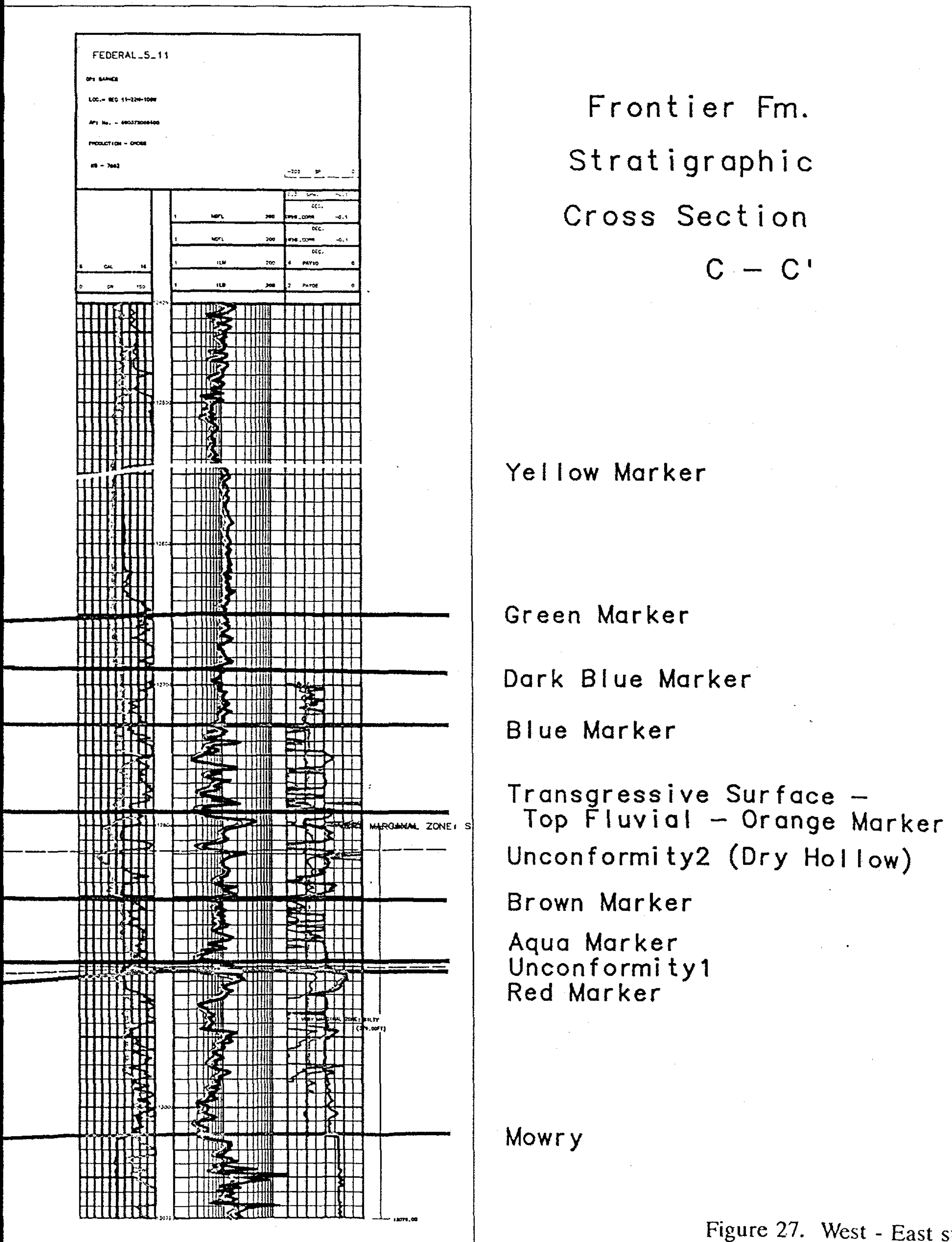
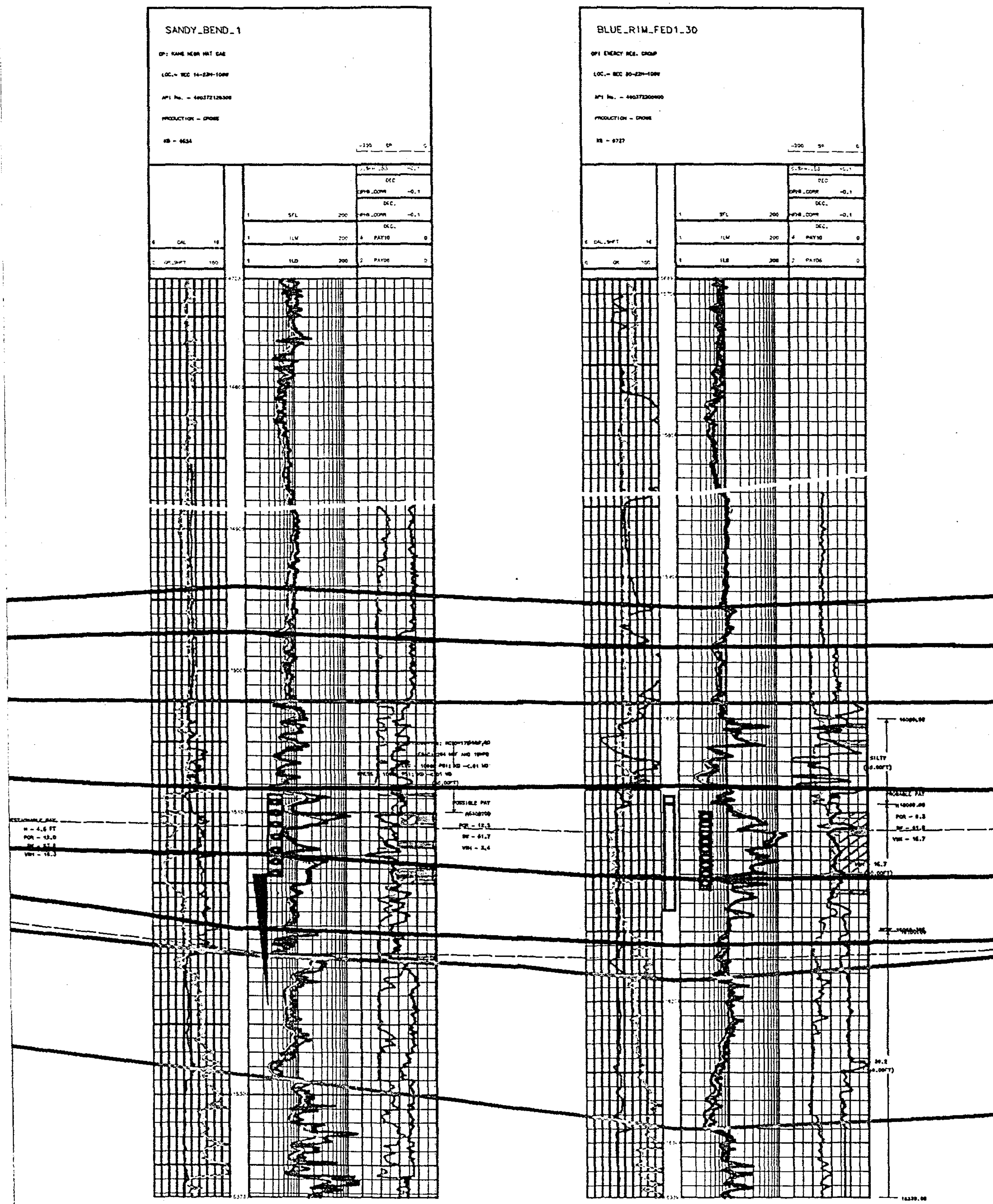


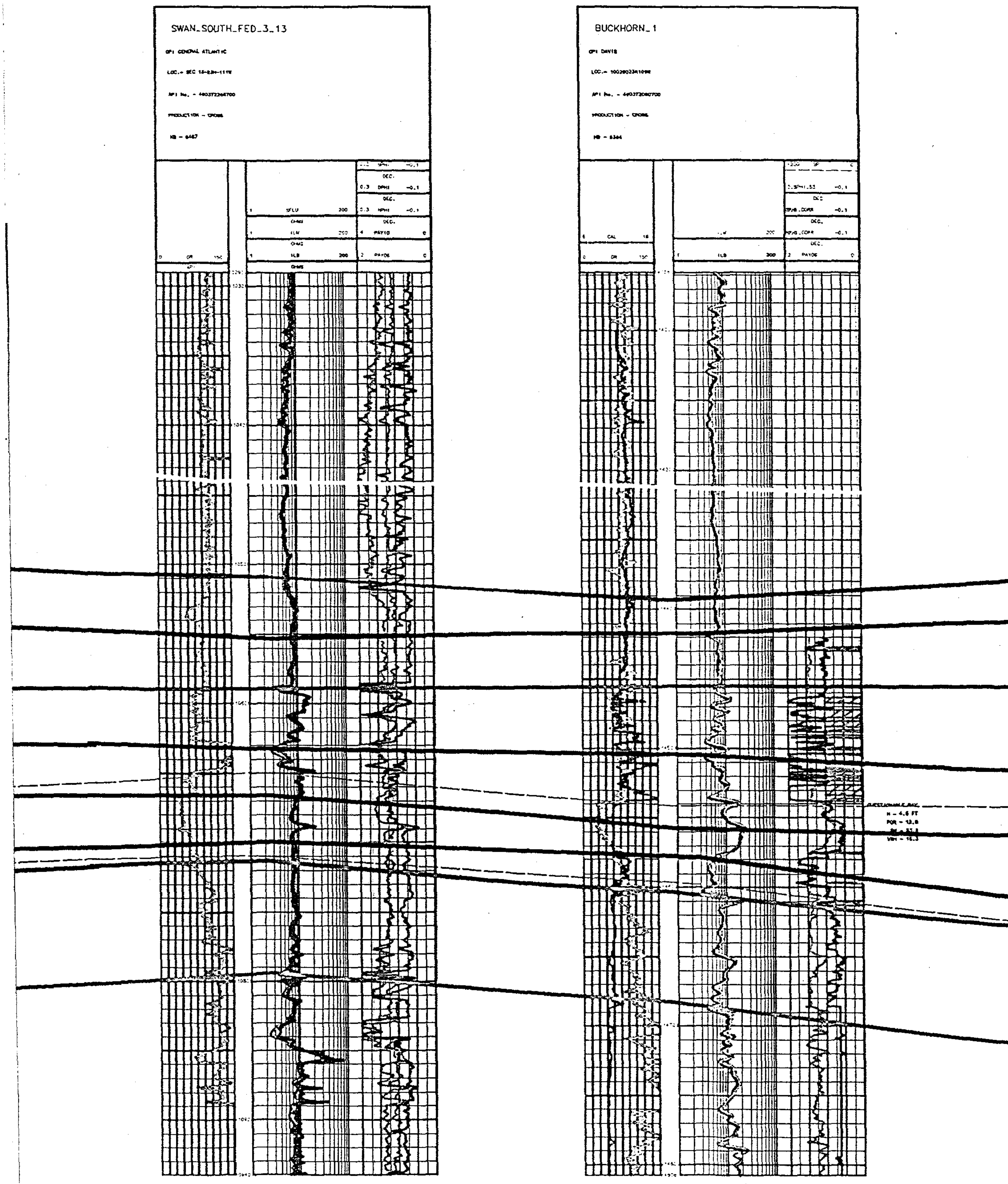
Figure 27. West - East stratigraphic cross-section of the Frontier Formation. Location of cross-section shown on Figure 19.

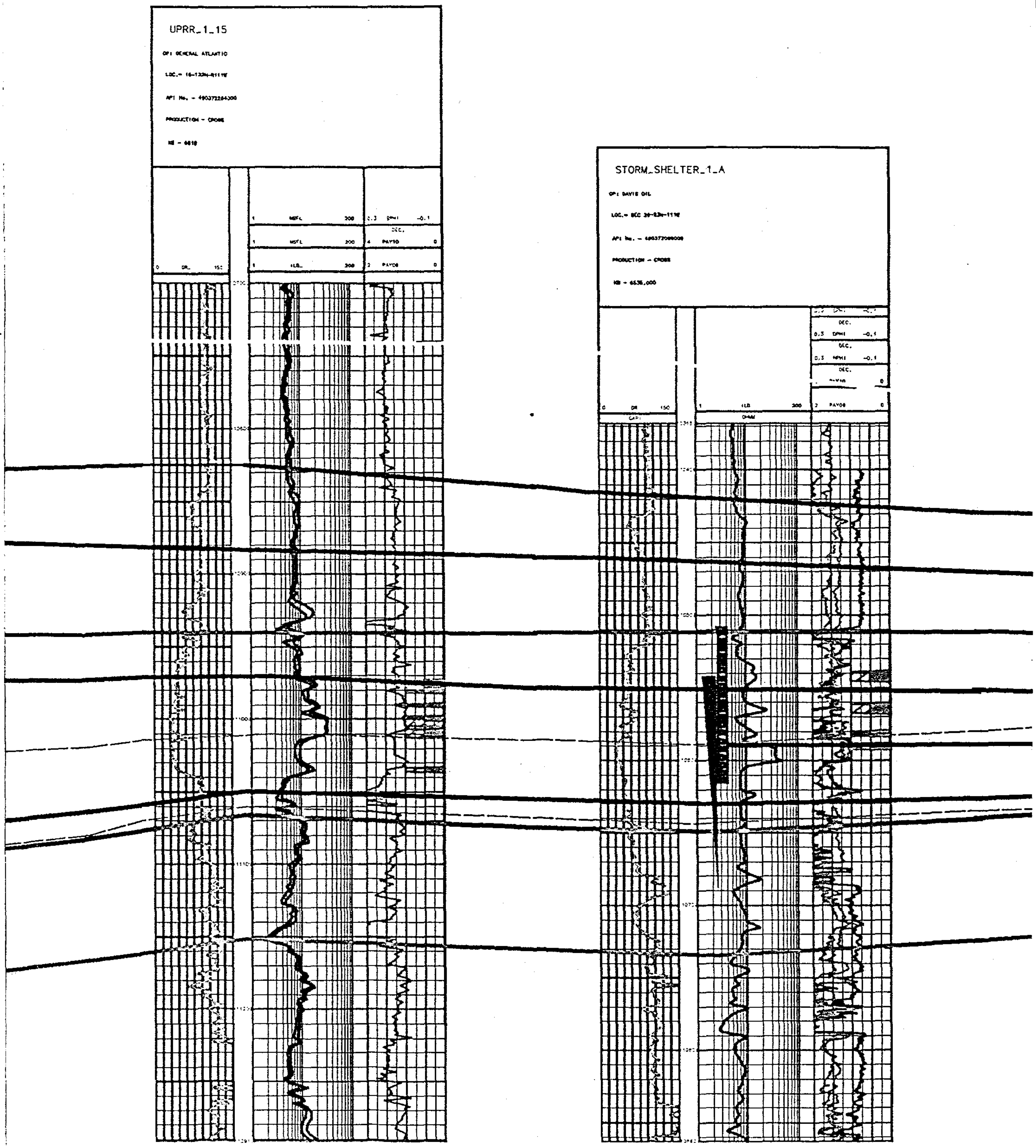
EAST



IP= 264 MCFD
frac: 316 Kgal
579 K # sand

IP= 1316 MCFD
frac: 52 Kgal
75 K # sand


SWAN_SOUTH_FED_3_13
BUCKHORN_1


UPRR_1_15
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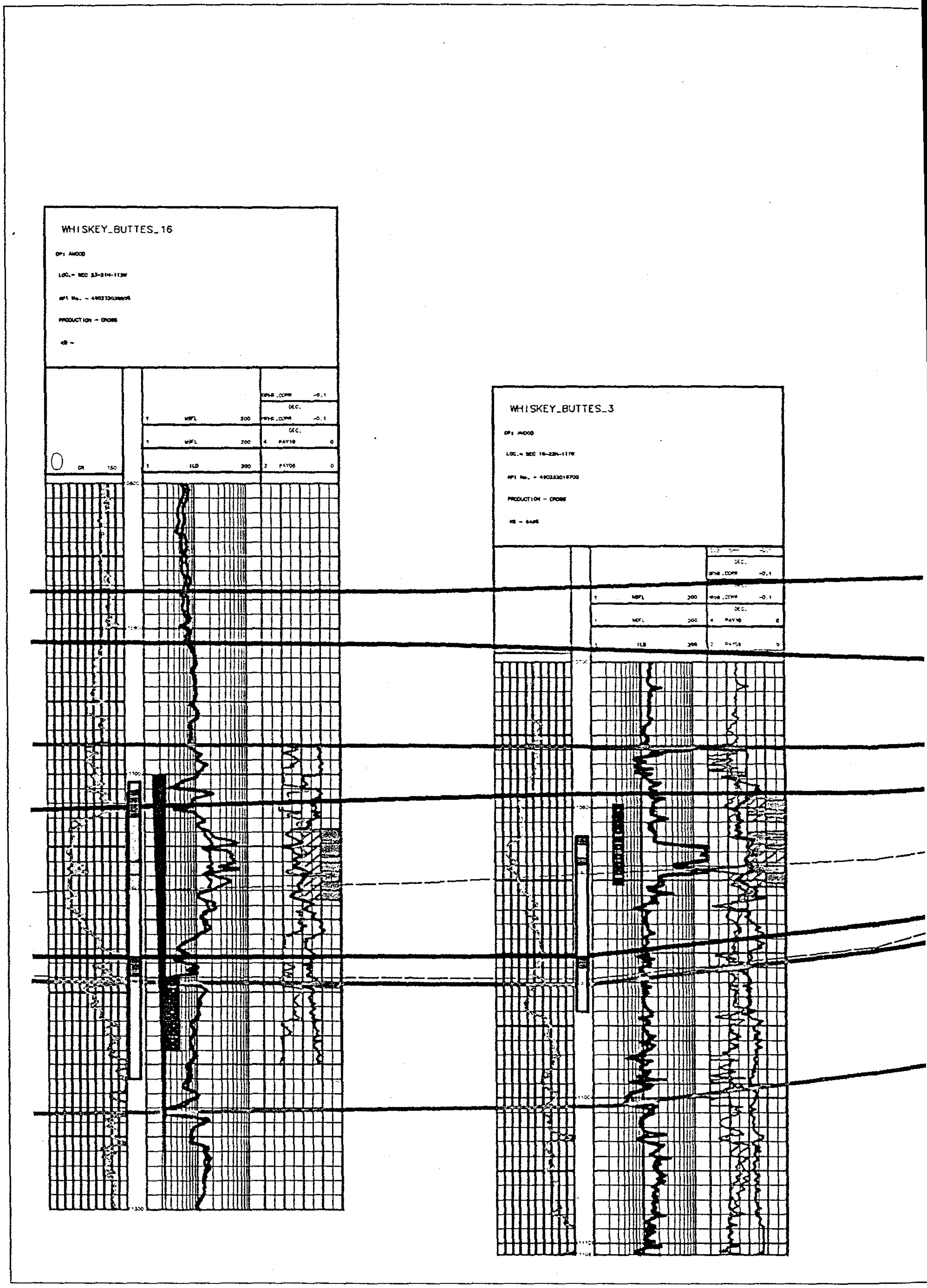
PRODUCTION - CROSS
0 GR 150
1 MSFL 200
0.3 DPHI -0.1
DEC.
4 PAY10 0
1 ILD 200
2 PAY08 0
STORM_SHELTER_1_A
OP: DAVIS OIL
PRODUCTION - CROSS
KB - 6535.000
0 GR 150
GAPI
1 ILD 200
OHMM
0.3 DPHI -0.1
0.3 NPHI -0.1
DEC.
2 PAY08 0

WEST



WHISKEY_BUTTES_16
PRODUCTION – CROSS
GR 150
MSFL 200
ILD 200
DEC.
PAY10
PAY06
WHISKEY_BUTTES_3
PRODUCTION – CROSS
MSFL 200
ILD 200
DEC.
PAY10

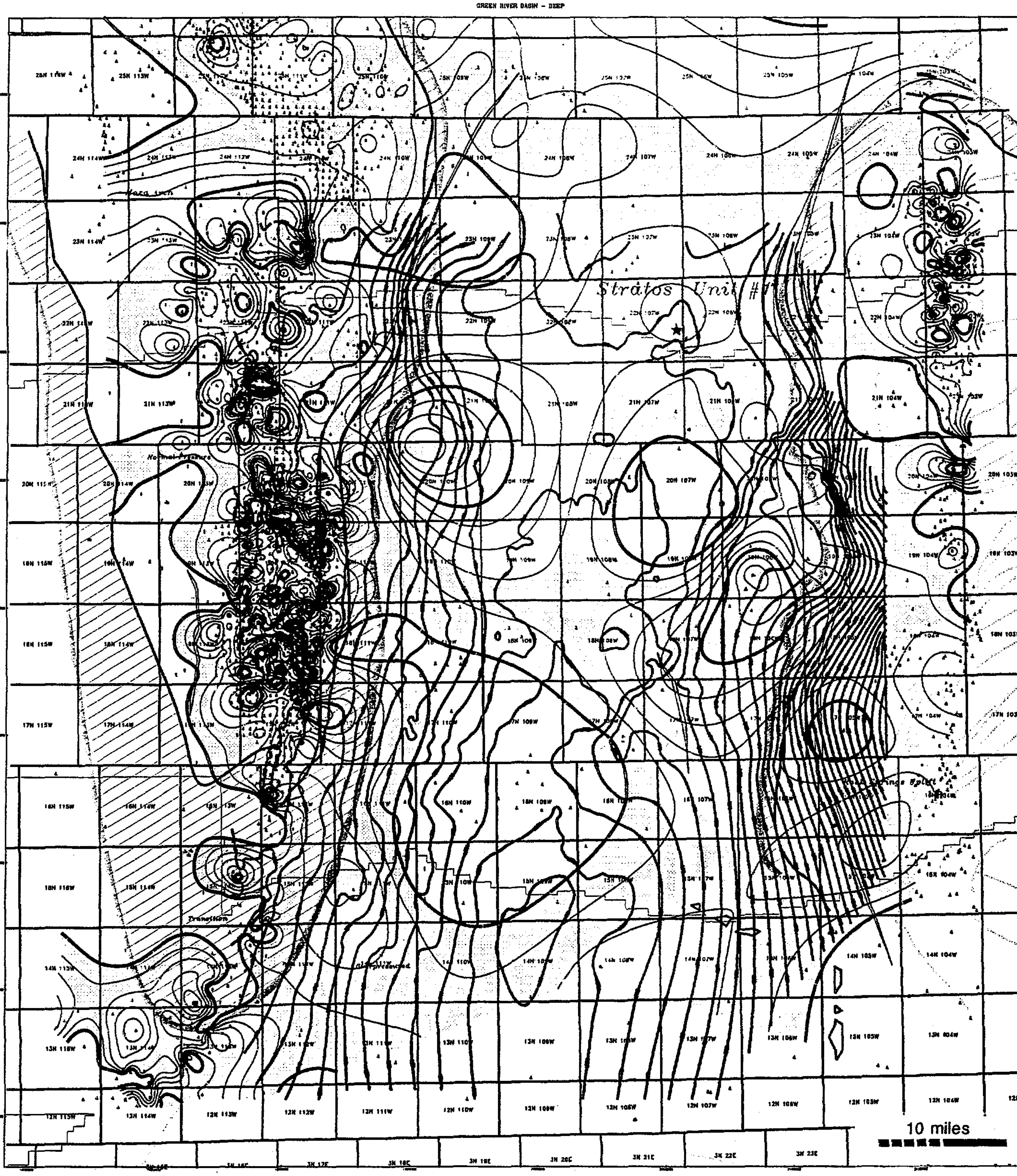


Figure 28. Regional isopach map of net feet of pay in the Second Frontier fluvial interval. Contour interval = 5 ft.

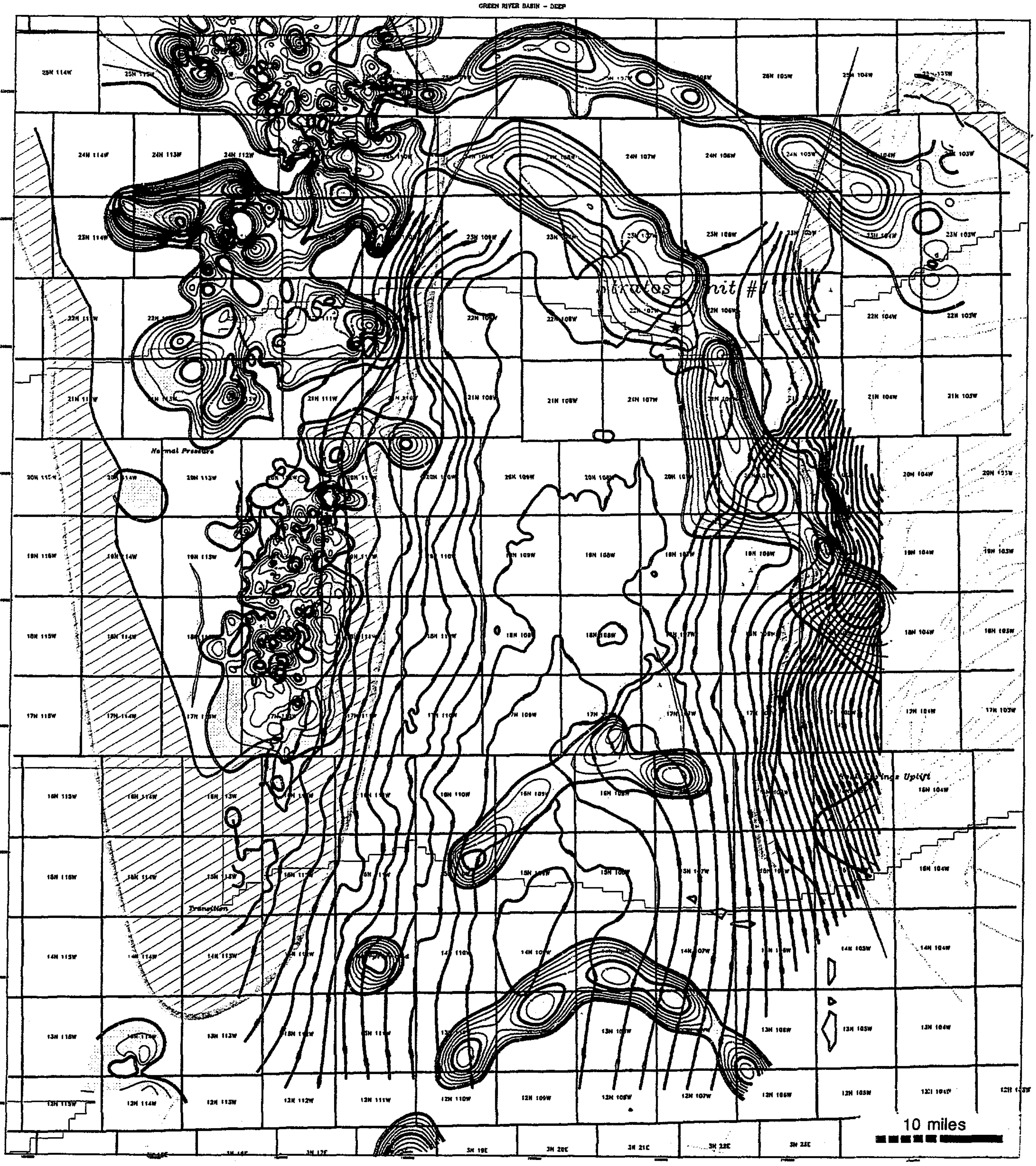


Figure 29. Regional isopach map of net feet of pay in the Second Frontier marine interval. Contour interval. = 10 ft.

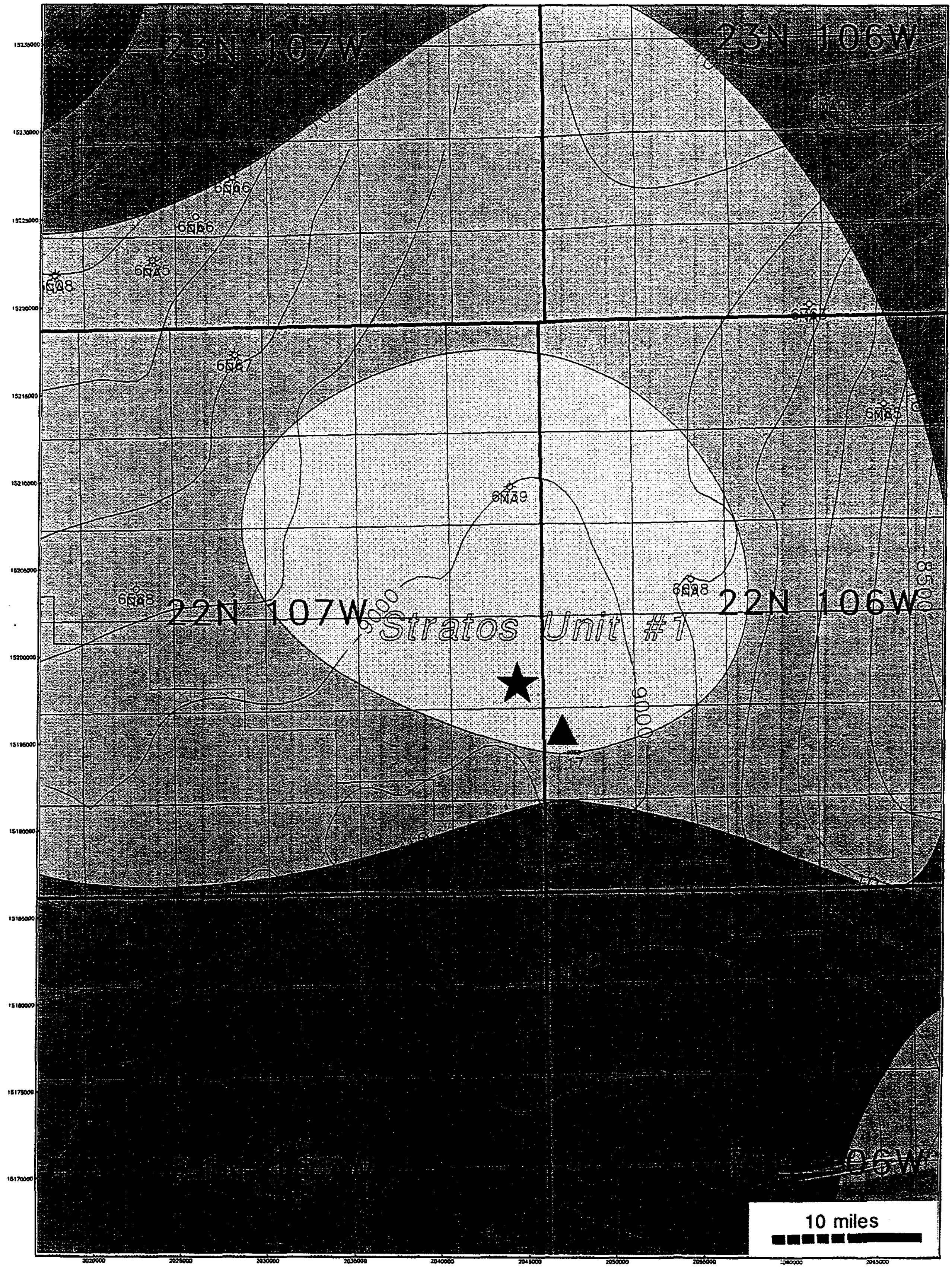


Figure 30. Local isopach map of net feet of pay in the Second Frontier fluvial interval at the Stratos proposed location (shown as star). Contour interval = 10 ft.

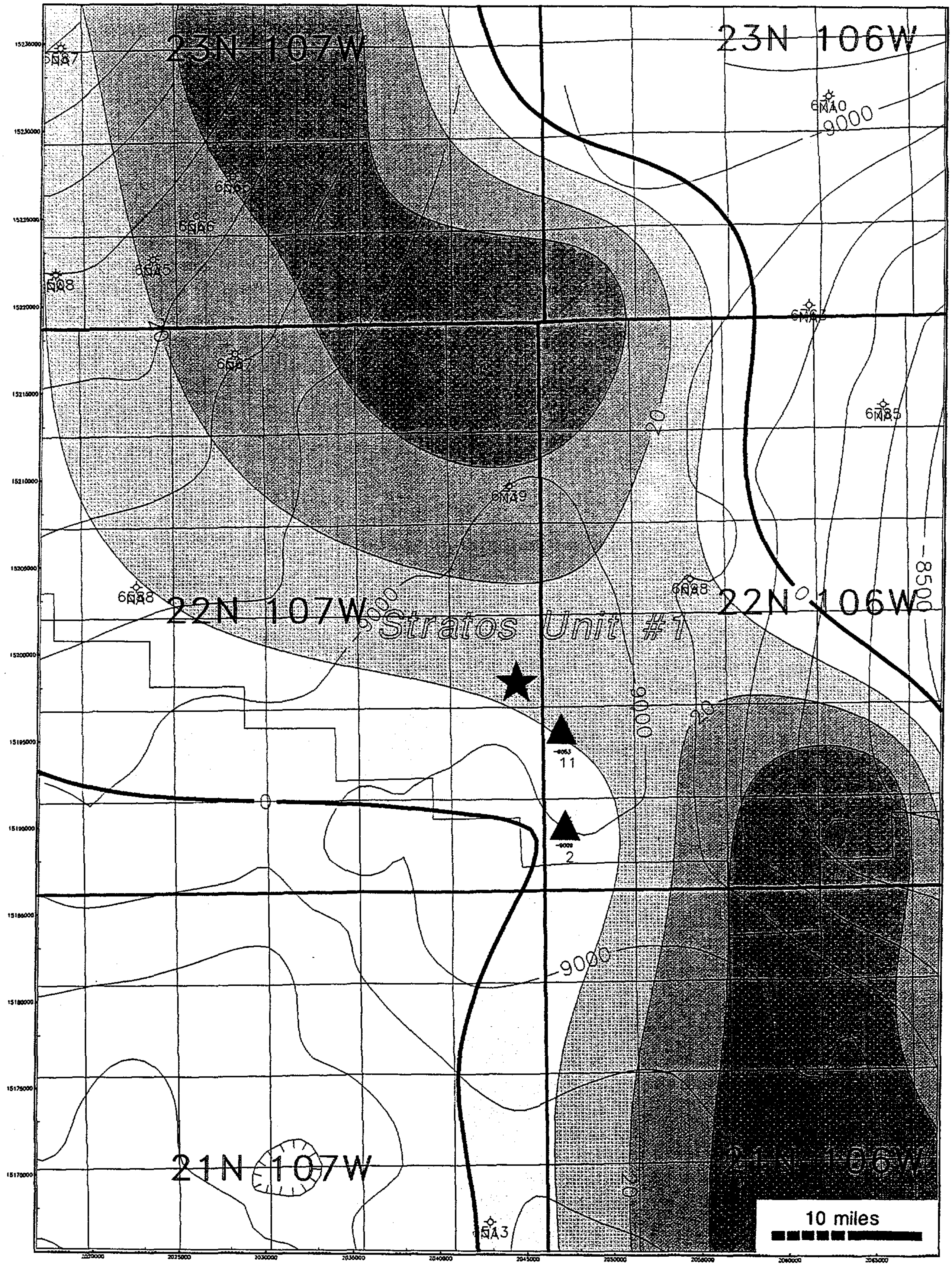


Figure 31. Local isopach map of net feet of pay in the Second Frontier marine interval at the Stratos proposed location (shown as star). Contour interval = 5 ft.

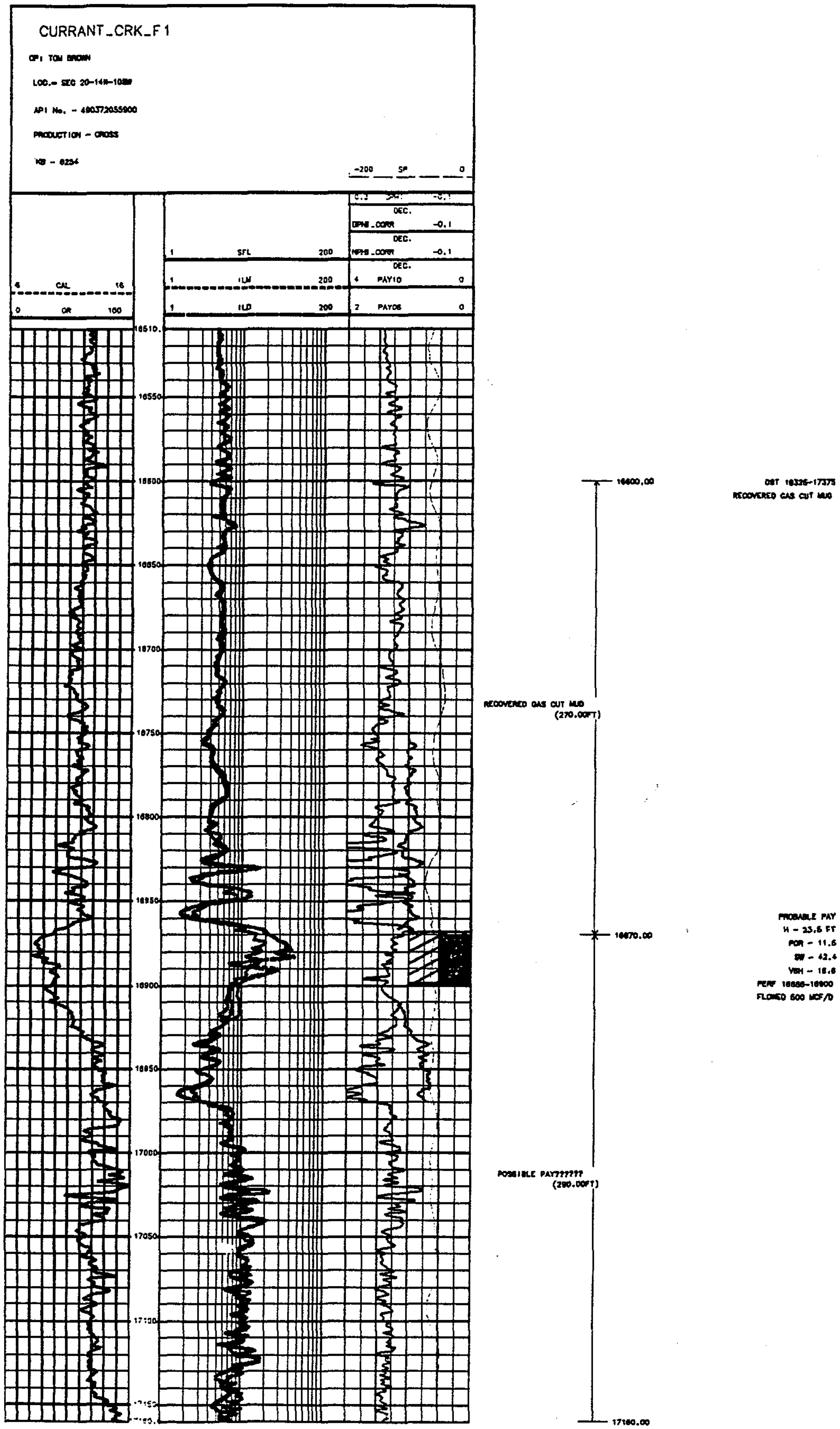
Table 1. Summary of Deep Green River Basin Wells

Well Name	Location	Spud Date	Completion Date	Frontier DST's and Drilling Shows	Frontier Production Tests	Net Pay Upper fluvial	Net Pay Lower fluvial	Total Net Pay Fluvial	Net Pay Marine below unconformity	Net Pay Brown marine sand	Net Pay Aqua marine sand	Net Pay Red marine sand	Total Net Pay Marine sand
Tom Brown Currant Creek #1	Sec. 20-T14N-R108W	'03/30/74	'04/30/74	16,325-17375 - rec. 1250' GCM; 100'GCWB; 5000' wtr. blanket FP 5822-6691 SIP 7770-4766 HP 10,386-10,191 BHT 284 F @19,254'	perf 16,886-16,900' flowed 500 MCFD	0.5	11.5	12	19	0	0	0	19
Davis Oil Silver Dollar #1 **Note - This well is not located within the zone of overpressure.	Sec. 11-T15N-R105W	01/20/78	04/21/78 P & A	IO 10 min. GTS in 17 min. at 121 MCF; ISI 20 min. FO 60 min. GTS immediately at 121 MCF; decr. to 1 # in 25 min. and remained steady; FSI 240 min.; rec 570' GCM; SIP 2119-2180	None	5	12	17	9.5	0	0	0	9.5
Husky #4-32-A Firehole	Sec. 32-T16N R105W	09/23/79	10/30/79 P & A	10,885-10,969 - rec. 500' WC; 277' MCW; NGTS; ISIP - 648 #; FSIP 686 #; BHT - 172 tried 2 more DST's, but they failed BHT 142 F @ 11,377'	None	2	11	13	2.5	0	0	0	2.5
Mountain Fuel Firehole #1	Sec. 12-T16N-R106W	05/13/61	07/27/61 P & A	25 unit gas increase; good yellow fluorescence and good yellow cut; black and brown staining BHT 159 F @ 11,170'	OHT #10; 10,444-68 - rec. 30'M; SIBPH 120-80 psi OHT #1; 10,474 to 506' - rec. 95'M; 452-288 psi								
Cities Service Rock Springs #1	Sec. 7-T17N-R105W	08/29/55	02/18/56 P & A	None reported BHT 145 F @ 9317'	None								
Davis Oil Little Miller Canyon #1	Sec. 21-17N-R105W			None reported BHT 157 F @ 8429'	None	0	0	0	0	0	0	0	0
Husky Husky-CPC 11-5	Sec. 5-T17N-R107W	01/10/78	08/14/78 TA	faint fluor. and weak cut; 15722 to 30' - 120 unit gas show; 15,755 to 65' - 217 unit gas show DST 15,617 to 15,864' IO 15 min. with weak blow; ISI 60 min., FO 240 min. with 2.5# to 211# in 205 min. - 38 MCF; GTS 15 min. to final SI TSTM;	None	5.5	14	19.5	0	0	0	0	0

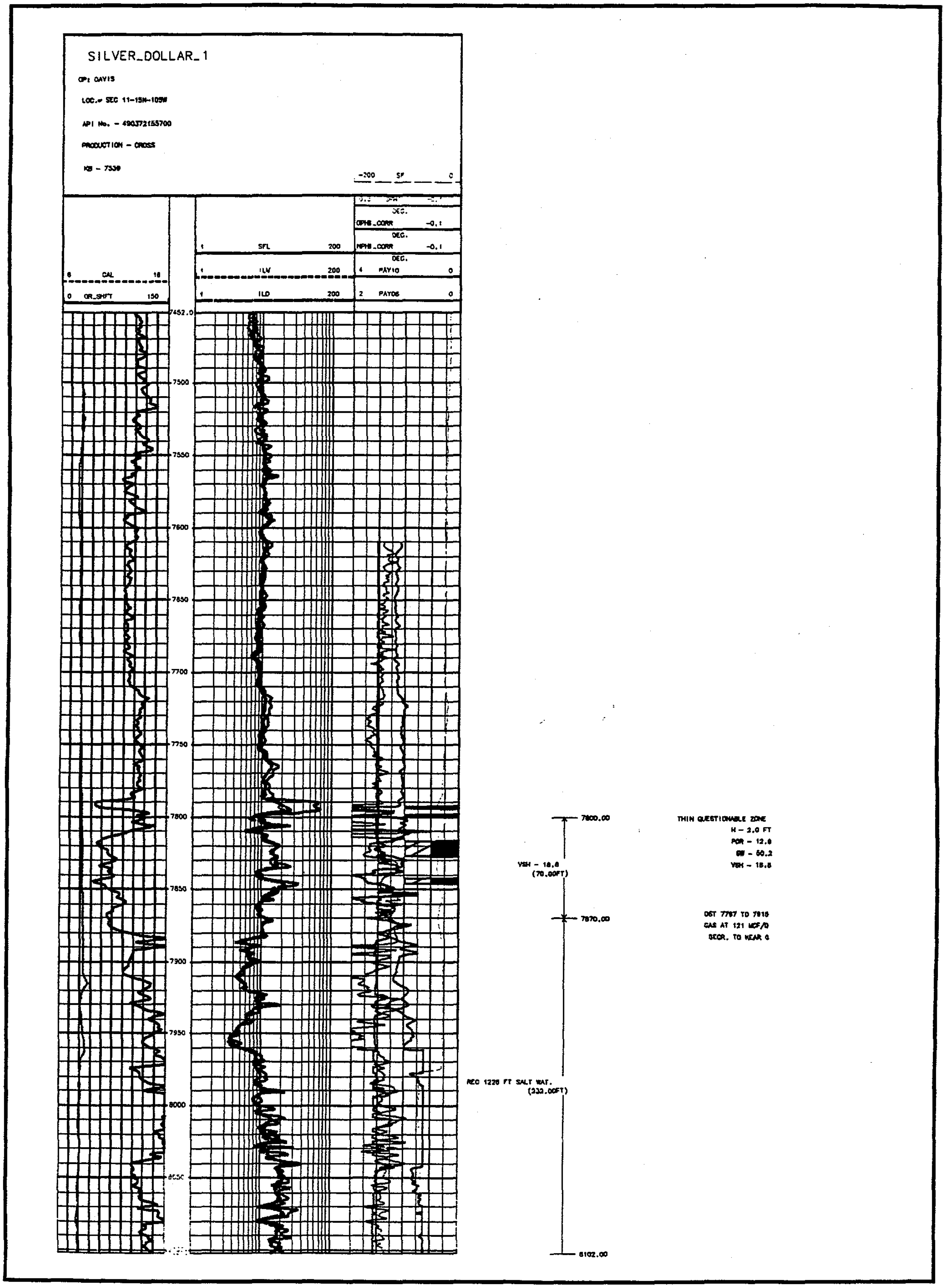
				FSI - rec 3000' GCWC; DP full of gas; FSIP - 3420 psi; BHT - 240									
Husky #3-26 Massacre Hills Federal	Sec.26-T17N-R108W	Original well spud 9/30/77 - TD 9830'; Re-entry spud on 9/1/78	08/15/79 TA	15,706-806' packers failed; pulled packers loose and had 6900' of fluid in DP; opened tool and reversed out 106 bbls HGCM. POH - 1500' of KCL wtr & 4500' HGCM; DST tools stuck on bottom BHT 258 F @ 16,352'	perf 15,793-818' acid perf with 89 bbls MOD with 500 SCF N2/bbl; 8100 psi; disp. with 29 bbls when packers failed acidized with 70 bbls MOD 101 acid with 500 SCF/bbl at 8300 psi; flowed back N1 acid gas; 190 MCFD on 1/2 " choke for 5 hours Re-perfed and re-acidized Frac'ed Frontier - 168 MCFD on 1/4" choke; av. 110 psi								
Union Oil of California White Mountain Unit 1-C-19	Sec. 19-T19N-R105W	09/16/71	05/03/72 P & A	14,469-557' - IO 3 min with weak to v. weak blow; ISI 60 min. op 40 min. with no blow and packers failed; rec. 5000' wtr cushion & 6267' M; top of mud and bottom of WC gas cut	perfed Dakota	0	8	8	0	0	0	0	0
Amoco TX O&G 1	Sec. 29-T19N-R105W		6/25/80 P & A	None	None	0	12	12	5	0	0	11	16
Davis Poitevant Federal #1	Sec. 28-T19N-R106W	12/08/77	Dakota gas	gas increase of 370 units; needed 10.6 # mud weight to kill gas out of Frontier BHT 220 F @ 15,772'	perfed Muddy/Dakota	2	37	39	0	0	0	0	0
Davis Oil Sue Federal # 1	Sec. 32-T19N-R106W	04/17/78	Frontier gas '5/16/79	cored Frontier 700 unit gas increase over 100 unit back-ground BHT 218 F @ 15,487'	perfed 14,653,55; 14,668-78; 14,690-704'; breakdown at 10 bbls/min at 6800 #; 71 bbls MS acid; 13.5/m CO2; 5000 gas MS acid - flowing 375 MCFD on 1/2" choke at 60# Frac'ed Frontier (10/10/78); averaged 300 to 1600 MCFD Acidized (1/10/79) Frac'd 5/6/79 and 5/17/79 - flowing back load; very	3	29	32	0	0	0	0	0

					little to no gas 7/8/79 - 118 MCFD on 24 hour test								
Davis Oil Dagger Federal #1	Sec. 2-T19N-R107W	09/18/81	01/13/82 P & A	240 unit back-ground gas with 1 to 2 foot flare through Frontier BHT 185 F @ 12,657'	None	0	0	0	0	10	0	0	10
Davis Oil Dines Unit #1	Sec. 7-T20N-R105W	04/23/77	01/11/82 P & A	cored Frontier up to 600 unit gas increase BHT 213 F @ 14,274'	perfed Frontier on 4/28/78 - 2.3 MMCF for 3 hrs, started loading up and died Acidized (5/3/78) - 100 MCFD 5/5/78-248 MCFD; acidized (5/17/78) - swabbed back acid then squeezed perfs 5/3-/78 Acidized Kf no report of flows 11/1/78-1/12/79 - brought in workover rig, acidized flowed 13 MCFD	0	4.5	4.5	1	1.5	0	0	2.5
Davis Oil Dines Unit #2	Sec. 18-T20N-R105W	04/12/78	Frontier gas '6/16/79	cored Frontier 100-300 unit increase while drilling and coring Kf BHT 190 F @ 14,439'	perfed Kf - break-bown - flowed ~578 MCFD frac'ed Kf IP 652 MCFD 7/9/79	0	15	15	1 ?	?		2	3
Barnes Expl. 5-11 Federal	Sec. 11-T22N-R105W	10/27/94	7/18/75	DST'ed Dakota and Paleozoics	None	1	3	4	3	0	0	0	3
ERG Blue Rim Federal 1-30	Sec. 30-T22N-R106W	03/06/82	11/10/89 P & A	cored Frontier BHT 295 F @ 16,968'	perfed Frontier - 1.316 MMCF - acid-ized then frac'ed but numerous downhole problems	10.5	6.5	17	11.5	0	0	0	11.5
ERG Blue Rim Federal 1-31	Sec. 31-T22N-R106W	Re-entered to deepen well - 2/17/78	12/12/78 - Frontier gas 12/1/87 P & A	BHT 270 F @ 16,846'	11/26/78 - perfed Kf - flowed ~110 MCFD; Breakdown Kf - flowed 817 MCFD frac'ed - flowed 1.797 MMCFD 8/83 - T/A until gas marketing estab-lished 1/15/86 - first sales to WNG pipeline 11/7/87 Amoco assumed operator	3	5	8	2	0	0	0	2

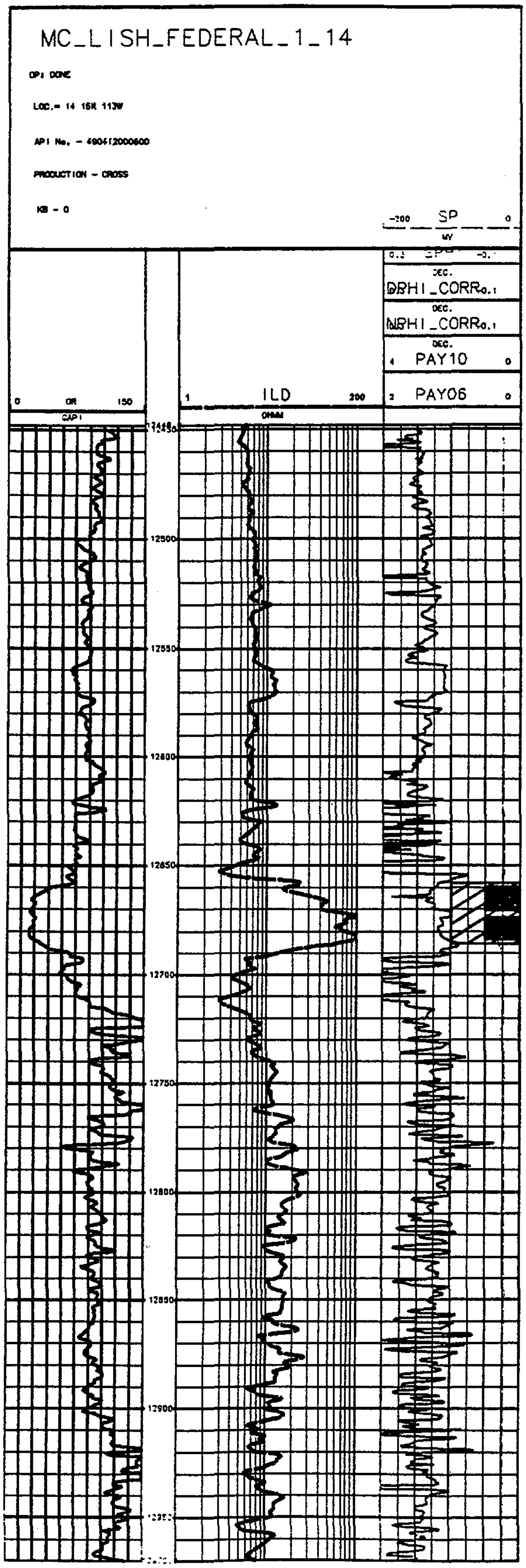
					duties 11/24/87 Amoco states it has no intention of P&A; will submit a workover procedure to state 12/1/87 P & A								
Wolf Energy #1 Sandy Bend	Sec. 14-T23N-R108W	12/4/74	7/25/75 - Frontier gas	DST 15,143-237' r. 9000' WB, 90' GCM, 90' GCW IO 15 m, IFP 4299, FFP 4299; FO 1 hr. 40 m. - IFP 4332, FFP 4299; ISIP 9597 1 h. 30 m. FSIP 9467 BHT 245 F @ 16,382'	PTF 100 MCFD from 15,088-15,149', frac'ed Frontier with SWFR-316000 gals 579000 lbs sand IPF 264 MCFD, 40 BW, 24/62 ck. 24 hrs. from perfs 15,088-15,149'	0	8.5	8.5	8	10	0	1	19
Davis Buckhorn Unit 1	Sec. 28-T23N-R109W	5/31/76	7/18/76	None BHT 224 F @ 14,868'	None	0	0	0	0	0	0	0	0
American Hunter #1 Enterprise	Sec. 30-T25N-R107W	8/2/81	4/20/82	Frontier core BHT 259 F @ 17,052'		4	6	10	0	4 ?	?		4
Davis Oil #1 Simpson Gulch	Sec. 31-T25N-R107W	7/30/75	8/14/77 Mesa-verde gas	None BHT 280 F @ 17,002'	None	1	2	3	0	0	4.5	0	4.5
American Hunter #1 Faraway	Sec. 17-T25N-R108W	5/27/81	10/26/81	Frontier core DST 15,205-280' - closed chamber test rec. 4000'WC, 3228' M; ISIP 6165; Misrun lost packer seat; BHT 272 F @ 16,522'	None	4	5	9	3.5	9.5	0	0	13
Davis Oil Simson Unit 1	Sec. 25-T25N-R108W	6/15/79	8/17/79 P & A	BHT 288 F @ 17,026'		5	3	8	0	0	0	2	2
Davis Oil #1 Eighteen Mile Unit	Sec. 14-T25N-R109W	06/13/75	08/11/75 P & A	14,391-14,485 - rec. 3825' GCWB; 75'GCM 14,503-14,701 - GTS in 1 hr 30 min at 13 MCFD; rec. 4020' GCWB; 180' GCM; BHT - 284		3	0	3	12	8	5	0	25



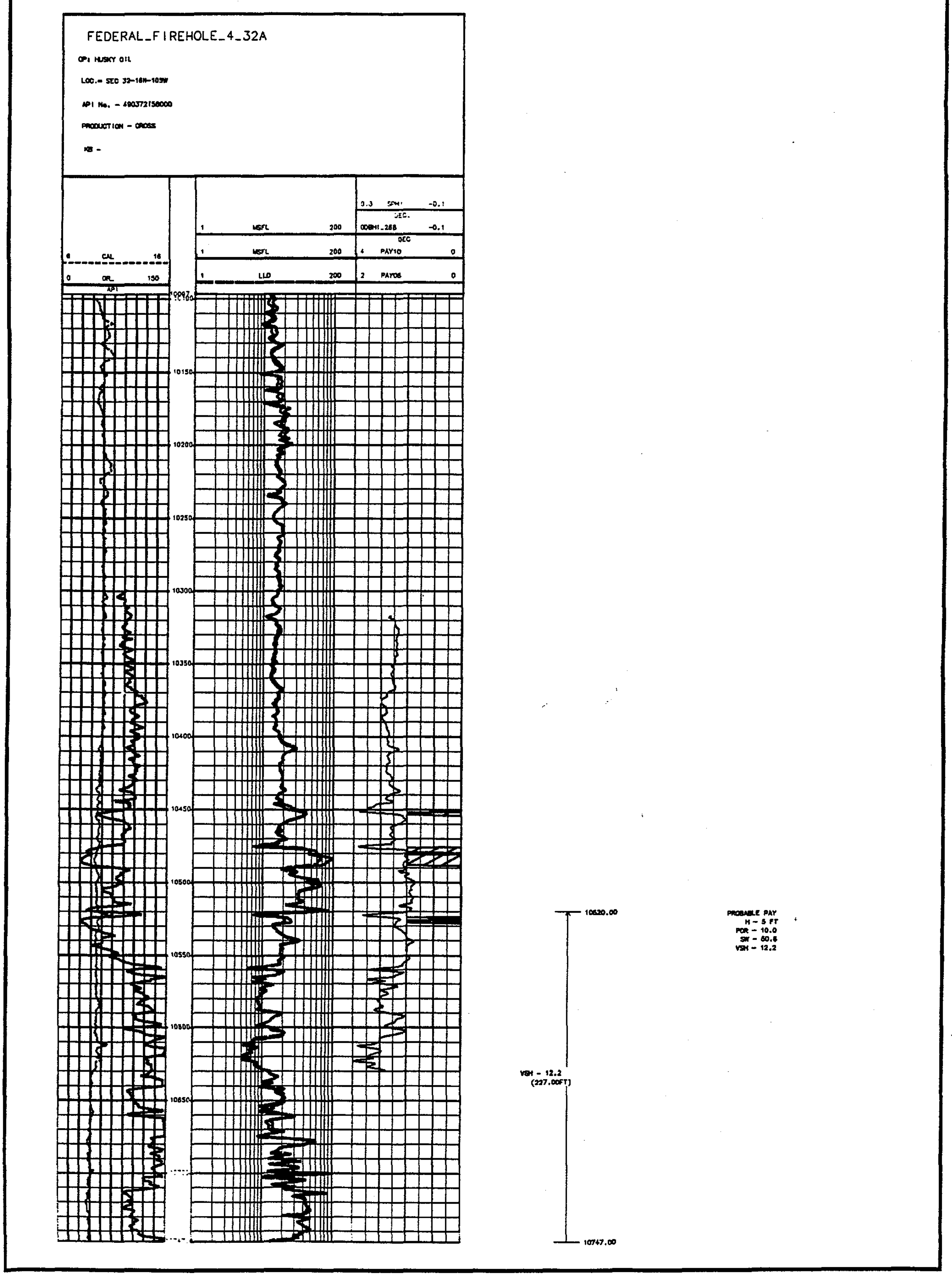
CURRANT_CRK_F1
OP: TOM BROWN
LOC.= SEC 20-14N-108W
API No. - 490372055900
PRODUCTION - CROSS
KB - 6234
-200 SP 0
DEC.
DPHI_CORR -0.1
DEC.
NPHI_CORR -0.1
DEC.
1 SFL 200
1 ILM 200
1 ILD 200
4 PAY10 0
2 PAY06 0
6 CAL 16
0 GR 100
16600.00
DST 16326-17375
RECOVERED GAS CUT MUD
RECOVERED GAS CUT MUD
(270.00FT)
16870.00
PROBABLE PAY
H - 23.6 FT
POR - 11.6
SW - 42.4
VSH - 16.6
PERF 16866-16900
FLOWED 500 MCF/D
POSSIBLE PAY??????
(290.00FT)
17160.00

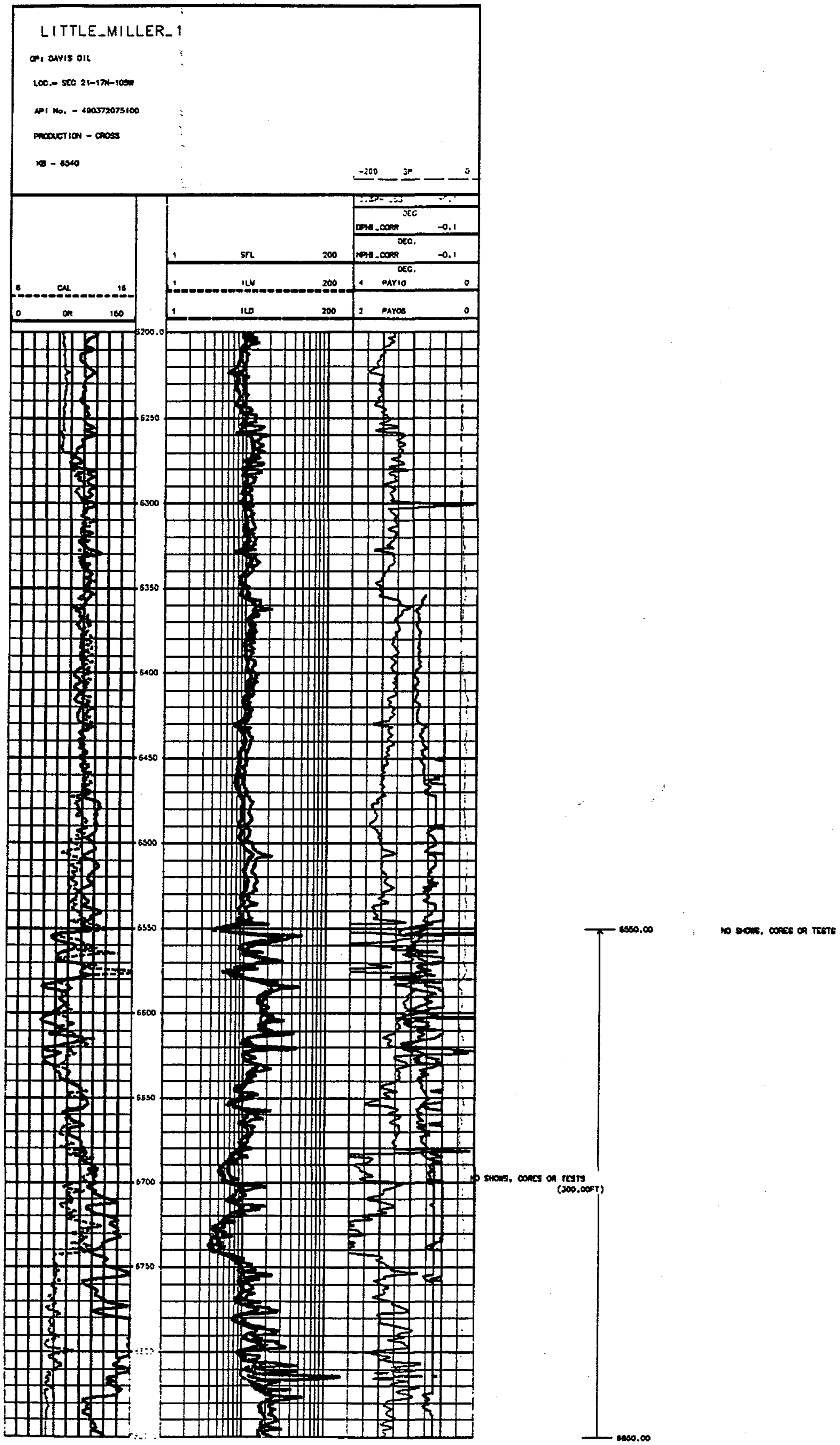


SILVER_DOLLAR_1
OP: DAVIS
LOC.= SEC 11-15N-105W
API No. - 4903721553700
PRODUCTION - CROSS
KB - 7530
-200 SP 0
DEG.
DPHS_CORR -0.1
DEG.
NPHS_CORR -0.1
DEG.
4 PAY10 0
2 PAY06 0
1 SFL 200
1 ILM 200
1 ILD 200
6 CAL 16
0 GR_SHFT 150
7452.0
7500
7550
7600
7650
7700
7750
7800
7850
7900
7950
8000
8050
7800.00
7870.00
8102.00
VSH - 18.8
(70.00FT)
REC 1226 FT SALT WAT.
(232.00FT)
THIN QUESTIONABLE ZONE
H - 2.0 FT
POR - 12.8
SW - 50.2
VSH - 18.8
DST 7797 TO 7816
GAS AT 121 MCF/D
DECR. TO NEAR 0

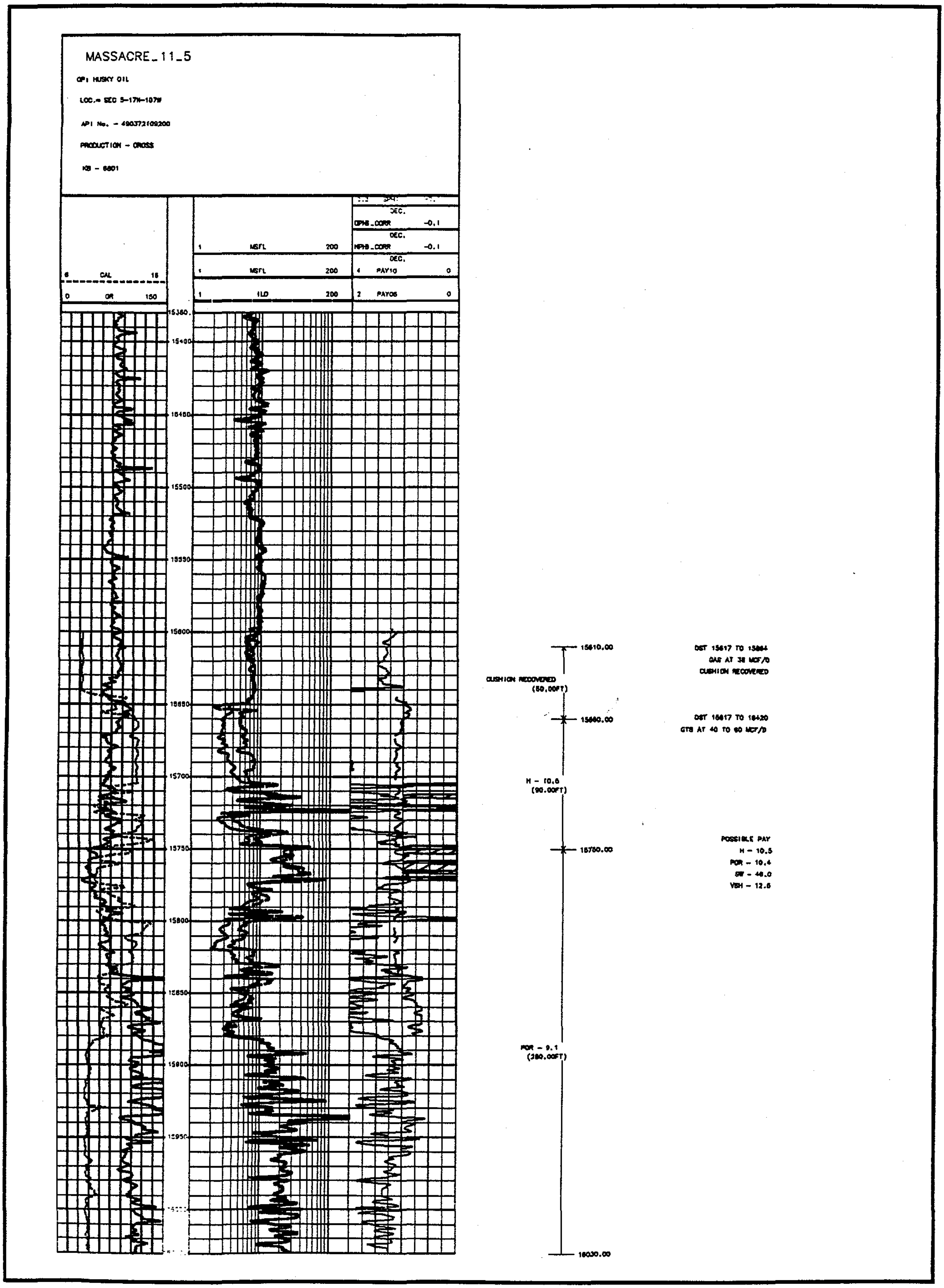


MC_LISH_FEDERAL_1_14
OP: DONE
LOC.= 14 15N 113W
API No. - 4904120006000
PRODUCTION - CROSS
KB - 0
-200 SP 0
MV
DEC.
DRHI_CORR
DEC.
NPHI_CORR
DEC.
PAY10
PAY06
0 GR 150
GAPI
1 ILD 200
OHMM
12500
12550
12600
12650
12700
12750
12800
12850
12900
12950

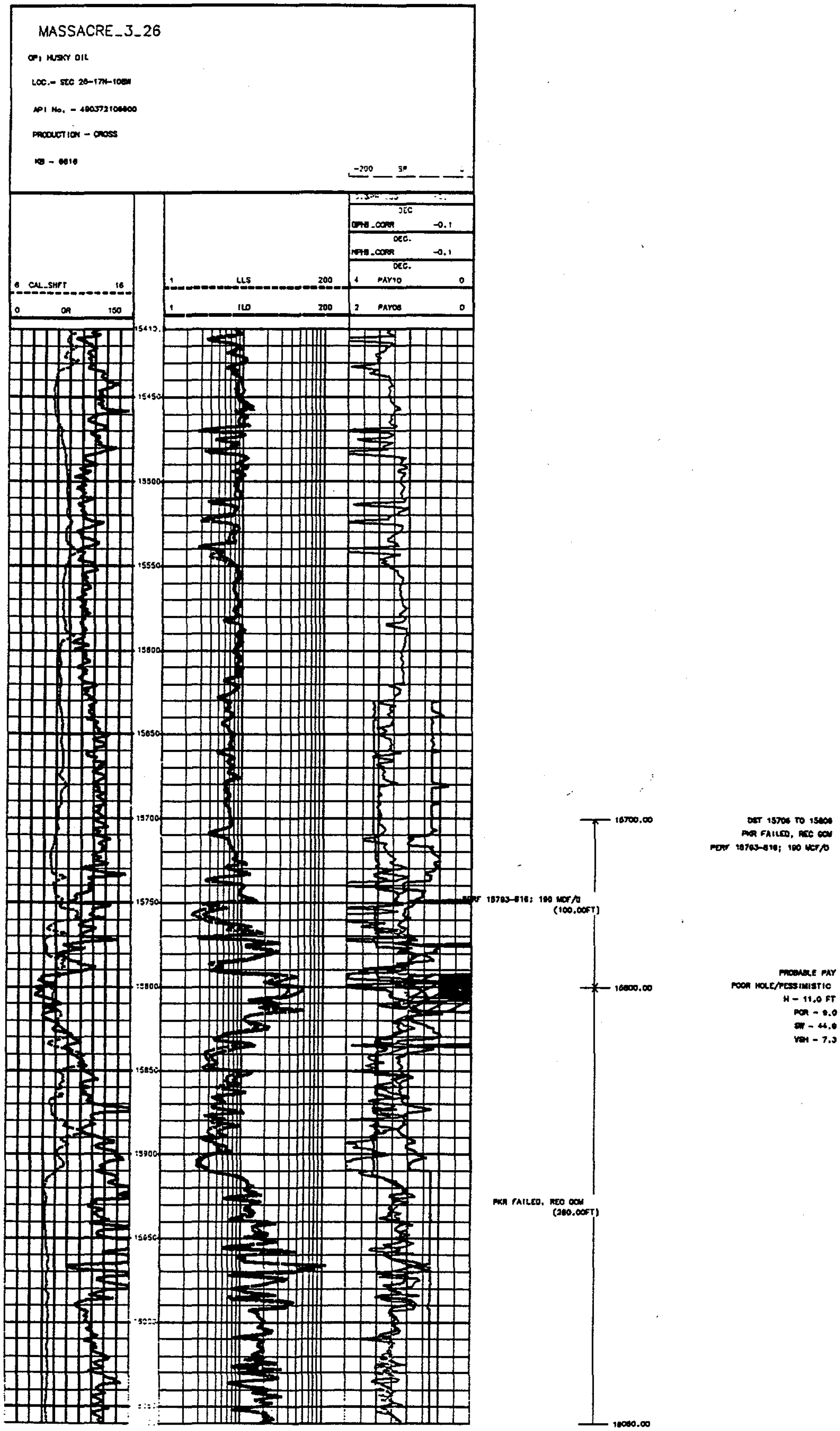

FEDERAL_FIREHOLE_4_32A
OP: HUSKY OIL
LOC.= SEC 32-18N-105W
API No. - 490372158000
PRODUCTION - CROSS
KB -
6 CAL 16
0 GR 150
API
1 MSFL 200
1 MSFL 200
1 LLD 200
0.3 -0.1
DEC.
-0.1
DEC
4 PAY10 0
2 PAY05 0
10150
10200
10250
10300
10350
10400
10450
10500
10550
10600
10650
10620.00
VSH - 12.2
(227.00FT)
10747.00
PROBABLE PAY
H - 5 FT
POR - 10.0
SW - 60.6
VSH - 12.2

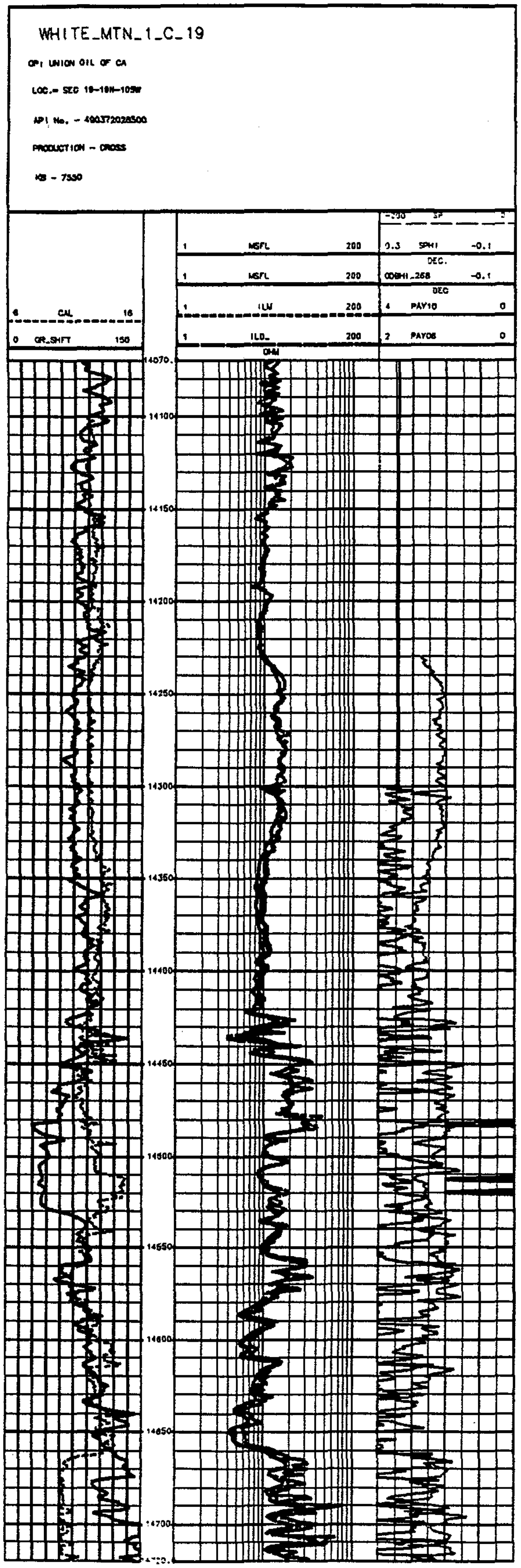


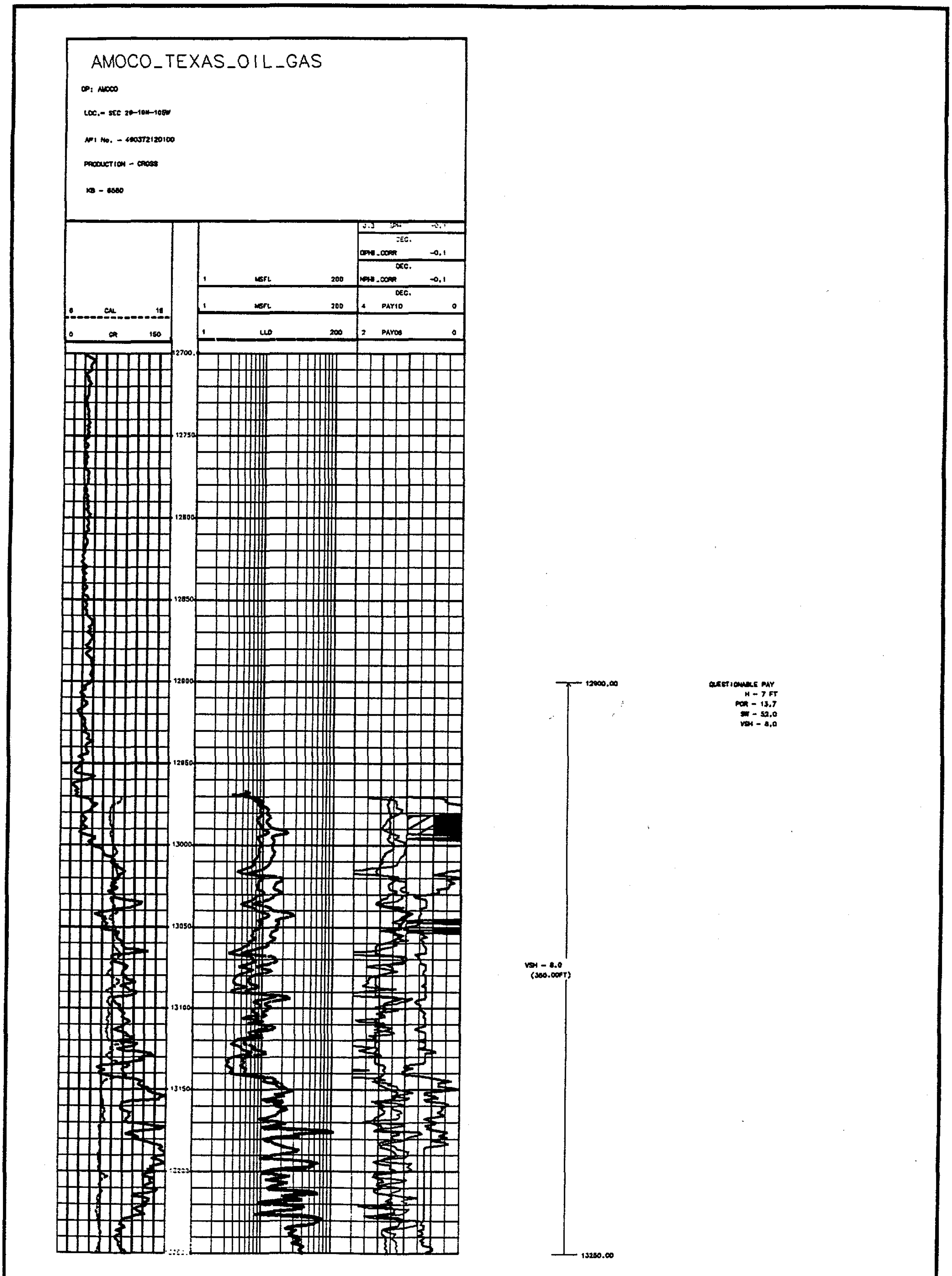
LITTLE_MILLER_1
OP: DAVIS OIL
LOC.= SEC 21-17N-105W
API No. - 490372075100
PRODUCTION - CROSS
KB - 6540
-200 SP 0
DEC.
DPHI_CORR -0.1
DEC.
NPHI_CORR -0.1
DEC.
4 PAY10 0
2 PAY05 0
1 SFL 200
1 ILM 200
1 ILD 200
6 CAL 16
0 GR 150
6200.0
6250
6300
6350
6400
6450
6500
6550
6600
6650
6700
6750
6550.00
NO SHOWS, CORES OR TESTS
NO SHOWS, CORES OR TESTS
(300.00FT)
6850.00

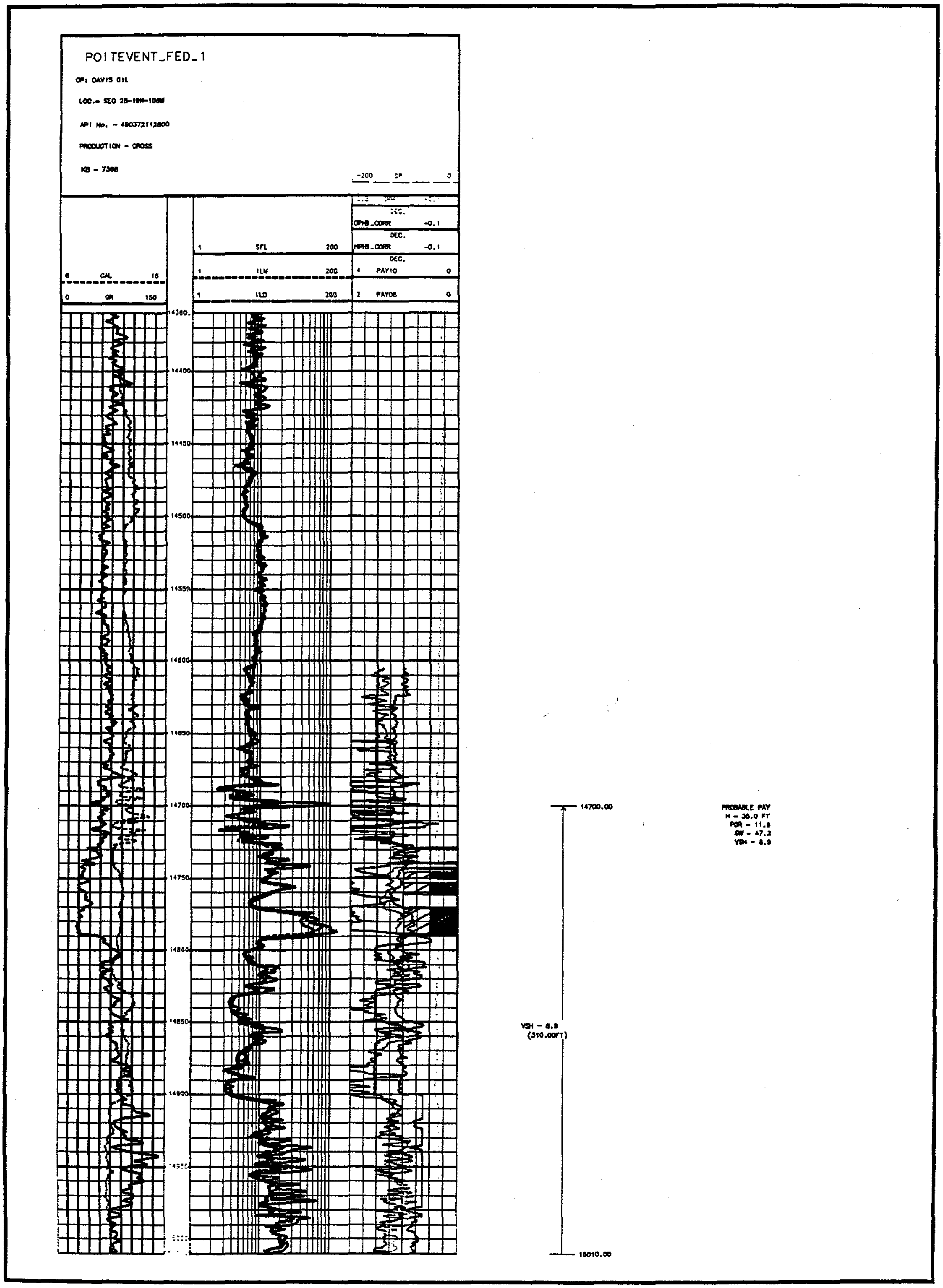


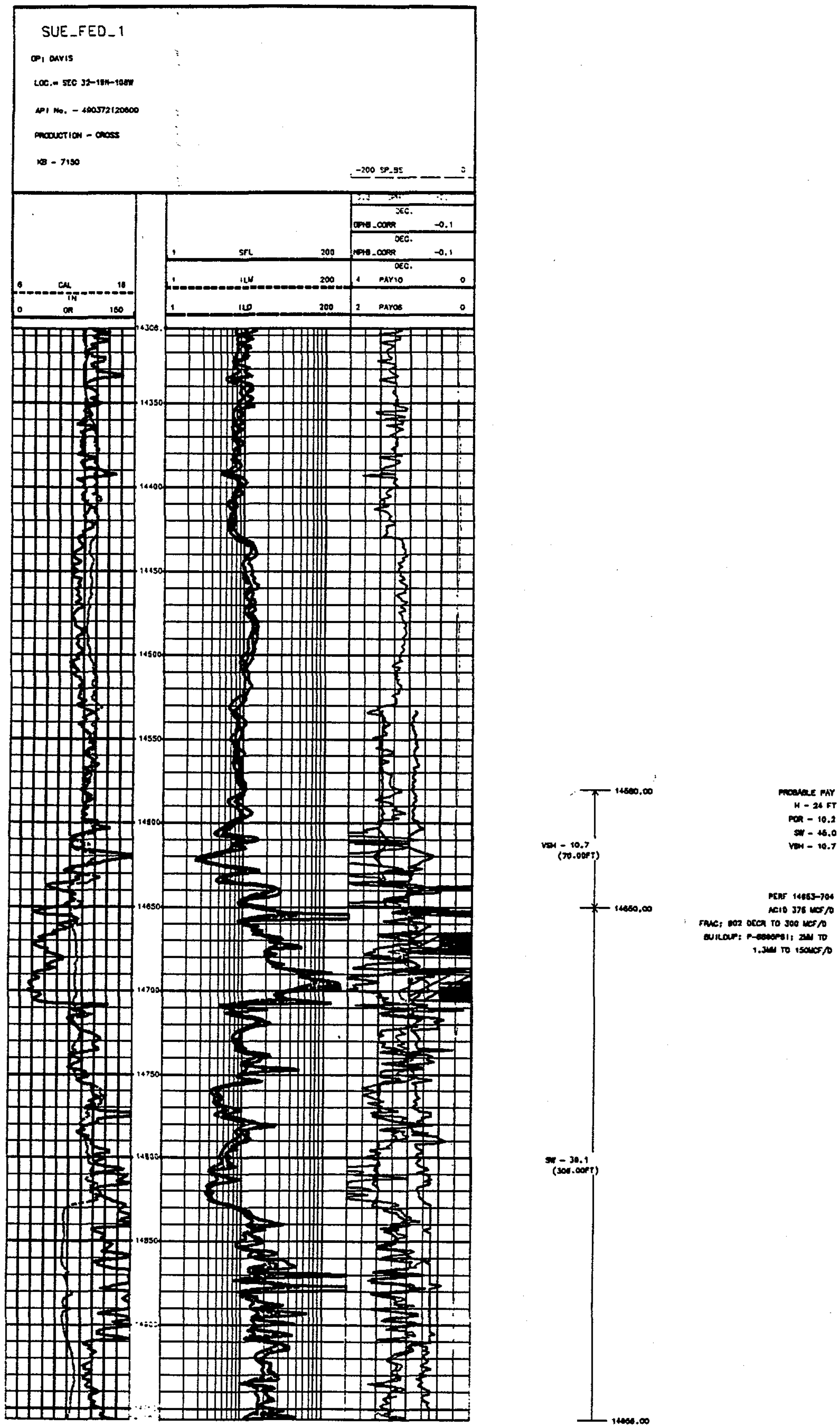
MASSACRE_11_5
OP: HUSKY OIL
LOC.= SEC 5-17N-107W
API No. - 490372109200
PRODUCTION - CROSS
KB - 6801
DPHB_CORR -0.1
NPHB_CORR -0.1
DEC.
1 MSFL 200
4 PAY10 0
6 CAL 16
0 GR 150
1 ILD 200
2 PAY05 0
15400
15450
15500
15550
15600
15650
15700
15750
15800
15850
15900
15950
15610.00
15750.00
16030.00
CUSHION RECOVERED
(50.00FT)
H - 10.6
(90.00FT)
POR - 9.1
(280.00FT)
GAS AT 38 MCF/D
CUSHION RECOVERED
GTS AT 40 TO 60 MCF/D
POSSIBLE PAY
H - 10.5
POR - 10.4
SW - 40.0
VSH - 12.6

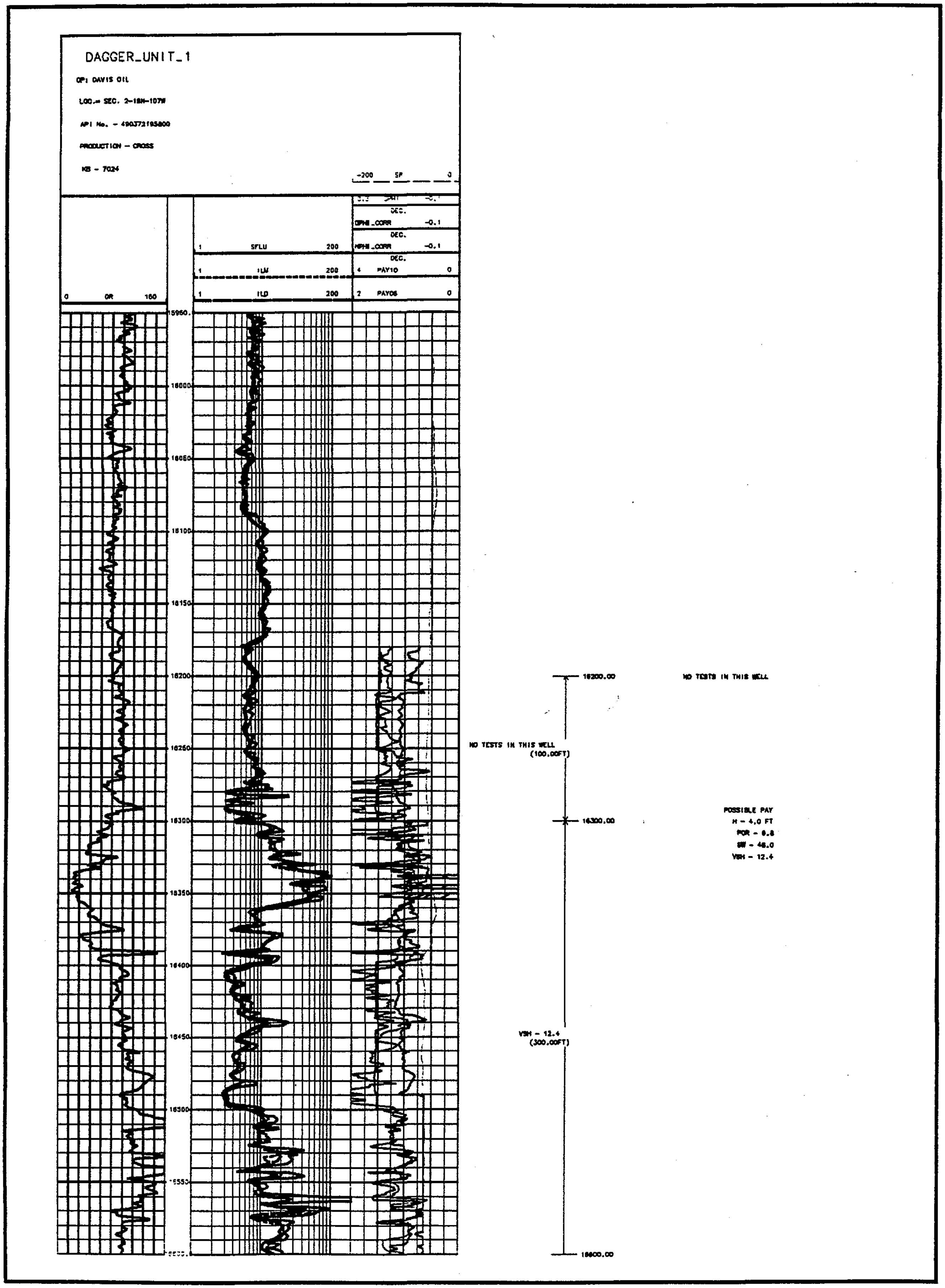

MASSACRE_3_26
OP: HUSKY OIL
LOC.- SEC 26-17N-106W
PRODUCTION - CROSS
-200 SP
DEC.
DPHS_CORR -0.1
DEC.
NPHS_CORR -0.1
DEC.
6 CAL_SHFT 16
0 GR 150
1 LLS 200
1 ILD 200
4 PAY10 0
2 PAY06 0
15450
15500
15550
15600
15650
15700
15750
15800
15850
15900
15950
15700.00
DST 15706 TO 15806
PKR FAILED, REC GCM
PERF 15763-816; 190 MCF/D
PERF 15763-816; 190 MCF/D
(100.00FT)
15800.00
PROBABLE PAY
POOR HOLE/PESSIMISTIC
H - 11.0 FT
POR - 9.0
SW - 44.0
VSH - 7.3
PKR FAILED, REC GCM
(380.00FT)
16080.00

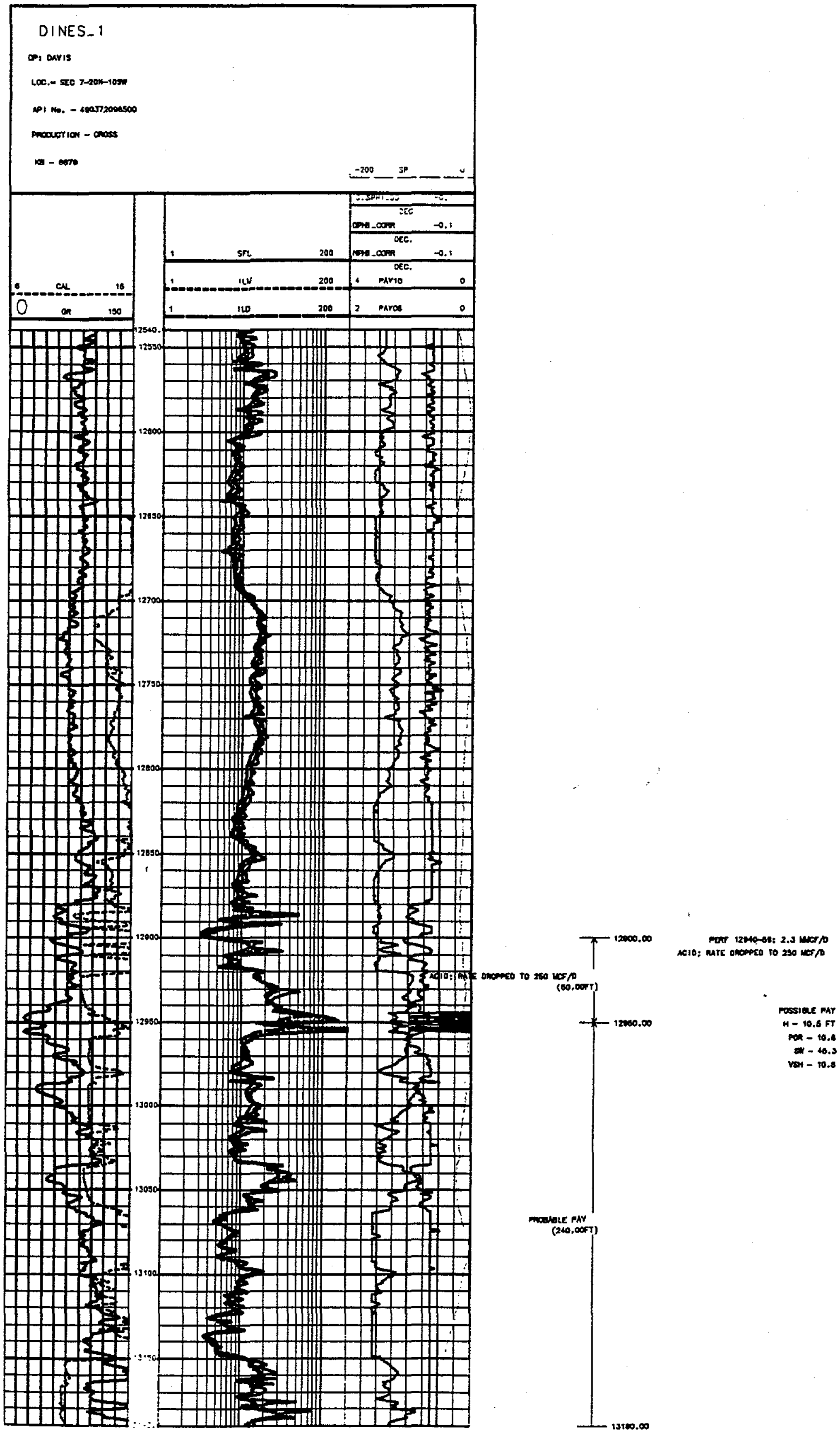

WHITE_MTN_1_C_19
OP: UNION OIL OF CA
LOC.= SEC 19-19N-105W
API No. - 4903720285OO
PRODUCTION - CROSS
KB - 7550
CAL
GR_SHFT
MSFL
ILM
ILD_
OHM
SP
SPHI
DEC.
PAY10
PAY06
14100
14150
14200
14250
14300
14350
14400
14450
14500
14550
14600
14650
14700


AMOCO_TEXAS_OIL_GAS
OP: AMOCO
LOC.- SEC 29-19N-105W
API No. - 490372120100
PRODUCTION - CROSS
KB - 6580
DEC.
DPHI_CORR -0.1
DEC.
1 MSFL 200
NPHI_CORR -0.1
DEC.
1 MSFL 200
4 PAY10 0
6 CAL 16
0 GR 150
1 LLD 200
2 PAY06 0
12700.
12750
12800
12850
12900
12950
13000
13050
13100
13150
12900.00
QUESTIONABLE PAY
H - 7 FT
POR - 13.7
SW - 52.0
VSH - 8.0
VSH - 8.0
(350.00FT)
13250.00

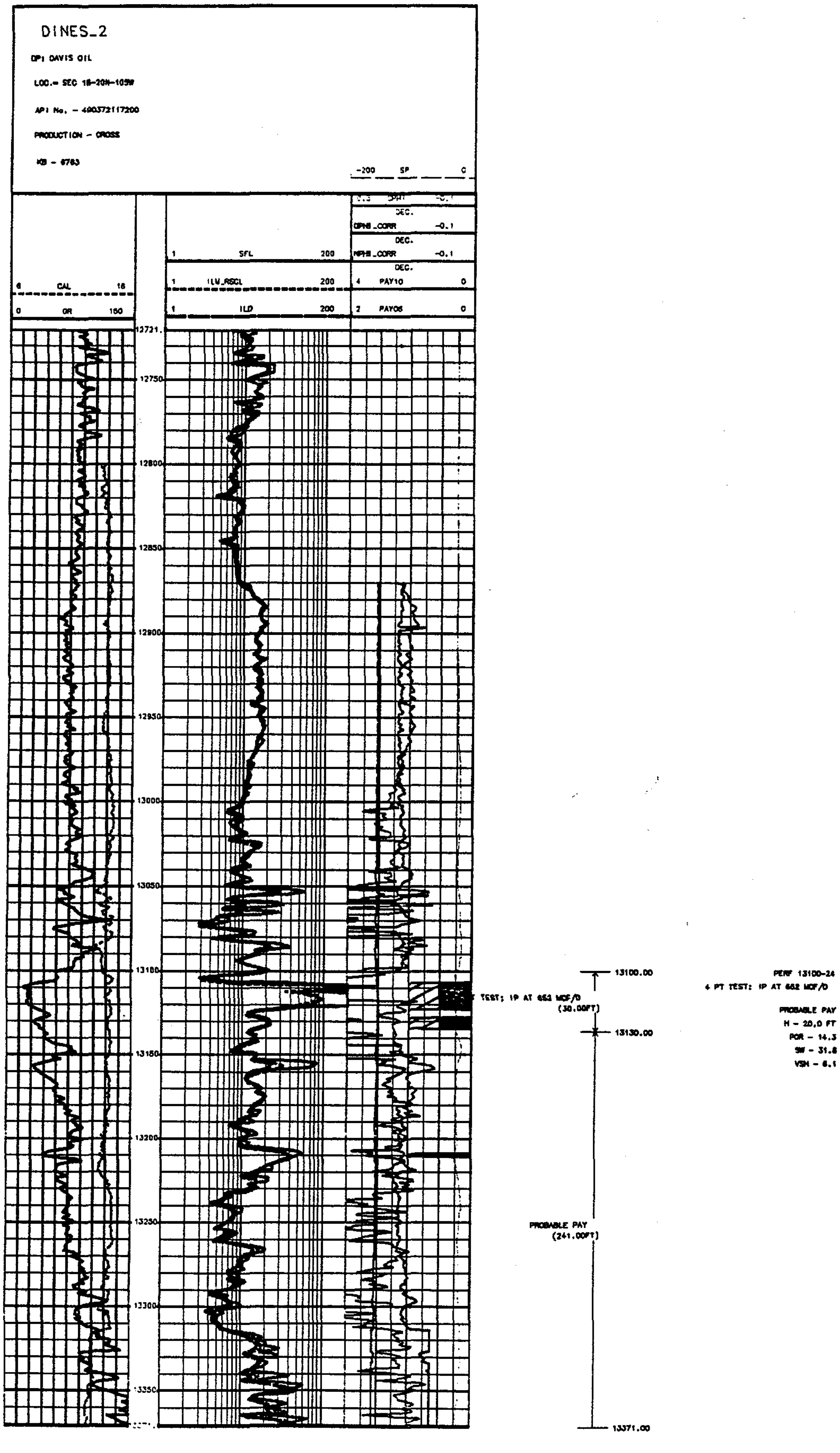

POITEVENT_FED_1
OP: DAVIS OIL
LOC.= SEC 28-18N-108W
API No. - 490372112800
PRODUCTION - CROSS
KB - 7388
-200 SP 0
DEC.
OPHS_CORR -0.1
DEC.
NPHS_CORR -0.1
DEC.
1 SFL 200
1 ILM 200
1 ILD 200
6 CAL 16
0 GR 150
4 PAY10 0
2 PAY05 0
14380.
14400
14450
14500
14550
14600
14650
14700
14750
14800
14850
14900
14700.00
PROBABLE PAY
H - 36.0 FT
POR - 11.9
SW - 47.2
VSH - 8.9
VSH - 8.9
(310.00FT)
15010.00


SUE_FED_1
OP: DAVIS
LOC.= SEC 32-18N-108W
API No. - 490372120600
PRODUCTION - CROSS
KB - 7150
-200 SP_BS 0
DEC.
DPHB_CORR -0.1
DEC.
NPHB_CORR -0.1
DEC.
4 PAY10 0
2 PAY06 0
1 SFL 200
1 ILM 200
1 ILD 200
6 CAL 18
IN
0 GR 150
14350
14400
14450
14500
14550
14600
14650
14700
14750
14800
14850
14580.00
14650.00
VSH - 10.7
(70.00FT)
PROBABLE PAY
H - 24 FT
POR - 10.2
SW - 46.0
VSH - 10.7
PERF 14663-704
ACID 376 MCF/D
FRAC; 802 DECR TO 300 MCF/D
1.3MM TO 150MCF/D

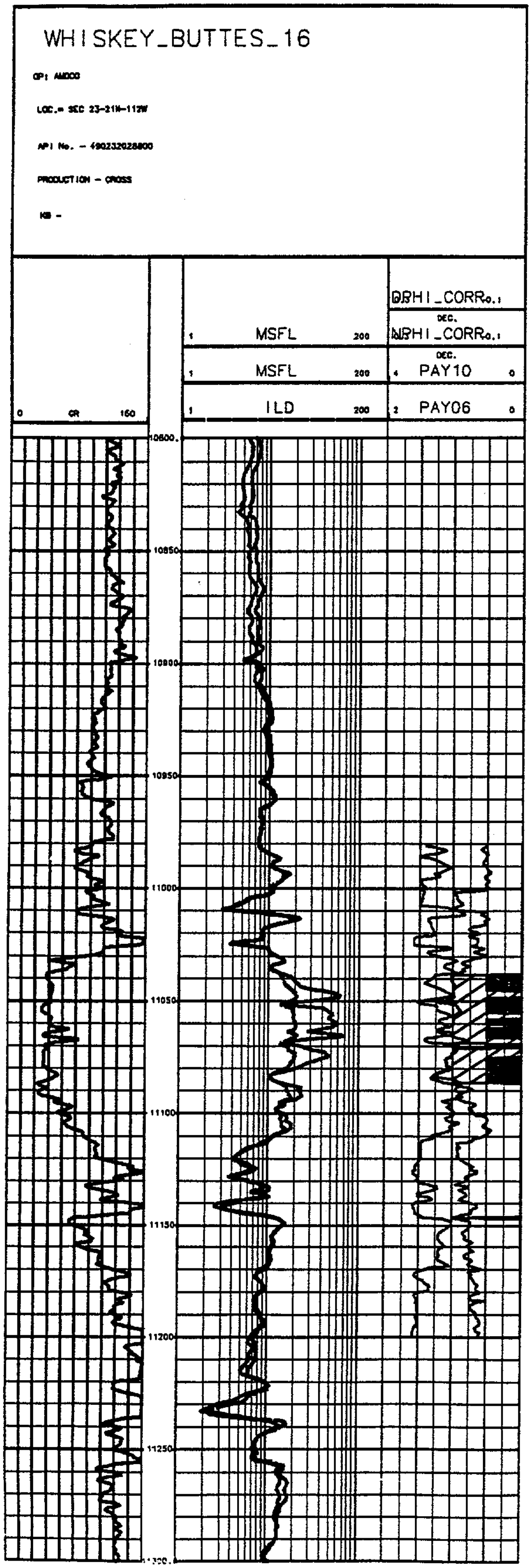

DAGGER_UNIT_1
OP: DAVIS OIL
LOC.= SEC. 2-18N-107W
API No. - 490372195800
PRODUCTION - CROSS
KB - 7024
-200 SP 0
DEC.
DPHI_CORR -0.1
DEC.
NPHI_CORR -0.1
DEC.
4 PAY10 0
2 PAY05 0
1 SFLU 200
1 ILM 200
1 ILD 200
0 GR 150
15950.
16000
16050
16100
16150
16200
16250
16300
16350
16400
16450
16500
16550
16200.00
NO TESTS IN THIS WELL
NO TESTS IN THIS WELL
(100.00FT)
16300.00
POSSIBLE PAY
H - 4.0 FT
POR - 8.8
SW - 46.0
VSH - 12.4
VSH - 12.4
(300.00FT)
16600.00

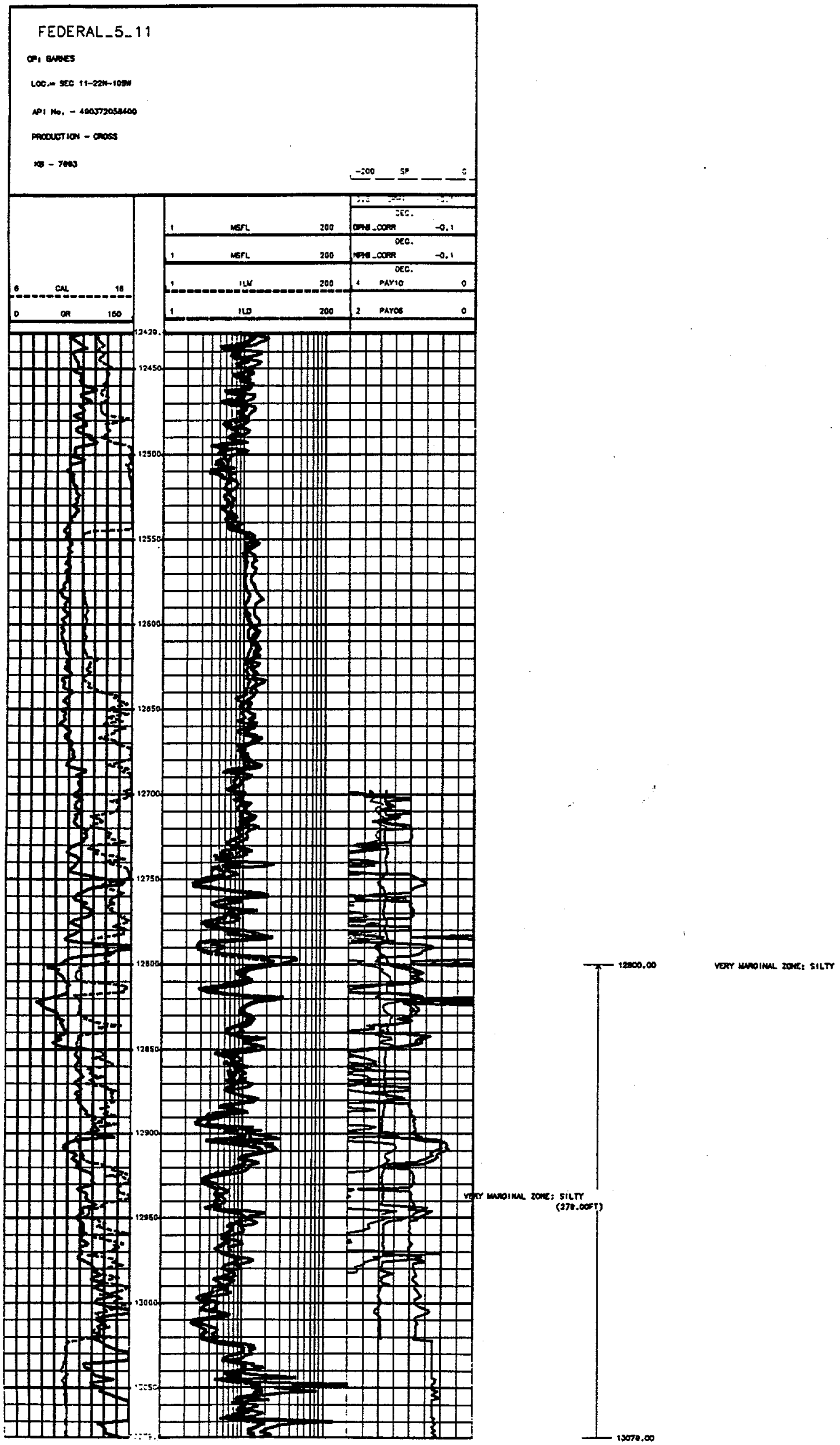


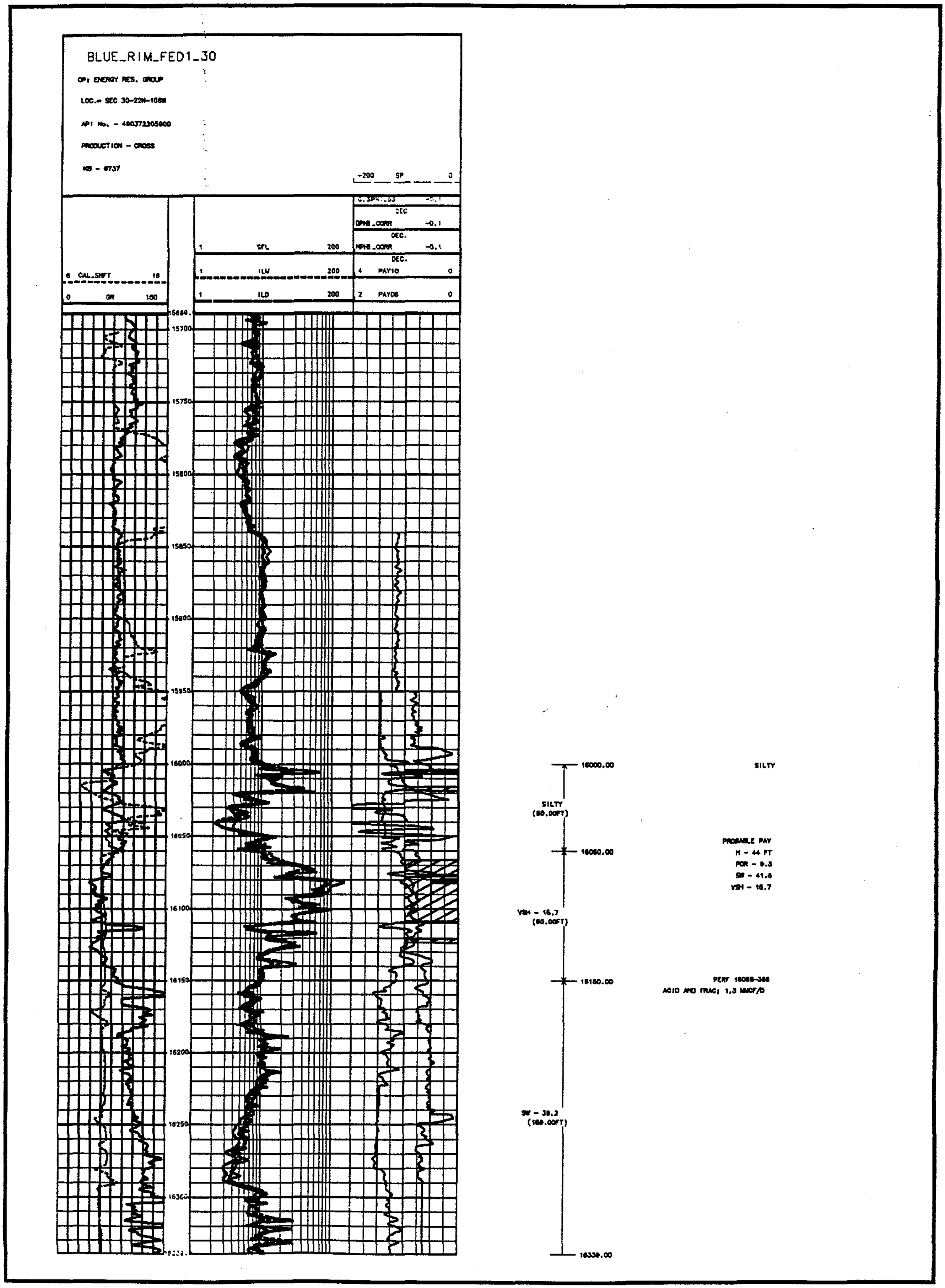
DINES_1
OP: DAVIS
LOC.= SEC 7-20N-105W
API No. - 490372096500
PRODUCTION - CROSS
-200 SP
DPHS_CORR -0.1
DEC.
NPHS_CORR -0.1
DEC.
1 SFL 200
1 ILM 200
1 ILD 200
4 PAY10 0
2 PAY05 0
6 CAL 16
0 GR 150
12540.
12550
12600
12650
12700
12750
12800
12850
12900
12950
13000
13050
13100
13150
12900.00
12960.00
13180.00
PERF 12940-68: 2.3 MMCF/D
ACID; RATE DROPPED TO 250 MCF/D
(60.00FT)
POSSIBLE PAY
H - 10.5 FT
POR - 10.4
SW - 46.3
VSH - 10.8
PROBABLE PAY
(240.00FT)



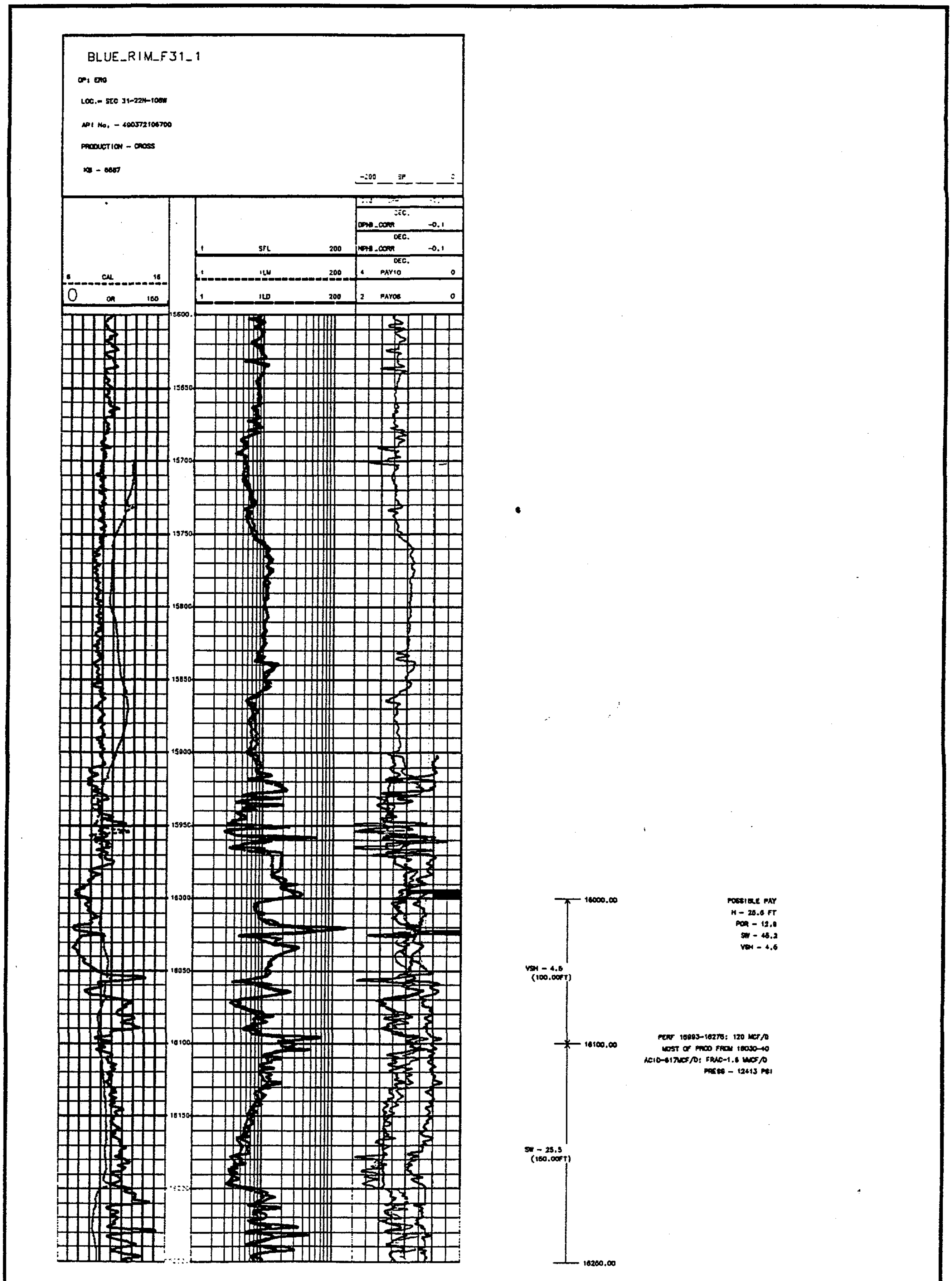
DINES_2
OP: DAVIS OIL
LOC.= SEC 18-20N-105W
API No. – 4903721172OO
PRODUCTION – CROSS
KB – 6763
-200 SP 0
DPHI
DEC.
DPHI_CORR -0.1
DEC.
1 SFL 200
NPHI_CORR -0.1
DEC.
6 CAL 16
1 ILM_RSCL 200
4 PAY10 0
0 GR 150
1 ILD 200
2 PAY05 0
12731.
12750
12800
12850
12900
12950
13000
13050
13100
13150
13200
13250
13300
13350
TEST; IP AT 652 MCF/D
(30.00FT)
13100.00
13130.00
PERF 13100-24
4 PT TEST: IP AT 652 MCF/D
PROBABLE PAY
H – 20.0 FT
POR – 14.3
SW – 31.8
VSH – 6.1
PROBABLE PAY
(241.00FT)
13371.00


WHISKEY_BUTTES_16
OP: AMOCO
LOC.= SEC 23-21N-112W
API No. - 490232028800
PRODUCTION - CROSS
KB -
0 GR 150
1 MSFL 200
1 MSFL 200
1 ILD 200
DPHI_CORR 0.1
DEC.
NPHI_CORR 0.1
DEC.
4 PAY10 0
2 PAY06 0
10800.
10850
10900
10950
11000
11050
11100
11150
11200
11250

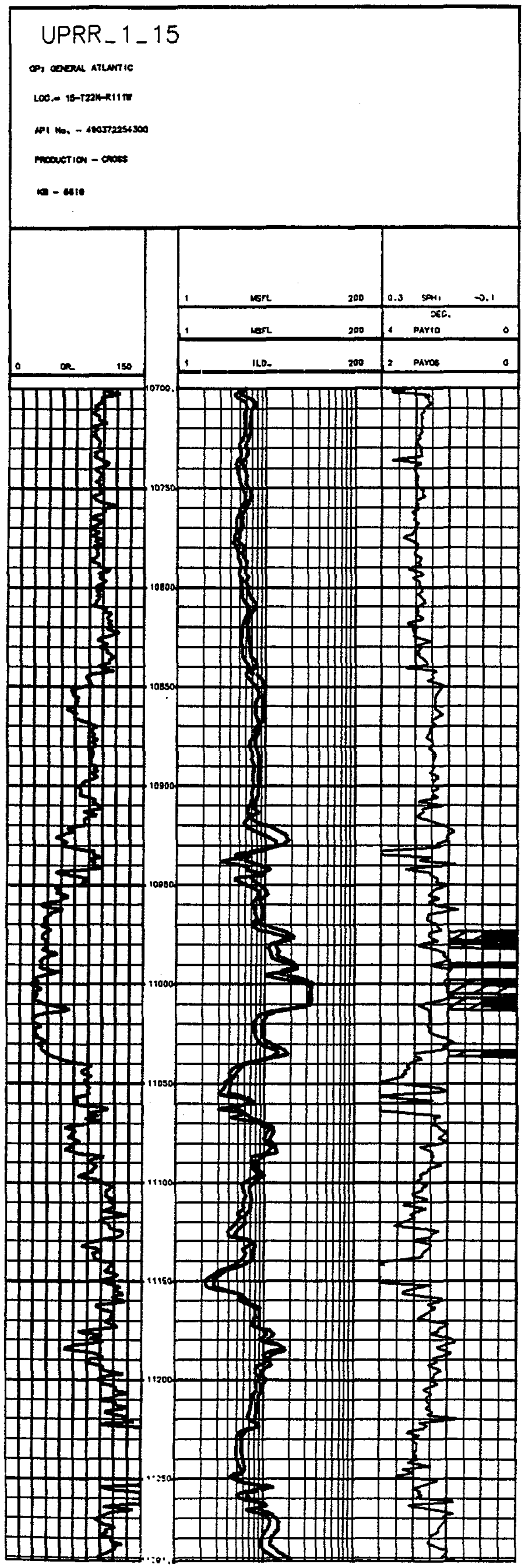

FEDERAL_5_11
OP: BARNES
LOC.= SEC 11-22N-105W
API No. - 490372058400
PRODUCTION - CROSS
KB - 7093
-200 SP 0
DEC.
1 MSFL 200
DPHI_CORR -0.1
DEC.
1 MSFL 200
NPHI_CORR -0.1
DEC.
6 CAL 16
1 ILM 200
4 PAY10 0
0 GR 150
1 ILD 200
2 PAY06 0
12420.
12450
12500
12550
12600
12650
12700
12750
12800
12850
12900
12950
13000
12800.00
VERY MARGINAL ZONE: SILTY
VERY MARGINAL ZONE: SILTY
(279.00FT)
13079.00

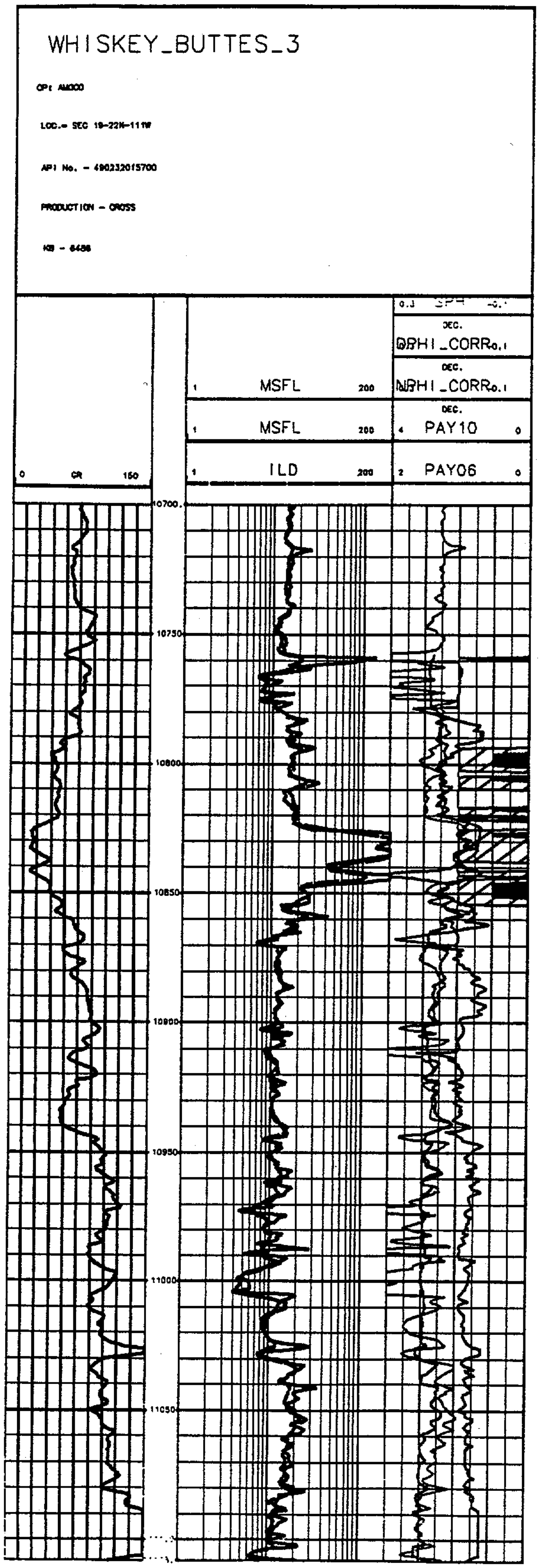


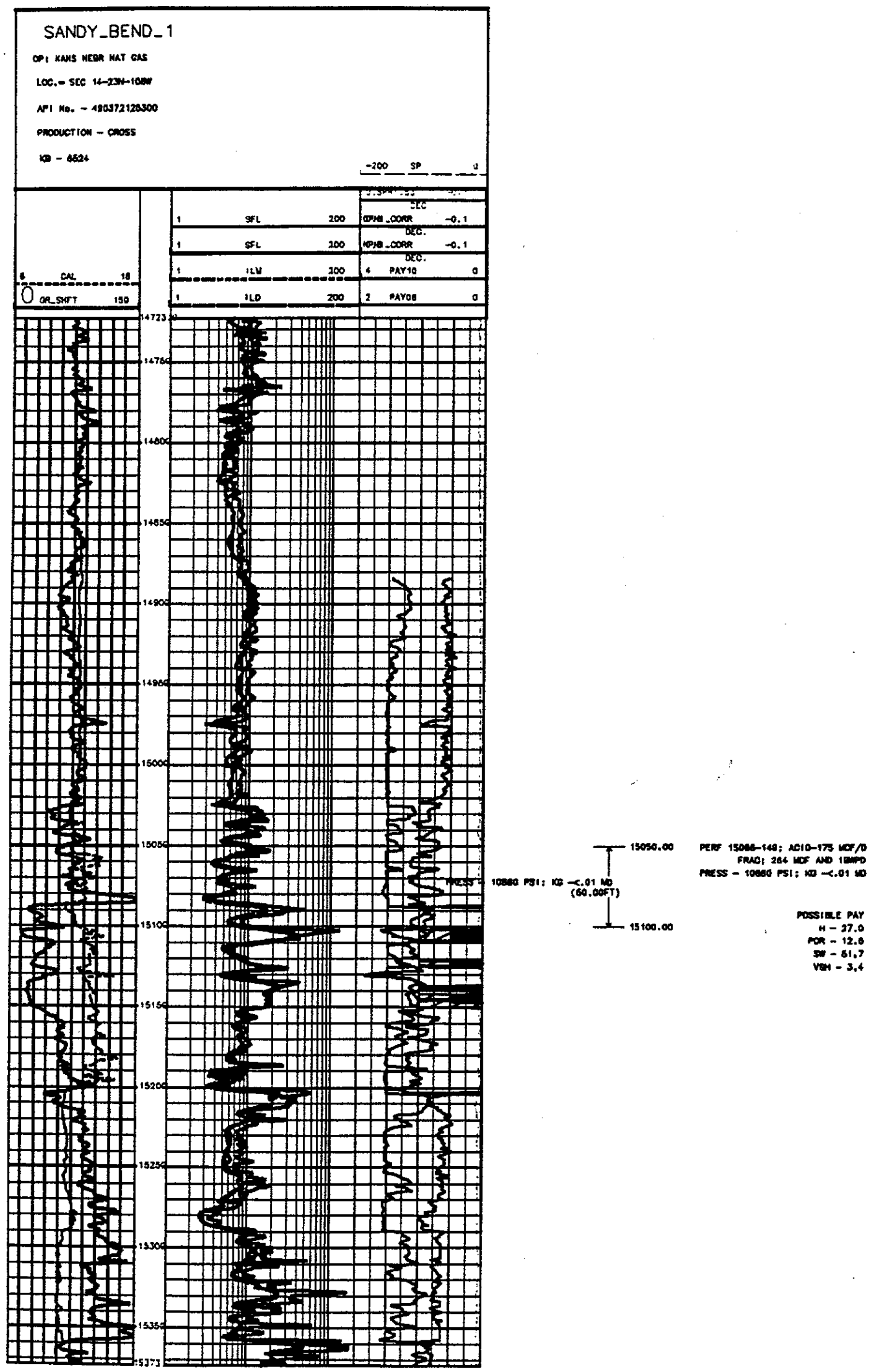
BLUE_RIM_FED1_30
OP: ENERGY RES. GROUP
LOC.= SEC 30-22N-108W
API No. - 490372205900
PRODUCTION - CROSS
KB - 6737
-200 SP 0
DPHI_CORR -0.1
DEC.
NPHI_CORR -0.1
DEC.
4 PAY10 0
2 PAY06 0
1 SFL 200
1 ILM 200
1 ILD 200
6 CAL_SHFT 16
0 GR 150
15700
15750
15800
15850
15900
15950
16000
16050
16100
16150
16200
16250
16300
16000.00
SILTY
(60.00FT)
16060.00
VSH - 15.7
(90.00FT)
16150.00
SW - 38.2
(189.00FT)
16339.00
SILTY
PROBABLE PAY
H - 44 FT
POR - 9.3
SW - 41.6
VSH - 15.7
PERF 16068-368
ACID AND FRAC; 1.3 MMCF/D

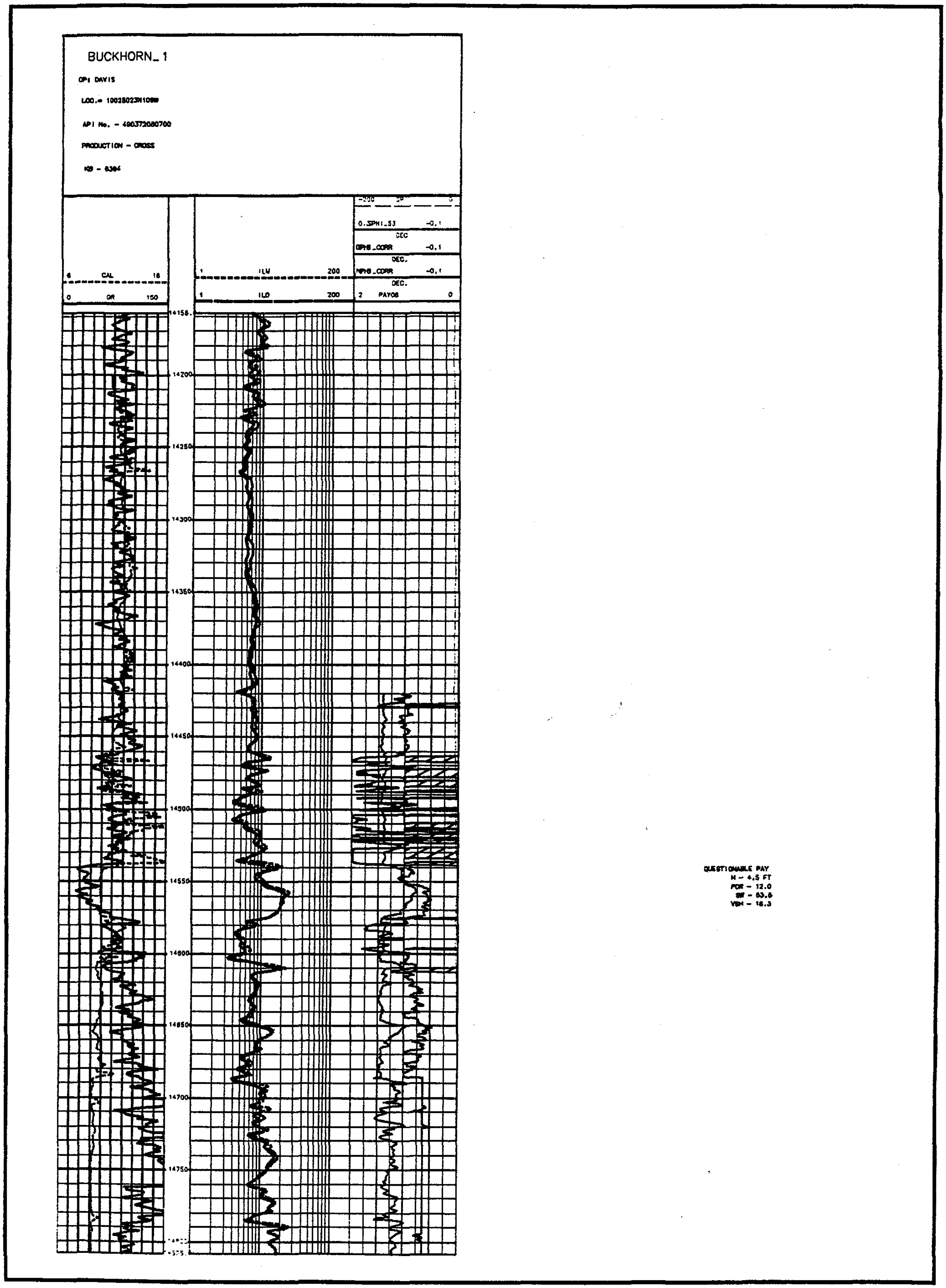


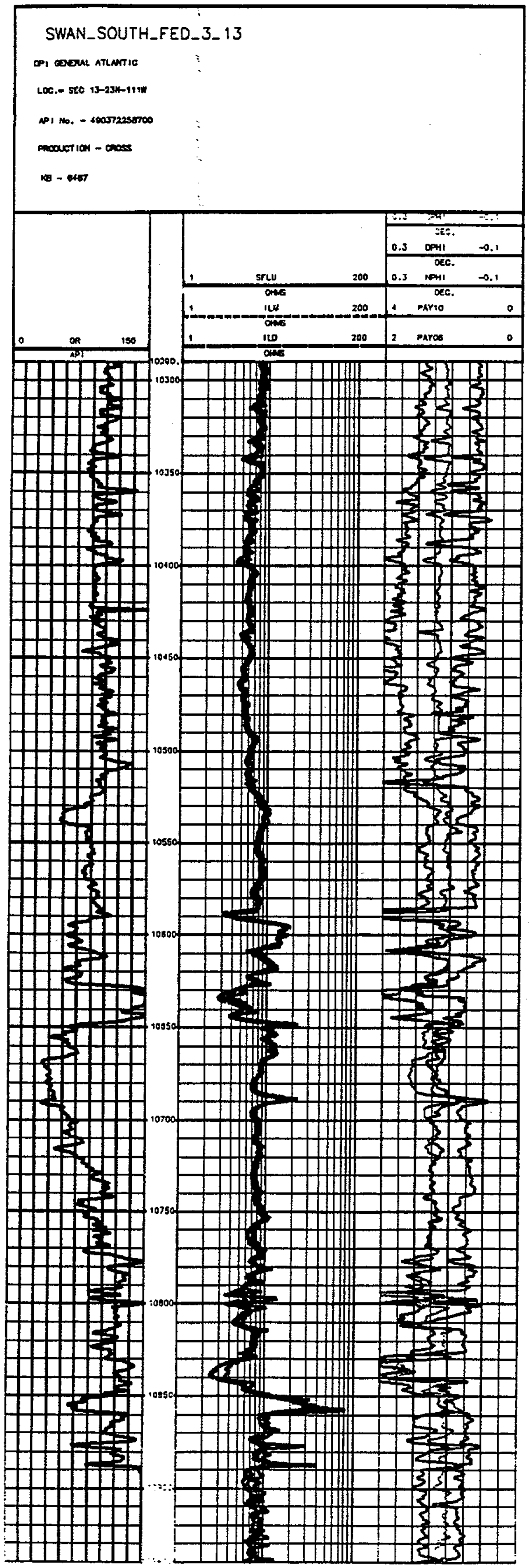
BLUE_RIM_F31_1
OP: ERG
LOC.= SEC 31-22N-106W
API No. - 490372106700
PRODUCTION - CROSS
KB - 6667
-200 SP 0
DEC.
DPHB_CORR -0.1
DEC.
NPHB_CORR -0.1
DEC.
4 PAY10 0
2 PAY06 0
1 SFL 200
1 ILM 200
1 ILD 200
6 CAL 16
0 GR 150
15600.
15650
15700
15750
15800
15850
15900
15950
16000
16050
16100
16150
16000.00
VSH - 4.6
(100.00FT)
16100.00
SW - 25.5
(160.00FT)
16260.00
POSSIBLE PAY
H - 25.6 FT
POR - 12.8
SW - 45.2
VSH - 4.6
PERF 15993-16276: 120 MCF/D
MOST OF PROD FROM 16030-40
ACID-617MCF/D: FRAC-1.6 MMCF/D
PRESS - 12413 PSI

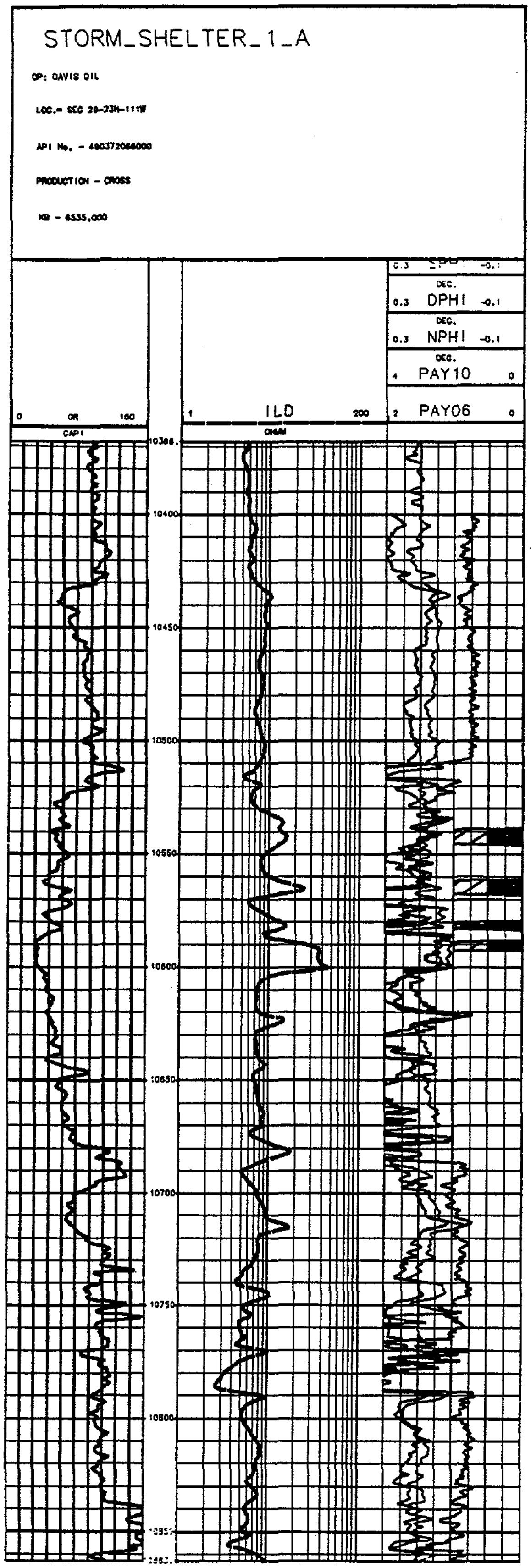

UPRR_1_15
OP: GENERAL ATLANTIC
LOC.= 15-T22N-R111W
API No. - 490372254300
PRODUCTION - CROSS
KB - 6610
0 GR 150
1 MSFL 200
1 MSFL 200
1 ILD 200
0.3 SPHI -0.1
DEC.
4 PAY10 0
2 PAY06 0
10700.
10750
10800
10850
10900
10950
11000
11050
11100
11150
11200


WHISKEY_BUTTES_3
OP: AMOCO
LOC.= SEC 19-22N-111W
API No. - 490232015700
PRODUCTION - CROSS
KB - 6486
DEC.
DPHI_CORR
DEC.
NPHI_CORR
DEC.
1 MSFL 200
1 MSFL 200
4 PAY10 0
1 ILD 200
2 PAY06 0
0 GR 150
10700
10750
10800
10850
10900
10950
11000
11050

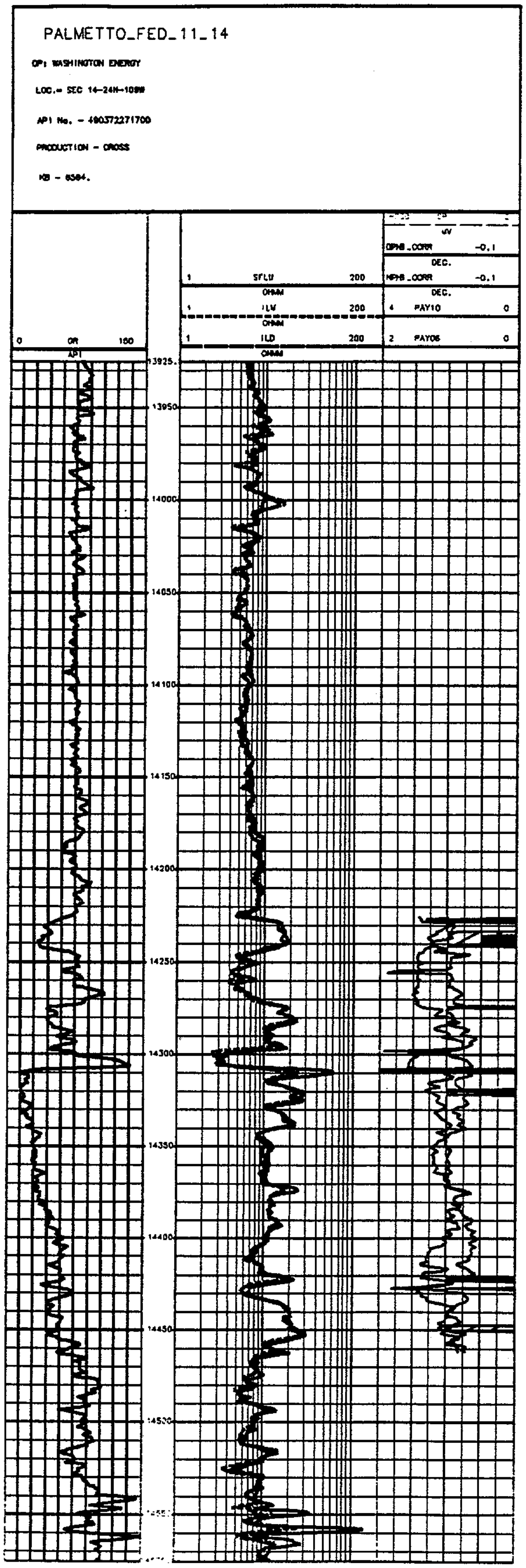

SANDY_BEND_1
OP: KANS NEBR NAT GAS
LOC.= SEC 14-23N-108W
API No. - 490372126300
PRODUCTION - CROSS
KB - 6624
-200 SP 0
1 SFL 200
1 SFL 200
1 ILM 200
1 ILD 200
DPHB_CORR -0.1
NPHB_CORR -0.1
4 PAY10 0
2 PAY06 0
6 CAL 16
0 GR_SHFT 150
14723
14750
14800
14850
14900
14950
15000
15050
15100
15150
15200
15250
15300
15350
15373
15050.00
15100.00
(60.00FT)
PERF 15066-149; ACID-175 MCF/D
FRAC: 264 MCF AND 18MPD
PRESS - 10880 PSI; KG -<.01 MD
POSSIBLE PAY
H - 27.0
POR - 12.8
SW - 61.7
VSH - 3.4

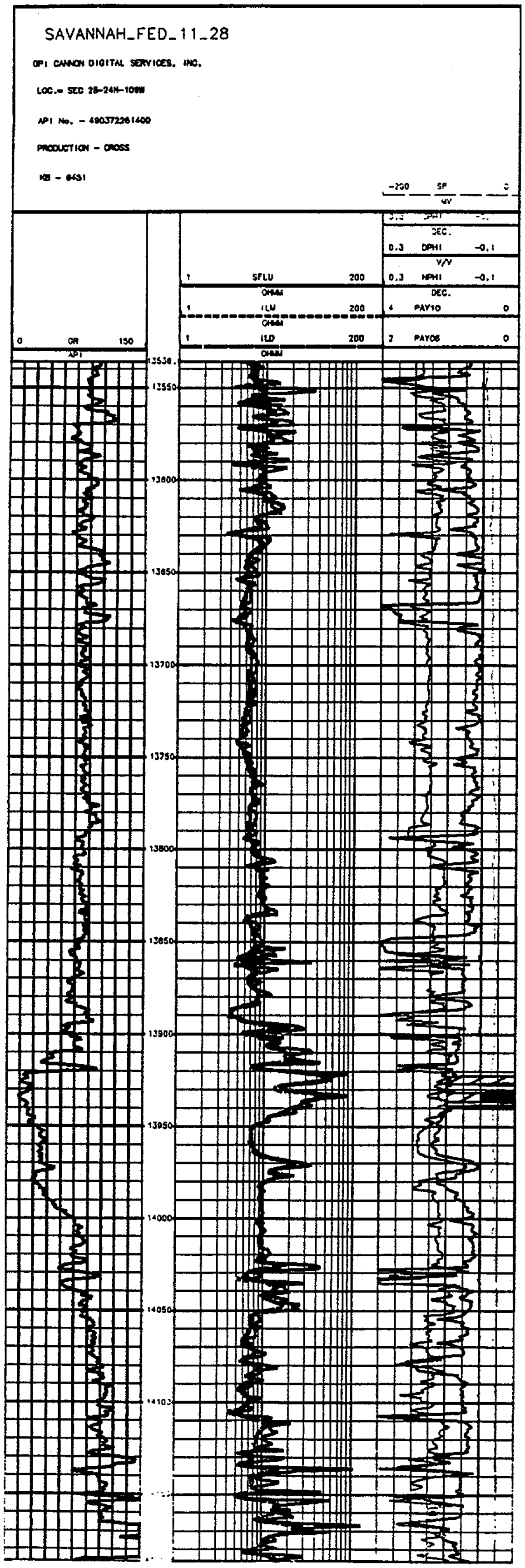

BUCKHORN_ 1
OP: DAVIS
LOC.= 10028023N108W
API No. - 490372080700
PRODUCTION - CROSS
KB - 6384
-200 SP 0
0.SPHI_53 -0.1
DEC
DPHS_CORR -0.1
DEC.
NPHS_CORR -0.1
DEC.
6 CAL 16
0 GR 150
1 ILM 200
1 ILD 200
2 PAYOS 0
14158.
14200
14250
14300
14350
14400
14450
14500
14550
14600
14650
14700
14750
QUESTIONABLE PAY
H - 4.5 FT
POR - 12.0
SW - 63.6
VSH - 16.3

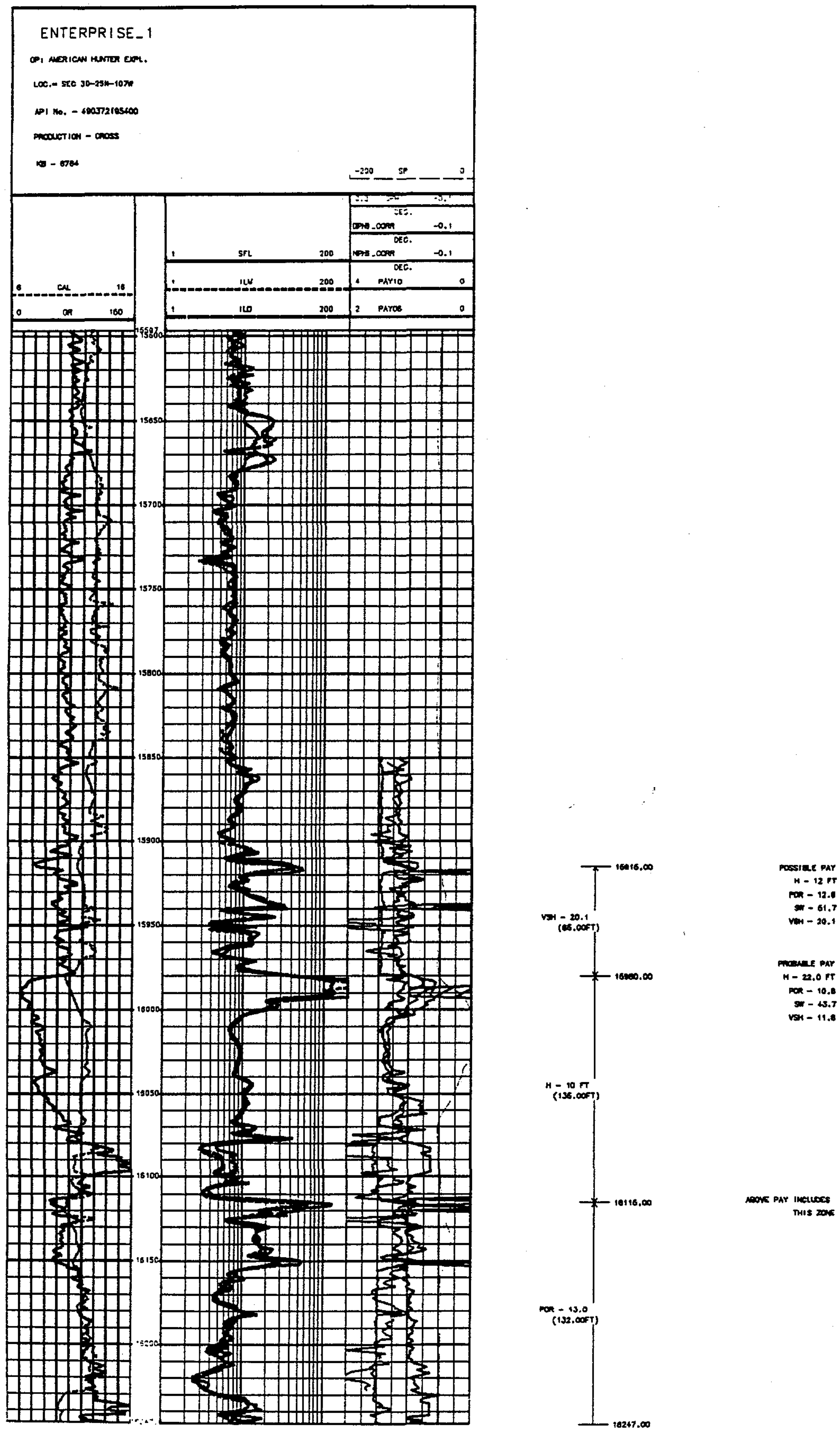

SWAN_SOUTH_FED_3_13
OP: GENERAL ATLANTIC
LOC.= SEC 13-23N-111W
API No. - 490372258700
PRODUCTION - CROSS
KB - 6467
DEC.
0.3 DPHI -0.1
DEC.
1 SFLU 200
0.3 NPHI -0.1
OHMS
DEC.
1 ILM 200
4 PAY10 0
OHMS
0 GR 150
1 ILD 200
2 PAY06 0
API
OHMS
10290.
10300
10350
10400
10450
10500
10550
10600
10650
10700
10750
10800
10850



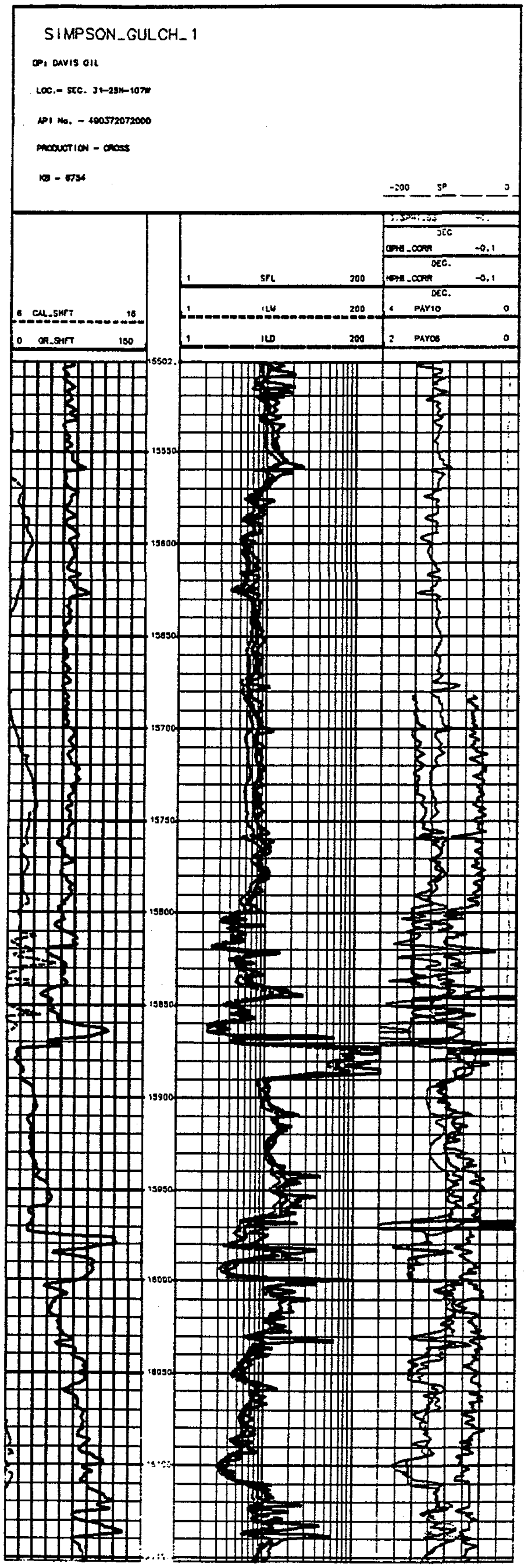
STORM_SHELTER_1_A
OP: DAVIS OIL
LOC.= SEC 20-23N-111W
API No. - 490372066000
PRODUCTION - CROSS
KB - 6535.000
0 GR 160
GAPI
1 ILD 200
OHMM
0.3 DPHI -0.1
DEC.
0.3 NPHI -0.1
DEC.
4 PAY10 0
2 PAY06 0
10388.
10400
10450
10500
10550
10600
10650
10700
10750
10800


PALMETTO_FED_11_14
OP: WASHINGTON ENERGY
LOC.= SEC 14-24N-109W
API No. - 490372271700
PRODUCTION - CROSS
KB - 6584.
0 GR 150
API
1 SFLU 200
OHMM
1 ILM 200
OHMM
1 ILD 200
OHMM
mV
DPHS_CORR -0.1
DEC.
NPHS_CORR -0.1
DEC.
4 PAY10 0
2 PAY06 0
13925.
13950
14000
14050
14100
14150
14200
14250
14300
14350
14400
14450
14500

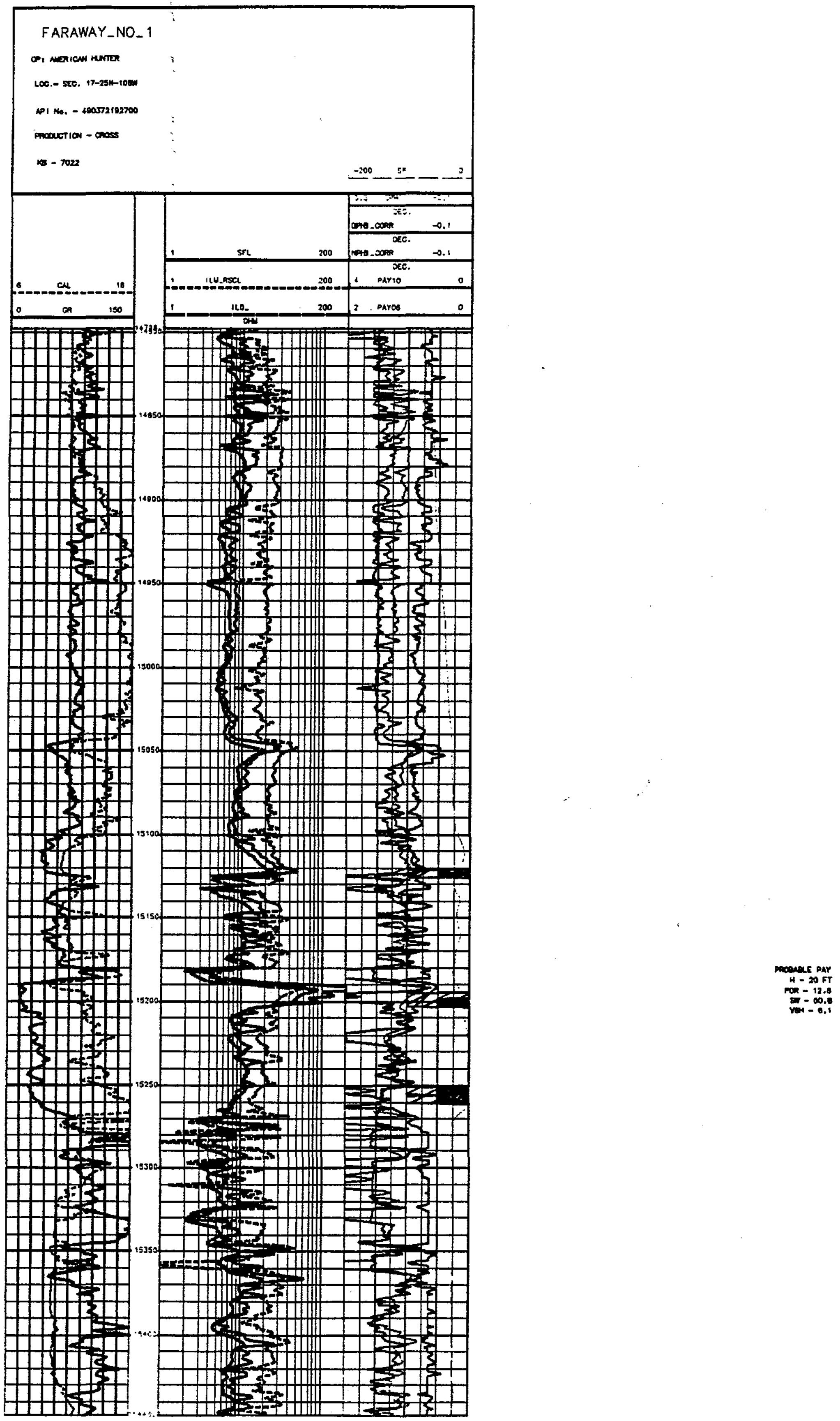

SAVANNAH_FED_11_28
OP: CANNON DIGITAL SERVICES, INC.
LOC.= SEC 28-24N-100W
API No. - 490372261400
PRODUCTION - CROSS
KB - 6431
-200 SP 0
MV
DEC.
0.3 DPHI -0.1
V/V
0.3 NPHI -0.1
DEC.
4 PAY10 0
2 PAY06 0
1 SFLU 200
OHMM
1 ILM 200
OHMM
1 ILD 200
OHMM
0 GR 150
API
13550
13600
13650
13700
13750
13800
13850
13900
13950
14000
14050
14100



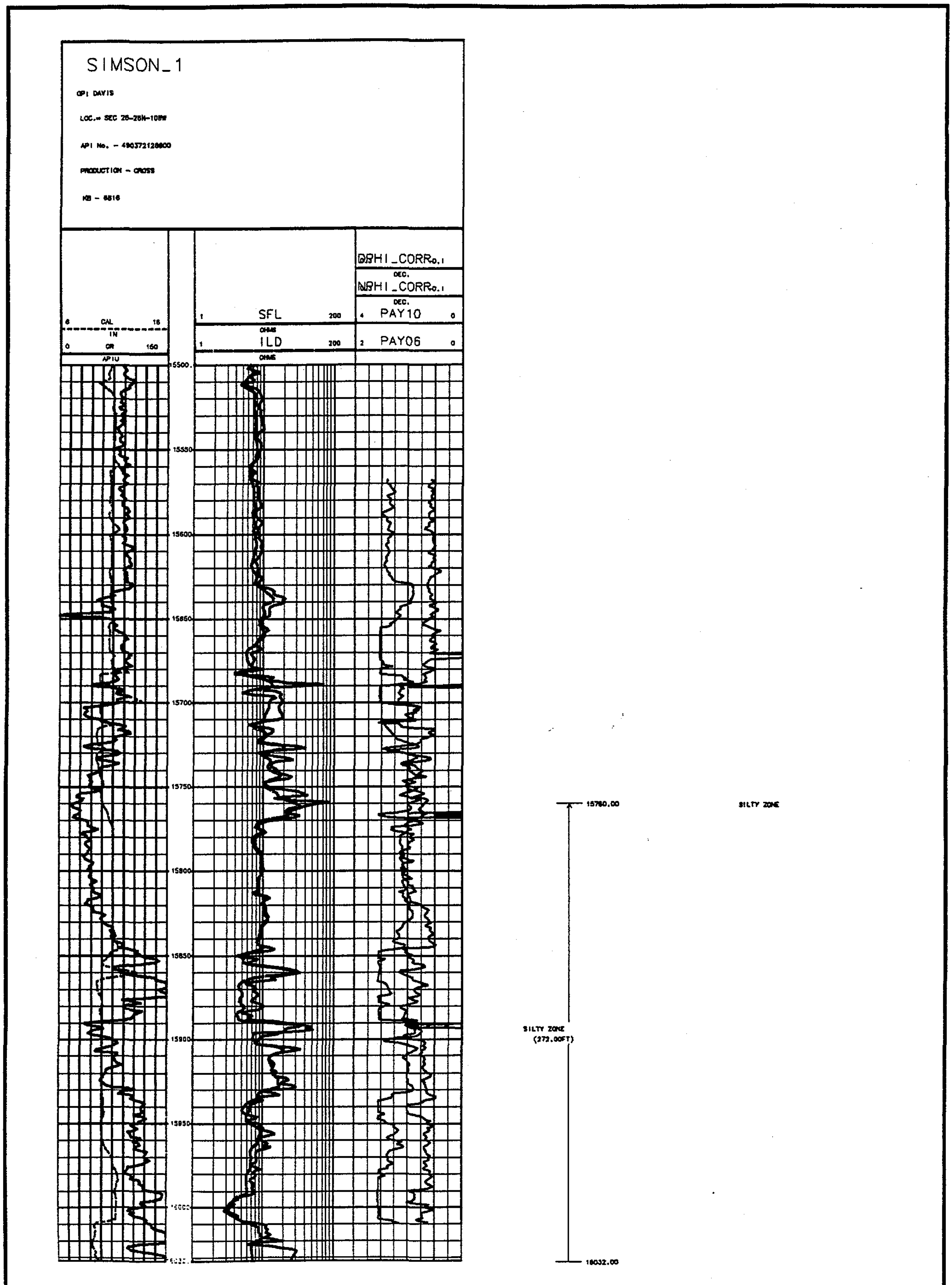
ENTERPRISE_1
OP: AMERICAN HUNTER EXPL.
LOC.= SEC 30-25N-107W
API No. - 4903721?5400
PRODUCTION - CROSS
KB - 6784
-200 SP 0
DEG.
DPHB_CORR -0.1
DEG.
NPHB_CORR -0.1
DEG.
4 PAY10 0
2 PAY05 0
1 SFL 200
1 ILM 200
1 ILD 200
6 CAL 16
0 GR 150
15597
15600
15650
15700
15750
15800
15850
15900
15950
16000
16050
16100
16150
16200
15916.00
VSH - 20.1
(65.00FT)
15980.00
H - 10 FT
(136.00FT)
16116.00
POR - 13.0
(132.00FT)
16247.00
POSSIBLE PAY
H - 12 FT
POR - 12.8
SW - 61.7
VSH - 20.1
PROBABLE PAY
H - 22.0 FT
POR - 10.8
SW - 43.7
VSH - 11.8
ABOVE PAY INCLUDES
THIS ZONE



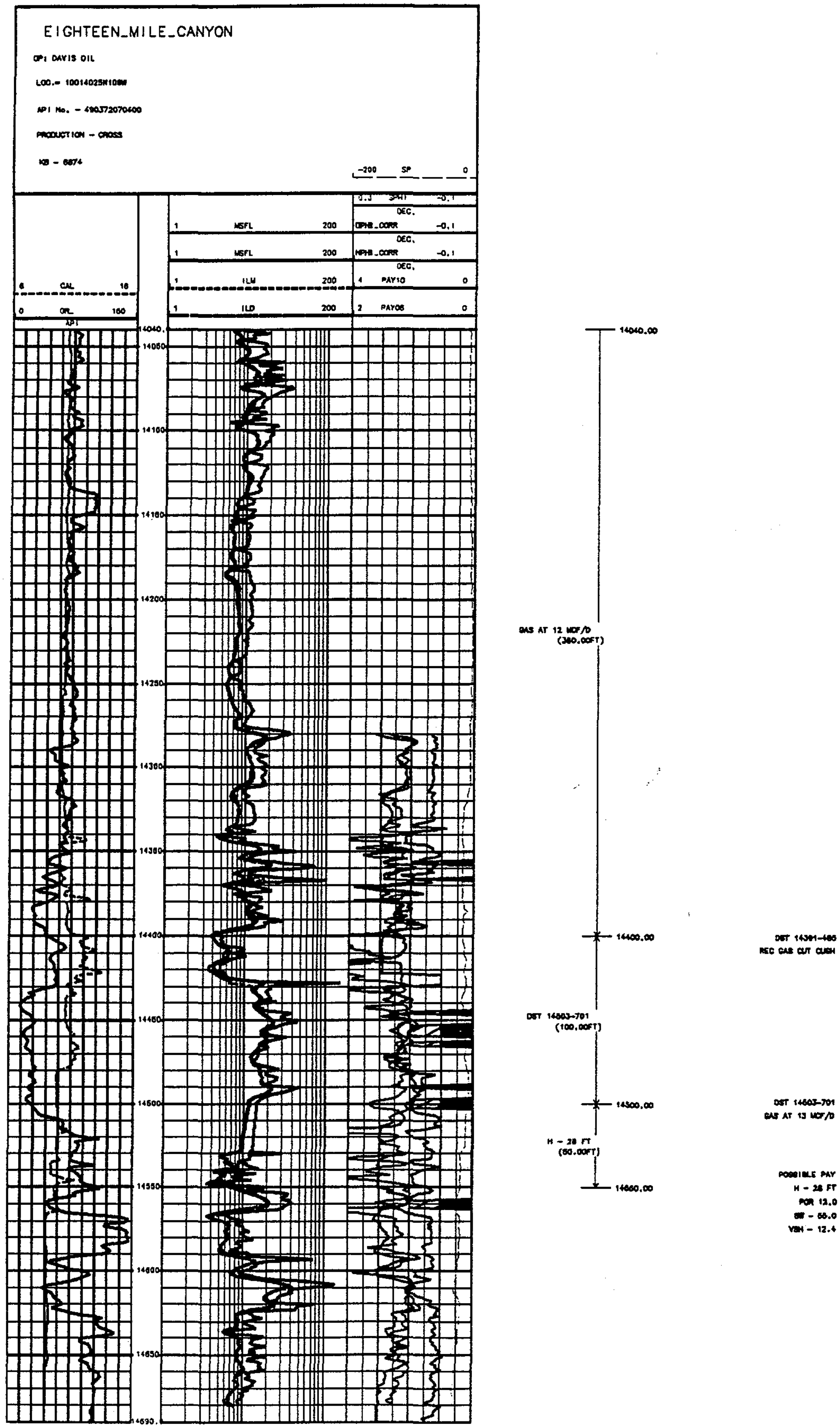
PROBABLE PAY
H - 8.0 FT
POR - 11.8
SW - 41.1
VSH - 6.2



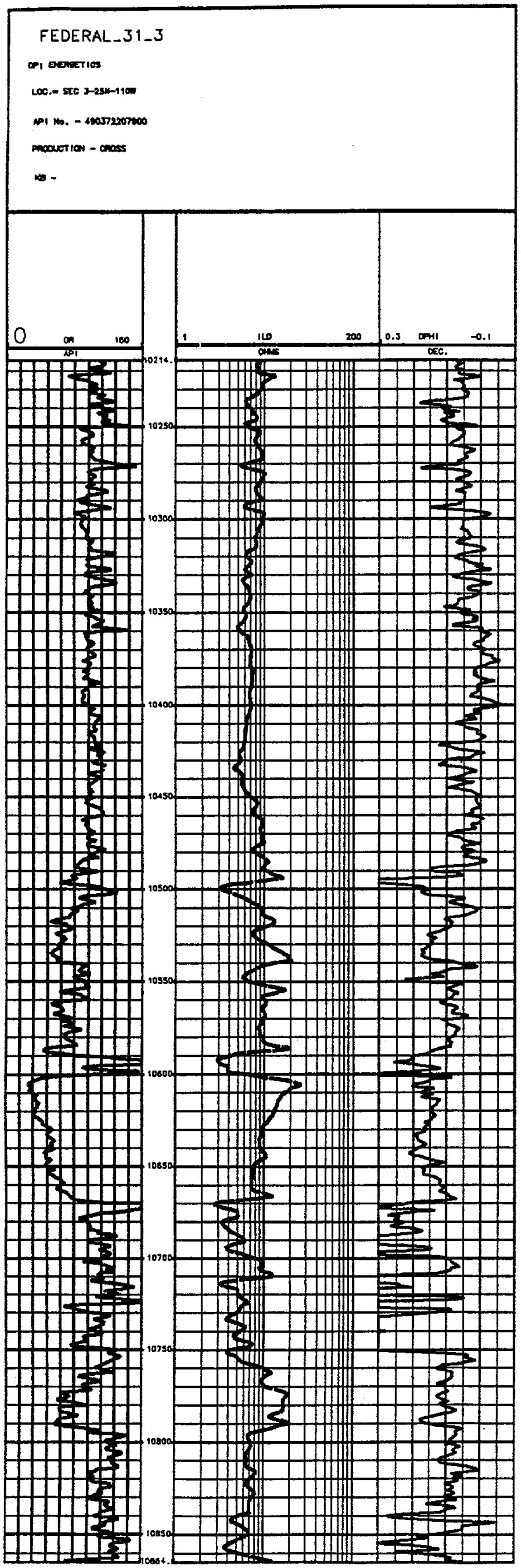
FARAWAY_NO_1
OP: AMERICAN HUNTER
LOC.- SEC. 17-25N-108W
API No. - 490372192700
PRODUCTION - CROSS
KB - 7022
-200 SP 0
DEC.
DPHB_CORR -0.1
DEC.
NPHB_CORR -0.1
DEC.
4 PAY10 0
2 PAY06 0
1 SFL 200
1 ILM_RSCL 200
1 ILD_ 200
OHM
6 CAL 16
0 GR 150
14850
14900
14950
15000
15050
15100
15150
15200
15250
15300
15350
15400
PROBABLE PAY
H - 20 FT
POR - 12.8
SW - 60.8
VSH - 6.1

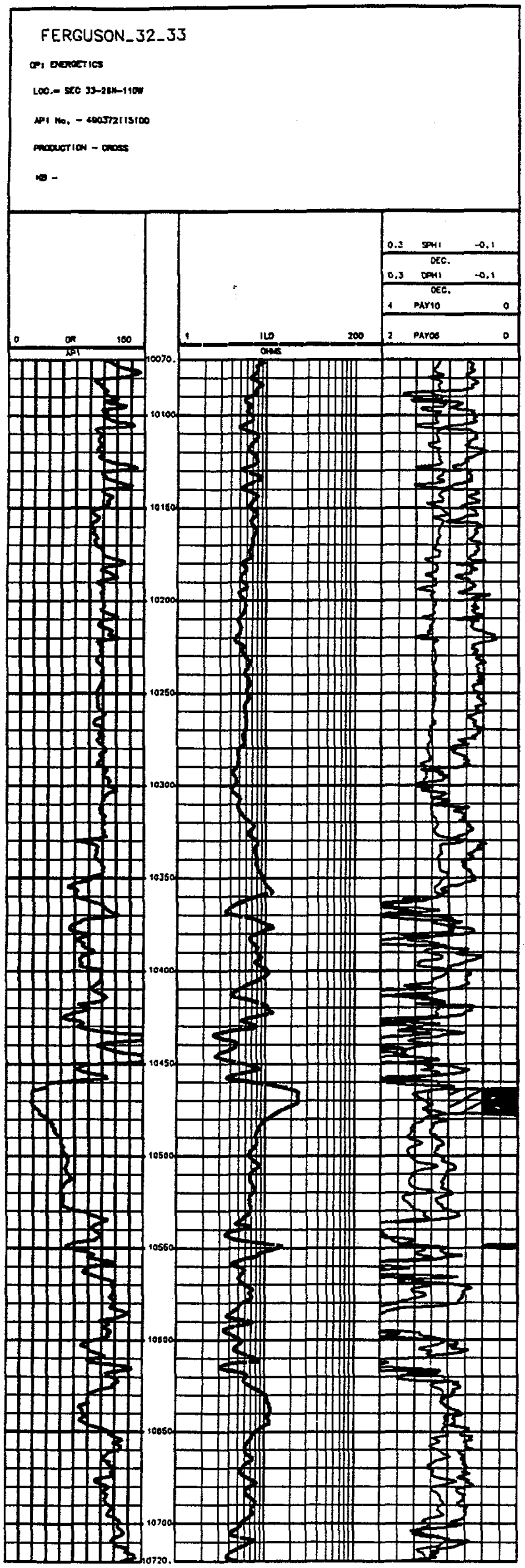


SIMSON_1
OP: DAVIS
PRODUCTION - CROSS
DRHI_CORR
NPHI_CORR
SFL
ILD
PAY10
PAY06
CAL
GR
15760.00
SILTY ZONE
SILTY ZONE
(272.00FT)
16032.00



EIGHTEEN_MILE_CANYON
OP: DAVIS OIL
LOC.= 10014025N108W
API No. - 490372070400
PRODUCTION - CROSS
KB - 6874
-200 SP 0
SPHI -0.1
DEC.
1 MSFL 200
DPHB_CORR -0.1
DEC.
1 MSFL 200
NPHB_CORR -0.1
DEC.
6 CAL 16
1 ILM 200
4 PAY10 0
0 GRL 160
API
1 ILD 200
2 PAY06 0
14040.
14050
14100
14150
14200
14250
14300
14350
14400
14450
14500
14550
14600
14650
14690.
14040.00
GAS AT 12 MCF/D
(380.00FT)
14400.00
DST 14391-486
REC GAS CUT CUSH
DST 14503-701
(100.00FT)
14500.00
DST 14503-701
GAS AT 13 MCF/D
H - 28 FT
(60.00FT)
14560.00
POSSIBLE PAY
H - 28 FT
POR 12.0
SW - 56.0
VSH - 12.4


FEDERAL_31_3
OP: ENERGETICS
LOC.= SEC 3-25N-110W
API No. - 490372207900
PRODUCTION - CROSS
KB -
0 GR 160
API
1 ILD 200
OHMS
0.3 DPHI -0.1
DEC.
10214.
10250
10300
10350
10400
10450
10500
10550
10600
10650
10700
10750
10800
10850
10864.


FERGUSON_32_33
OP: ENERGETICS
LOC.= SEC 33-28N-110W
API No. - 4903721115100
PRODUCTION - CROSS
KB -
0 GR 150
API
1 ILD 200
OHMS
0.3 SPHI -0.1
DEC.
0.3 DPHI -0.1
DEC.
4 PAY10 0
2 PAY06 0
10070.
10100
10150
10200
10250
10300
10350
10400
10450
10500
10550
10600
10650
10700
10720.