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PROGRESS AT THE EUROPEAN HDR PROJECT AT SOULTZ-SOUS-FORÊTS: PRELIMINARY RESULTS FROM THE DEEPENING OF THE WELL GPK2 TO 5000 m

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ABSTRACT

The successful circulation test carried out at Soultz in 1997 demonstrated that it is possible to circulate at flow rates of around 90 tons/h between two wells with a separation of 450 m and in the depth range of 3000 – 3500 m. However, the future industrial deployment of the HDR technology developed at Soultz requires that the past experiments be replicated at higher temperatures and larger flow rates in order to further improve the efficiency and economy of the technology. Consequently, it was decided to extend the investigations down to 5,000 m. At this depth temperatures of around 200°C were anticipated.

Fig. 1 ENEL's MAS 6000 rig in Soultz, 1999

Between mid February to end of May 1999 (in 104 days) the well GPK2 at the Soultz HDR site was successfully re-entered and deepened from 3876 m to a final depth of 5084 m and fully completed. Re-entry included the pulling of the existing 3211 m long internal 9 5/8“ by 7“ casing string, fishing of a submersible pump and some 150 m of 2 3/8“ tubing, sealing of a major loss zone and opening of a 6 1/4“ well section in granite (3211 - 3876 m) to 8 1/2“ hole size. The well was extended to 5048 m in 8 1/2“ hole size and again completed with a floating 9 5/8“ by 7“ casing string. The casing shoe is at 4431 m. A bottom hole core was taken in the depth range 5048 - 5051 m. The core recovery was app. 40%. A pilot hole in 6 1/4“ was drilled from 5051 - 5084 m for in situ stress measurements.

First scientific investigations included borehole logging (NGS, CLIPER, ARI, UBI, TEMP), geological investigations (cuttings, core), seismic monitoring while drilling, slug tests and low rate production tests for geochemical and gas analyses of the formation fluids. Initial temperature logs showed around 200^o C at 5000 m. Geological investigations and borehole logging indicate a strong degree of fracturation in the open hole section between 4431 - 5084 m. Several zones of hydrothermal alteration were identified.

THE HISTORY OF THE WELL GPK2

The well GPK2 had been completed in early 1995 to a depth of 3876 m (Fig. 3). The temperature exceeded 168^o C at 3800 m (deepest observation point). During the drilling of GPK2, a large permeable fault was encountered at around 2110 m depth. From there onwards this fault caused total fluid losses during drilling.
In spring 1995 a submersible pump, 150 m of 2 3/8“ tubing, some power cable and a tubing clamp had been lost in GPK2 during a scientific hydraulic experiment and were still lying at the bottom of the well. The open hole section of GPK2 had been stimulated twice in 1995 and 1996 in order to create an underground heat exchanger (Gérard et al., 1997). A total of 58,000 m^3 of water were injected below the

casing shoe at a maximum flow rate of about 78 l/s. In 1997, during a 4 months "closed loop" circulation experiment, 244.000 tons of hot brine at rates of up to 90 tons per hour had been produced from the stimulated section in GPK2 (Baumgärtner et al., 1998, Jung et al. 1998).

ACCOMPANYING DEVELOPMENTS

The re-entry and deepening of the well GPK2 was accompanied by several technical developments.

Past experience at Soultz had shown that - at least for the hostile conditions found in Soultz (hot brines, gases) - for temperatures exceeding 120 to 140^o C conventional rubber based packer elements cannot be used. New casing packer elements based on inflatable metal shells were developed in a close cooperation between SOCOMINE and MeSy GmbH. The packers were designed to be as simple and sturdy as possible, trying to avoid problems with complex mechanics at high temperatures. A solution was found by using inflatable soft metal shells which are inflated through cement injection. Selecting the right alloy, the behavior of such metals can be adapted to the prevailing chemical and temperature boundary conditions. For the extension of GPK2, for the 8.5" open hole section in granite, a packer design with a mandrill of 7" 26 lb./ft C 95 casing and a sleeve made of a salt water resistant Cu alloy was chosen. Packer setting occurs through cement injection. Numerous laboratory tests with such metal packer elements were run. Deformation of the sleeve (at room temperature) started at around 10 MPa. Setting pressures could be as high as 25 MPa. The packer elements designed for an 8.5" open hole could inflate up to 10" hole size. A special test set up was designed in order to measure the anchoring strength of a single packer element. The anchoring tests were performed inside test pipes with varying IDs from 8.5" to 10". The anchoring force of a single element increased from a minimum of 30 tons inside a totally smooth steel pipe to over 100 tons as soon as some minor irregularities (simulating a rough borehole wall) were machined into the test pipe. For the application in the GPK2 well, in order to facilitate the handling, the casing-packer elements were designed in such a way that 7 packer elements together with an upper and lower casing pop-joint (necessary to be able to set the slips on the rig floor and to run centralizers) could be pre-assembled to one long single packer unit at the length of a Range 3 casing joint (app. 12 m). This packer unit was designed to support the full weight of the internal 9 5/8" by 7" casing string (> 4400 m, estimated weight in water: 160 tons). Patents for this metal casing-packer technology are pending.

High temperature cementing strategies (up to 170 - 190^o C) for the complex formation fluids encountered in Soultz were developed in a cooperation between Schlumberger Dowell (Vechta), SOCOMINE, SII of Houston, Ruhr-University Bochum, BGR Hannover and IFP Paris. Cementing at higher temperatures is a primary cause of wellbore problems, major time losses and casing problems throughout the geothermal industry as whole. Working in mixed brines at varying salt concentrations adds considerably to the problem. Having this in mind, the Soultz project has been making strong efforts to overcome these problems. In the case of GPK2, cementing operations were anticipated:

- to seal the loss zone at 2110 m
- to isolate the bottom section of the new internal casing string and to inflate the casing packers.

Work on the development of new cementing strategies started as early as mid 1998. As a result of the joint investigations, a three-step program was proposed:

The first step was to replace cement wherever possible with a filler which should form a hydraulic seal but which should not bind with the casing string. Such materials should be used to seal longer sections of the annulus of the floating internal casing string. Numerous laboratory experiments with fly ash as base material were performed in 1998. These tests and analyses showed that some fly ashes have excellent settling and thus sealing capacities as long as they are kept in the slag below a critical concentration (this critical concentration depends on the type / origin of the fly ash). During the course of these investigations, clear differences in the settling capacity were observed between fly ashes of different origin !

The second step was to eliminate Portland cement, as far as possible, from the cement mixtures in order to reduce the time constraints. Portland cement (especially under high temperatures) has the characteristic to harden very rapidly ("flash") - once the retardation period has passed. Furthermore, especially Magnesium Chlorides as they are found in the brines at Soultz destabilize the cement reaction.

Numerous laboratory experiments, adapted to the conditions encountered in the Soultz granites, were performed with cement mixtures based on blast furnace based cements (BFC) and fly ash. These developments were triggered through experiences from oil wells in North Germany which had shown that cement mixtures based on BFC are less sensitive to mixed brines in the well than conventional API class G cements. The resulting cements are called HMR cements (High Magnesium Resistant cement):

Portland cement + blast furnace >
blast furnace cement
(APPROX.: 30 + 70)

blast furnace cement + fly ash filler > HMR cement
(Varying mixing ratios + RETARDER)

The compressive strengths achieved with these cements in laboratory are comparable to those observed for API type class G cements. Furthermore, HMR cement mixtures set only gradually with time, no flashing is observed. This behavior clearly improves the safety of the operations at high temperatures. However, hardening of the cement occurs also somewhat slower than for class G-cements.

The third step taken was to overcome the salinity problems by calibrating, testing and making up all cements slurries using a brine with an NACL concentration of 200 g/l, which is nearly twice the total natural salt concentration found in the Soultz area. This way a contamination of the cement with the much more complex natural brine could be eliminated.

THE RIG SELECTED

In order to safely re-enter and deepen the well GPK2 from 3976 m to 5000 m, a land rig of the 1500 hp class (1300 - 1700 hp) was necessary (Fig. 1). After an extensive review, it was decided to select a rig of ENEL (Italy) based on the cost and the quality of the rig, the associated equipment (tubing, mud logging, coring, casing handling), the support to the rig, the size and the power of the rig. The main parameters of the rig selected are listed below:

MASSARENTI 6000 EE

Nominal power:	1700 hp (diesel-elect.)
Max. drilling depth (5“ DP):	5.200 m
Hook load:	453.000 kg
Setback load:	272.000 kg
Rotary load:	453.000 kg
Comb. substructure load:	725.000 kg
Motors:	4 x ISOTTA FRASCHINI / 16 cyl / 900 hp
Generators:	4 x ANSALDO M2V 500 CH / 670 KW
SCR unit:	1 x G.E. µDrill 3000 / 6 bays

MAIN OPERATIONAL STEPS

During the re-entry and deepening of the well GPK2 several crucial technical operations had to be performed. These are described below in the sequence of operations (see Figures 2 & 3).

pulling of the internal casing string

The 9 5/8“ by 7“ casing string in GPK2 which had been installed in 1995 was isolated by a rubber casing packer and some 150 m of a sand and barite packing in the annulus (see Fig. 3). As the weight of the casing string in brine was in the order of 110 tons (128 tons in air) the maximum pulling force had to be restricted to 204 tons (i.e. 450.000 lb.), in order to not risk to tear apart the string. The casing string was engaged using a casing spear and was worked in the load range between 100 to 190 tons for about 5.5 hours before it came free.

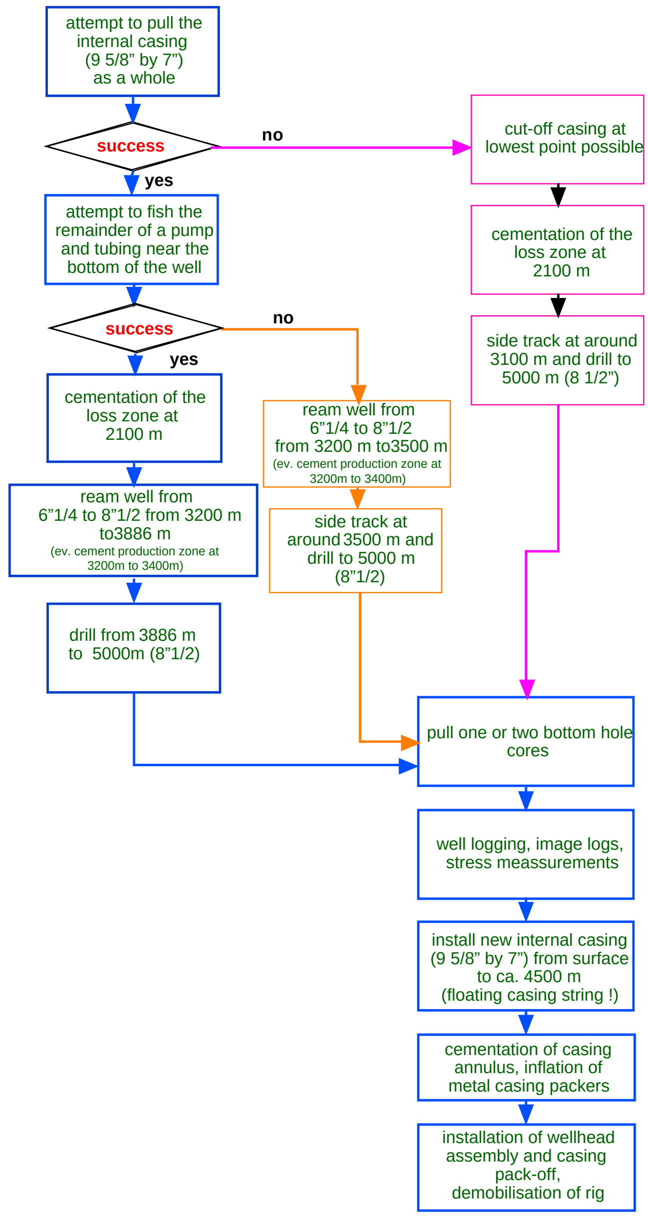

Fig. 2: Planned sequence of operations during the re-entry & deepening of GPK2

As the casing appeared to be still in good condition, it was decided to inspect & repair the best joints and to re-run them.

recovery of a submersible pump and some 150 m of 2 3/8“ tubing

The second critical operation was the recovery of a submersible pump and some 150 m of 2 3/8“ tubing

(on top of this some 200 m of power cable and a tubing clamp had dropped in the well at that time). The fishing operation was engaged immediately after the 9 5/8“ by 7“ casing was pulled (19. - 25.2.99).
First the well was cleaned to the top of the fish with a 6 1/4“ bit. The fish had been tagged by wireline at 3623 m. During the next step of the operation more than 1 m of the 2 3/8“ tubing (first collar) was milled using a 5 7/8“ flat bottom mill. Once the top collar was milled it was possible to grab the tubing with an overshot and retrieve the 150 m of tubing in one run. At this point, the submersible pump, the tubing clamp, the power cable plus some centralizer pieces from the casing removal still remained at the bottom of the well. During a second mill run with a 5 1/2“ flat bottom mill it was possible to destroy the vast majority of these pieces. As it turned out, after the cementation of the loss zone and the opening of the well to 8 1/2“, another mill run was required to fully clean the well (15. - 16.3.99).

sealing-off of a major loss circulation zone at a depth of around 2110 m
During drilling of GPK2 in 1994/95 a major loss zone was encountered at 2110 - 2111 m. From this point on, GPK2 had to be drilled without returns (total losses). In order to improve the control of the drilling operations, it was decided that this zone has to be cemented. Past experience had shown that treatments with pills of slag slurry and LCM did not promise a large probability of success. Before the cementation, a 3 m^3 high viscosity was spotted below the loss zone at 2110 m. The loss zone was then successfully isolated during 3 subsequent cementing operations using HMR cements. For this application BFC and fly ash were mixed in equal proportions. The cement was designed for a bottom hole curing temperature of 120^o C. The retarder used was D13. All three cement jobs were pumped through open ended drill pipe.

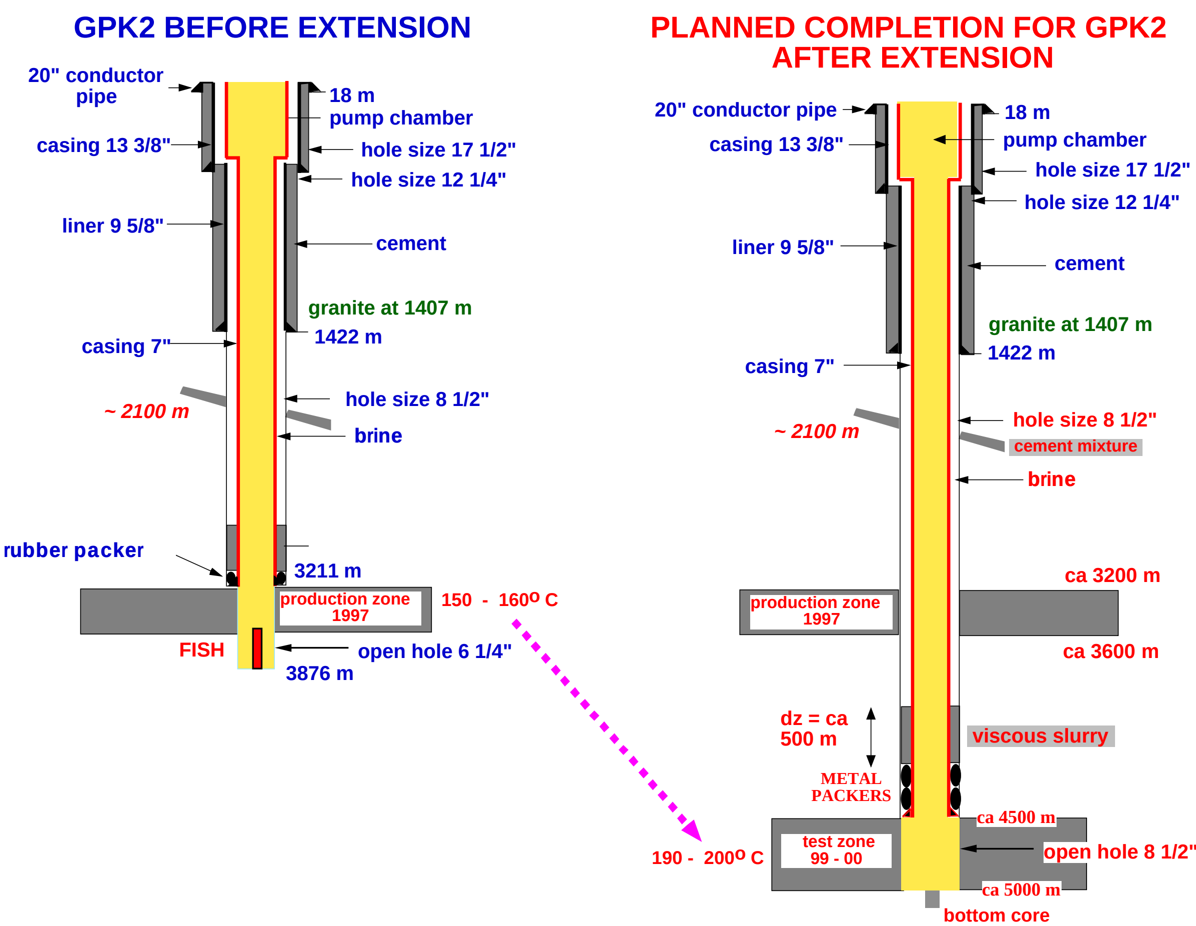

Fig. 3: A comparison: GPK2 before & after extension (planning)

drilling hot & fractured granite
At the beginning of the drilling operations some 600 m of hole inside granite had to be opened from 6.25“ to 8.5“. Hole opening was performed with a standard 3 cone roller bit (SECURITY H100 FL, IADC code 837Y). The 665 m (3211 - 3876 m) were reamed in 102.5 hours, consequently the average penetration rate was close from 6.5 m/h at an

average weight on bit of 7 tons. 4 bits were used, the average length of hole opened per bit was 166 m.
Drilling in 8.5“ was mainly performed with **drill bits** of the type H100 FL of SECURITY. With increasing depth the temperature impact on the roller bearings became apparent, more sealing failures could be observed. The penetration rates continuously dropped from about 2.8 to less than 2 m/h at weights on bit between 8-12 tons. The meters per bit dropped in parallel from 127 m (3900 - 4000 m depth range) to 50 to 70 m at depths below 4500 m. Some difficulties were encountered with **drilling breaks** i.e. zones of increased alteration or fracturing within the granite. The most important zone of this kind was intersected right at the bottom of the old well (3876 m). At this depth hole sizes of more than 30 inches over a length of more than 15 m were recorded. The **increasing drag and torque** lead to modifications in the bottom hole assembly and the mud system. Between 3884 m and 4608 m the drag increased by more than 60 tons. This increase of drag was accompanied by an increase of hole inclination (see below). The drag was fought by reducing the number of drill collars in the bottom hole assembly and replacing them by heavy weight drill pipe. However, at the same time further difficulties related to **wear and stress cracking** in the bottom hole assembly (BHA) were observed. In the depth range around 4200 m first stress cracks appeared in the roller reamer bodies. Several reamers had to be sent for repair. Consequently, depending on the availability of reamer bodies, varying reamer configurations were run. The problem disappeared once the RPM were dropped from 65 to 60. It can be speculated that these cracks were related to the fact that the vibrations of the drill string in the well had hit a resonance frequency. The wear observed on the bottom hole assembly (and the drill string) was always related to certain geological features (quartz content in the granite) - often in combination with very fine cuttings in the mud system. Several attempts were made to overcome the wear and drag problems through modifications in **the mud system**. The base mud used was a salt water mud made up with brine produced from GPK1 and weighted up to balance the formation pressure (app. 1.06 - 1.07 g/cm^3). Corrosion protection was achieved through the addition of Caustic Soda (pH 10) and a filming agent. With this simple mud, good drilling results had been achieved in 1992 (GPK1) and 1995 (GPK2 first part). Furthermore, this mud had proved to be very cost efficient (Baumgärtner et al., 1995). In order to reduce the drag & torque in the well an **environmentally friendly lubricant** called ECOL LUBE from AVA, Italy, was added to the mud system. ECOL LUBE is based on vegetable oils and synthetic polymers. This product was used very successfully in the depth range from about 4700 m to TD. In parallel to the use of ECOL LUBE as a lubricant, hole cleaning was improved through the addition of Attapulgit (salt water drilling clay) to the drilling mud in order to increase the viscosity.

The safety of the handling of the mud on surface could be considerably improved through the installation of a plate heat exchanger for **mud cooling**. This exchanger was linked to a 25,000 m^3 lagoon from which cold water was circulated through the exchanger at a rate of app. 150 m^3/hour. This way, the mud temperature at the surface (at the outlet of the heat exchanger) could be kept below 40^o C. The mud circulation rates used were 1650 l/min while drilling 8.5“ and app. 900 l/min while drilling the pilot hole in 6.25“. Some of the technical difficulties described here are clearly also related to the **well trajectory.** Down to 3876 m, i.e within the existing well, GPK2 can be described as ”near vertical“ (< 6^o inclination). During the extension of the well borehole inclination was recorded at intermittent intervals using a TOTCO and a high temperature single shot inclinometer. On 7.5.99 a wireline gyro survey was run by Scientific Drilling inside the drill string from 2764 m to 5014 m. During this log it was confirmed that a dog leg exists in GPK2 in the depth range between 3870 - 3910 m. In this depth range also a considerable hole enlargement was observed during caliper logging. Within this zone, the part of bottom hole assembly obviously had no wall contact and lost its capacity to steer. It is interesting to observe also that this dog leg had probably already been initiated in 1995 using a 3.5“ drill string and a slimmer, more flexible bottom hole assembly ! Between 3870 - 3910 m hole inclination jumped from 1^o to 8^o and continued to build from there on until it approached 26^o at 4450 m. At this depth the inclination was dropped again slowly to about 16^o near the bottom of the well. Considering the above described difficulties with hole drag and torque, drilling engineering concentrated in maintaining the well trajectory, reducing the build tendency and finally dropping the well.

installation and isolation of a floating casing string at a depth of 4431 m

GPK2 was completed in the period between 13.5. to 28.5 1999. Again, a floating 9 5/8“ by 7“ mixed casing string was installed as the production / injection string (Fig. 4). To a large degree it was possible to re-run those casing joints which had been pulled at the beginning of the operations. Before being re-used each of these joints was carefully inspected and repaired if necessary. The casing to be installed was a mixed string assembled of:

0-501 m:	9 5/8“ 47 lb./ft N80 BTC (pump chamber)
cross-over:	9 5/8“ 47 lb./ft - 7“ 23lbs/ft (L80)
501- 2167 m:	7“ 23 lb./ft L80 BTC (6.25“ drift)

2167-4419 m: 7“ 26 lb./ft C95 BTC (6.25“ drift)
4419-4431 m: packer assembly (7 metal packers), float shoe & float collar

In order to isolate and anchor the casing string near the shoe and to support the weight of the casing string it was decided to first pump some 1000 m of a filler (fly ash), followed by app. 250 m of cement in the annulus of the casing and to install 7 metal casing-packers which are inflated with cement.
Critical points for the design of the completion were:

- the weight of the string hanging on the top joints of the 7“ 23 lb./ft casing during installation of the casing
- the burst pressure of the 7“ 23 lb./ft casing during the inflation of the packer elements
- to avoid a break-down respectively fluid losses in the open hole section due to the increased weight of the fluid column in the well
- identification of a suitable zone (caliper < 10“) for the setting of the inflatable packer elements.

The weight of the casing string during installation was controlled running a float shoe and float collar in combination. In order to reduce the differential pressure across the 7“ 23lbs/ft casing it was decided to tail the cement in the casing string with a heavy brine of 1.20 g/cm^3 density. To avoid fluid respectively cement losses in the open hole section it was decided to sand-up the well from the bottom to some 10 m below the casing shoe. Although this was a somewhat lengthy operation it offered the maximum guarantee to circulate the filler and cement behind the casing string. The open hole section for the setting of the packer elements was selected on the basis of the results of wireline logging (caliper, UBI). Complications occurred trying to achieve a depth match between drilling and wireline depths because of the very different thermal stretch observed in the wireline and the 5“ drill string. The installation of the casing string could be performed without any difficulties. A total of 34 m^3 of fly ash slurry, 8 m^3 of HMR high temperature cement and - seperated by a plug - 2 m^3 of HMR cement for packer inflation and 97.3 m^3 of displacement were pumped. The cement density was 1.90 g/cm^3. The retarder used was D28. This way a pumping time in the order of 10 hours at 170^o C could be achieved. The fly ash filler was mixed at a density of 1.37 g/cm^3. During the cementing and filler injection minor difficulties occurred due to a leak which occurred in the packer assembly during inflation. Rapidly increasing the injection rate it was possible to raise the packer setting pressure to about 17 MPa and to seal the leak with appr. 1 m^3 of additional cement cement. After cementation, the well was shut-in for 2 days with the casing still being held in the elevators. After these 2 days, first the casing pressure was checked (casing integrity test). The casing was holding 7.5 MPa. At this point decision was made to fully slack-off the casing weight. The casing and the sand from the open hole section were then cleaned using a 6.25“ tooth bit. Once the plug and float shoe were drilled only 4 meters of cement was found below the casing shoe indicating that the cement and filler had fully risen into the annulus.

First SCIENTIFIC RESULTS

Geological investigation

The geological investigation consisted of coring, analysis of chip sample and geophysical logging.

Coring

The deepest core at the Soultz site before the deepening of GPK2 had been collected near the bottom of the GPK1 well (3523 - 3526 m). At that time, in early 1993, coring had been performed using a positive displacement motor and a diamond coring assembly. Two main problems had been observed during the coring operation in 1993:

- a motor failure
- a partial unscrewing of the core barrel (twice !)

Both problems could be identified as temperature related technical difficulties. As the conditions for coring after deepening of GPK2 had to be expected as even more hostile, after a careful analysis of all available techniques, it was decided to run a conventional roller cone coring bit without any motor in the well. Both, the core bit (SMITH X3TC7 7 7/8“) and the core barrel (Christensen 6 1/4“ x 3“) were furnished by the drilling contractor, ENEL. Coring in GPK2 was performed on May 9th 1999 in the depth range from 5048 m - 5051 m. The 7 7/8“ coring bit was operated at 55 rpm and 5 tons on bit.
the depth range from 5048 m - 5051 m. The 7 7/8“ coring bit was operated at 55 rpm and 5 tons on bit.
The penetration rate averaged 1.7 meters per hour.

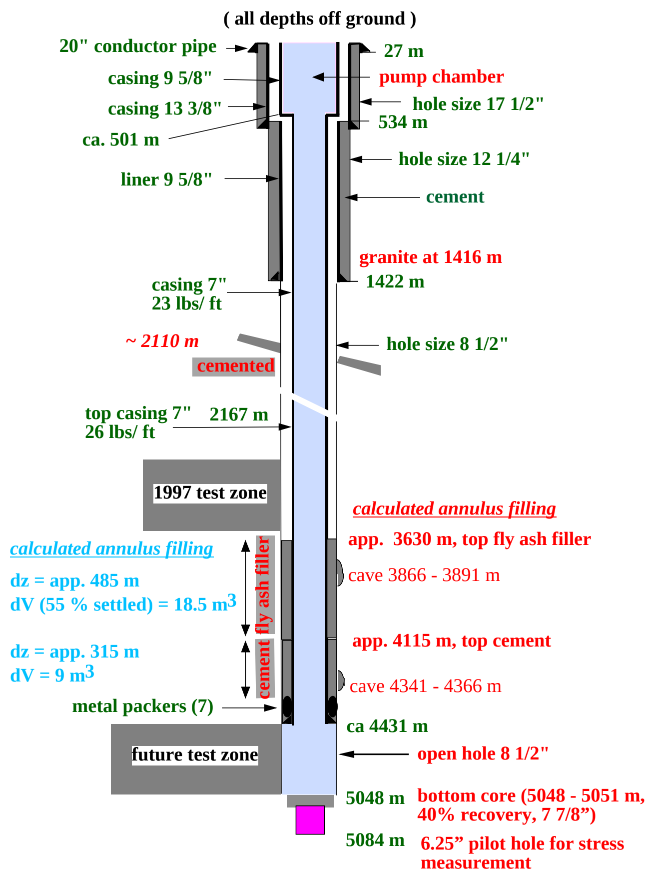

*Fig. 4: GPK2 after re-entry and deepening to 5084 m (app. 5024 m **TVD**)*

After 3 meters of coring, the penetration rate dropped significantly, indicating that the bit was probably worn. A total of app. 1.2 m of core (40 %) could be recovered. The remainder of core had been lost on bottom because it was not caught by the core catcher. Nevertheless, this short core proved to be a very good example of the varying types of granite encountered at this depth. The analyses on the cores are continuing but the initial data suggests that 3 facies were found. Beside one piece of xenolith and one piece of the "standard" coarse grained Soultz granite, the remainder of the core consisted of a much more fine grained 2 mica-granite. Some pieces of the core show well developed fractures sealed with hydrothermal deposits which are presently under analysis.

Cutting analysis

Cuttings were sampled continuously through out the extension of GPK2. Samples were collected, washed and analyzed. Cutting analyses showed that GPK2 penetrated into granite down to the bottom. Numerous alteration and fracture zones exist below 4000 m. Several sections show the presence of Xenolith. Two major deep fracture zones could be deducted from cutting analysis: 4580-4600 m & 4775 m. Below 4860 m cutting analyses as well the core indicate that quite some petrographic variation occurs at this depth. Beside the coarse grained "Soultz type granite", fine grained two-mica granite, biotite rich granite and xenolith rich facies are found. These granites could be interpreted as intrusions across the main granitic facies (Genter, 1999).

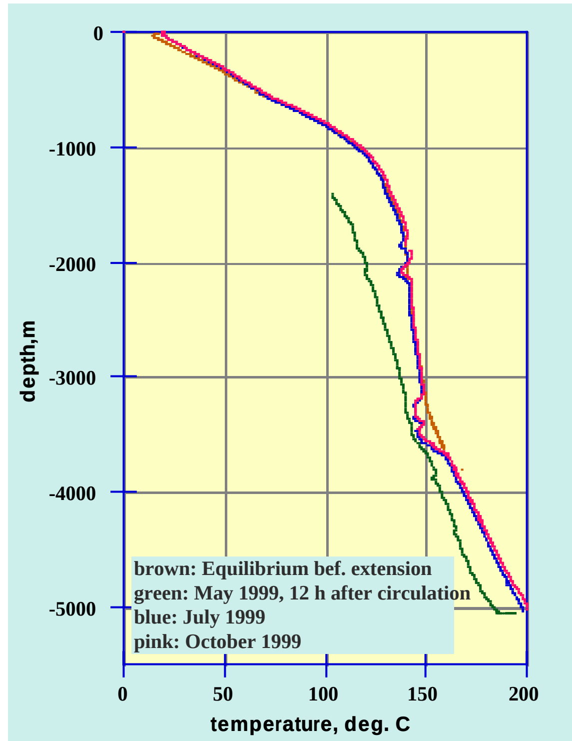

Fig 5. Comparison of temperature logs in GPK2 (Temperature logs: GGA & Socomine)

Geophysical logging

The information on the joint network has been well documented from the continuous cores and borehole imaging logs in existing wells (Genter and Traineau, 1992). The observations suggest that there are two principal joint sets striking N10ºE and N170ºE and dipping 65ºW and 70ºE respectively (Genter and Dezayes, 1993). The granite is pervasively fractured with a mean joint spacing of about 1 jt/m. The following geophysical logs were run during the extension of GPK2: HNGS (2000–4500 m), 6-arm caliper (3200–4625 m), ARI (3500–4500 m) and UBI (3200–3875 m). All logging tools were temperature restricted to 175^{o} C and data evaluation is still ongoing. The data analyzed so far data indicate that the well is significantly enlarged in diameter at various depths below 3850 m. The joint network and pattern of alteration appears to be similar to that found higher up in the well (z < 4500 m). Image logs below 4500 m depth are planned for the near future.

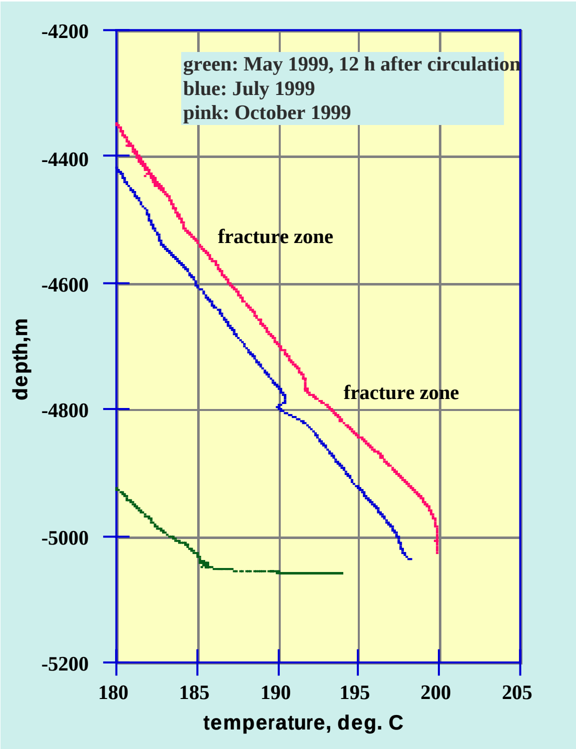

Fig 6. Development of the near bottom temperature in GPK2 (logs: GGA & Socomine)

Temperature

Various models / extrapolations indicated that GPK2 will have to be extended to 5000 m depth to obtain the temperatures in the order of 200° C (± 10°). An initial temperature log was carried out during the drilling operation, 12 hours after the completion of the 8-1/2" diameter well to 5048 m. The tool was parked near the bottom and temperature was still rising (194°C) when the tool failed. The survey showed that the target temperature had been reached. Two months after the completion of the well, a temperature log was run which confirmed that the bottom hole temperature was very close to 200°C (Fig. 5). It is interesting to note that a temperature anomaly exists near the very bottom of GPK2 (Fig. 6, log of Oct. 1999). This anomaly is marked by an increase in the temperature gradient followed by a zone of app. 50 m length with a near constant temperature (note: tool records pressure & temperature to control proper tool movement). Unfortunately, presently the logging tools are blocked at a depth of app. 5019 m (TD: 5084 m) and are unable to record the continuation of this anomaly.

Hydraulic characteristic of the basement

An initial slug test carried out in August 1999 showed that the injectivity of the open hole of GPK2 was around 0.3 (l/s)/MPa (Weidler, 1999) which is compatible to that measured for shallower depth (3200 – 3600 m) in GPK2 for a comparable open hole length i.e. 0.33 - 0.38 (l/s)/MPa. Further low flow rate tests are planned for February 2000 and a medium flowrate stimulation is anticipated for March / April 2000. The preliminary data indicate that the hydraulic characteristics for stimulation will be similar to those in the 3.5 km range, taking into consideration the depth, fluid density, temperature, etc..

Geochemical behavior

For an analysis of the deep formation fluids the well was put on production (26.10.- 1.12.99, production rate 10-15 l/min) using a small submersible pump. The total volume produced was in the order of 500 m^3 (well volume ~125 m^3). The evaluation of this test is still undergoing. Nevertheless, it can be stated that the produced fluid is very similar to fluid samples taken at shallower depth, except for the silica content. The SiO_2 content increased up to 425 mg/l. This value - used as a geothermometer - would mean that the brine produced has seen temperatures of more than 260° C (Azaroual, 1999), thus indicating that the fluid probably has been migrating upward. The pH observed (after CO_2 degassing) was in the order of 5.4. The salinity was measured at 100 g/l. The production test was accompanied by a careful gas monitoring. The data analysis is still undergoing.

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