DIFFERENCES IN MUD SYSTEMS FOR GEOTHERMAL PRODUCTION AND WIRE LINE CORING RIGS

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Desert Drilling Fluids

ABSTRACT

There is indeed a difference! A difference between the technology involved in the design and maintenance of a wire line coring fluid and the design and maintenance of production drilling fluids. There is a similarity in the testing equipment and the parameters used to check both of these two drilling systems. At this point products and applications begin to vary. The terminology used by drillers changes, annular sizes change from inches to tenths of inches. Both systems have a difference in drilling techniques, hole sizes, annular spaces, RPMs of the drill string, etc., that they require their own special drilling fluid technology. This paper explains these differences and how to design and maintain a high temperature coring fluid for wire line exploration drilling.

INTRODUCTION

In recent years the use of wire line drilling has gained in popularity as a method of geothermal exploration and scientific evaluation of thermal regimes. Wire line coring has many benefits, ie; greater mobility for remote areas and different terrain, precise data from a continuous core, less mobilization and re-mobilization costs.

DIAMOND CORING

Modern Diamond Coring is the outgrowth of experiments of Jean Rudolphe Leschot, an engineer living in Paris about 1862. He conceived the idea of using diamonds in an annular ring for cutting blasts holes. The bit had an OD of 1.6 inches. These first machines had hand rotation and feed and were operated by two men.

By 1890 M.J. Chapman was granted a patent mentioning the use of "a stream of water and a quality of plastic material...., whereby the core formed in the casing will be washed out and an impervious wall formed along the outside".

Modern day core rigs have bit sized ranging from 1.8 to 4.7 inches. They can approach 1000 RPM of the drill rods, and larger core rigs have depth capacities of 15,000 ft. to 20,000 ft. These rigs use specifically designed drilling fluids.

OIL FIELD ROTARY DRILLING

The recorded history of rotary drilling combining a circulating fluid is probably best recorded in 1845, when a French Engineer named Fauvelle circulated water through a "hollow boring rod worked by a rotary movement with a turning handle".

In 1866, a Patent was issued to P. Sweeney for a stone drill which incorporated many features of the rotary drilling system. It included a hollow stem auger, a swivel head to admit fluid to the drill stem, a roller type bit, a modified derrick to support the mechanism, and a crew device to force the bit down into the rock.

On Jan. 10, 1901, Captain Anthony Lucas, using this rotary drilling technique discovered the famous Spindletop field, a Beaumont, Texas, producing 100,000 barrels of oil per day.

GEOTHERMAL

The earth's natural heat has been used to generate electricity since the early 1900's when steam was harnessed to provide lighting at Larderello, Italy.

In 1922, The Geysers Development Company completed well No. 1 in Sonoma County, California at a depth of 203 ft. with steam temperatures of 327°F.

It was not until 1958 that liquid-dominated hydrothermal reservoirs were exploited on a large scale beginning with the Wairakei plant in New Zealand. Since that time, other countries including the United States have been using their geothermal resources for electric power.

DRILLING FLUIDS

When you consider how drilling fluids fit into the picture of rotary drilling, it is important to remember that the drilling fluid (mud) is another rig "tool", that when properly used, can minimize costs and maximize results.

Captain Anthony Lucas would herd cows through his drilling water pond to stir up "mud" and help him clean the hole. In 1926 a patent was issued to Mr. B.K. Strand covering the addition of weighing materials to drilling mud. Drilling fluid technology had begun.

The importance of drilling fluid slowly gained recognition. Between 1916 and 1929 only three papers were written on drilling fluid. In 1930 there were 23, in 1991, there will probably be 50 papers published. The number of in house research papers is unknown.

From 1929 to the 50s the drilling fluid market focused on oil field needs. Oil Companies conducted in-house research into drilling fluids. Major mud companies did their own research and trained field engineers. Drilling Fluid Technology was not taught in most colleges.

A few small colleges and Universities, however, had limited drilling fluid courses. The Universities of Texas and Oklahoma finally initiated some comprehensive courses in drilling fluids in the 1940's.

MUD TESTING

As drilling fluid technology progressed it became necessary to analyze various parameters of the fluid.

Density, viscosity (resistance to flow), and gelation properties were being measured by 1930. Since that time the dynamic development in drilling fluid technology has rapidly accelerated. Now mud testing is not only performed in laboratory environments but also at the rig site by equipment transported to the job by the "mud" engineer.

These on-site tests can include, but are not limited to: density, viscosity, gel strength, filtration properties, hydrogenion determination, sand content, solids and clay content, pH, alkalinity, calcium and chloride content.

In most instances the equipment and chemicals used to check mud properties are identical for any drilling fluid system, ie; oil/gas, water well, geothermal production, geothermal wire line exploration, and mineral exploration.

FUNCTIONS OF DRILLING FLUIDS

The basic function of a drilling fluid is to minimize adverse down hole conditions, equipment wear, and overall drilling costs, and maximize hole stability, penetration rate, sample or core recovery, and formations protection.

Therefore, if the mud functions are somewhat identical for all types of drilling and the testing equipment is identical for testing most drilling fluids, there should be no problem in similar applications of technology between geothermal production drilling and geothermal wire line coring exploration, WRONG! DEAD WRONG!

PRODUCTS AND PRODUCT APPLICATION

We see a definite difference between drilling fluid products and product applications between geothermal development wells and wire line exploratory wells.

Most of this difference can be attributed to the physical differences, mainly in the size of the drilling equipment and the down hole tools. (fig. 1 - Table 1) There is also a different objective between production (<u>produce</u> the resource) and exploration (<u>find</u> the resource).

GENERAL ANALYSIS OF PRODUCTS APPLICATIONS AND VARIANCES

<u>VISCOSITY</u>

Products

Production Rig -	Standard Bentonite Lime Sepiolite
Wire Line Rig -	Extra High Yield Bentonite (Minimize solids) Polymers (Liquid-Dry)

<u>DENSITY INCREASE</u>

Products

Production Rig -	Barite Can tolerate to 18#/gal
Wire Line Rig -	Saline Solutions (Soluble solids will not centrifuge out in the rods) Limited to 8.7#/gal. of insoluble solids.

FILTRATE CONTROL

Products

Production Rig	-	Dry Polymers
Wire Line Rig	-	Liquid Polymers Stabilized Starches

pH CONTROL

Products

Production Rig	-	Caustic Soda Soda Ash
Wire Line Rig	-	Soda Ash only recommended

SAND CONTENT CONTROL

Production Rig	-	Can tolerate sand content of +- 2% volume.
Wire Line Rig	-	No tolerance for sand content.

DIFFERENTIAL PRESSURE STICKING

Production Rig	-	Low probability due to wider variance between hole diameter and pipe size.
Wire Line Rig	-	High probability due to annular space (measured in tenths of inches).

TORQUE

Production Rig	-	Generally not a high frequency problem - however, deviated holes and high temperatures down hole can produce high torque production drilling.
Wire Line Rig	-	Torque has to be closely controlled on wire line rigs - small annulus and high RPM (500) plus poor mud (high solids) can result in high torque.

High torque in wire line coring can be a fatal problem if not minimized. The small rod-to-formation annuli lends to high torque, particularly in crystalline rock at elevated temperatures. Polymers begin to bread down at about 250°F, thereby losing viscosity and lubricity.

Most commercial lubricants become inefficient either with temperatures greater than 250°F and/or time (30 minutes to an hour). However, a torque reducer, (that reduce is an emulsion of complex stearate) will reduce torque at elevated temperatures 300°F+ such as encountered at Sandia National Laboratories VC-2B, Valles Caldera, New Mexico and the University of Hawaii core project near Hilo, Hawaii with temperatures of near 600°F.

HEAT EXCHANGE

Production Rig	-	Temperatures, high temperature fluids encountered at depth usually manifest themselves at surface and can even "flash" to steam in the hole while being circulated to the surface.
Wire Line Rig	-	Wire Line coring exhibits an unusual phenomena of a down hole heat exchange. High Fluid temperatures encountered down hole may heat the drilling fluid to complete degradation. As the fluid rises, the same phenomena occurs. The fluid can loose heat to the formation while being circulated, leading to the erroneous impression that there is no heat down hole.

LOST CIRCULATION

Lost circulation is perhaps the major problem encountered in geothermal exploration and production drilling. So far, no 100% effective, inexpensive cure has been found.

Production Rig	-	Lost circulation zones <u>must</u> be cured before advancing the hole. Collapsed casing may result during production if voids are not sealed while drilling. Generally production type rigs have the capabilities to mix and circulate large volumes of lost circulation material with particle sizes greater than 1/4".

Wire Line Rig - On wire line core rigs lost circulation is often simply "by passed" by coring "blind". Lost Circulation materials must be small enough to pass through all of the down hole tools and the bit.

DESIGN AND MAINTENANCE OF WIRE LINE CORE FLUID

As can be seen by the comparison of a geothermal drilling rig and a typical wire line core rig, (table 2) there is a considerable difference in pump capacity, mud tank capacity and solids control equipment.

Because of this factor, there is a much narrower margin of error when planning a mud system for a wire line core rig. The smaller diameter hole and the lower volume of the mud system make accurate monitoring of the system and important part of a successful drilling program.

On wire line core rigs, the solids control is a critical factor. Unlike a rotary drilling rig, where the solids are relatively large and an be screened out over the shale shaker, the solids from a wire line core rig are like a fine textured face power (98% less than 74 micron) and must be controlled with proper polymers and polymeric deflocculants.

Without the addition of these materials, the high RPM of the drill string causes solids to be centrifuged to the inside wall of the rods, thus forming a mud ring that prevents the overshot from reaching the core barrel for recovery.

Core fluids must be designed with simplicity in mind. Exotic and numerous products are generally not necessary. Low solids, low filtrate and reduced torque must be maintained.

A basic core fluid is usually composed of:

- Fresh water
- Soda ash - to control pH and calcium
- Extra high yield bentonite (minimal qualities)
- Liquid anionic polymer for viscosity
- Polyanionic cellulose for filtrate control

For gouge or unstable zones, an inhibited fluid using potassium chloride to retard swelling clays is recommended.

SUMMATION

Drilling rigs are drilling rigs, testing is testing, mud properties are mud properties, geothermal "holes" are geothermal "holes", therefore all mud systems are the same!, WRONG! DEAD WRONG!

Geothermal mud systems require careful planning if a project is to be completed in a problem free, economical and time

Table 2

GENERIC COMPARISON OF DRILLING RIGS

	GEOTHERMAL	TYPICAL HEAVY DUTY WIRE LINE CORE RIG
Depth Range (feet)	6,000 to 12,000	2,000 to 10,000
Mast (feet)	Min. height 136	60
Mud Pumps	2 Min. 1,000 Hp	Bean, 37 USGPM at 700 Psi
Mud Tanks	Shaker - 500 bbl Suction - 500 bbl	Mix Tanks 400 gal Circulating tank 400 gal Special designs to 75 bbl
Mud Agitators	4 Ten Hp mixers 2 In shaker tank 2 in suction tank	None to 1 or 2 Lightning mixers
Water Storage	Min. 500 bbl capacity	400 gal - 75 bbl
Shale Shaker	Dual - Min. Capacity of 1,200 gal/min.	Not necessary for Diamond coring (98% of cuttings are below 74 Microns)

efficient manner. It is critical that the following factors be taken into careful consideration at the onset of the program: exploration vs. production goal, size of rig, pump capacity, geographical location of well site, formation characteristics, et., etc. Wire line core rigs are an excellent tool for exploration. The require their own particular drilling fluids. Any successful drilling project is based on careful planning, which is tailored toward holistic drilling practices. Prevention of problems is the ultimate secrets of success.

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REFERENCES

Cummings, J.D., "Diamond Drill Handbook", Second Edition, 1962.

"Manual of Drilling Fluids Technology", Baroid Corporation, 1972.

"The Geothermal Resource", Petroleum Information Corporation, 1979.

Walker, S.H. and Millheim, K.K., "An Innovative Approach to Exploration and Exploitation Drilling - The Slim-Hole High Speed Drilling System", Journal of Petroleum technology, Sept. 1990.

Lysne, P., and Jacobson, R., "Scientific Drilling in Hydrothermal Terrain", Scientific Drilling, 1:184-192, 1992.

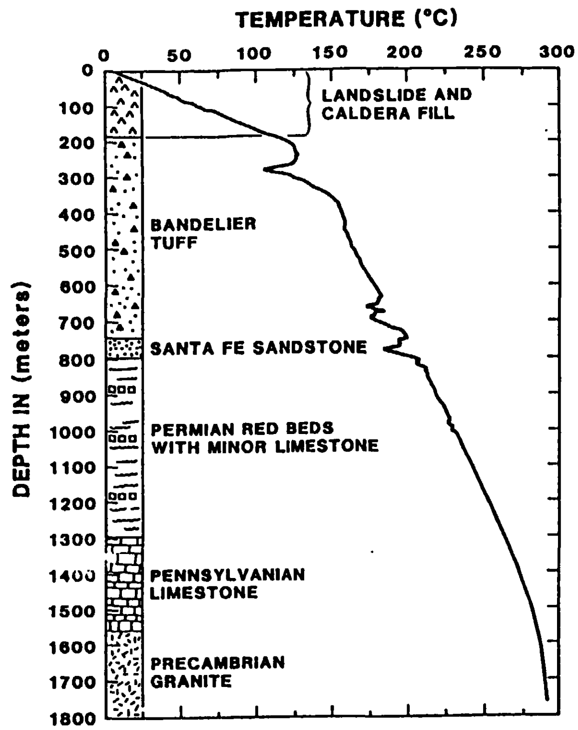


Figure 2

Temperature Log of the VC - 2B corehole. Return mud temperatures were less than 10 degrees centigrade above input temperature.

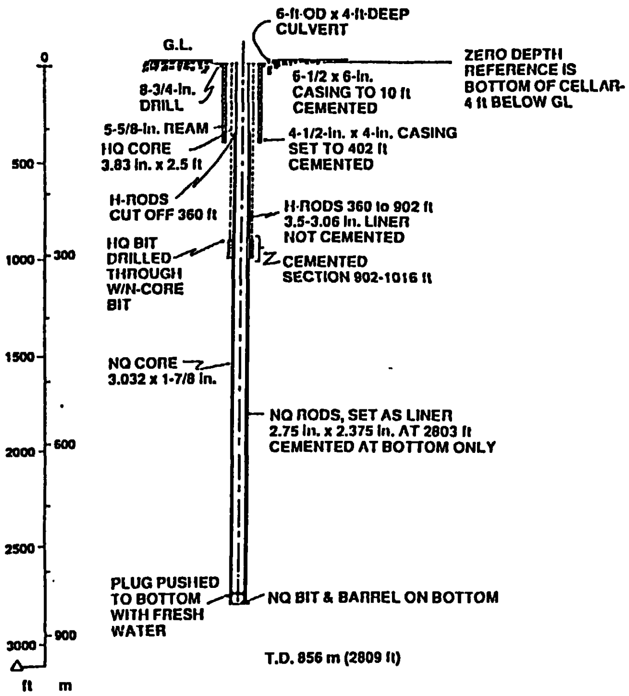
Rowley, J.C., "Coring Technologies for Scientific Drilling Projects - An Overview", LANL 10485-OBES, Aug. 1985.

"Sourcebook of the Production of Electricity from Geothermal Energy", Brown Univ., Joseph Kesting, Ed. in Chf. DOE R/A4051-1, Contract EY-76-S1051 A0002, March 1980.

Finger, J., "Drilling Fluid Temperatures in a Magma Penetrating Wellbore", Geothermal Resources Council Transactions, Vol. 10, Sept. 1986.

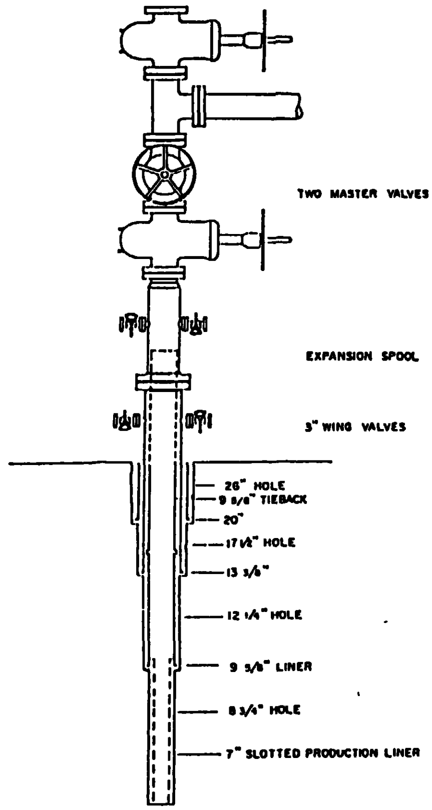
Rhodes E., et al; "Slim Hole Rig Completes Continuously Cored Wells in Delaware Basin", personal paper.

"Geothermal Exploration in the First Quarter Century", Geothermal Resources Council, Special Report No. 3, Edited by Anderson, D.N., and Hall, B.A., 1973.



ACTUAL (as-built) VC-1 CONFIGURATION

LANL-Rowley



SCHEMATIC DIAGRAM OF BACA COMPLETION

UNOCAL-Pye

Figure 1 - Comparative configuration of a wire line cored hole and a rotary drilled production well.

TABLE I

COMPARISON OF TYPICAL, CONVENTIONAL ROTARY CORING TECHNOLOGIES

Usual Application	Depth, km (ft) Typical	Maximum[a]	Core Sizes cm (in.)	Rotating Speed rev/min	Bit Types	Annulus Size cm (in.)	Remarks
Mining	1 (3 000)	5 (15 000)	2.5 to 7.5 (1 to 3)	100-2000	Diamond & drag	0.3 (1/8)	Characterized by narrow kerf-cutting and light-weight hardware. Continuous core with wireline retrieval. Long bit life in hard rock, maximum lithologic information.
Oil & Gas	2 (6 000)	15 (45 000)	5.0 to 10.0 (2 to 4)	50-80	Diamond, drag, & roller cone	5.0 (2)	Large annulus; rugged, heavy hardware; single round trip per core run. Softer sedimentary rock; lithologic data for a few spot cores over short intervals.

[a]With currently, readily available equipment.