SodM End of Well Report HEK-GT-02

Ce-Ren Beheer B.V.

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CONTENTS

APPENDICES

Appendix I. Lithology Log
Appendix II. Drilling Log
Appendix III. Directional Reports
Appendix IV. Wireline Logging Report
a. USIT 13 3/8" casing
b. USIT 9 5/8" casing

1 GENERAL PROJECT DATA

Field	Heemskerk
Well Number:	HEK-GT-02 (-ST02)
Well Name	Heemskerk-GT-02
Well Type	Geothermal production well
Start Date	30-09-2013
End Date	2-01-2014
Days Operational	95 days
Operator	Ce-Ren Beheer B.V.

Surface Location

Latitude & Longitude	Geographical
4° 38' 27.163 E 52° 30' 30.160 N	X: 104,306.00 Y: 502,453.00

Grid Coordinate System	Rijksdriehoeksmeting / Netherlands New
Drilling Contractor	Daldrup & Söhne AG
Drilling Rig	DS 20, Drillmec HH300

Project Management:

Project Leader	Wart van Zonneveld
Drilling Manager	Maarten Middelburg
Drilling Engineer	Kornelius Boersma
HSE Manager	Guus Wiering / Ferdinand Gubler

Drilling Supervisors on 2 week rotational scheme:

Drilling Supervisor	Peter Nutters
Drilling Supervisor	Garry Schrage

Other:

Well Site Geologist	Julien Smeulders
HSE Supervisor	Roel Tjoelker

2 WELL SUMMARY

Primary Objective		Rotliegend (Slochteren Sandstones)	
Primary Objective Depth		2820m MDBRT	2528 m TVDBRT
Total Depth		2954.2 m MDBRT	2602 m TVDBRT
Elevation	RT – GL	7.73 m	
	GL – NAP	2.5 m	
	NAP – RT	10.23 m	

Table 1: HEK-GT-01 well summary

Item	m MDBRT	m TVDBRT	Comments
20" Conductor	84.0	84.0	20" conductor driven to 84m MDBRT.
17 1/2" Hole TD	1323	1308	17½" section drilled in four bit runs with KCL/Polymer WBM of 1.20-1.22sg.
13 3/8" Casing	1424	1407	13 3/8" casing run and set at 1034.1m MDBRT. Pressure test 13 3/8" Csg to 274 bar, no cement to surface rig down cement head. WOC, cut window in 20" conductor, RIH 3/4" stinger and tagged cement @ 90m. Cement remaining annulus 13 3/8" Csg Open Hole/20" Conductor to surface with 2 Haney units and 2 stingers, cement 1.8 sg.
12 1/4" Hole TD	2659	2393	12 1/4" section drilled in 4 bit runs with KCL/Polymer WBM of 1.21-1.29sg. at 1944 Static losses 18 m3/h. Spot 5 m3 LCM pill on bottom. Reducing mud weight further to obtain 1.17sg due to the losses. Not all losses cured at 2018. Changed motor at 2018 m. drill to 2160, 3m3 losses/hr. at 2220 total losses, cured with hvis pill. Again losses at: 2401, 2507,2566, total losses for the section 1838m3. Run 9 5/8 liner
9 5/8" Liner	2659	2393	9 5/8"liner run and set at 2659 m. Top of cement of 9 5/8" liner between 1808m and 1945m. Dropped ball and installed cement head. Circulated ball down and set hanger with 120 bar. No cement at surface, about 2 m^3 spacer returned of total 6 m^3 spacer pumped. No bump was seen, so no pressure test possible on green cement; tested casing and liner, including liner lap, against grey cement to reduced pressure 50 bar for 15 minutes. Test was ok. Repeat run CBL recommended.
8 1/2" Hole TD	2954	2600	8 1/2" section drilled in one bit run with /Polymer/Calcium carbonate WBM of 1.08 – 1.12 sg. Acid soaking with HCL.
6 5/8"Liner	2954	2600	6 5/8" liner run and set at 2954m MDBRT. Liner hanger top @ 2618m MDBRT

Actual time depth graph

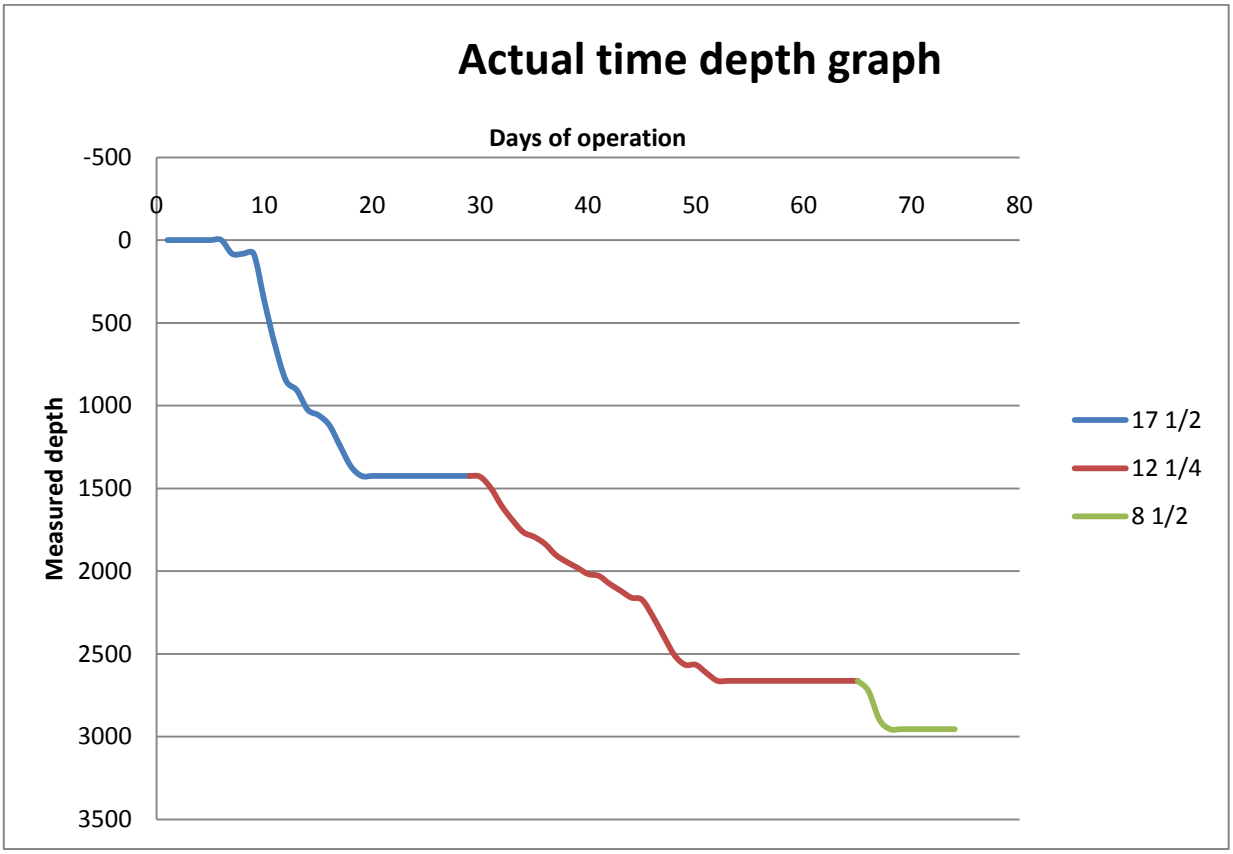

Figure 1 Actual Time Depth Graph

2.1 DIRECTIONAL PLOTS

The well has been drilled directionally until the end of the 8 ½" section (2954 m MDBRT); the trajectory plots are displayed below.

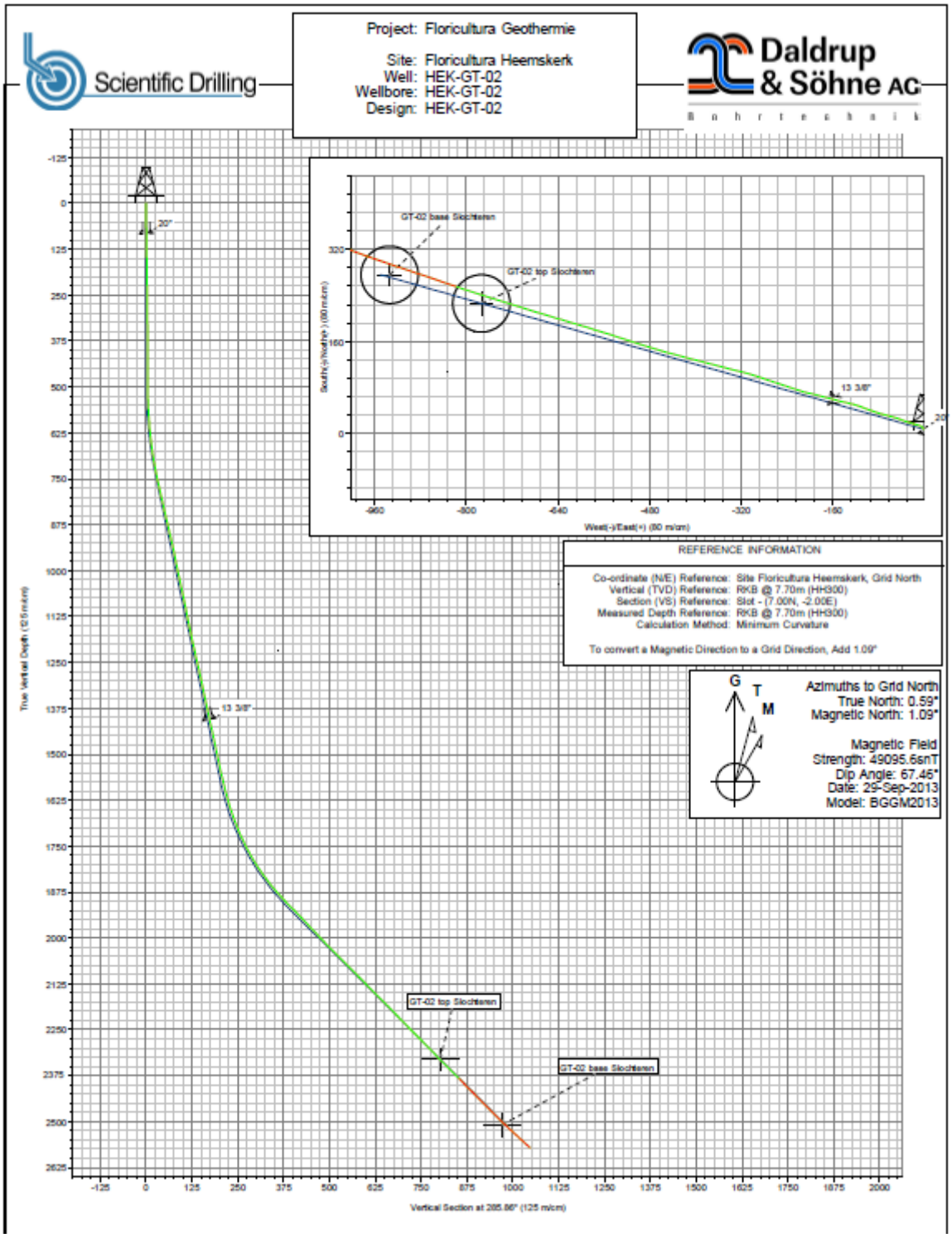

Figure 2: HEK-02 directional plot – drilled (green) vs. planned (blue)

2.2 TECHNICAL SUMMARY

2.2.1 Casing

Table 2: HEK-GT-02 tubular summary

Item	Top casing	Weight	Grade	Connection
20" Conductor	0	20mm W/T	n/a	n/a
13 3/8" Casing	0	68 ppf	L80	Premium
9 5/8" Liner	1307	40 ppf	L80	Premium
6 5/8" Liner	2365	24 ppf	L80	Premium

2.2.2 Cement

Table 3: HEK-02 cement summary

Item	TOC (MDBRT)	Lead Slurry Volume (m^3)	Lead Slurry Weight (sg)	Tail Slurry Volume (m^3)	Tail Slurry Weight (s.g.)	Type
13.3/8" Casing	No cement at surface	123.5	1.8	22	1.9	Class G
9 5/8" Liner	No returns	79	1.60 – 1.63	15.3	1.92	Class G
6 5/8"Liner	n/a	n/a	n/a	n/a	n/a	n/a

3 DRILLING FLUID SUMMARY

Per section the following drilling fluid types have been used:

Table 4: HEK-02 drilling fluid summary

Section	Type
17 1/2”	KCL/Polymer WBM
12 1/4”	KCL/Polymer/Glydril WBM
8 1/2”	NaCl/Polymer/Kreide WBM

The figure below shows the mud weight versus depth during drilling operations.

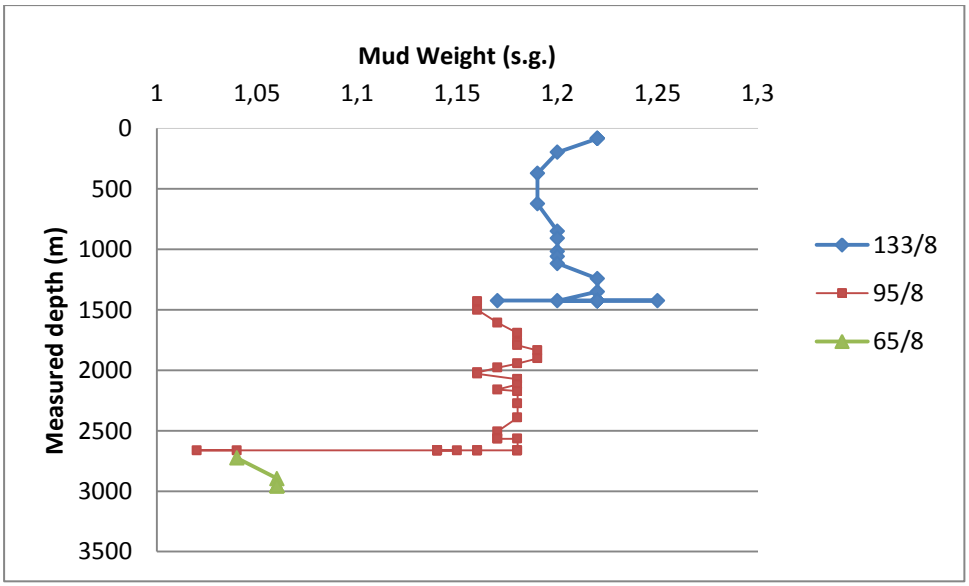

Figure 3: HEK-02 mud weight vs. depth

4 GEOLOGY

Below the geological column with vertical and along hole depths below RT.

Table 5: HEK-02 geological summary

Lithostratigraphic Column Floricultura, HEK-GT-02 Julien Smeulders2013							Depth (m) Rotary table	
Era	Group	Period	Formation	Epoch (Age)	Member	Lithology	TV-RT	AH-RT
Cenozoicum		Quaternary	"Diverse"	*Holocene-Pleistocene*		Diverse continental deposits, mostly fluvial sands and silts intercalated by some thin layers of grey or greenish-grey, silty clays.	0	**0**
			Maassluis NUMS	*Early Pleistocene*		Deposits of coastal sands, very fine to medium coarse, calcareous, shell bearing, mica rich. Silty to sandy, grey to dark grey clay containing shells and mica.	260	**260**
	Upper North Sea NU	Tertiary	Oosterhout NUOT	*Pliocene*		Deposits of shallow marine greenish clays, sandy clays, silts and coastal sands.	435	**435**
			Breda NUBA	*Miocene*		Sequence of marine, glauconitic sands, silty to sandy clays and clayey silts. In many places a glauconite-rich layer occurs at the base.	565	**565**
	Middle North Sea NM		Rupel NMRF	*Oligocene/Eocene* Rupelian to Chattian	Rupel Clay NMRFC	Marine clays that become more silty towards base and top. It is rich in pyrite, contains hardly any glauconite & CaCO3 tends to be concentrated in the septaria layers.	811	**815**
				Priabonian - Rupelian	Vessem NMRFS	The member consists of silty to clayey sands with a low glauconite content; flint pebbles or phosphorite nodules commonly occur at the base.	878	**883**
	Lower North Sea NL		Dongen NLFF	*Early Eocene* Ypresian	Ieper NLFFI	Soft, tough and sticky to hardened and friable clay. The lower part is characterised by its brown-grey colour (pyrite, coalified plant remains). The upper two-thirds have a characteristic green-grey colour.	882	**888**
					Basal Dongen Tuffite NLFFT	Tuffaceous clays, blue to violet-grey in colour, alternating with dark-grey and red-brown clays.	939	**946**
			Landen NLLF	*Late Paleocene* Thanetian	Landen Clay NLLFC	Generally dark-green, hard, flaky clay, somewhat silty, containing glauconite, pyrite and mica.	934	**940**
Mesozoicum	Rijnland KN	Cretaceous	Vlieland Claystone KNNC	*Early Cretaceous* Valanginian to Barremian/Early Aptian		Dark brownish-grey to grey claystone. Mica and very fine lignitic matter are common. The formation can be very silty to sandy with many intercalated siltstone and very fine sandstone beds. Slightly calcareous.	958	**965**
	Schieland SL		Breeveertien* SLDB	*Late Jurassic to Early Cretaceous* Early Kimmeridgian - Valanginian		Interval of grey-brown, carbonaceous, but also variegated or red, silty claystones, fine- to medium-grained sandstones with bed thicknesses up to several metres, and coarse-grained, thick-bedded sandstones. Dispersed lignitic matter, siderite spherulites and concretions are common.	998	**1006**
	Altena AT	Jurassic	Werkendam ATWD	*Early to Middle Jurassic* Late Toarcian to latest Bajocian		Grey, slightly marly, shaly claystones. Towards the middle a more calcareous, silty to sandy interval occurs. Pyrite, carbonaceous matter, macrofossils, iron oolites & up to dm-size siderite nodules can be common.	1011	**1025**
			Aalburg ATAL	*Early Jurassic* Hettangian to Pliensbachian		Sequence of dark-grey, calcareous, locally silty or sandy, claystones containing occasional thin argillaceous limestone (fossil hash) beds.	1070	**1080**
	Upper Germanic Trias RN	Triassic	Sleen ATRT	*Late Triassic* Rhaetian		Sequence of grey, fossiliferous, claystones, overlain by brown, locally sandy claystones.	1358	**1374**
			Keuper RNKP	*Middle to Late Triassic* Late Ladinian-Norian	Dolomitic Keuper RNKPD	A sequence of anhydritic, partly dolomitic or marly claystones, containing fine-grained sandstone intercalations. Grey to green colours are common.	1363	**1380**
					Red Keuper Claystone RNKPR	Red, silty clay- or marlstones (high gamma-ray readings). These rocks are strongly variegated displaying red, green, yellow and grey colours.	1367	**1383**
					Lower Keuper Claystone RNKPL	A dolomitic claystones with some sandstone and/or anhydrite stringers. The lower part is characterized by greyish colours, in the upper part red (-brown) colours predominate. The anhydrite content gradually increases towards the top.	1376	**1393**
			Muschelkalk RNMU	*Middle Triassic* Late Anesian/Early Ladinian	Upper Muschelkalk RNMUA	"Trochitenkalk": A dololmite-marl alternation with a distinct dolomite interval at its base.	1446	**1475**
					Middle Muschelkalk RNMUA	Light greenish/grey marlstone unit which contains some anhydrite beds in the basal part.	1510	**1530**
					Muschelkalk Evaporite RNMUE	This unit is composed of halite or in places where the salt has been leached of a thin succession of anhydrites.	1534	**1554**
					Lower Muschelkalk RNMUL	Alternation of mainly light-greenish/grey limestone or dolomite and marl beds.	1570	**1591**
			Röt RNRO	*Middle Triassic* Early Anisian	Upper Röt Claystone RNROU	A red-brown and grey to violet, silty, anhydritic, dolomitic, argillaceous succession. Towards the basin-fringe, more intercalated sandstones appear. Dolomitic beds occur in the uppermost part.	1636	**1660**
					Upper Röt Evaporite RNRO2	An alternation of thin-bedded rock-salt and anhydrite.Towards the basin-fringe, this member grades laterally into an anhydrite-claystone alternation	1754	**1787**
					Intermediate Röt Claystone RNROM	A thin, reddish brown, silty, anhydritic claystone interval.	1757	**1790**
					Main Röt Evaporite RNRO1	The base if this member is marked by a thin anhydrite, followed by a massive halite, which is capped again by a relatively thin anhydrite. Intercalations of thin claystone beds.	1766	**1801**
			Solling RNSO	*Lower Triassic* Latest Scythian	Solling Claystone RNSOC	Red, green and locally grey claystones. Within the member, occasional sand stringers are present.	1791	**1830**
					Solling Sandstone RNSOB	A light-coloured sandstone interval which has a characteristic expression.The sandstone is dolomite-cemented.	1844	**1894**

Lithostratigraphic Column Floricultura, HEK-GT-02 Julien Smeulders2013							Depth (m) Rotary table	
Era	Group	Period	Formation	Epoch (Age)	Member	Lithology	TV-RT	AH-RT
Mesozoicum	Lower Germanic Trias RB	Triassic	Volpriehausen RBMV	Scythian	Volpriehausen Clay/Siltstone RBMVC	This unit consists of stacked, small-scale fining-upwards cycles of fine-grained sandstone, siltstone, and claystone. Oolite beds may be intercalated. It displays reddish to greenish colours. A number of claystone beds yield anomalously high readings on the gamma-ray log.	1850	1901
					Lower Volpriehausen Sandstone RBMVL	This member is a well-defined, pink to grey, (sub-) arkosic sandstone unit, frequently displaying a distinct, blocky character on the gamma-ray logs.	1900	1968
			Lower Buntsandstein RBSH	*Latest Permian* to *Early Scythian*	Rogenstein RBSHR	This member is distinguished from the Main Claystone Member by the regular intercalation of up to 1 m thick oolite beds in the small-scale cycles.	1943	2028
					Main Claystone Member RBSHM	The member consists of a succession of red-brown to green silty, sometimes anhydritic claystones. Some thin sandstone beds and oolitic	2124	2281
Paleozoicum	Zechstein ZE	Permian	Zechstein Upper Claystone ZEUC	*Upper Permian* *Thuringian*		The formation is composed of red-brown to pale brown, occasionally grey-green claystones with some anhydrite and/or carbonate stringers. In the upper part thin, well-cemented, sandy beds may occur.	2202	2390
			Zechstein 4 (Aller) ZEZ4		Z4 Pegmatite Anhydrite ZEZ4A	A distinct white anhydrite unit, commonly with coarse halite crystals.	2206	2396
					Red Salt Clay ZEZ4R	A red, generally anhydritic claystone. It may include some calcareous or dolomitic intercalations.	2207	2398
			Zechstein 3 (Leine) ZEZ3		Z3 Carbonate ZEZ3C	'Plattendolomit'. A brownish, slightly argillaceous, dolomitic limestone or coarse-crystalline dolomite.	2215	2409
					Grey Salt Clay ZEZ3G	A grey claystone with a high gamma-ray response and corresponding low velocities on the sonic log.	2242	2446
			Zechstein 2 (Stassfurt) ZEZ2		Z2 Roof Anhydrite ZEZ2R	A thin (few metres) and pure anhydrite unit.	2245	2451
					Z2 Middle Claystone ZEZ2M	A red-brown to grey dolomitic claystone, interbedded with thin anhydrite layers. Sandstone beds may be intercalated. An anhydrite layer in the basal part can be distinguished separately as the Z2 Fringe Anhydrite Mb.	2248	2455
			Zechstein 1 (Werra) ZEZ1		Z1 Anhydrite ZEZ1W	A massive anhydrite body which attains a huge thickness in the sub-basins. Dolomite stringers occur frequently within the unit.	2271	2487
					Z1 Middle Claystone ZEZ1M	A red, light-red to light-grey claystone and siltstone, interbedded with anhydrite. It may contain some sandstone beds.	2279	2498
					Z1 Fringe Carbonate ZEZ1F	A grey to brownish limestone or dolomite; some anhydrite may be present. Some claystone beds occur. Commonly it grades from argillaceous limestone at the base into crystalline dolomite at the top.	2311	2543
					Z1 Lower Claystone ZEZ1G	A grey to brown claystone or marl, in places dolomitic or anhydritic. It shows an upwards increase in carbonate content, grading from claystone into marl.	2338	2582
					Coppershale ZEZ1K	A microlaminated, brownish-black bituminous shale with a thickness of 0,5 to 1 m. It is characterized on wire-line logs by high gamma-ray	2382	2644
	Upper Rotliegend RO		Slochteren ROSL	*Saxonian*		Sequence of usually pink to pale red-brown, occasionally yellow or grey, sandstones with subordinate amounts of intercalated dark red, red-brown or green-grey silty claystones. Locally a conglomeratic base is present.	2384	2646
						TD @ base Slochteren Fm	2599	2955

RT-GL= 7.7m; GL-NAP= -2.5m; NAP-RT= 10.2m

Slochteren Formation was approximately 100 m shallower than expected. Top Slochteren was expected at 2611 m TVD while it was actually at 2530 m TVD. Base Slochteren was expected at 2850 m TVD while it was actually at 2730 m TVD. This also explains why drilling was continued deeper than planned.

5 WELL SCHEMATIC

A detailed well schematic summarizing all casing sizes, cement jobs and suspension status is shown below.

Note: well depth is not to scale.

Item Description All depths from RT	Wellhead and Xmastree **HEK-GT-02**	Depth m tvd	Depth m ah	Hole ID in	Pipe OD in	Collar OD in (nom)	Pipe ID in	Pipe ID in (drift)
20" Stove pipe		84,00	84,00	Driven	20,000		18,500	
		TOC: Surface						
9 5/8" liner hanger		1307	1323	Top of liner				
13 3/8 "casing #68 L80 Gas tight Premium		1407	1424	16,000	13 3/8"	14,375	12,415	12,259
		TOC: 1945						
6 5/8" liner hanger		2365	2618	Top of liner				
9 5/8" liner #43,5 L80 Gas tight Premium		2393	2659	12.1/4	9 5/8"	10,626	8,835	8,679
			top screen @ 2659 m					
			bottom screen @ 2954,2 m					
6 5/8" liner #24 L80 Premium		2600	2954	8,500	6 5/8"	7,283	5,921	5796
Open hole 8.1/2" (TD)			2954					

Figure 4: HEK-02 well schematic