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OIL CONSERVATION DIVISION

ENGINEERING AND GEOLOGIC REPORT
August 1, 1988

Case 9478

Proposed Haley Chaveroo San Andres Unit
Chaveroo San Andres Field
Chaves and Roosevelt Counties, New Mexico

I. SAN ANDRES REGIONAL GEOLOGY. The San Andres Formation is one of the most prolific hydrocarbon-bearing horizons of the Permian Basin. It consists of a cyclic sequence of shallow-water carbonates and evaporites which progressed across the Northwest Shelf toward the Midland and Delaware Basins. San Andres production exists through the vertical stacking of porous dolomitic reservoirs. Stratigraphic trapping of hydrocarbons results from porosity pinch-outs defined by the degree of dolomitization and anhydrite plugging, both vertically near the top of depositional cycles, and on a regional scale. Stratigraphic trapping, combined with subtle structural nosing and changes in dip, define the limits of production. Reservoir zones are regionally correlatable and mappable. Major productive trends pinch out northward onto the Matador Arch causing this feature to be a major influence on San Andres deposition and production.

The San Andres fields on the Northwest Shelf are primarily stratigraphic traps; however, subtle structural noses and dip changes limit production on both a local and regional scale.

II. STRATIGRAPHY. At its type locality in the San Andres Mountains of New Mexico, the San Andres Formation consists of a 32 foot (10 meters) thick basal yellowish sandstone and 578 foot (176 meters) of overlying dark-gray to black petroliferous limestone (Lee and Girty, 1909; Kottlowski et al., 1956; Gratton and LeMay, 1969). This section apparently corresponds to the lower half of the uneroded subsurface San Andres of the Northwest Shelf (Kottlowski, et al,, 1956; Kinney, 1969).

The San Andres consists of interbedded dolomites, anhydrites, and minor limestones, which directly overlie the sandy anhydritic dolomite of the Glorietta and Yeso formations (Leonardian). The San Andres is directly overlain by the evaporitic dolomites of the Grayburg Formation of the Artesia/White Horse Group (upper-middle Guadalupian).

The San Andres Formation over much of the Northwest Shelf can be divided into upper and lower parts based on the occurrence of a regionally correlatable marker bed, a silt-stone 5-10 foot (1.5-3 meters) thick, known as the "Pi" marker, which typically occurs 400-650 feet (122-198 meters) below the formation top. From bottom to top, the lower part of the San Andres, which may be up to 800 feet (244 meters) thick, is a large-scale shoaling depositional cycle. It is formed of open-marine shelf deposits, overlain by a thick package of restricted shelf and tidal-flat deposits, and capped by supratidal deposits. Depositional facies of the San Andres Formation have been previously described in detail (Gratton and LeMay, 1969, Silver and Todd, 1969; Chuber and Pusey, 1972; Meissner, 1972; Todd, 1976; Dutton et al, 1979; Hafner, 1979; Ramondetta, 1982). This regressive sequence of deposits represents progradation of facies to the south across the Northwest Shelf and toward the adjacent basins.

The cyclic nature of the restricted shelf and tidal-flat deposits of the lower San Andres has formed stratigraphic traps whose mechanism is the occurrence of impermeable anhydrite and tight dolomites between vertically stacked porosity zones commonly about 50 feet (15 meters) thick (Gratton and LeMay, 1969; Pitt and Scott, 1981; Ramondetta, 1982). The anhydrite layer is thicker to the north (updip), providing an impermeable regional porosity plug that parallels the deeper structural trend of the Matador Arch.

III. POROSITY ZONES. Eight porosity zones are defined at various depths below the Pi marker. Regionally, these zones represent, from bottom to top, cyclic deposition of carbonates and evaporites which become increasingly evaporitic upward through the section. Zones 2 through 4 comprise the productive interval are major hydrocarbon-producing zones, pinching out north and parallel to the Matador Arch.

Dip cross-sections of the San Andres show that the deeper porous zones 7 and 8 are regionally extensive across the Northwest Shelf and Matador Arch. Although zones 7 and 8 are typically porous, the porosity occurs in a water-saturated dolomitic limestone which has not proven productive.

EXHIBIT VIII.

Zones 1 through 5 extend across the Northwest Shelf to their regional pinch-out against the Matador Arch. The reservoir zones correlate to anhydrite and anhydrite-plugged dolomites facies farther north (Gratton and LeMay, 1969; Pitt and Scott, 1981). Reservoir zones are stacked, with increasingly shallower production located farther southward.

IV. STRUCTURAL INFLUENCES. Most San Andres fields on the Northwest Shelf are primarily stratigraphic traps, controlled by a combination of extensive dolomitization and anhydrite plugging. However, subtle structural elements on both a local and regional scale have some bearing on the localization of hydrocarbons in the San Andres Formation. Subtle structural nosing and changes in dip are important in localizing hydrocarbons in the porous reservoir zones (Gratton and LeMay, 1969). Gratton and LeMay (1969) showed that the Chaveroo field of Roosevelt County, New Mexico, results from a combination of stratigraphic, structural, and hydrodynamic interaction. The field produces from three vertically-stacked dolomite reservoirs on two subtle structural noses. Production is limited on the eastern edge of the field by porosity pinch-outs associated with steepening of dip.

The subtle structural influences evident on a local scale are also important on a regional scale. Two important structural features have a marked influence on San Andres production on the Northwest Shelf: a) the Matador Arch; and b) the shallow expression of the Wolfcamp-Pennsylvanian Shelf edge of the Midland Basin. The Matador Arch was a positive feature throughout much of the Mississippian and Pennsylvanian; undoubtedly, it remained a regional high even in the Late Permian. The southern-most wells in the Slaughter-Levelland Field produce from several porosity zones. These zones pinch out regionally updip onto the Matador Arch -- a pattern that is repeated and typifies the Northwest Shelf. All productive San Andres reservoirs that are major hydrocarbon producers pinch out onto this structural feature, restricting production in an east-west trend across the Northwest Shelf which parallels the Arch. Whereas, porous zones are developed north of the Arch (Pitt and Scott, 1981), they are stratigraphically deeper and typically produce water. In addition, the percentage of halite increases north of the Matador Arch. Indeed, the Matador Arch probably marks the southern extent of major halite deposition and the northern extent of reservoir-facies deposition.

V. RESERVOIR CHARACTERISTICS. Core analysis porosities in the Chaveroo Field range up to 20 percent, but the higher porosities are quite often in very thin zones. Permeabilities in the Field are less than 1 millidarcy with an occasional thin interval of higher permeability, but high permeability is usually associated with fracturing. A continuous 35 foot vertical fracture was evident in one core from the Field. Such fractures are felt to be important drainage factors in the Field.

Water-oil contacts in San Andres fields are rather hard to pick as each small porosity zone may have its own separate oil-water contact or because of low permeability may have water interspersed throughout the porous section. The depletion of water during production in some wells seems to be an indication of the validity of the above hypothesis. Typically oil and water cumulative production is about equal during primary recovery. Although it is difficult, if not impossible, to define an oil-water contact datum, it is possible to locate a datum below which all zones produce primarily water.

Chaveroo Field wells sometimes evidence high initial production and rapid decline to relatively low-rate, flatter decline. This suggests initial fracture production depleting by solution gas drive to matrix permeability production both directly to the well bore and through the fracture system. There is evidence of fracture orientation in a northwest/southeast direction. This can be expected in secondary structural north/south arching considering stress parallelogram analysis.

VI. CHAVEROO SAN ANDRES FIELD. As shown on "Exhibit VIII. A.", the Chaveroo San Andres Field is located on the county line separating Chaves and Roosevelt Counties, New Mexico. The field name itself is a contraction of Chaves and Roosevelt. The Field, located geologically on the south flank of the Matador Arch on the Northwestern Shelf, was discovered in March, 1965, with the completion of the Champlin Petroleum Company and Warren American Oil Company No. 1 Hondo State. This well was plugged back from a total depth of 9,100 feet to 4,400 feet. The field now has 425 wells. Production is a sour 24° A.P.I. gravity crude and the cumulative field production was 22,913,530 barrels of oil, 33,609,070 MCF of gas, and 27,187,621 barrels of water as of January 1, 1988.

The discovery was made using a combination of subsurface geology and reflection-seismograph data. Oil production is from a gray-to-brown fine crystalline to granular anhydritic dolomite with fine vuggy inter-crystalline and fracture-type porosity zones located approximately 650 feet below the top of the San Andres of Guadalupian (Permian) age. The Field contains a gross pay section of approximately 200 feet. The Field structure consists primarily of a southward plunging nose. Reservoir conditions are controlled by thin porosity zones which pinch out updip.

"Exhibit VIII.B." contains a geologic report dated November, 1966 prepared by the Roswell Geological Society with attached structural and isopachus maps. This report summarizes the technical information available fourteen months after the Field was discovered. The outline of the proposed Haley Chaveroo San Andres Unit ("HCSAU") has been drafted onto the maps for reference. It is important to note in this Roswell Geological Society report the reported parameters of average reservoir data as follows: 6% porosity, 0.7 md permeability, 26° A.P.I. black sour crude, initial bottom hole pressure of 1340 psi at +140 datum and an average reservoir temperature of 110°F. These technical averages were confirmed by additional development. The current low well production and fluid levels indicate that solution drive primary recovery has depleted reservoir pressure to probably less than 100 psi. The exception to this depleted pressure is in areas of salt water disposal where pressures are often higher.

VII. PROPOSED HALEY CHAVEROO SAN ANDRES UNIT ("HCSAU"). The HCSAU area has geologic characteristics and reservoir conditions similar or superior to the rest of the Field. It is favored as an area of relatively high per well recovery as shown in Exhibit VIII.H., "Derivation of Tract Participation Factors", attached. Forty-two (42) wells in HCSAU have recovered 3,075,508 barrels of oil to January 1, 1988 or an average of 73,226 barrels of oil per well. The Field average has been 53,914 barrels per well from 425 wells. As indicated in Exhibit VIII.I., "Decline Curves for Wells Within the Area of Review", current production is marginal and near economic limit. Uniform ownership of the royalty and working interests within the Unit area furthers the use of a simple Unit formula which credits cumulative production (essentially ultimate primary recovery) to January 1, 1988 as 80% of the formula and useable wells as 20%. Any other formula that is used will give the same Unit ownership with only the tract participation changing. This formula appears optimum.

Available core data as shown in Exhibit VIII.C., "Core Data," indicates porosity and permeability generally consistent with that reported by the Roswell Geologic Society Symposium in Exhibit VIII.B. with a slightly higher porosity and lower permeability for the HCSAU area. The well located in HCSAU Section 31P has produced approximately 42,000 barrels and the well in HCSAU Section 33K about 67,000 barrels. This would indicate that fracture systems, usually found in the San Andres trend, are a major contributor to production.

Exhibit VIII.D., "Tabulated Summary of Geological Data", does not provide any significant information concerning the gross producing section which is generally on the order of 200+ feet of gross thickness. Exhibit VIII.F., "Isopachus Map", is derived from the report of the Roswell Geologic Society Symposium which indicates a net productive interval above 4% porosity for the Unit area.

Exhibit VIII.E., "Structure Map", indicates a gentle nosing across the HCSAU, dipping to the southeast. A lower structural embayment in the southeast of Section 33 corresponds with a dry hole and lower oil recovery. This supports the theory that local structure affects reserve accumulation.

Exhibit VIII.G., "East/West and North/South Stratigraphic Cross Sections", suggest a general continuity of productive interval in the Unit area.

VIII. SUMMARY. A review of technical data and proposed operational plans indicate that the HCSAU area is similar or superior to the rest of the Chaveroo San Andres Field. The Unit area is typical or superior to numerous other San Andres fields in the Northwest San Andres trend area that have been waterflooded successfully. The proposed operational plans appear to be sound. The unitization and waterflooding of the Unit should: a) protect correlative rights; b) promote the conservation of petroleum; and c) prove beneficial to the interest owners, and county, state and federal treasuries.

IX. RECOMMENDATION. It is recommended that expeditious approval of the Unit be sought and that the proposed waterflood project be commenced as soon as possible.

MURPHY OPERATING CORPORATION

Bert H. Murphy, Chief Engineer
Registered Professional Engineer,
New Mexico License #10243 and
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HALEY CHAVEROO SAN ANDRES UNIT

SUPPLEMENTAL DATA REQUIRED BY FORM C-108

INDEX OF EXHIBITS

FILE 3.

Exhibit VIII. - Engineering and Geological Report - Proposed Haley Chaveroo San Andres Unit, prepared by Bert H. Murphy, Registered Professional Petroleum Engineer, dated August 1, 1988.

Exhibit VIII.A. - General Location Map;

Exhibit VIII.B. - Report dated November, 1966 prepared by Roswell Geological Society Symposium with attached structural and isopachus maps and type log;

Exhibit VIII.C. - Core Data - "Completion Coregraph" for State "AZ" Well #2 located within Unit Area; "Completion Coregraph" and "Core-Gamma Correlation" for State "CVB" Well #1 located in near proximity of Unit in Section 31, T-7-S, R-33-E;

Exhibit VIII.D. - Tabulated Summary of Geological Data;

Exhibit VIII.E. - Structure Map with proposed Unit Area delineated;

Exhibit VIII.F. - Isopachus Map with proposed Unit Area delineated;

Exhibit VIII.G.1. - East-West Stratigraphic Cross-Section

Exhibit VIII G.2. - North-South Stratigraphic Cross-Section.

Exhibit VIII.H. - Chart, Derivation of Tract Participation Factors.

Exhibit VIII.I. - Decline Curves for Wells within Area of Review.