Case History Baroid Industrial Drilling Products



Successful Core Recovery in Jwaneng's Volcaniclastic Kimberlite Using PETROFREE® System

Location: Jwaneng, Botswana (Africa)



Project Scope

The goal of this drilling project was to provide data that would be used "to define internal geology, and determine grade and diamond size distribution" to support the open pit mining operations until 2030, beyond which the mine may then commence underground operations. Recovery of competent core for the data acquisition, validation and interpretation phase was the customer's goal (Buying Influence concept). At first, core recovery of 90% defined success; however, it soon became apparent that the geological staff required 100% recovery of pristine core.

Baroid IDP Engineered Solution

In 2008 Baroid IDP met with Jan Dewet of Dewet Drilling Botswana to discuss a single sales objective of demonstrating the use of EZ-MUD® GOLD polymer to inhibit highly reactive clay formations. Following those meetings Dewet was awarded the contract with Debswana for the Jwaneng Resource Extension Project II (JREP II). Baroid IDP was asked to provide a fluids solution for this operation.



The original coring fluid used in order of addition to make-up water was:

- Soda Ash: $\sim 1.5 \text{ kg/m}^3$ to maintain pH at 8.5 to 9.5, reduce Calcium to < 100 mg/l for maximum bentonite yield.
- Bentonite: 17 kg/m³ to maintain viscosity at 35-40 sec/quart (sec/liter)
- BDF[™]-437 filtration control agent: 5 kg/m³ to maintain filtrate loss to between 8 12 cc/30min.
- EZ-MUD[®] GOLD clay and shale stabilizer: 2.85 kg/m³ to inhibit and stabilize kimberlites.
- N-SEALTM spun fiber lost circulation material: See loss of circulation contingency
- **O** PENETROL[®] wetting agent: 1 liter/m³ if to inhibit sticking tendency of kimberlites to down hole tools

Use of, and adaptation of modern drilling technologies will be critical to the success of the drilling. As a result, JREP drilling program is supported by experienced mud technicians and engineers.



Engineered Fluid Solutions Customized To Maximize Wellbore Value

During the initial drilling phase, the highly inhibitive, low filtrate, water-based coring fluid described above was used. However, the Volcaniclastic kimberlite (see XRD and SEM analysis in TS-349, Collins 2010) was too reactive to the free water in the fluid and deteriorated at an alarming rate. Fluids using a competitive CMC product were also tested however it was impossible to

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contain the reaction between the volcaniclastic kimberlite and water.

In the Pyroclastic kimberlite sections both the Baroid engineered fluid and a competitors CMC product produced acceptable core. Therefore, JREP II decided based on their concept, to use a PETROFREE® drilling fluid system to recover acceptable volcaniclastic core. The Baroid IDP laboratory analysis provided a controlled examination of several water based fluids and a PETROFREE System. The JREP II geologists felt that the analysis credibly demonstrated sufficiently reliable information



Volcaniclastic kimberlite cored in North Pipe showing degradation.

to use a PETROFREE System in the volcaniclastic kimberlite in the North Pipe. The detailed empirical data provided by the Baroid IDP laboratory convinced JREP II to purchase the proposed solution.



Due to mixing limitations in the field slight adjustments were made.



Lab formulated PETROFREE® System ① 0.96 bbl* PETROFREE Base Oil ② 2.25 lb/bbl EZ-CORE™ Emulsifier ③ 10 lb/bbl GELTONE® II Viscosifier ④ 2% Water by volume * 1 bbl = 42 U.S. gallons = 159 liters	
3 rpm = 2	Marsh Funnel Viscosity = 41 sec/liter Plastic Viscosity (PV) = 12 lb/100ft ² Yield Point (YP) = 3 lb/100ft ² 10 sec gel strength = 3 lb/100ft ²

10 min gel strength = $6 \text{ lb}/100 \text{ft}^2$

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The key win for JREP II is clearly visualized in photo below. At 317.4m, the volcaniclastic kimberlite which was encountered immediately upon drilling out cement with the PETROFREE fluid is competent and unreactive, precisely what the geologists required. The site geologists were "gob smacked" at the excellent core recovery.



The specific gravity continued to climb due to the lack of mechanical solids control from 0.86 to 0.92 and at ~337m a highly fractured zone of mudstone with calcareous intrusions was encountered. Incidentally, the natural fractures were mechanically propagated through repeated attempts to break the core by reciprocating the pipe. Frequent blasting at the mine also contributed to overcoming the fracture gradient, leading to the influx of formation fluid. By calculation, approximately 600 liters of formation fluid entered the mud through the fractured mudstone causing the PV/YP to go from 12/3 to 23/12 while the OWR dropped from 98/2 to 85/15, far below the fluid maintenance goal of 95/5. Regardless, the penetration rate when on bottom (10 cm per 30 seconds) was excellent for the North Pipe and amply demonstrated the durable and robust nature of the fluid. The concentration of EZ-CORE[™] emulsifier was increased to 2% by volume from 1% to maintain the passive emulsion, the OWR was restored, and the core continued to be gauge and 100% recovered. After 341m depth no more formation water was encountered. The performance of the PETROFREE[®] system during the water influx provided confidence in the increased stability of the volcaniclastic kimberlite in a higher OWR.



Formation water entered the hole through the fractured mudstone encountered at ~337m

job. The rig was forced to move several times weekly during the project due to local blasting. During these times the entire rig and all of the equipment had to be moved off the location to the operations yard. This meant that the volcaniclastic kimberlite was exposed to the PETROFREE fluid for sometimes 24 hours without circulation. Those sections remained opened and competent.

Mine operational issues were an ongoing problem with this coring

Unfortunately the hole had to be abandoned at 349m due to calcareous fractures in mudstone which caused hole collapse and mine operations issues.

Economic Value Created for Customer

The value created by the PETROFREE system was a clear demonstration that the volcaniclastic kimberlite can be recovered in in-situ condition using this system. This type of information will provide JREP II with reliable information to continue the mining operations to 2023. The resolution of the problem of the volcaniclastic kimberlite disintegrating in water based fluid was resolved and the mine is determining where future holes in the North Pipe will be drilled using the PETROFREE system.





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