

ROCK FRACTURE IN GEOTHERMAL ENERGY SOURCES: APPLICATION OF THE TCD AND THE SED CRITERION

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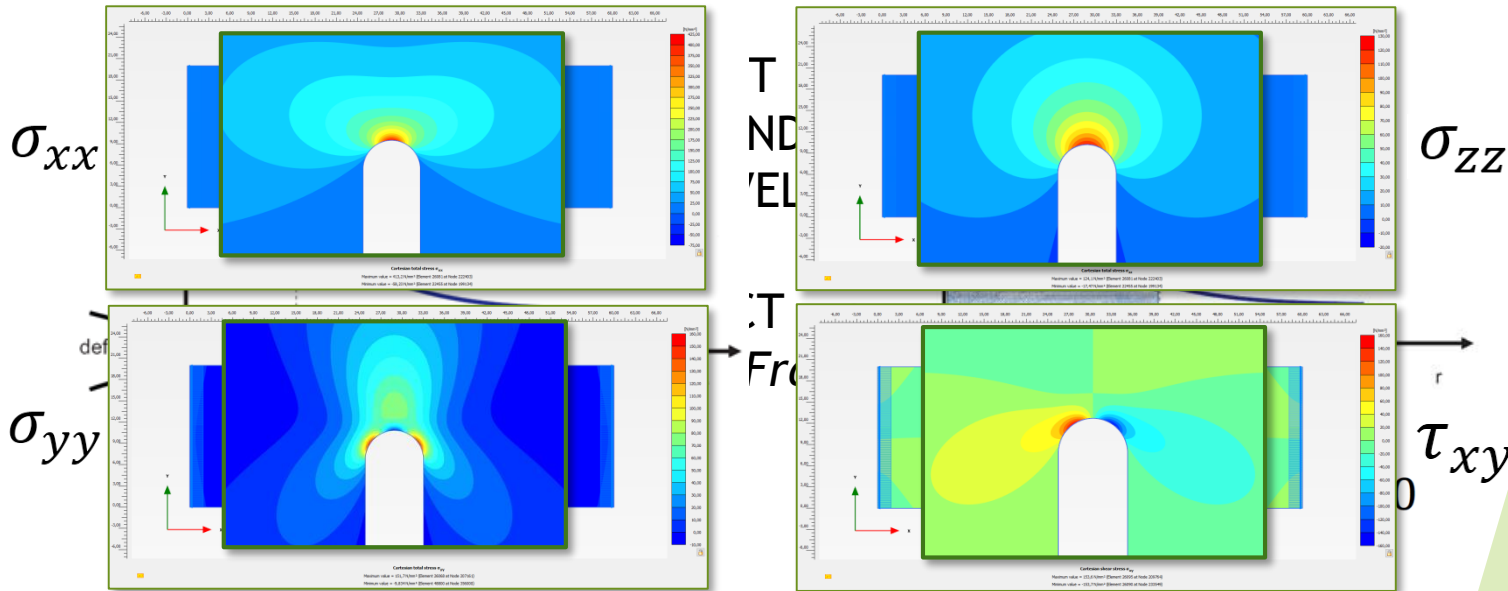
NATIONAL PLAN PROJECT
(Ref.: BIA2015-67479-R)

INTRODUCTION

- ▶ THIS PROJECT AIMS TO ANALYZE THE BRITTLE BEHAVIOR OF ROCKS SUBJECTED TO HIGH TEMPERATURES AS THOSE COMMON IN GEOTHERMAL APPLICATIONS (UP TO 250°C).

▶ THEORY OF THE CRITICAL DISTANCES (TCD)

▶ STRAIN ENERGY DENSITY (SED) CRITERION.



INTRODUCTION

CURRENT
SITUATION

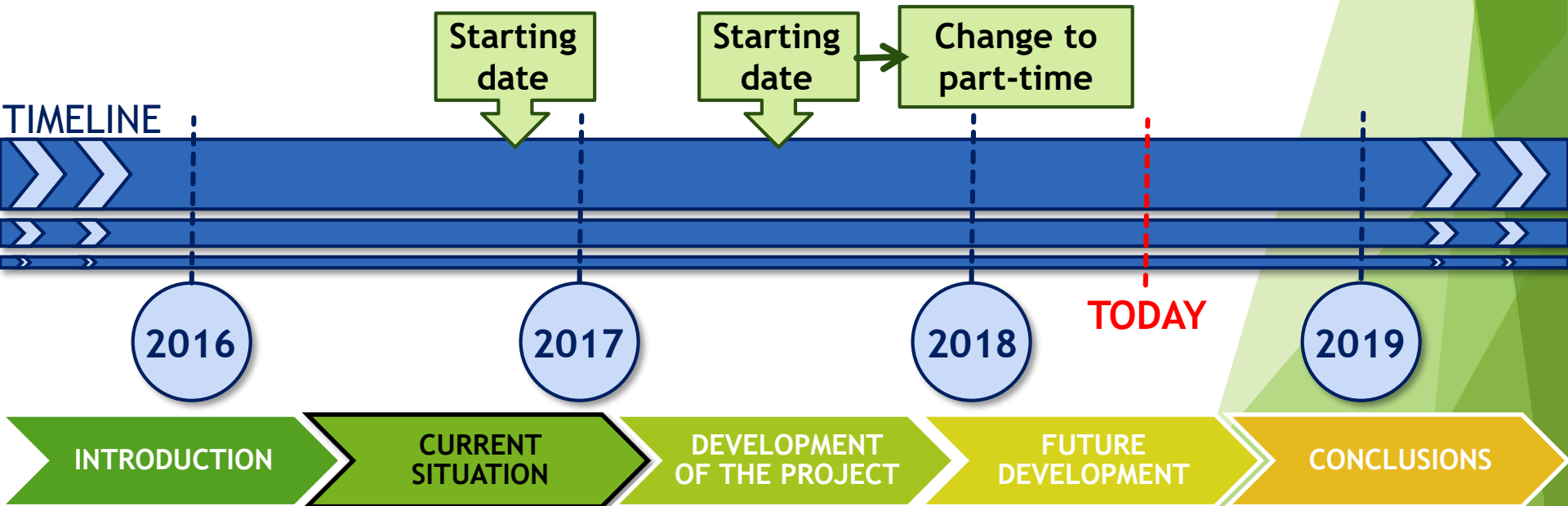
DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

CURRENT SITUATION

- ▶ OFFICIAL STARTING DATE OF THE THESIS (FULL-TIME): 23/11/2016
- ▶ START WORKING AT *CIMENTACIONES ABANDO SL* IN BILBAO (PART-TIME: 60%): 10/07/2017
- ▶ CHANGE WORKING REGIME OF THE THESIS TO PART-TIME (40%)



DEVELOPMENT OF THE PROJECT

BASIC SKILLS

- Systematic understanding of a field of study and command of the skills and research methods related to the field. **CB11**
- Skill to conceive, design or create, implement and adopt a substantial process of research or creation. **CB12**
- Skill to contribute to the enlargement of the knowledge limits through an original research. **CB13**
- Skill to carry out a critical analysis and assessment and synthesis of new and complex ideas. **CB14**
- Skill to communicate with the academic [...] community [...] in the ways and languages of common use in the international scientific community. **CB15**
- Skills to encourage [...] the scientific, technological, social, artistic or cultural progress in a society based on knowledge. **CB16**

CAPACITIES AND PERSONAL ABILITIES

- Cope in context in which there is little specific information. **CA01**
- Find the key questions to be answered to solve a complex problem. **CA02**
- Design, create, develop and undertake new and innovative projects in the knowledge scope. **CA03**
- Work both in teams and individually in an international or multidisciplinary context. **CA04**
- Integrate knowledges, face complexity and formulate judgements with limited information. **CA05**
- Intellectual criticism and defence of solutions. **CA06**

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

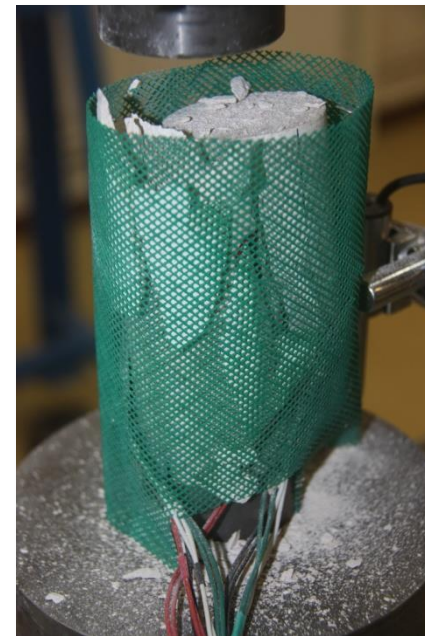
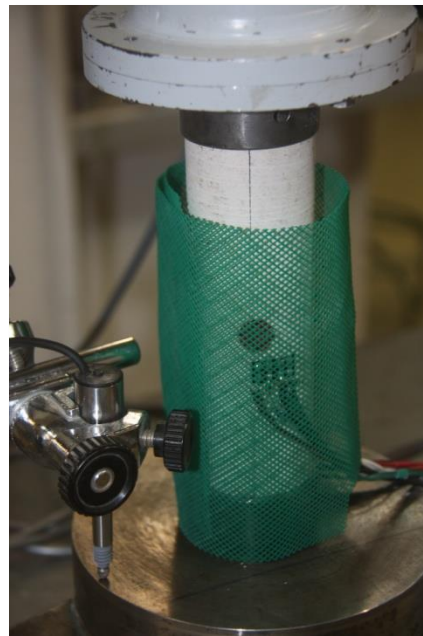
FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

LABORATORY CAMPAIGN:

TESTS	ROCKS	REPET.	TEMP.	TOTAL
SIMPLE COMPRESSION TETS	4	12	1	48



CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

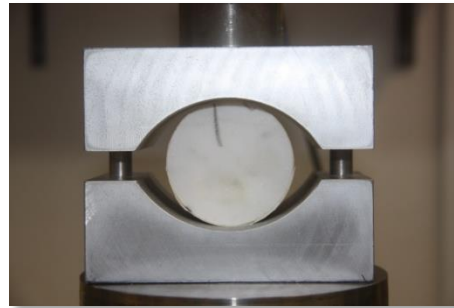
FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

LABORATORY CAMPAIGN:

TESTS	ROCKS	REPET.	TEMP.	TOTAL
SIMPLE COMPRESSION TETS	4	12	1	48
BRAZILIAN TESTS	4	6/12	6	288



CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

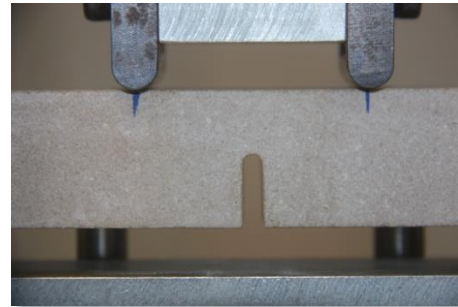
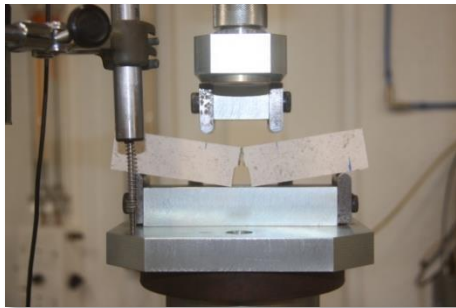
FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

LABORATORY CAMPAIGN:

TESTS	ROCKS	REPET.	TEMP.	TOTAL
SIMPLE COMPRESSION TESTS	4	12	1	48
BRAZILIAN TESTS	4	6/12	6	288
4-POINT BENDING TESTS	4 x 8	6/12	4	792



CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

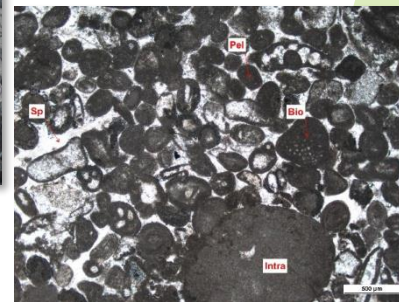
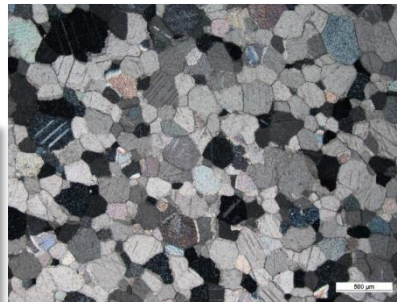
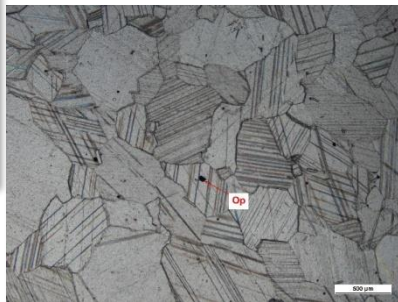
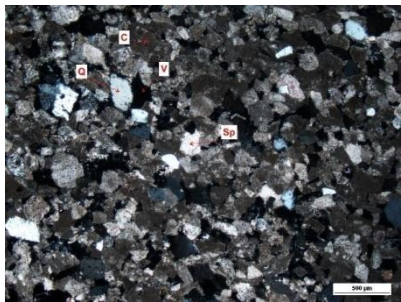
FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

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4-POINT BENDING TESTS	4 x 8	6/12	4	792
PETROGRAPHIC CHARACT.	4	-	-	-



CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

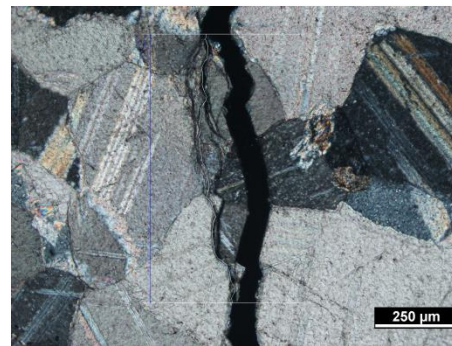
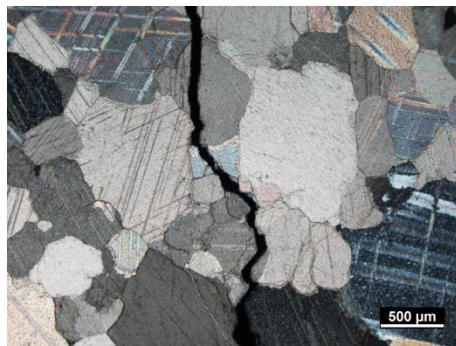
FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

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SIMPLE COMPRESSION TETS	4	12	1	48
BRAZILIAN TESTS	4	6/12	6	288
4-POINT BENDING TESTS	4 x 8	6/12	4	792
PETROGRAPHIC CHARACT.	4	-	-	-
MICROSTR. ANALYSIS	4 x 3	6/12	1	96



CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

PUBLICATIONS:

- ▶ **NOTCH EFFECT ON THE FRACTURE OF SEVERAL ROCKS: APPLICATION OF THE THEORY OF THE CRITICAL DISTANCES** - *J. Justo, J. Castro, S. Cicero, M.A. Sánchez-Carro, R. Husillos (2017). Theoretical and Applied Fracture Mechanics 90, 251-258.*
- ▶ **ENERGETIC APPROACH FOR FRACTURE ASSESSMENT OF SEVERAL ROCKS CONTAINING U-SHAPED NOTCHES: APPLICATION OF THE SED CRITERION** - *J. Justo, J. Castro, S. Cicero (2018, under revision). International Journal of Rock Mechanics and Mining Sciences.*

CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

COURSES:

- ▶ RESERVOIR GEOMECHANICS: *Prof. Mark Zoback - University of Stanford*
- ▶ SAP2000
- ▶ WINTER SCHOOL ON GEOMECHANICS FOR ENERGY AND THE ENVIRONMENT: *Prof. L. Laloui y A. Ferrari - EPFL*

CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT

CONGRESSES:

- ▶ XX SIMPOSIO NACIONAL DE INGENIERÍA GEOTÉCNICA Y 5AS JORNADAS LUSO ESPAÑOLAS DE GEOTECNIA - *La Coruña*
- ▶ INTERNATIONAL SYMPOSIUM ON NOTCH FRACTURE - *Santander. Paper: Notch effect on the fracture of several rocks: application of the Theory of the Critical Distances*
- ▶ EUROPEAN PLAXIS USERS' MEETING - *Schrobenhausen (Alemania). Paper: FEA for fracture assessment on rocks containing U-shaped notches: An energetic continuum approach*
- ▶ IX SIMPOSIO NACIONAL SOBRE TALUDES Y LADERAS INESTABLES - *Santander*

CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

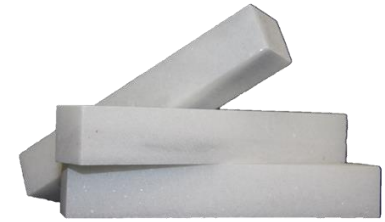
CONCLUSIONS

DEVELOPMENT OF THE PROJECT



STRENGTHS

WEAKNESSES



OPPORTUNITIES

THREATS



CB11

CB12

CB13

CB14

CB15

CB16

CA01

CA02

CA03

CA04

CA05

CA06

INTRODUCTION

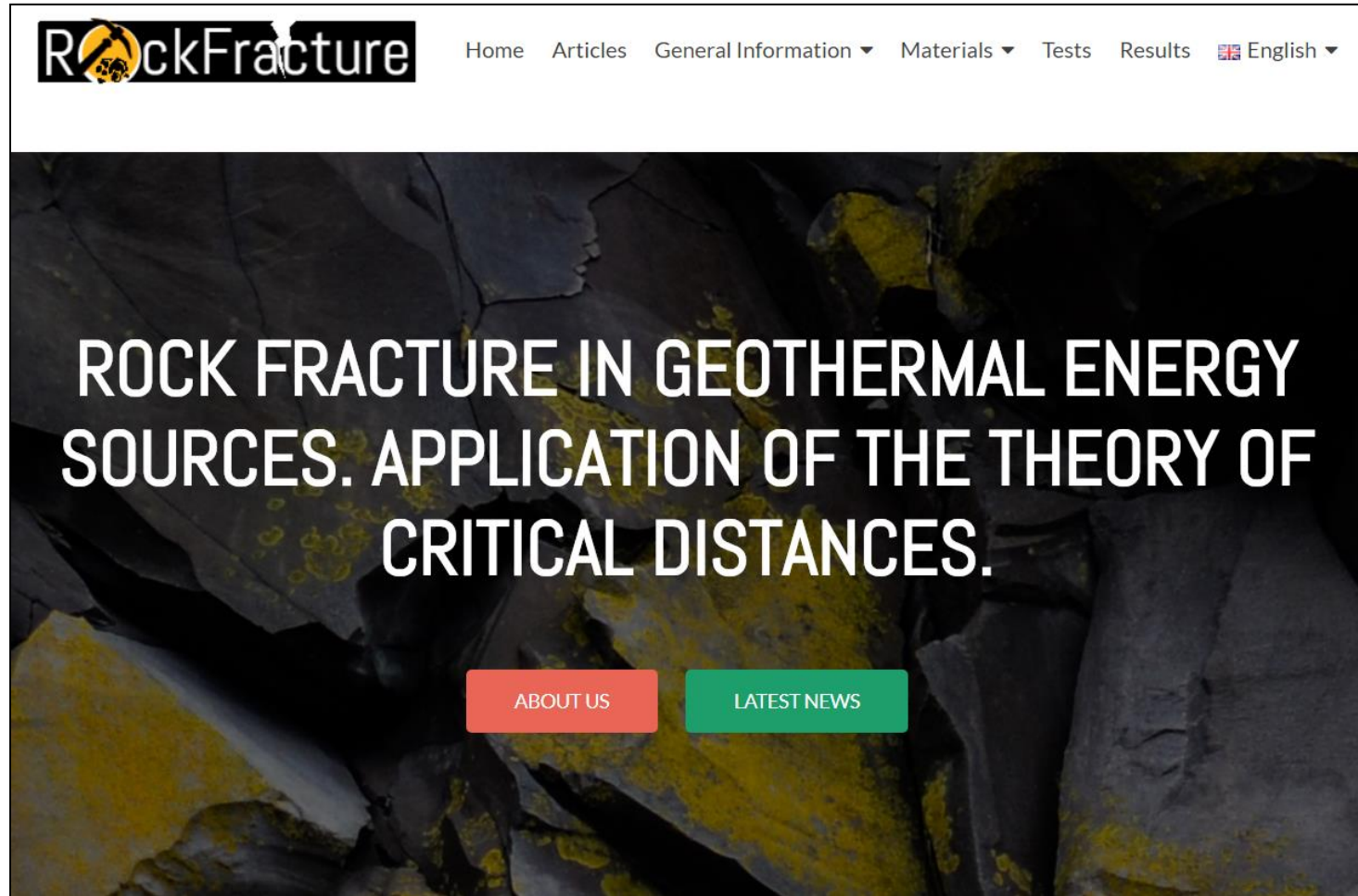
CURRENT SITUATION

DEVELOPMENT OF THE PROJECT

FUTURE DEVELOPMENT

CONCLUSIONS

DEVELOPMENT OF THE PROJECT



INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

FUTURE DEVELOPMENT

LABORATORY CAMPAIGN:

TESTS	ROCKS	REPET.	TEMP.	TOTAL
SIMPLE COMPRESSION TETS	4	6	3	72
3-POINT BENDING TESTS (MIXED MODE)	1x8x5	6	1	240
THERMAL CONDUCTIVITY	4	3	-	12
THERMAL DILATATION	4	4	12	192
TRIAXAL TEST	4	3	6	72
MICROSTR. ANALYSIS	4 x 3	6	1	72
OTHERS...	?	?	?	?



INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

FUTURE DEVELOPMENT

CONGRESSES:

- ▶ **EUROCK2018: GEOMECHANICS AND GEODYNAMICS OF ROCK MASSES** - *Saint Petersburg (Russia), 22-27 May 2018. Paper: Comparison between an energetic continuum approach and a local failure criterion for the fracture prediction of rocks containing U-shaped notches*
- ▶ **IX CONFERENCE ON NUMERICAL METHODS IN GEOTECHNICAL ENGINEERING** - *Oporto (Portugal), 25-27 June 2018. Paper: Elastic and plastic anisotropy in soft clays: a constitutive model*
- ▶ **XXVI EUROPEAN YOUNG GEOTECHNICAL ENGINEERS CONFERENCE** - *Graz (Austria), 11-14 September 2018. Paper: FEA for fracture assessment of rocks through and energetic approach: Application of the SED criterion*
- ▶ **INTERNATIONAL SYMPOSIUM ON ENERGY GEOTECHNICS** - *Laussane (Switzerland), 25-28 September 2018. Paper: Influence of temperature on the fracture toughness of several rocks*
- ▶ **XVII EUROPEAN CONFERENCE ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING** - *Reykjavik (Iceland), 1-6 September 2019. Paper: Influence of temperature on the tensile strength of a limestone and a marble*

INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

FUTURE DEVELOPMENT

OTHERS:

- ▶ PUBLICATIONS, COURSES, ETC.
- ▶ COMPULSORY MULTIDISCIPLINARY TRAINING (ADVANCED COURSE) - EDUC.
- ▶ INTERNATIONAL MOBILITY - TU BERGAKADEMIE FREIBERG (3 MONTHS)



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INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS

CONCLUSIONS

- ▶ THE LABORATORY CAMPAIGN AND SCHEDULE ARE BEING FULFILLED AND DO ALLOW THE VALIDATION OF BOTH THE TCD AND THE SED CRITERION FOR ROCK FRACTURE ASSESSMENT.
- ▶ THE OBTAINED RESULTS HAVE LED TO TWO PUBLICATIONS (Q1) SO FAR, BUT NEW PUBLICATIONS ARE EXPECTED.
- ▶ THE DEGREE OF ACCOMPLISHMENT OF BOTH THE BASIC SKILLS AND THE CAPACITIES AND PERSONAL ABILITIES IS ADEQUATE. HOWEVER, THE FUTURE DEVELOPMENT OF THE PROJECT (COURSES, PUBLICATIONS, CONGRESSES,...) AIMS TO CONTINUE WORKING ON THESE SKILLS AND CAPACITIES.
- ▶ AN INTERNATIONAL MOVILITY IS EXPECTED FOR 2019 (3 MONTHS): TU BERGAKADEMIE FREIBERG AT GERMANY.
- ▶ THE DEVELOPMENT OF THE THESIS IS BEING CARRIED OUT AS PLANNED INITIALLY, ALTHOUGH THE WORKING PLAN AND TIMETABLE HAVE BEEN ADAPTED TO THE CURRENT WORKING REGIME.

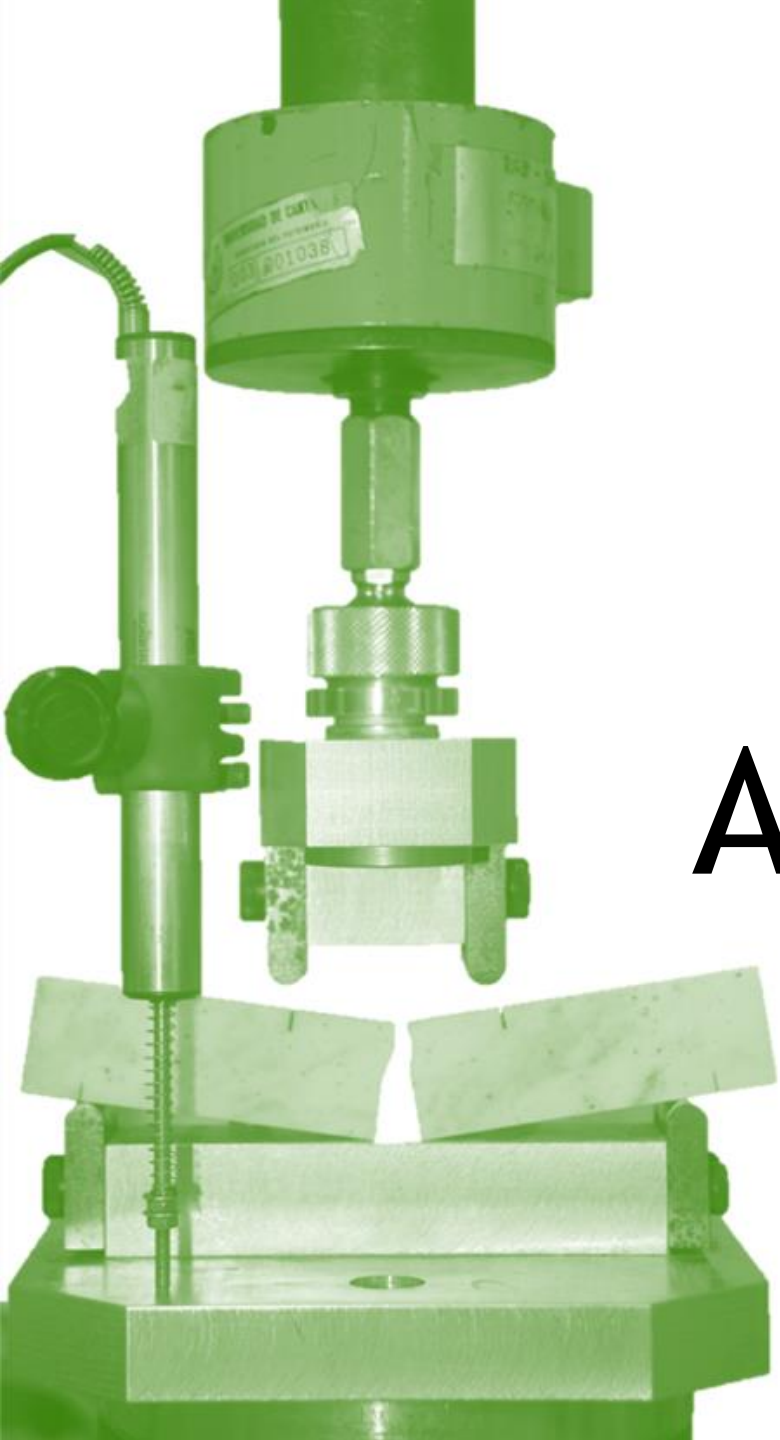
INTRODUCTION

CURRENT
SITUATION

DEVELOPMENT
OF THE PROJECT

FUTURE
DEVELOPMENT

CONCLUSIONS



**THANK
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