Micro Turbine Drilling – MTD

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Introduction

In geothermal drilling, there is a high risk that the hydraulic connectivity to the surrounding reservoir rock is lower than expected, resulting in low production rates and thus poor efficiency[1]. Fraunhofer IEG has therefore developed the innovative drilling technology Micro Turbine Drilling - MTD to solve this problem. This technology makes it possible to drill additional branches - so-called micro sidetracks - from the main well at low cost in order to improve the connectivity.

Fig. 1: Schematic representation of the MTD process including different components of the system

Micro Turbine Drilling (MTD)

The main component of the MTD process is a high-speed micro drilling turbine driven by high-pressure fluid. Equipped with an impregnated diamond drill bit, it is possible to cut through hard rock and steel in a single operation. This eliminates the need to change the drill bit during operation, saving time and money. To connect a formation using ⌀40 mm micro-sidetracks, a deflector shoe is installed inside the cased well to the desired drilling depth using jointed pipes. Then, the drilling unit attached to a flexible hose is run in to drill first through the casing and then further into the formation. The compact design of the drilling tool allows a deflection of the micro sidetracks of approx. 50° in a 5 1/2" casing. Since the drilling tool consists of temperature-resistant components, the MTD can also be used for very deep, high-temperature geothermal wells.

Fig. 2: On-site setup in the Bedretto Underground Laboratory (BUL) in Switzerland for proof of concept (left), Fraunhofer IEG engineers inspecting the micro-sidetracks using a downhole camera (right)

Table 1: Information about all drilled micro-sidetracks

Horizon	Depth (m)	Hole No.	Angle (°)	Sidetrack length (m)
1	171.7	H1-1	180°	~ 0.5
		H1-2	270°	~ 0.15
2	210.4	H2-1	270°	~ 0.9
		H2-2	235°	~ 0.8
3	255.7	H3-1	270°	~ 0.4
4	276	H4-1	290°	~ 1.3
		H4-1	270°	~ 0.7
5	283.75	H5-1	305°	~ 0.8
6	306.5	H6-1	250°	~ 0.8
7	324.6	H7-1	272°	~ 0.7

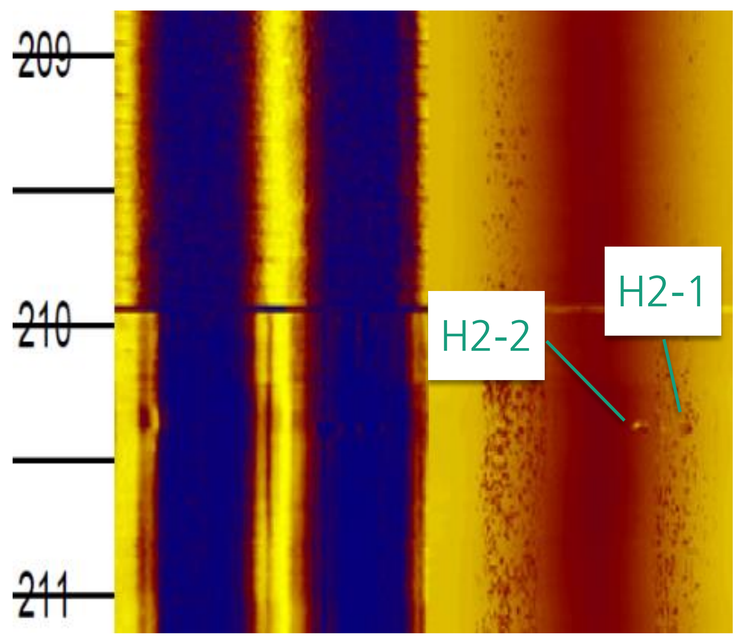

Fig. 3: Acoustic (ATV) televiewer image from Horizon 2

Proof of Concept

In 2021 a proof of concept of the MTD was demonstrated in the Bedretto Unterground Laboratory (BUL) in Switzerland[2]. Tests were carried out in a 350 m deep and 35° inclined 8.5″ borehole in granite with a 7″ steel casing. 10 micro-sidetracks in 7 different horizons were drilled with a length up to ~1.3 m under different orientation through the casing into the granite (Table 1). With an Acoustic Televiewer (ATV) the actual position of the micro-sidetracks was determined (Fig. 3 and Fig. 4 [right]).

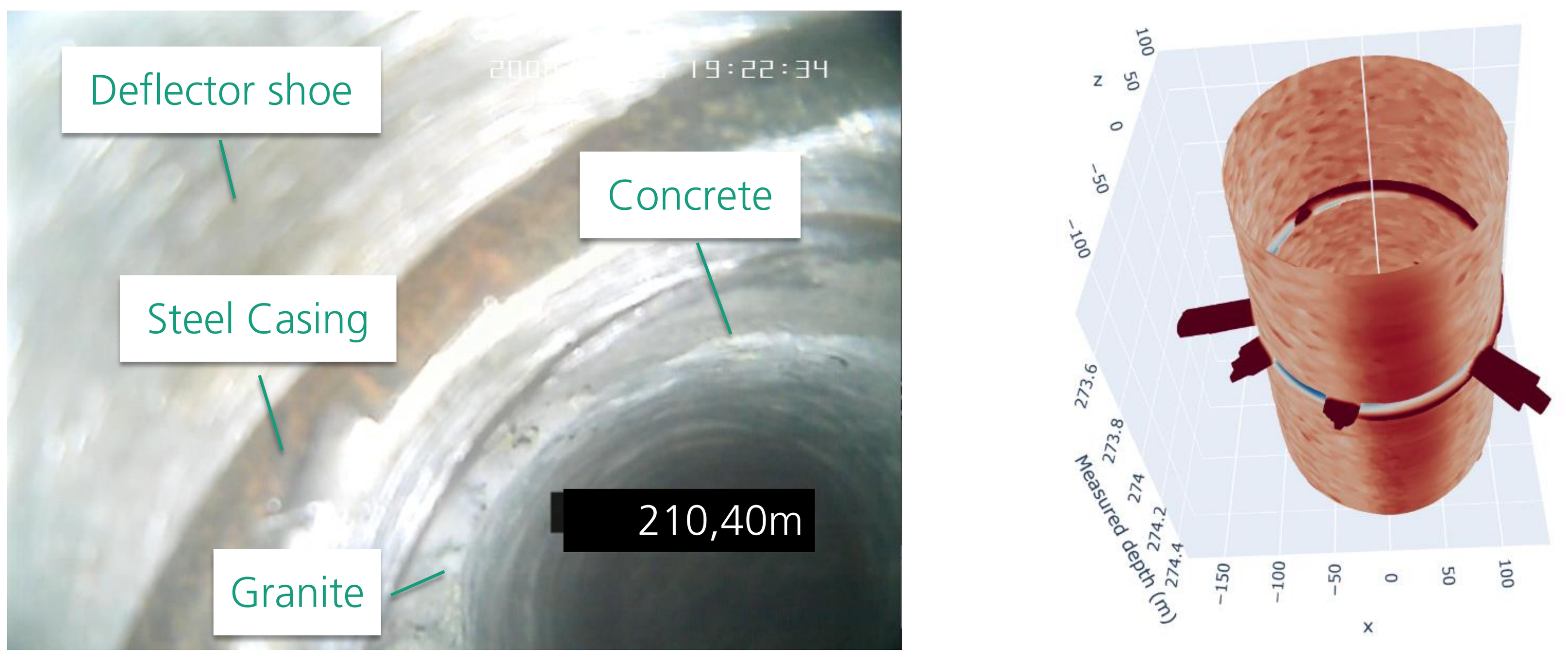

Fig. 4: Downhole camera image showing the entrance of H2-2 (left), ATV caliper log showing a 3D reconstruction of the borehole including micro-sidetracks from initial open-hole tests (right)

A micro-borehole camera was used to inspect each micro-sidetrack and determine the actual length. Fig. 4 shows the entrance of one of the micro-sidetracks. It can be clearly seen how the casing was drilled first, then the concrete, and finally the granite. The time required to drill the casing ranged from 30 to 60 minutes in each case. The rate of penetration (ROP) when drilling the granite was between 1-3 m/h.

Conclusion

Tests have proven that the MTD can be used to drill micro-sidetracks from a well through steel casing into hard rock such as granite. This way, surrounding fracture zones can be connected and production rates can be increased in a cost-effective manner. This was not possible for us with previous technologies such as conventional Radial Jet Drilling – RJD [3] and now opens up new possibilities for the geothermal industry.

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