Volatiles Analysis of Cuttings from the FORGE 58-32 Well-“Logging” High Temperature Wells, Evaluating Communication Pathways, and Implications for Completions in Enhanced Geothermal System Wells

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Cuttings from the Frontier Observation for Research in Geothermal Energy (FORGE) Phase 2 58-32 well at the Milford site in Utah were analyzed in late 2021 using rock volatiles stratigraphy (RVS). 58-32 was drilled as a test bed for enhanced geothermal system (EGS) activities targeting a granitoid encountered at ~3200 ft with temperatures ≥175°C present below ~6500 ft. The granitoid has little natural permeability and must be stimulated to provide an appropriate reservoir for EGS. Cuttings were analyzed from above the granitoid at 3000 ft to 7500 ft near TD; sampling was denser near the granitoid interface and the in three 2019 granitoid stimulations zones. RVS data provided unique insights into communication pathways along faults and fractures, showed strong correlations to porosity and fracture density-offering an opportunity to log the higher temperature sections of the well where wireline tools do not function, and demonstrated relationships that appear to have been predictive of the success of the 2019 stimulations.

RVS is an advanced geochemical technique that extracts, identifies, and quantifies 35+ entrained volatiles including water, sulfides, noble gases, carbon dioxide, and molecular oxygen and nitrogen. The volatiles are extracted by a series of gentle (no heat or solvents used) vacuum extractions and measured on a unique cryo-trap mass spectrometry system developed and built by Advanced Hydrocarbon Stratigraphy; the ease with which volatiles are extracted provides information on the environments where they reside. Cuttings or core samples sealed at the well site can be used for RVS, but legacy materials, including low porosity rock types, can be effectively analyzed years after drilling; the 58-32 cuttings were 4+ years old when analyzed. Legacy samples are crushed during analysis opening tight pore spaces/exposing fresh surfaces and generating a mechanical strength index. RVS data were combined with other data from 58-32 including limited wireline data, an image log to TD, other cuttings data, and stimulation information. This combination allowed for validation of RVS signatures from other applications. Major findings include: correlation of water content to porosity and fracture density-water, in small quantities, is present in what available porosity there is; the distribution of various sulfur species, CO_2, and helium show correlations to faults and fractures providing information on communication along these features; helium shows discrete build ups at some changes in minerology likely indicating tight rock features serving as baffles/seals. Perhaps most importantly water and mechanical strength measurements appear to be predictive of stimulation experiences; of the three 2019 stimulation zones the highest mechanical strength and lowest water content are observed in stimulation zone 3 which was considered not to be successfully stimulated due to a lack of critically stressed fractures. "

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