ANTI-CORROSION WELL CONCEPT. THE BONNEUIL-SUR-MARNE (PARIS BASIN) CASE STUDY

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ABSTRACT

Conventional (steel cased) well physical life in thermochemically adverse environments hardly exceeds thirty years, a life span requiring due chemical inhibition protection.

The anti-corrosion well concept is a material response to corrosion damage. Its architecture combines steel propping casings and freely suspended (production/injection), corrosion resistant, fibreglass liners. The free annulus eases liner replacement whenever the material undergoes material destructuring (weep), therefore avoiding the drilling of a new well. It offers also a facility to inject fluids for either integrity control or/and chemical/bacterial inhibition purposes.

1. INTRODUCTION

The Paris suburban areas enjoy an almost unique setting where a dependable geothermal reservoir of regional extent, hosted by the Dogger (mid Jurassic age) carbonate rocks, matches large concentrations of social dwellings eligible to geothermal district heating (GDH). This attractive resource to market adequacy definitely contributed to make the Paris Basin GDH a top ranked achievement of its kind, surpassing the city of Reykjavik GDH scheme.

Milestones

The foregoing led to the launching by the State, in the aftermath of the mid 1970s oil shocks, of a thorough development programme, which peaked by the mid 1980s with the completion of 54 GDH systems and a yearly heat production nearing 2 000 GWht. These schemes applied the doublet concept of heat farming, combining a production well and an injection well pumping the heat depleted brine into the source reservoir.

As of year 2006, 34 doublets remained online, a score deemed positive. Actually many obstacles, from early infantile diseases to teenage and entrepreneurial maturity, jammed the learning curve inherent to any new energy route.

From 2007 onwards, drilling resumed and geothermal exploitation was revisited by twelve new (doublets) and rehabilitated (triplets) GDH grids, generating an overall energy output close to 1 300 GWht/yr.

Technological insight

Doublet typology moved from the early two vertical, slim diameter (7"), 1 km spaced, well design to two larger diameter (9"5/8) wells, deviated from a single drilling pad, nowadays a standard. The consolidated carbonate reservoir rocks favours openhole production/injection thus avoiding screen gravel packed completions.

Well architectures comply with conventional drilling/completion routine practice unless otherwise inspired by more daring designs.

GDH grid layouts most often cope with retrofitting and high service temperatures/pressures constraining heating efficiencies and exploitation economics.

The nature of the formation fluid, a corrosive, slightly acid (pH # 6), saline (20 g/l eq. NaCl), hot (60-80°C) brine with a CO_2/H_2S enriched solution gas phase (0.10 to 0.15 GWR) requires the implementation of titane alloyed plate heat exchangers, soft casing steel grades, downhole chemical inhibition lines, and surface degassing/abatement facilities whenever well head self flowing production pressures fall below bubble point.

New trends

Those address essentially key reservoir assessment, innovative well design, corrosion/scaling abatement and sustainable resource management issues.

As a result:

(i) Geomodelling of multilayered heterogeneous reservoir structures enabled to realiably appraise actual reservoir cooling kinetics thanks to the sandwich model concept;

(ii) Fibreglass, annulus free, lining of steel cased wells provide a material response to corrosion damage and a guarantee for longer well life;

(iii) Projected sub-horizontal well architectures are likely to significantly increase productive/injective capacities and heat recovery from the reservoir;

(iv) Bottomhole coiled tubing type chemical injection lines succeeded in defeating corrosion/scaling. Addition of a pressure/temperature control module offers a means for monitoring reservoir performance and well damage premises; and

(v) New triplet well arrays, sustaining early doublet longevities, and access in real time to the Dogger exploitation data base make it possible to best optimise reservoir management.

Hence, the year 2020 target - 50 or so operating doublets/triplets supplying yearly 2 000 GWh_t - becomes a realistic objective.

The foregoing addresses the case study of the implementation of the anti-corrosion well concept on the Bonneuil-sur-Marne (south Paris) geothermal site.

2. PROJECT OBJECTIVE

Bonneuil-sur-Marne (Fig. 1) is a medium size suburban city located south of Paris. The city heating grid is connected to a geothermal district heating doublet since 1986 (Fig. 2). This commitment to renewable energy is a consequence of an exceptionally dependable reservoir hosted by a Dogger (mid Jurassic) carbonate formation providing a 75°C hot water produced under self-flowing conditions. However, the Dogger brine hot water being highly corrosive and the production well GBL1-ST drilled in 1995 undergoing severe damages needed to be replaced. Furthermore, the development of the city and neighbouring localities requires a two-fold increase of the heat demand in the near future (fig 4), an issue which could lead to a drop of the renewable production share unless appropriate alternative remedials be implemented. As a result, the heating grid operator SETBO decided to commission an anti-corrosion well combining steel cased fiberglass lined architecture to achieve high deliverability, along sustainable operation and, last but not least, extended well longevity.

Figure 1: Location map

Figure 2: Site view

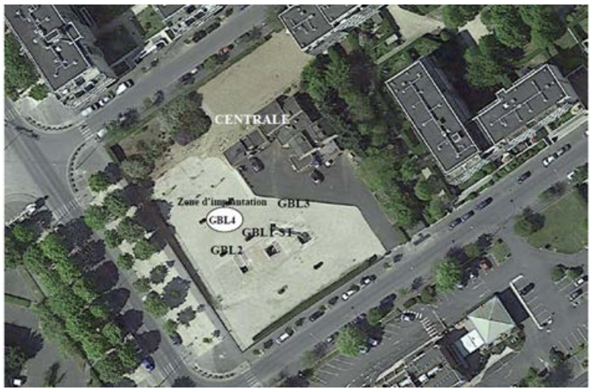

Figure 3: Aerial view of the site and location of the GBL4 anti-corrosion well.

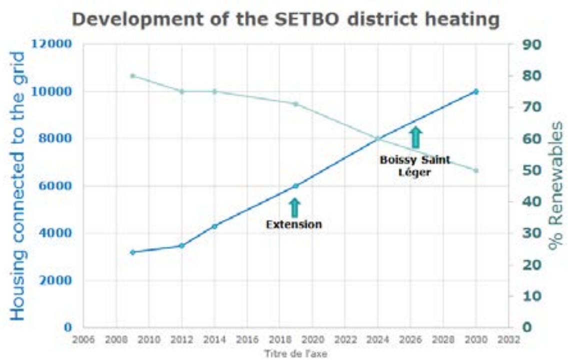

Figure 4: Development of the district heating in Bonneuil-sur-Marne

3. ANTI-CORROSION COMPOSITE WELL ARCHITECTURE

The GBL4, 2020 m deep -38° slanted, well combines a large (20"x13"3/8) steel cased propping column and a twin (13"3/8x9"5/8) fiberglass production liner assembly, the casing x liner annulus being kept free(i.e. not cemented) (Fig. 5), a design initiated in 1985 on the emblematic Melun l'Almont GDH well GMA4, completed though via a simplified architecture (single 13"3/8casing/9"5/8 fiberglass liner) and production (self-flowing) mode [1].

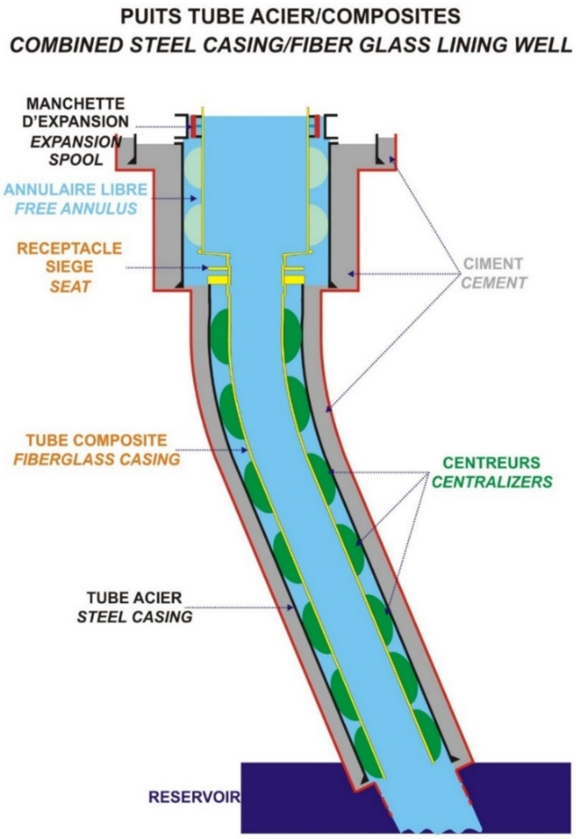

Figure 5: Anticorrosion well architecture

This former experience validated the fiberglass lining concept with respect to material aging (no fiberglass wheep nor destructuring), well integrity (no heavy-duty workover and no acidizing so far), reduced maintenance (only one master valve change since operation start-up), well productive performance (artesian, non-sustained, 300 m3/h flowing rate under 2 bar well head pressure), in spite of below bubble point self-flowing production and related fluid degassing.

Present well architecture addresses an artificial lift, pump sustained, production, which implied significant design modifications, chiefly:

(i) an upper, wider (13"3/8OD -11.97" ID) liner section acting as a pumping chamber, sized to accommodate a 500 HP rated ESP, placed under compression between the wellhead and the lower section;
(ii) a lower and slimmer (9"5/8OD –7.74" ID), freely suspended production liner;
(iii) a (13"3/8x9"5/8) liner connecting system, placed at the (20"x13"3/8) casing interface, allowing for a free annular fluid (a make-up corrosion inhibitor agent) passage, indeed a key issue, and,
(iv) a wellhead expansion spool.

The additional capital investment costs (ca 20% compared to a conventional 13"3/8x 9"5/8steel cased well architecture) will get payed back in less than eight years thanks to yearly OM costs savings.

4. CHALLENGES

Site limitations

The geothermal site is in a densely populated urban area surrounded by collective housing and a school. The available surface of 4500 m2 disposed on two levels had to accommodate a heavy duty (280 t hook load capacity) drilling rig and all equipment (Fig. 6).

Anticollision management

The presence on the existing site of three wells and the limited spacing available to seat the new well GBL4 lead to the decision to carry out gyro surveys in the first 500 m of the existing wells. The new well GBL4 was drilled directionally with a nudge of 5° to the north in order to secure sufficient spacing from the existing wells (fig 7).

Drilling large diameter on 17''1/2 to the top of the reservoir

The entire section was drilled with PDM motor in sliding and rotary with PDC drilling bit and was secured by adequate drilling fluid formulations for wellbore stability whilst crossing heterogeneous sedimentary layers sections.

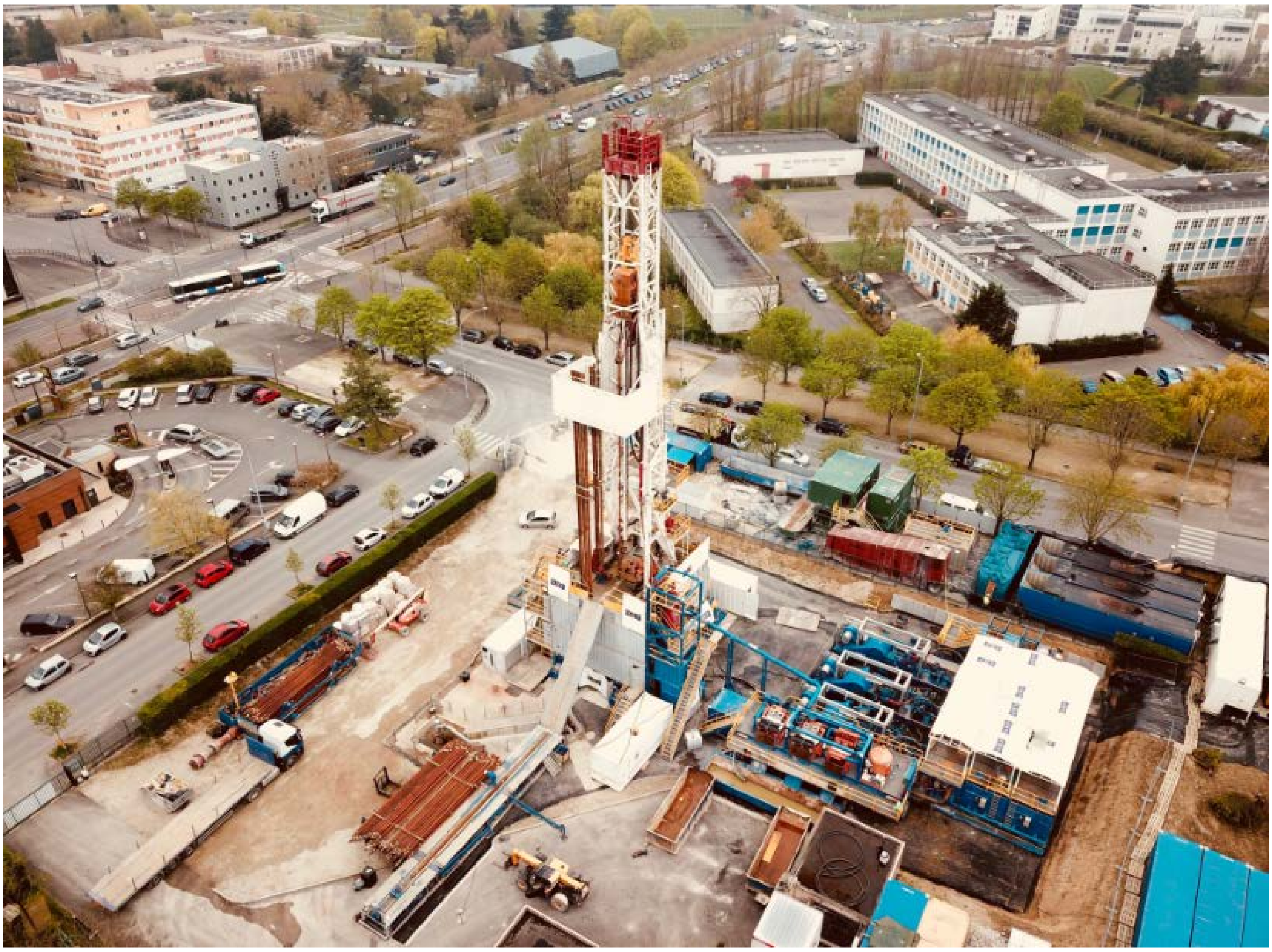

Figure 6: Bonneuil-sur-Marne drill site aerial view (courtesy of SMP)

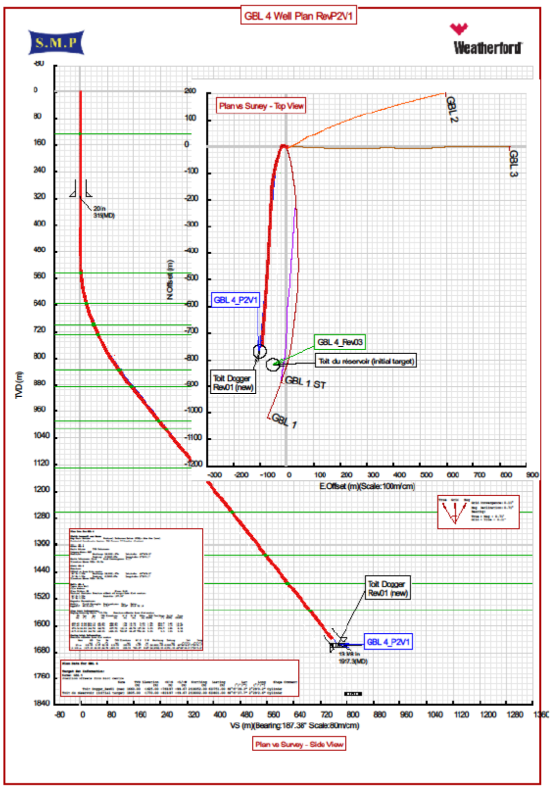

Figure 7: Well GBL4 directional profile

Staged cementing and placement of an abrasive fibre plug to favour enhanced cement bounding

This technique was deployed first in geothermal well cementing in order to reduce the possibility of channelling and micro annulus between the cement and the casing. The expectations were met and proven by later CBL/VDL/IBC inspection.

Combined (pumping chamber-production column) fibre glass liner allowing fluid motion in the free (i.e non-cemented) steel casing x fibre glass liner annular space.

The depicted well architecture in Fig. 5 required the design of a special suspension spool for the 9”5/8 fibre glass section which had to accommodate continuity of treated fluid motion between the combined 13”3/8 x 9”5/8 fibre glass x 20”x13”3/8 steel casing annuli.

The 13”3/8 fibre glass section being in compression the well head was equipped with an expansion spool allowing for 500 mm expansion and maintaining perfect seal of the annulus against the flow oth the geothermal water.

Reservoir impact optimisation by hydro-thermo-dynamical simulations.

In order to preserve the sustainable exploitation on the site, hydro-thermo-dynamical simulation were carried out in order to match production history and to predict future thermodynamic behaviour of the site. The task was quite challenging because the limited margin within of the concession in order to secure another 25 years of exploitation, and minimise the interference of the neighbouring doublets in exploitation.

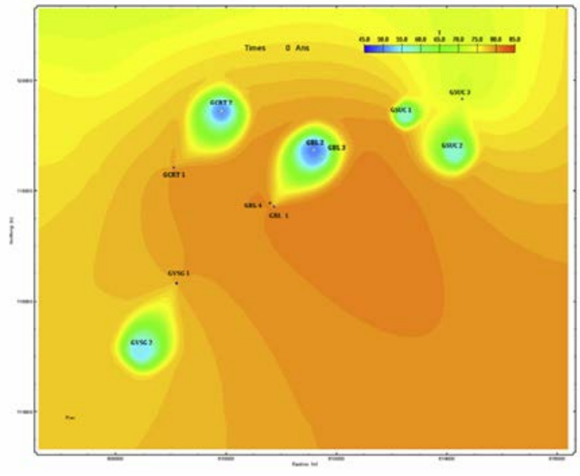

Figure 8: Simulated hydrothermal impacts

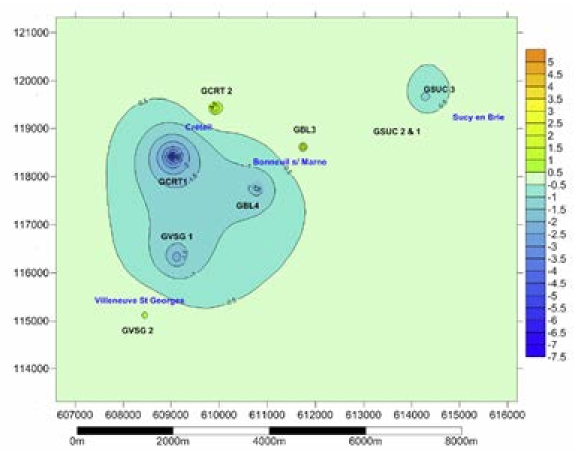

Figure 9: Simulated local and regional interferences

6. RESULTS

The well GBL4 was put into operation end of September 2018. As already announced by the well tests, the well is able secure easily 250 m3/h @ 5 bar WHP artesian flow.

Fig. 10 shows the comparison between the performances of the old production well GBL1-ST and the new GBL4 production well.

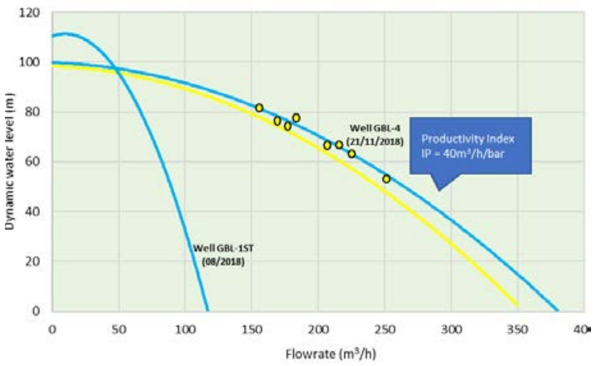

Figure 10: Well performances

7. CONCLUSIONS

Given the foregoing, it is expected this, smart well, material answer to thermochemically hostile corrosive fluid environments, elsewhere securing well longevities and low operation/maintenance (OM) costs, raises due interest among geothermal operators and stakeholders.

REFERENCES

Ungemach P. A New Geothermal Well Concept. IGA News. Quat. 20; Jan. March 1995, .12-13.

Ungemach, P. Carbonate Geothermal Reservoir Management in France. Int. Geoth. Days, IGD Poland 2004. Low Enth. Geoth. Resources Expl. and Development, Zakopane, Sept. 2004,13-17

Ungemach, P. et al (2011). Geomodelling and Well Architecture, Key Issues to Sustainable Reservoir Development. Proc. 3Gth Work. Geoth. Res. Eng. Stanford, Ca, 31 Jan.-02Feb., 2011.

Ungemach, P. et al (2013). Geothermal Low Grade Heat Reclamation. A Reservoir Engineering Approach. European Geoth. Conf., EGC 2013, Pisa, Italy, 5-7 June, 2013.

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The strong involvement of SETBO motivated the whole team (Fig. 11) to achieve this smart well.

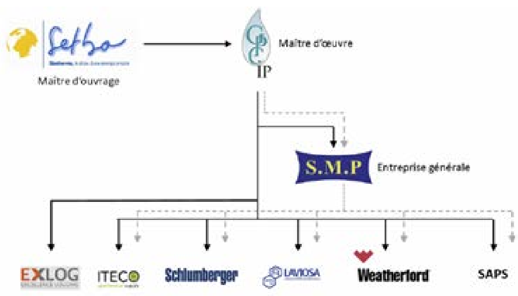

Figure 11: Project team