ENGINEERING AND GEOLOGIC REPORT
July 15, 1989

Proposed Jennifer Chaveroo San Andres Unit
Chaveroo San Andres Field
Roosevelt County, 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.

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 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. Zones 2 through 4 which comprise the productive interval are major hydrocarbon-producing zones and pinch 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.

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 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 developed north of the Arch are stratigraphically deeper and typically produce water (Pitt and Scott, 1981). 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 generally average between 6 and 8%. Available core analyses indicate that permeabilities in the Field are less than 1 millidarcy. However, core data is extremely limited and, therefore, existing core information may not be representative of reservoir characteristics throughout the Field. The high cumulative production from certain existing wells supported by volumetric engineering analysis suggests higher and more continuous permabilities throughout portions of the Chaveroo Field. This is particularly applicable to the wells within the proposed Unit Area.

Water-oil contacts in San Andres fields are somewhat difficult to determine due to the existence of a broad oil-water transition zone and a possible "tilted" oil-water contact. Typically, oil and water cumulative production is about equal during primary recovery.

Certain Chaveroo Field wells exhibit 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 419 wells. Production is a sour 24° to 28° A.P.I. gravity crude and the cumulative field production was 23,131,431 barrels of oil, 34,070,069 MCF of gas, and 28,100,918 barrels of water as of January 1, 1989. The original 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 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 iso-pachus maps. This report summarizes the technical information available fourteen months after the Field was discovered. 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. 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 JENNIFER CHAVEROO SAN ANDRES UNIT ("JCSAU"). The JCSAU 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. Seventy-one (71) useable wells in JCSAU have recovered 4,962,726 barrels of oil to January 1, 1989 or an average of 69,898 barrels of oil per well. The Field average has been 55,206 barrels per well from 419 wells. As indicated in Exhibit VIII.I., "Decline Curves for Wells Within Area of Review", current production is marginal and near economic limit. The proposed Unit formula is based upon 80% total primary production to January 1, 1989 (essentially equates to ultimate primary recovery) plus 15% total useable wells plus 5% total surface acreage. This formula appears to be optimum given engineering and geological considerations.

The limited core data as shown in Exhibit VIII.C., "Core Data", indicates that porosity and permeability in the JCSAU area is generally consistent with that reported by the Roswell Geologic Society Symposium. Note, however, that these cores may not be representative of the overall reservoir characteristics of the JCSAU area because they come from relatively low recovery wells (± 29,000 BBL/well) when compared to the cumulative production of ±70,000 barrels per well for the average JCSAU well.

Exhibit VIII.D., "Tabulated Summary of Geologic Data," provides information concerning the gross producing section which is generally on the order of 200+ feet of gross thickness.

Exhibit VIII.E., "Structure Map", indicates a southeast plunging monoclinal structure with localized highs in the southwest and northwest portions of Section 35 and the center of Section 19. Higher recovery trends with the strike of the structure until reduced by lower permeability toward the updip pinch out and by higher water saturation in the downdip area.

Exhibit VIII.F., "Iso-Cum Base Map", illustrates the cumulative oil production contours. This "iso-cum" mapping method is preferred to the iso-pach map as a tool for evaluating future secondary oil productivity.

Exhibits VIII.G.1 through VIII.G.7., various "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 JCSAU 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.

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