



DELIVERABLE D3.1

Petrophysical effects induced by laser on hard/soft rocks

Lead Beneficiary: UNIPD

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ABBREVIATIONS AND GLOSSARY OF ACRONYMS

Acronym	Extended definition
BSE	Backscattered electron
DG	Department of Geosciences
DLT	Discrete Laser Tests
EDS	Energy Dispersive Spectroscopy
FEG	Field emission gun
IR	Infrared
LLT	Linear Laser Tests
OM	Optical microscopy
PPL	Plane polarized light
ROP	Rate of Penetration
SE	Secondary electron
SEM	Scanning Electron Microscopy
SR	Red sandstone
SY	Yellow sandstone
TCS	Thermal Conductivity Scanner
UNIPD	University of Padua
WD	Working distance
XPL	Crossed polarized light
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence
Symbol	Definition
P	power (kW)
ρ	density (g/cm ³)
P_p	power density (W/cm ³)
E	Young's Modulus (GPa)
Ab	water absorbance (%)
V_p	P-wave velocity (km/s)
V_s	S-wave velocity (km/s)
ν	Poisson's ratio (-)
G	shear modulus (GPa)
λ	thermal conductivity (W/m·K)
C_p	volumetric thermal capacity (J/m ³ ·K)
α	thermal diffusivity (m ² /s)
S_E	specific energy (kJ/cm ³)
t_i	time of irradiation (s)
T	temperature (°C)
T_s	average temperature of spallation (°C)

EXECUTIVE SUMMARY

This report focuses on the project activities related to the laser-rock interactions studied in the three experimental laser drilling tests, performed during two campaigns in the dedicated test facility of Fraunhofer-IAPT in Hamburg, Germany. Three types of lithologies were selected for initial laboratory tests: granite, sandstone, and limestone. The petro-thermo-mechanical phenomena occurring during laser irradiation, such as spallation, melting, and evaporation, were recognized and described in detail. The laser drilling process was assessed by IR imaging, and analysis of irradiated rocks. This comprehensive approach provided information about the most effective process for rock removal as being spallation, occurring at low temperature ($<700^{\circ}\text{C}$) and capable of drilling boreholes up to 18cm in diameter. Melting-evaporation drilling was also achieved ($>2000^{\circ}\text{C}$). The presence of vitrified walls was confirmed, however for a much smaller borehole diameter $< 2\text{cm}$. The laser working parameters and experimental setup were optimized based on the observed phenomena. After the experiments, sections of boreholes were cut out and examined. The microscopic observations on the unaffected and affected rock thin sections have been performed with use of polarized optical and scanning electron microscopy revealing micro-fracturing of the rock. The depth and density of damages was characterized and quantified.

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