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Training of Geothermal Experts: The Joint Master Program in Applied Geophysics of TU Delft, ETH Zurich and RWTH Aachen

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ABSTRACT

The Joint Master in Applied Geophysics is a two-year M.Sc. program offered by three of Europe´s leading science and technology institutions: TU Delft, ETH Zürich and RWTH Aachen University. The program builds on the strengths and complementary expertise in Earth Sciences at these three universities. It offers a combination of study and research, leading to an outstanding qualification in applied geophysics. Apart from hydrocarbon exploration and management, the program focuses on environmental and engineering geophysics and in particular, on geothermal energy exploration and management. Geophysical techniques supporting geothermal and hydrocarbon exploration and management are taught not only in the classroom, but in the field and at the processing console as well. Future geothermal experts are taught about field and laboratory techniques for geothermal prospecting; thermophysical rock properties; thermal signatures of various transient and steady-state heat transfer processes; quantifying flow from its thermal signature; types of geothermal resources; assessment of geothermal potential and evaluation of corresponding heat mining techniques; design calculations for heat mining installations. Teaching methodologies include a modern internet-based Live-Voting application, which helps quickly identify how well the students understood lecture materials. The Applied Geophysics program is run in close collaboration with industry. Companies support the program by providing funding, grants for scholarships, opportunities for research projects, and by experts for special lectures or co-supervision of master thesis projects.

1. INTRODUCTION

The IDEA League Joint Master Programme in Applied Geophysics Geophysics is a two-year M.Sc. program which was launched in 2006 by the IDEA League universities TU Delft, ETH Zurich and the RWTH Aachen University.

The program takes advantage of complementary expertise in Earth Sciences at these three universities. TU Delft is well known for its hydrocarbon exploration and management, close ties to major petroleum companies and geophysical service providers, and a worldwide alumni network. ETH Zürich has its principal strength in engineering and environmental geoscience, close cooperation with civil engineers, and is proud of 21 Nobel Prizes bestowed in various disciplines. RWTH Aachen is Germany´s largest technical university, and is among the top eleven universities in Germany (http://www.excellence-initiative.com/start , http://www.exzellenz-initiative.de/foerderlinien/zukunftskonzepte). It has well-known expertise in basin modeling and geothermal exploration and management, and close collaboration with industry. For more information on the three universities, do visit their internetsite: www.tudelft.nl , www.ethz.ch and www.rwth-aachen.de .

The histories of Aachen, Delft and Zürich date back to medieval time, and their historic character is still visible in the old city centers. All three cities have large student populations with vibrant student life and they share an international outlook. With the excellent public transportation systems, much of Europe is within easy reach.

The Program combines coursework and research, thus bringing the student into the focus of modern industrial developments in applied geophysics and leading to an outstanding qualification in the field. Apart from hydrocarbon exploration and management, the program focuses on environmental and engineering geophysics and in particular, on geothermal energy exploration and management.

The two-year program comprises 18 months of course work, divided into three teaching periods in Delft, Zürich, and Aachen. During this time, students attend lectures and participate in extensive hands-on data acquisition and processing exercises. Lectures on various research-level subjects are also included in the program. The final five months are devoted to a research thesis project at one of the three universities or in industry. The thesis is a key component in the preparation and training of specialists for the practical world.

Figure 1 provides an overview of the student numbers, giving a glimpse into the generally rising popularity of the Program. High admission standards and program quality, as well as a closely-knit student community have resulted in an excellent rate of on-time completion of the program, of over 92 %. To accommodate the need of students from countries around the world to enroll earlier, the application deadline for comprehensive scholarships was moved from 1 April during the academic year 2011/12 to the much earlier date of 1 November 2011 (with the coincidental reduction in the number of applications).

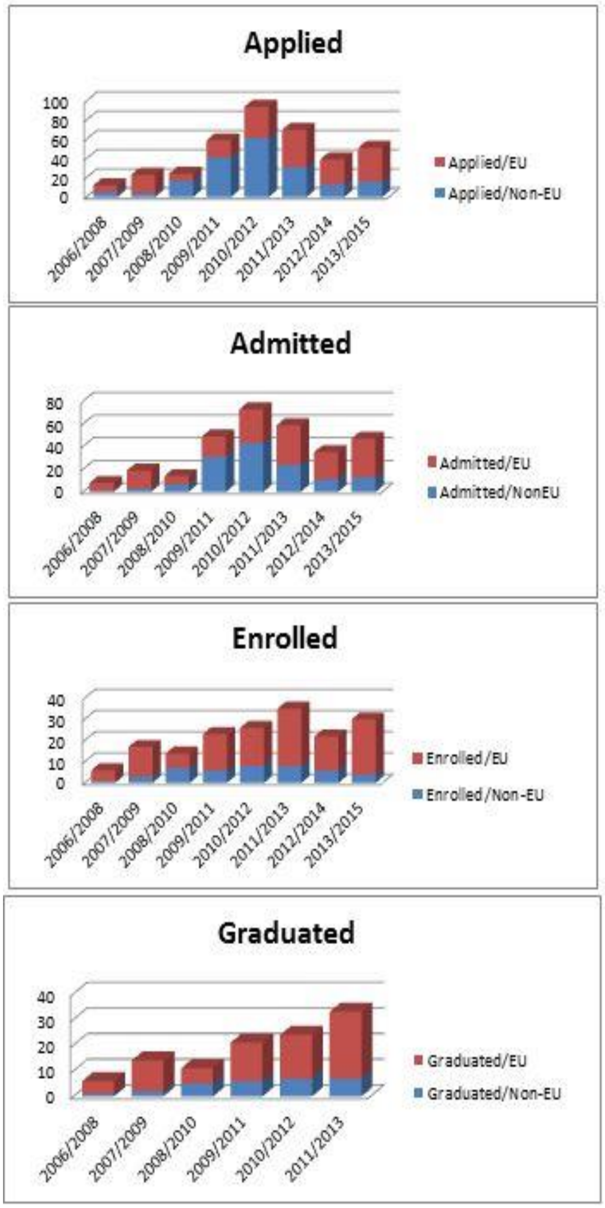

Figure 1: Development of student numbers (number for applied and admitted students 2006/2008 are as estimated). European Union (EU) numbers also include students from EFTA countries (e.g. Switzerland).

Participation of students from all around the world in the program has been one of the major highlights of the program: Figure 2 provides information about the worldwide distribution of the student origin.

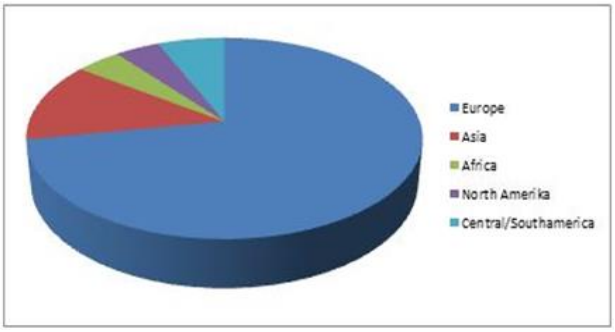

Figure 2: Worldwide distribution of students by origin (over the period 2006-2013).

In Figure 3, multicultural origin of European students is highlighted, coming from 16 countries (with applications from another two European countries for 2014/15).

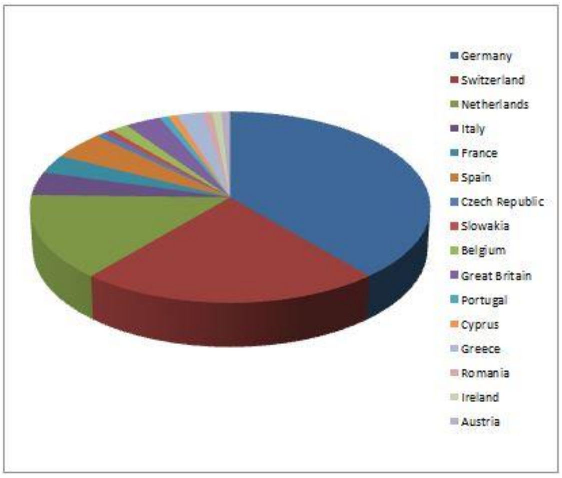

Figure 3: Distribution of European students by country (2006-2013).

These statistics illustrate that (i) the student numbers are rising, and (ii) there is a large diversity among the students.

2. COURSEWORK

Course subjects comprise geothermics; petrophysics; geophysical logging; sedimentary basin modeling and dynamics; geophysical modeling and inversion; electromagnetic exploration; reflection seismology; seismic imaging; hydrology; rock-fluid interactions; soil mechanics; exploration geology; sequence stratigraphy; Small-scale NMR, electrical & spectral induced polarization methods; remote sensing of sedimentary basins; engineering geophysics; prospect evaluation/risk analysis/portfolio management.

Geophysical techniques supporting geothermal and hydrocarbon exploration and management are taught in a multifaceted program which includes both theoretical and practical aspects.

Teaching methods include hands-on simulation and data analysis exercises, field work both in exploration methods and borehole logging and a modern internet-based Live-Voting application, which helps identifying quickly how well the students understood the lecture.

Within the geothermics course, students get to understand thermal rock properties (Hartmann et al., 2007), and terrestrial heat transport by heat conduction and advection. They learn to appreciate flow-related thermal signatures and to quantify flow in various transient and steady-state heat transfer processes. They can use this knowledge in tasks such as the detection of minute subsurface flow (Zschocke et al. 2005) and the evaluation of the geothermal potential of a given region. They are acquainted with different types of geothermal reservoirs and evaluation of the corresponding prospecting techniques and heat mining strategies, as well as different techniques available for designing suitable heat mining installations (Huenges, 2010).

A large variety of Master thesis topics is made available to students in the program each year, and among these are generally also diverse topics in geothermal research and development. Students who select these topics can work with a state-of-the-art general-purpose reactive transport simulation code, SHEMAT (Clauser, 2003), thus acquiring skills in reservoir modeling with a tool capable of handling a wide variety of thermal and hydrogeological problems.

3. INDUSTRIAL PARTICIPATION

The Applied Geophysics program is run in close collaboration with industry. Companies support the program by providing funding, grants for scholarships, opportunities for research projects, and by experts for special lectures or co-supervision of master thesis projects. Companies participate in opportunities to get to know the students and to present company research opportunities, such as at the annual master theses presentation event, and the events of presenting scholarships at the welcome ceremony in Delft and at the awards ceremony at the historical Aachen city hall. Industry-sponsored stipends from Enel, e.on, RWE Dea, Shell, and Wintershall are available for international and European students as comprehensive and tuition scholarships. More information can be found at http://www.idealeague.org/geophysics/admission/scholarships .

4. CONCLUSION

In a highly acclaimed setting of three Europe´s Universities, TU Delft, ETH Zürich and the RWTH Aachen University, an inspiring and internationally diverse Master program advances the training of future geothermal experts. Students are taught about field and laboratory techniques for geothermal prospecting; thermophysical rock properties; thermal signatures of various transient and steady-state heat transfer processes; quantifying flow from its thermal signature; types of geothermal resources; assessment of geothermal potential and evaluation of corresponding heat mining techniques; design of heat mining installations. Master thesis projects in foundational and industrial geothermal research give a special opportunity to students to acquire skills in geothermal reservoir modeling and simulation.

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