

Characterizing the Effects of Laser Perforation on Carbonate Rocks

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ABSTRACT

Perforation is an essential to provide channels for hydrocarbons to flow from reservoirs into wells. High-power laser radiation (HPLR) has shown great potential to provide an alternative means for drilling and perforation. HPLR is contactless and waterless technology that can improve conductivity and reduce general damage to the rock formation. The dynamics in this application are involved and intense; yet, they can be controlled to achieve different applications in subsurface environments. In our work we develop a comprehensive characterization protocol to determine the effect of laser radiation on rocks. Here we present the elements of a comprehensive characterization of laser-perforated rocks; introduce the principles of laser-rock interaction; describe the physical effects through advanced characterization results; and discuss future developments. Since a significant proportion of Middle East reservoirs are carbonates, the first experiments were done on carbonate samples from US quarries. In a later phase we will extend the study to sandstones and shale reservoir rocks from the Middle East. The characterization process takes advantage of advanced tools and qualitative petrology to describe the physical and chemical changes in the laser-perforated samples. We use Micro CT to measure the changes in porosity, connectivity, and general structure of the samples; thin-section, XRD, and XRF to analyze chemical and mineralogical changes; thermal gravimetric analysis to gauge thermodynamic properties; and UV-VIS-IR to quantify electromagnetic changes. The results, coupled with real-time observations of the process, provide an in-depth view of the physical dynamics. It shows how lasers can alter the inner structure of the rocks, change their porosity, and affect the pore connectivity. This insight is critical to understand the effects, optimize the subsurface photonic tools, and expand their applications.