Joint MSc programme in applied geophysics: a new concept in geophysics education

Alan G. Green* and Hansruedi Maurer (ETH Zurich), Evert Slob and Kees Wapenaar (TU Delft), and Christoph Clauser and Ralf Littke (RWTH Aachen) introduce a new joint MSc programme in applied geophysics run by three of Europe's leading education institutions specializing in earth sciences.

Readers of *First Break* are well aware of humanity's dependence on the Earth's resources. The principal sources of energy and the vast majority of raw materials required for the construction, manufacturing, and chemical industries are found in the outer layers of our planet. In many areas, vital water supplies are stored in the shallow underground and it is in the upper few tens of metres where household and industrial wastes are commonly buried. Knowledge of the shallow underground is important for the planning of major buildings and civil engineering projects and for predicting the consequences of natural catastrophes.

Most of the easily accessible natural resources were discovered and extracted during the 19th and 20th centuries. Recently, the booming economies of India, China, and Indochina and other factors have resulted in the demand for some key natural resources exceeding current supply capabilities. To meet the growing needs of the world's expanding population for natural resources, to resolve problems created by our misuse of the land, to provide critical data to architects and civil engineers, and to forecast the effects of natural disasters, it is necessary for us acquire ever more detailed knowledge of the structure, composition, and condition of the outer skin of the Earth. Fortunately, similar suites of geophysical tools can be used for the exploration and management of deeply buried natural resources and for tracing shallow contaminant plumes escaping from poorly conceived landfills.

During the period when natural resource prices were low (early 1980s to the early 2000s), the hydrocarbon, metallic mineral and related service industries substantially reduced their recruitment of applied geophysicists. As a consequence, fewer students entered the earth sciences and eventually a number of universities eliminated their applied geophysics programmes. These events have resulted in the present significant shortfall in highly qualified geophysicists. With the upcoming retirement of many geophysicists who entered the workforce three to four decades ago, this shortfall is likely to be exacerbated over the next few years.

To help satisfy the rising demand for highly qualified applied geophysicists, three of Europe's top technical universities (TU Delft, ETH Zurich, and RWTH Aachen) have recently launched a joint MSc programme in applied geophysics. Students receive training at all three universities to take advantage of the complementary expertise available in the respective earth science departments. Those who successfully complete the programme of study and research will be well qualified in applied geophysics related to either hydrocarbon exploration and management (TU Delft's strong points) or environmental and engineering investigations (ETH Zurich's strong points), including geothermal energy exploration and management (RWTH Aachen's strong points), with a solid background in the other speciality.

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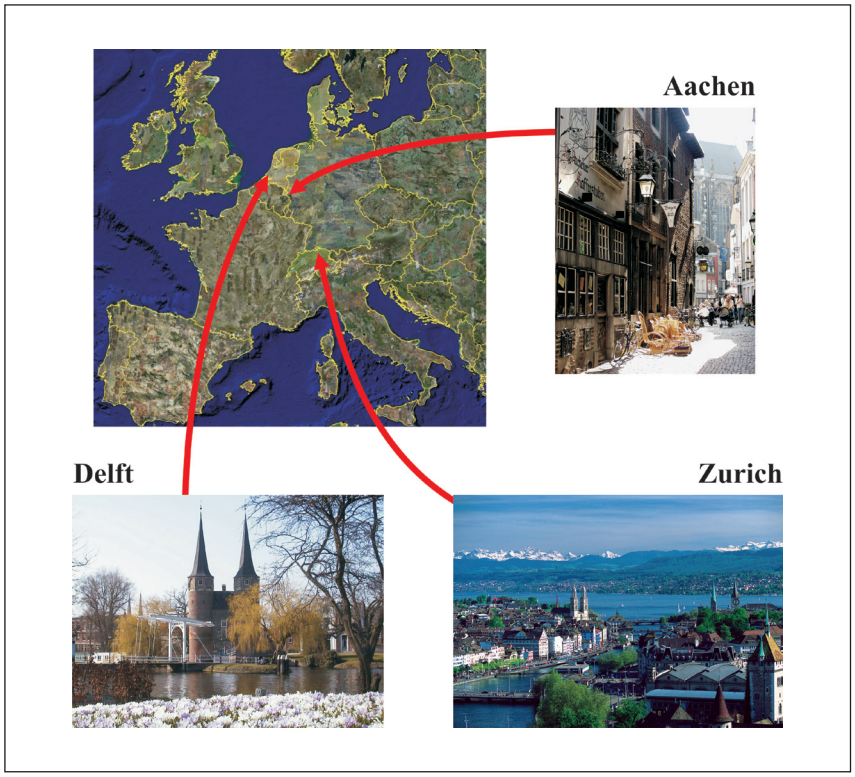
Academic aspects

Only top students are accepted for the joint MSc programme, which comprises a large number of core courses, a small selection of specialized courses and a final research-oriented thesis project (see table). The core courses provide the students with fundamental information essential for practising applied geophysics. In return for teaching the basic processes and important state-of-the-art technologies, independent thinking and integration of concepts and information are demanded of the students.

Throughout the two-year joint MSc programme, all of which is taught in English, the students gain hands-on experience in a wide variety of applied earth science topics. As examples, they each complete the processing of an industry seismic reflection data set using state-of-the-art software and, in teams, they design and execute a one-month investigation aimed at resolving actual engineering, environmental, or archaeological problems. The most modern surveying equipment (e.g., differential GPS, self-tracking laser theodolites) and geophysical instruments (e.g. magnetic, gravity, multi-channel seismic, ground-penetrating radar, multi-electrode geoelectric, time- and frequency-domain electromagnetic, nuclear magnetic resonance) are available for the investigations. After the field campaign, the teams are responsible for the processing and interpretation of the acquired data and for reporting the results of their studies.



The specialized courses reflect the research interests of the participating applied geophysics groups. They prepare the students for choosing a thesis research area that best suits their interests, knowledge, skills, and experience. The final theses are the result of approximately eight months of research, report writing, presentation, and examination. Many of the theses involve the integration of theory with data derived from field observations, field tests or laboratory work. The academic quality is guaranteed by integrating the theses into the research activities of one of the partner universities or a suitable industry, government or other university laboratory.

Culture and recreation

In addition to the obvious benefits of receiving a first-class academic education, the joint MSc students from diverse countries and cultures learn and profit from the experience of living in three of Europe's most dynamic mid-sized cities characterized by different western cultures. The acquired awareness of cultural diversity helps prepare them for working and assuming leadership roles in various modern companies and research environments.

Delft, Zurich, and Aachen all have rich heritages with impressive churches, ancient monuments, cobble-stone alleys, and a pedestrian-only old town centres. Although the history of the cities go back to medieval times, their outlook is now firmly rooted in the present with many high-technology companies and specialized institutes.

All three cities have large student populations with vibrant student life. They also have an international outlook in common. For a relaxing evening, there are numerous street cafés, restaurants, bars, discos, and nightclubs. There is also an abundance of opportunities for students interested in such outdoor activities as hiking, downhill and cross-country skiing, mountaineering, and sailing. Thanks to excellent public transport systems, much of Europe is within easy reach of the three cities (see map).

Although the cities share many features, there are also some notable differences. Delft is distinguished by its network of charming canals, Zurich by its breathtaking views of the Swiss Alps, and Aachen by its mineral and hot springs, at 70 °C Germany's hottest.

Practical aspects

For their course work, the students study together at each university and move between universities as a group. They spend roughly the same amount of time at each university (TU Delft: September to mid-January; ETH Zurich: February to mid-July; RWTH Aachen: the following mid-September to mid-December). Approximately two weeks is allocated for each move between countries and acclimatization to the local living conditions. For the final eight months of the joint MSc programme, the students must select the sites at which they will complete the research for their theses.

The annual tuition fee for students from EU and EFTA countries is €2000.00 (reduced rates are available for certain students) and for students from non-EU/EFTA countries it is €11,000.00. There is a very good chance that top students from non-EU/EFTA countries will have their fees reduced to €2000.00, at least for the first few years of the joint MSc programme. Moreover, industry partners provide a limited number of partial and full scholarships for truly excellent students. Various potential commercial partners are being approached with the intention of securing additional scholarships.

To minimize costs and logistical problems, the universities have organized inexpensive health insurance (currently €36.50 per month) and banking facilities that are valid in the Netherlands, Switzerland, and Germany, and have reserved a variety of inexpensive accommodation (mostly less than €300 per month) for the students. The universities also assist students from non-EU/EFTA countries secure the necessary visas.

Initial reactions

Although the joint MSc programme has only been underway for a few months, the following comments written by two German students - Peter Haffinger (Physics 'Vordiplom', RWTH Aachen) and Philipp von Wussow (Geophysics BSc, Kiel) - suggest that it is going to be successful.

They write: 'The great opportunity to get to know three European cities and their well-known universities combined with the unique educational programme led us to the joint master programme. Even though we have had quite different educational backgrounds, there were nearly no problems in following the lectures. The convergence courses brought us to a similar level in mathematics and geology and the different compulsory lectures and associated exams could be passed with varying degrees of effort. Some courses really demanded a lot of work, but with the very friendly and individual support of the lecturers, we all did quite well. Concerning the contents of the TU Delft periods 1 and 2, we dare to say that we acquired fundamental and necessary knowledge of a wide spread of geophysical applications, especially for hydrocarbon exploration. We now want to apply, deepen, and expand our skills during the next periods at Zürich and Aachen, but also within a challenging Masters thesis.

Formalities, like finding a place to stay or the registration at the town hall, were successfully completed with the

help of TU Delft staff members. All students ended up living in the same building with rooms next to each other, so that social integration has been no problem. Also, the international flair of the student house is a nice benefit. People from all over the world are gathered around us. Our rooms in Zürich have already been provided, such that a smooth continuation of our studies should easily be realized.'

Contacts

Further details on the joint MSc programme, including time schedules, course details and a brochure and application form that can be downloaded, are available at http://www.idealeague.org/geophysics/. This web site also contains addition information on the participating universities and three cities. Enquiries from students interested in registering for the programme and potential industry partners are welcome (E-mail: maurer@aug.ig.erdw.ethz.ch; e.c.slob@tudelft.nl; or c.clauser@geophysik.rwth-aachen.de).

MSc research thesis (8 months)

Convergence courses	Matlab
Geophysical modelling and inversion	Petroleum systems - sedimentary basin modelling
Electromagnetic methods	Exploration geology
Advanced reflection seismology and seismic imaging	Sequence stratigraphy
Reflection seismology processing (practical)	Petrophysics
Rock-fluid interactions	Geophysical logging and log interpretation
Groundwater for geophysicists	Geothermics
Geophysical field work and data processing	Geophysics special methods: nuclear magnetic resonance and spectral induced polarisation
Soil mechanics for geophysicists or Geophysics special subjects	Case studies in engineering and environmental geophysics or Petrophysics special subjects for petroleum studies

TU Delft; ETH Zurich; RWTH Aachen