RECENT APPLICATIONS OF BRINES AND TREATED BRINES IN PERMIAN BASIN DRILLING

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INTRODUCTION

From the earliest days of West Texas drilling, produced brines have been readily available. Drillers quickly realized, even in the early days, the advantages to be gained from drilling with clear brine.

Today, good quality brine is conveniently available to most parts of the Permian Basin at a delivered cost of 25¢ to 50¢ per barrel. The advantages of using clear brine as a drilling fluid have been adequately documented. [1,2,3] The more obvious advantages are: (1) improved penetration rate with a solids-free fluid as compared to a typical drilling mud; (2) clear fluid with a density of up to 10.0 ppg is available when needed for pressure balance; (3) the natural tendency of brine to "pickle" or inhibit the swelling of shaley formations, thus protecting production zones and hole condition in general; and (4) all these at a relatively low unit cost compared to conventionally formulated drilling fluids.

AREAS AND DEPTHS OF CLEAR BRINE DRILLING

The Permian Basin extends generally from the geographical center of the State of New Mexico to the east as far as Abilene and Del Rio and south to the Rio Grande River as shown in Fig. 1.[4] Virtually all of this wide area continues to use clear brine in some phase of the drilling operation. A portion of the Basin contains the Ochoa salt beds and salt stringers at relatively shallow depths. This is the crosshatched area on the map in Fig. 1. Saturated brine is used in this interval to prevent dissolution of the salt and consequent hole enlargement. Other zones throughout the Basin consist predominately of hard, competent carbonates that stand up well after drilling with clear brine, and which therefore can be drilled faster with clear brine than with formulated drilling fluids.

A typical graphic analysis of a deep well drilling program is shown in Fig. 2. On the left are the more important formation tops. To the right are typical casing sizes and depths. Adjacent to these are notes on the formation characteristics affecting the drilling program. To the right of center is a description of fluid types by interval. The five columns on the extreme right show in order mud weight, funnel viscosity, cumulative days, bits, and mud cost.

It is apparent from this chart that all but the Wolfcamp, Pennsylvanian interval (12,000 ft-17,000 ft) lend themselves to brine or diluted brine drilling. This amounts to about 75% of the total footage of a deep well.

TEMPORARY TREATMENT OF CLEAR BRINE

Referring again to Fig. 2, we see that at a depth of about 8000 ft some additional hole cleaning over that of clear brine may be helpful. At this depth, some formation sloughing may occur from increasing pore pressure as the Wolfcamp transition zone is penetrated. Then too, the lifting ability of clear brine is just barely adequate in this hole size at this depth.

A similar situation prevails below the Mississippian where clear brine is also used as the fluid medium. It has been found that regular "sweeps" of the hole in this situation allow continued clear brine drilling. In order to achieve maximum solids control, operators generally circulate the system through the reserve pit. This allows maximum settling time on the surface, but provides an unusually large volume for the circulating system. Raising the viscosity of the whole system would be quite uneconomical and would also eliminate the advantage available from clear fluid drilling. Thus, it becomes advantageous to raise the viscosity of a small portion of the fluid system—say 20-40 bbl—and use this as a "sweep" or "slug" to remove accumulated cuttings or cavings from the well bore.

Two methods are now widely used for this purpose. Both involve an extra mixing pit separate from the surface fluid system, but manifolded to the pump suction.

Asbestos

Several brands[5] of shredded asbestos fiber are available. A fairly low concentration of asbestos (2-5 lb/bbl) provides excellent lifting capacity to a fluid without noticeably increased viscosity values as commonly measured.

Asbestos requires adequate shear dispersion to reach its cuttings-carrying capability. For this reason, operators mix the extra pit well ahead of time using the fluid from the active system. To 50 bbl of clear water are added 5-10 sacks of asbestos; the mixture is stirred with the mixing pump until needed. Once or twice each 24 hours the mixed asbestos slurry is admitted directly to the pump suction, and about 25 bbl circulated through the hole.

When a mixing pit is not available or time does not allow premixing of the asbestos, it may be dumped dry and gunned directly into the suction pit near the pump suction. Ten to twenty 50 lb sacks are used in this way. Many operators continue to use this dry mixing technique, but more are now premixing because of the increased efficiency obtained from the asbestos.

Prehydrated Bentonite

If bentonite (fresh water clay) is prehydrated in fresh water before adding to a brine, the bentonite retains its viscosity and filtration control characteristics for a reasonable time. Bentonite added dry directly to a brine fails to yield viscosity or filtration control. Today an increasing number of operators are using prehydrated bentonite in slugs to sweep the hole while drilling with a clear brine system.

The technique is again to use a separate mixing pit; but, in this case, good fresh water is used. Soda ash is used to remove hardness before adding bentonite. A concentration of 20-30 lb/bbl bentonite is added to the fresh, treated water and allowed to hydrate and mix as long as possible before its intended use. A minimum mixing time of two hours is suggested—four hours is much better. As with the asbestos slurry, the bentonite slurry is admitted directly to the pump suction until about 25 bbl have been picked up. For rigs not equipped with a mixing tank, a small, compact prehydrating tank can be rented.

Neither the asbestos nor the bentonite shows any tendency to remain in the system and build viscosity over a period of continued use. Thus, the advantages of clear brine drilling are retained while the hole is being swept clean on a regular basis, or as required.

BRINE MUDS

There are several advantages of a brine mud over a fresh water mud that are immediately apparent. First, at any density above that of fresh water up to 10.0 ppg, no weighting material at all is required. This, of course, eliminates a significant portion of the cost of the system and also provides minimum solids which is so important to penetration rate. Second, for densities above 10.0 ppg much less weighting material is required than would be the case if fresh water were the base fluid. This provides the advantage in cost and solids content pointed out above. Third, the natural tendency of brines to "pickle" or inhibit the swelling characteristics of shale, provides better hole condition and less damage to possible producing zones.

FORMULATION OF BRINE FLUIDS

Conventional

At least one deep well operator in the Basin maintains that, with modern solids-control devices and techniques, a weighted starch, attapulgite (salt clay) system is ideal for drilling the pressured Wolfcamp, Pennsylvanian interval. This operator has recently (1972) drilled a well south of Pecos to a total depth of 17,000 ft in 150 days using a maximum mud weight of 14.0 ppg in the lower Pennsylvanian. Clear brines were used above the Wolfcamp and below the Mississippian. A brine mud without salt clay, as described below, should give improved penetration rate.

Prehydrated Bentonite

Properly prehydrated bentonite contributes materially to filtration and filter cake control in a brine system. The salt clays actually interfere with filtration control and tend to produce sticky, thick filter cakes. For these reasons it seems logical to build a brine mud with prehydrated bentonite. *Proper* prehydration of the bentonite is of paramount importance. When used temporarily in clear brine, the bentonite will retain its viscosity and filtration control for only a relatively short time. When used in a mud, these characteristics need to be retained as long as possible to delay deterioration of the bentonite into an inert solid which tends to retard penetration rate.

The bentonite should, of course, be prehydrated in the mixing pit in fresh water. The water should be treated with soda ash (not caustic soda) to remove hardness before adding bentonite. About 20-30 lb bentonite per bbl of water are added and allowed to mix and hydrate for a minimum of two hours. The longer the prehydration time the better. It may even be necessary to add more water as the bentonite continues to yield with time.

As the last step before the bentonite slurry is blended into the brine, the mix is treated with 4 lb/bbl ferrochrome-lignosulfonate and 1.0 lb/bbl caustic soda. The addition of ferrochrome-lignosulfonate to the *completely* hydrated bentonite protects it in the brine environment, and the bentonite continues to contribute to the rheology and filtration characteristics of the brine system for a much longer time than would be the case without the protective ferrochrome-lignosulfonate.

Filtration Control

A brine mud containing only prehydrated bentonite may have a filtrate of 30-50 ml API. This could be reduced further with additional prehydrated bentonite, *but* at the expense of higher solids and reduced penetration rate. Thus, it is desirable to use a separate additive to reduce filtration below 30-50 ml when necessary.

There are many filtration control additives that are effective in brine systems. Table 1 is reproduced from PES Drilling Fluids File[5], and lists the trade names and suppliers of these additives.

The selection of one or more of these materials would depend on economic considerations, compatability, and primarily on viscosity effect. Some of the materials tend to increase viscosity, some to reduce viscosity, and others have little effect on viscosity. Naturally, an operator will select the filtration control additive that affects the viscosity of his system in the desired direction.

TABLE 1—FILTRATION CONTROL ADDITIVES, TRADE NAMES AND SUPPLIERS

AMOCO DRILLAID 425, Amoco Chemicals Corp.
BASCO 50, Barium Supply Co.
BASCO CMC, Barium Supply Co.
BASCO STARCH, Barium Supply Co.
CMC (Generic name), Most mud companies
CARBOSE (CMC), BASF, Wyandotte Chemical Co.
CELLEX (CMC), Baroid Div, N L Ind.
DM (CMC), du Pont
DEXTRID, Baroid Div., N L Ind.
DRISCOSE (CMC), Drilling Specialties Co.
DRISPAC, Drilling Specialties Co.
FL-1, Montello, Inc.
H.Q.M., Harvest Queen Mill and Elevator Co.
HOLEMAKER BASE MIX, Montello, Inc.
KELZAN, Xanco
IMCOLOID, IMC Drilling Mud, Inc.
IMPERMEX, Baroid Div., N L Ind.
LAMCO STARCH, Louisiana Mud Co.
MIKOL, Krause Milling Co.
MILCHEM CMC, Milchem Drilling Fluids Div.
MILSTARCH, Milchem Drilling Fluids Div.
MY-LO-JEL, Magcobar Products
PAL MIX 100B, Petroleum Associates of Lafayette
PAL MIX 380, Petroleum Associates of Lafayette
PAL MIX "SUPER X", Petroleum Associates of Lafayette
QUALEX, du Pont
STABILOID, Anhauser Busch
UNI CMC, United Engineering Corp.
UNI STARCH, United Engineering Corp.
WHITE MIKOL, Krause Milling Co.

Shale Stabilization

Recent extensive laboratory work[6] has shown that shales absorb water, disintegrate and slough from two separate physical forces. These are osmotic hydration and surface hydration. Neither of these is related to API filtration or to hydrostatic pressure.

Osmotic hydration depends on the salinity balance between the water in the drilling fluid and the interstitial water in the shale body. In its simplest terms, osmotic hydration means that water will move from a lower salinity region to a higher salinity region. Therefore, to prevent osmotic hydration of a shale by the drilling fluid, the salinity of the drilling fluid should be higher than that of the formation water in the shale. This is accomplished by brine drilling fluids.

Surface hydration is the absorptive force of the shale structure itself. This force is the result of loss of water from the shale when compacted and subsequent stress relief when the shale is drilled. Surface hydration can be controlled by the adsorption of natural or synthetic polymers onto the face of the shale body. The effectiveness of this adsorption of polymers onto the shale varies from one polymer to the other. Laboratory tests on reconstituted shale bodies[6] have shown that the polysaccharides and/or the polyanionic-type polymers are effective in limiting surface hydration.

Brine Polymer Muds

These muds are a development of the technology described above, and are controlled day-to-day somewhat in the manner of the procedures above. The term "brine polymer mud" as used today is uniquely applied to a system meeting these criteria:

1. Base fluid: A potassium or sodium chloride brine. (Sea water on the Gulf Coast.)
2. Solids: Minimum; prehydrated bentonite or asbestos.
3. Rheology: Primarily yield point rather than plastic viscosity for carrying capacity and suspension. Controlled by choice of polymer.
4. Shale stability: Achieved by maintenance of desired polymer concentration based on specific tests.
5. Filtration: Not controlled as such, but generally quite low as a result of polymer additions.

Brine polymer muds represent a new concept in drilling fluids technology. A specific type and concentration of polymer in combination with a specific type and concentration of salt has demonstrated borehole stabilization capability beyond any observed previously with water-base muds.

Recent (1972) Applications of Brine Polymer Muds

Graphic records of several recent or currently drilling wells are shown in Figs. 3 through 10 at end of paper. The well reported in Fig. 6 was unusual in that a 17.2 ppg brine polymer mud was used routinely during part of the drilling. Analyses were supplied by Baroid Division of N L Industries.

CORROSION

All aqueous drilling fluids have some corrosive effect on casing and drill strings.[10] Brine fluids with low solids content may require more attention to corrosion control, since they can carry more dissolved oxygen.[11] A corrosion control program should be used with *all* aqueous drilling fluids. An effective, economical procedure is as follows:

1. Maintain pH at 10.0 or above. Use lime to control pH down to a depth where 150°F bottomhole temperatures are expected. At 150°F and above, caustic soda should be used to maintain pH, since lime contributes to scale formation on the drill pipe at 150°+F.
2. Reduce oxygen by the application of an oxygen scavenger. A catalyzed sodium sulfite has proved to be economical and effective.
3. Inhibit scale formation, whether maintaining pH with lime or caustic, by the addition of an organic phosphonate in very low concentration.
4. Maintain a film of inhibitor on the metal by regular application of a suitable film-forming amine. When H_2S or CO_2 are present or expected, additional pH control and film deposition should be applied.

CONCLUSION

Clear brine, treated brines, and brine polymer fluids have demonstrated many advantages in Permian Basin drilling. Chiefly, these advantages are economy, penetration rate, and hole stability. These systems are quite flexible in that any desired properties may be achieved in several different ways. Field development continues as of this writing to further refine field control procedures for weighted brine polymer fluids to attain greater cost reduction and further improved penetration rates. The author ventures to predict more and more use of these fluids in the immediate future.

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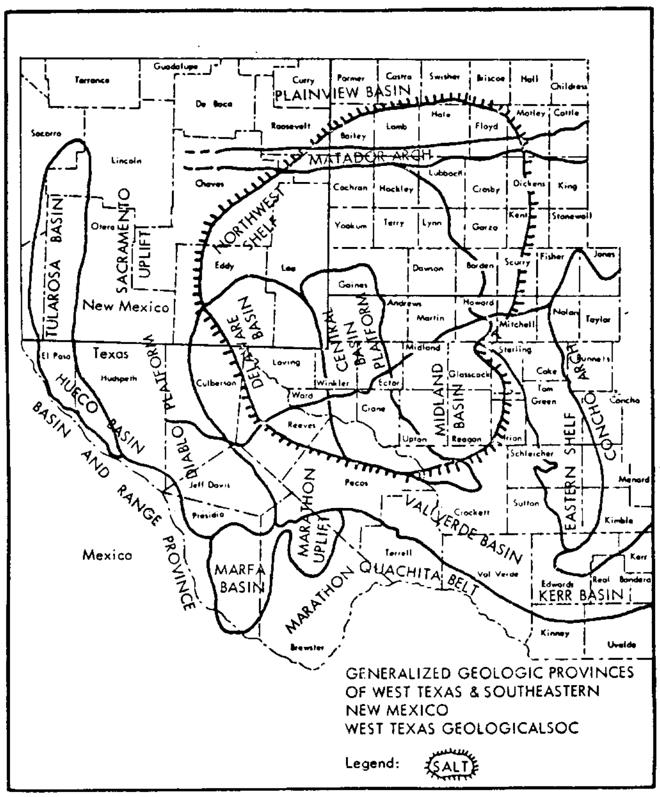

FIG. 1—GENERALIZED GEOLOGIC PROVINCES OF WEST TEXAS AND SOUTHEASTERN NEW MEXICO

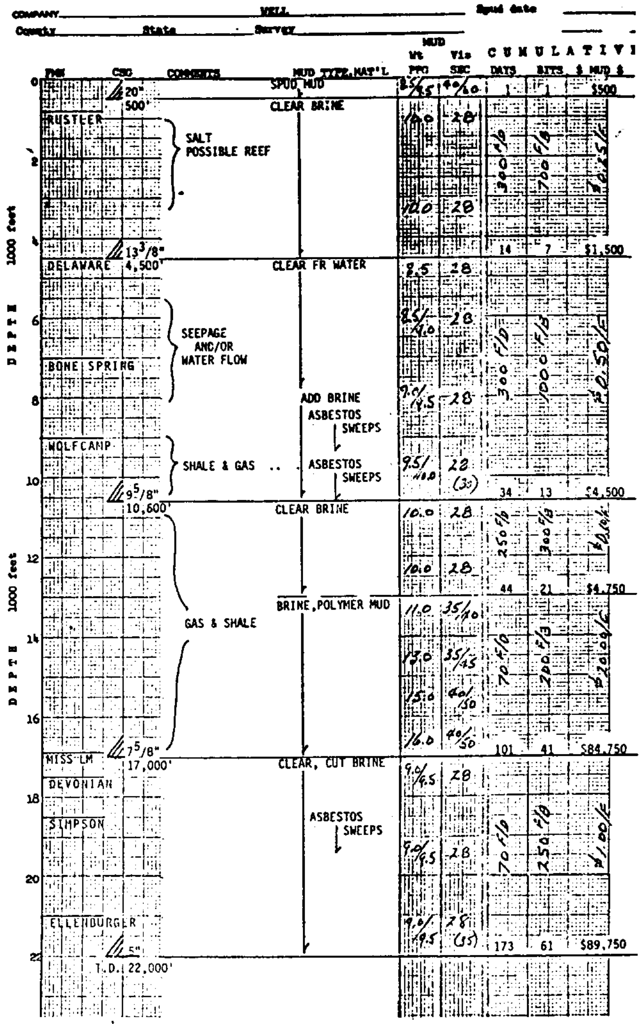

FIG. 2—TYPICAL GRAPHIC ANALYSIS OF A DEEP WELL DRILLING PROGRAM, DELAWARE BASIN

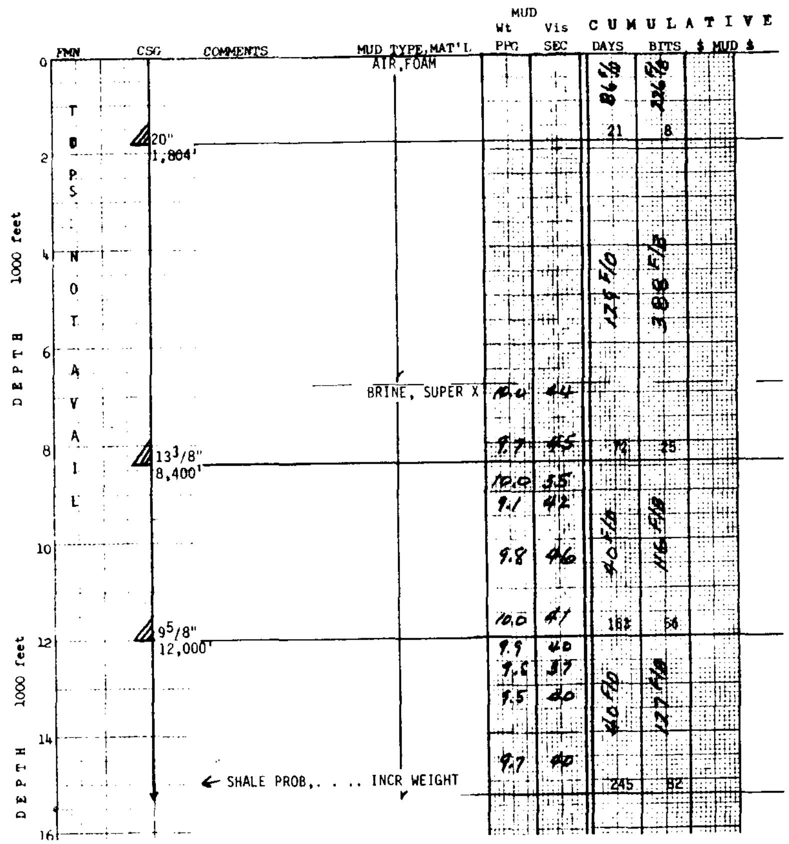

FIG. 3—TYPICAL DRILLING PROGRAM ANALYSIS; BRINE POLYMER MUD, BLACKSTONE SLAUGHTER FIELD, PECOS COUNTY, TEXAS (Reference 7)

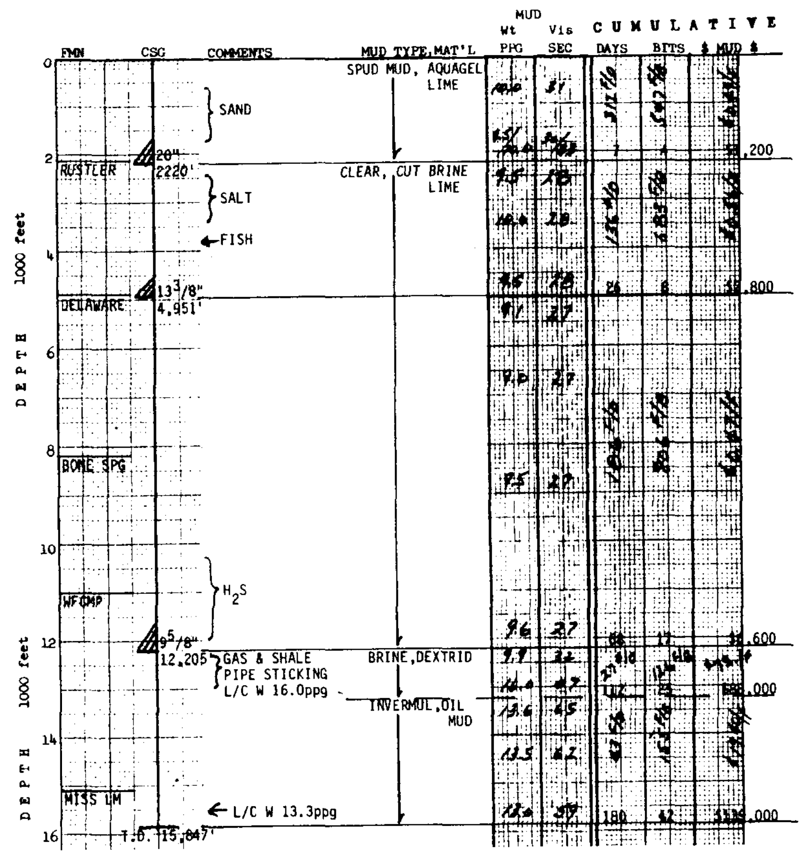

FIG. 4—TYPICAL DRILLING PROGRAM ANALYSIS; BRINE POLYMER MUD, HUTCHINGS SEALY AREA, WINKLER COUNTY, TEXAS.

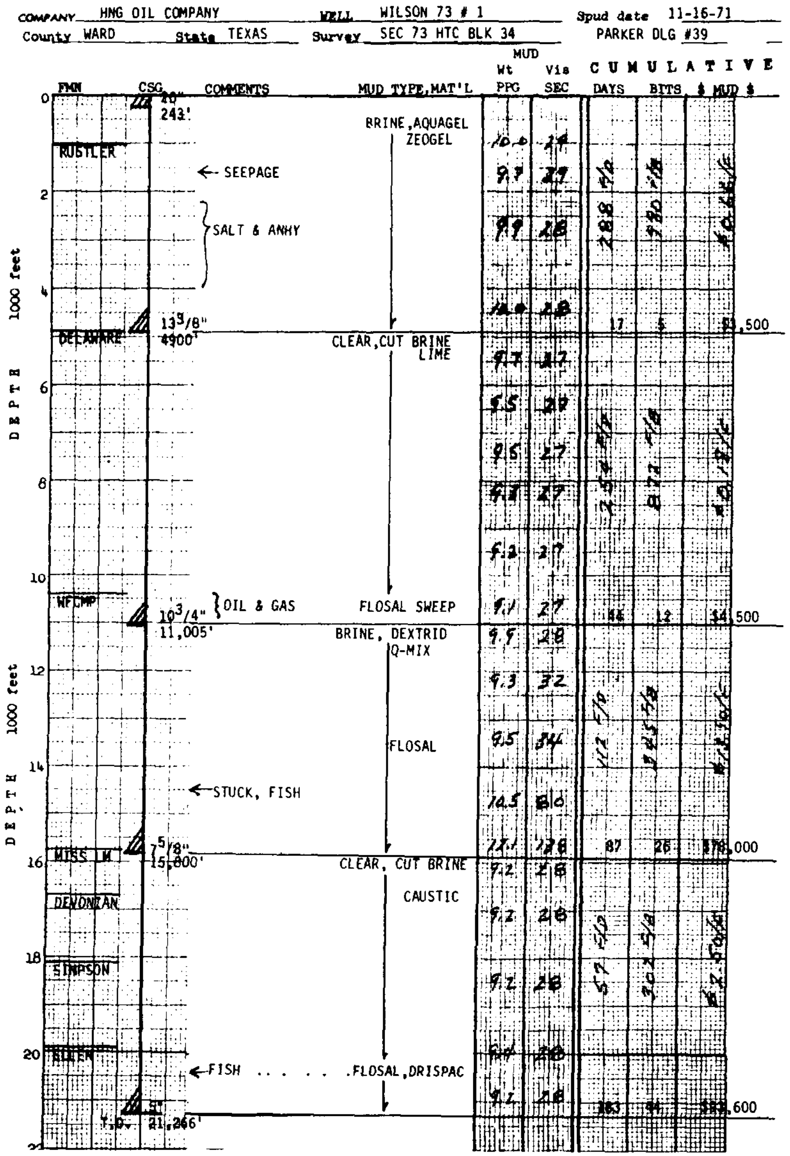

FIG. 5—DEEP DRILLING ANALYSIS;
BRINE POLYMER MUD, SOUTH PYOTE
AREA, WARD COUNTY, TEXAS.
(Reference 8)

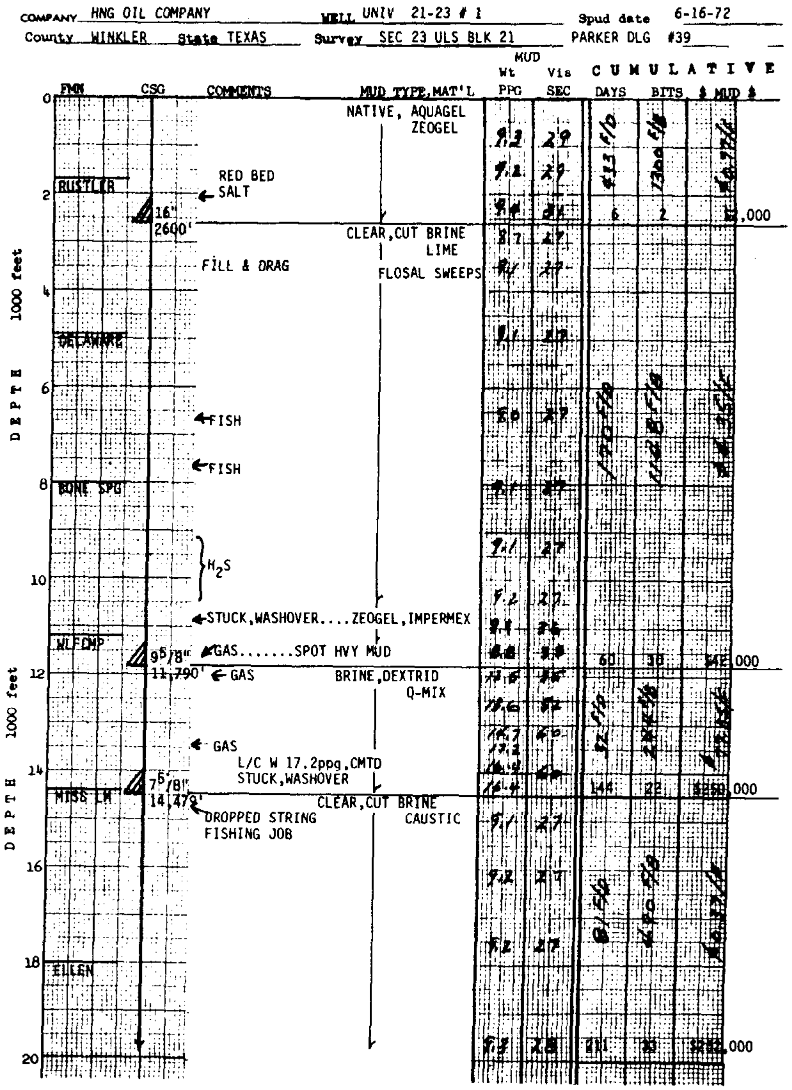

FIG. 6—DEEP DRILLING ANALYSIS;
BRINE POLYMER MUD, WINK AREA,
WINKLER COUNTY, TEXAS.
(Reference 9)

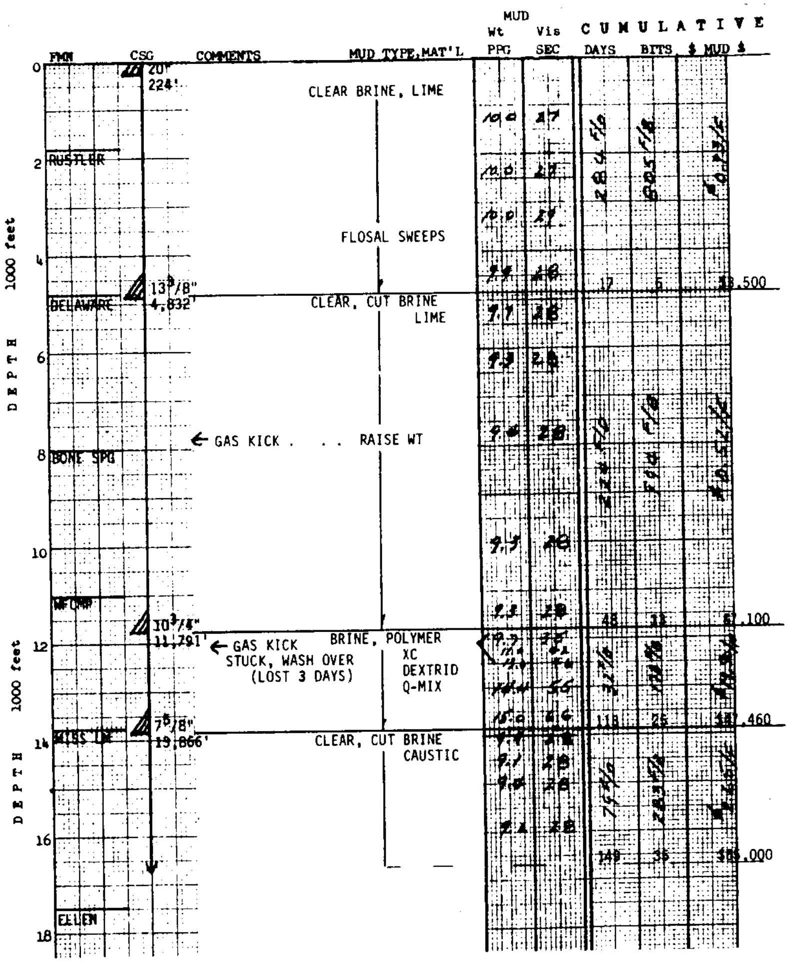

FIG. 7—DEEP DRILLING ANALYSIS; BRINE POLYMER MUD, NORTH PYOTE AREA, WARD COUNTY, TEXAS.

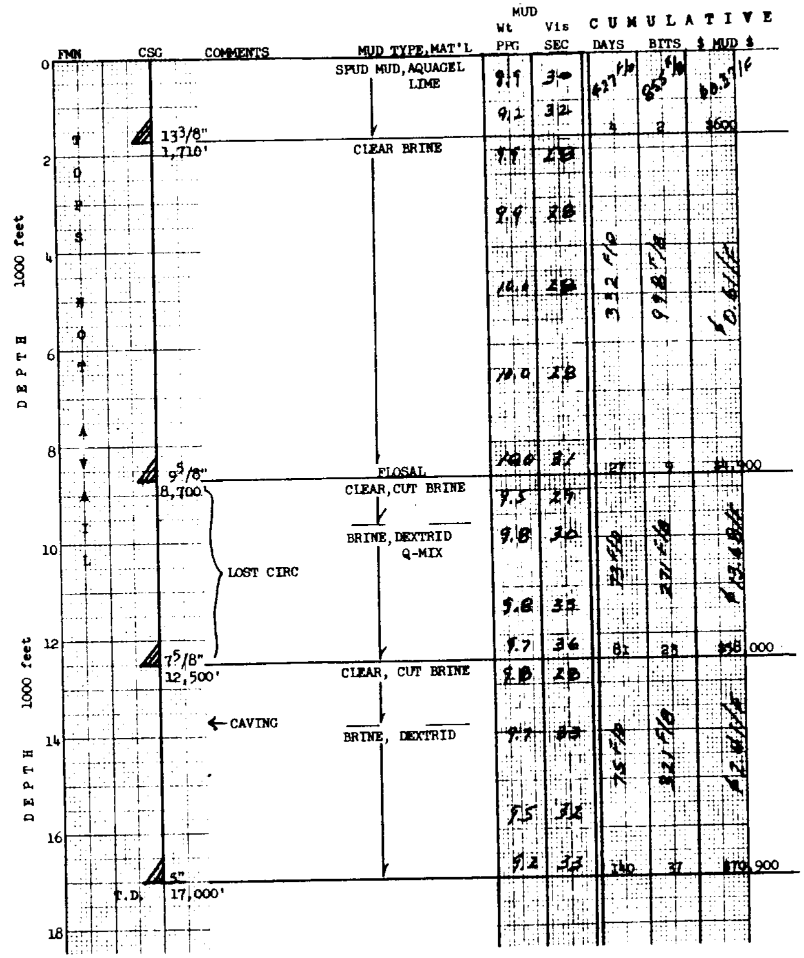

FIG. 8—DEEP DRILLING ANALYSIS, BRINE POLYMER MUD; COYANOSA AREA, REEVES COUNTY, TEXAS.

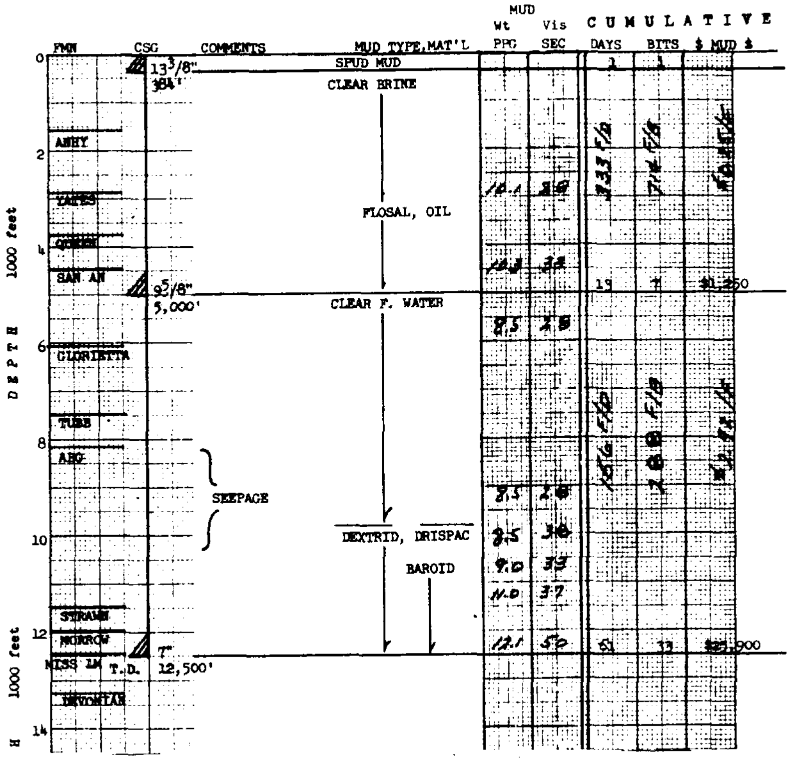

FIG. 9—DEEP DRILLING ANALYSIS, BRINE POLYMER MUD, LEA COUNTY, NEW MEXICO.

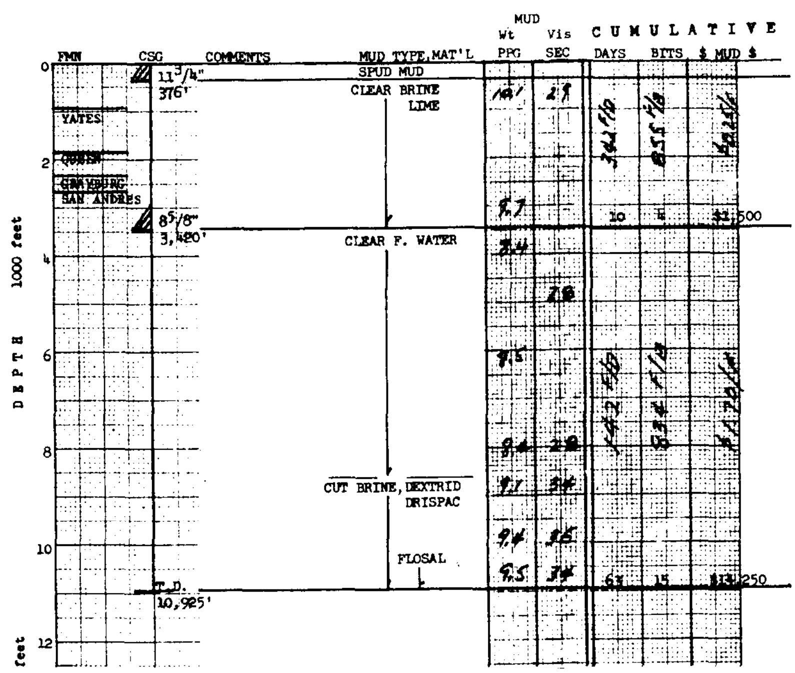

FIG. 10—DEEP DRILLING ANALYSIS, BRINE POLYMER MUD; EDDY COUNTY, NEW MEXICO.