

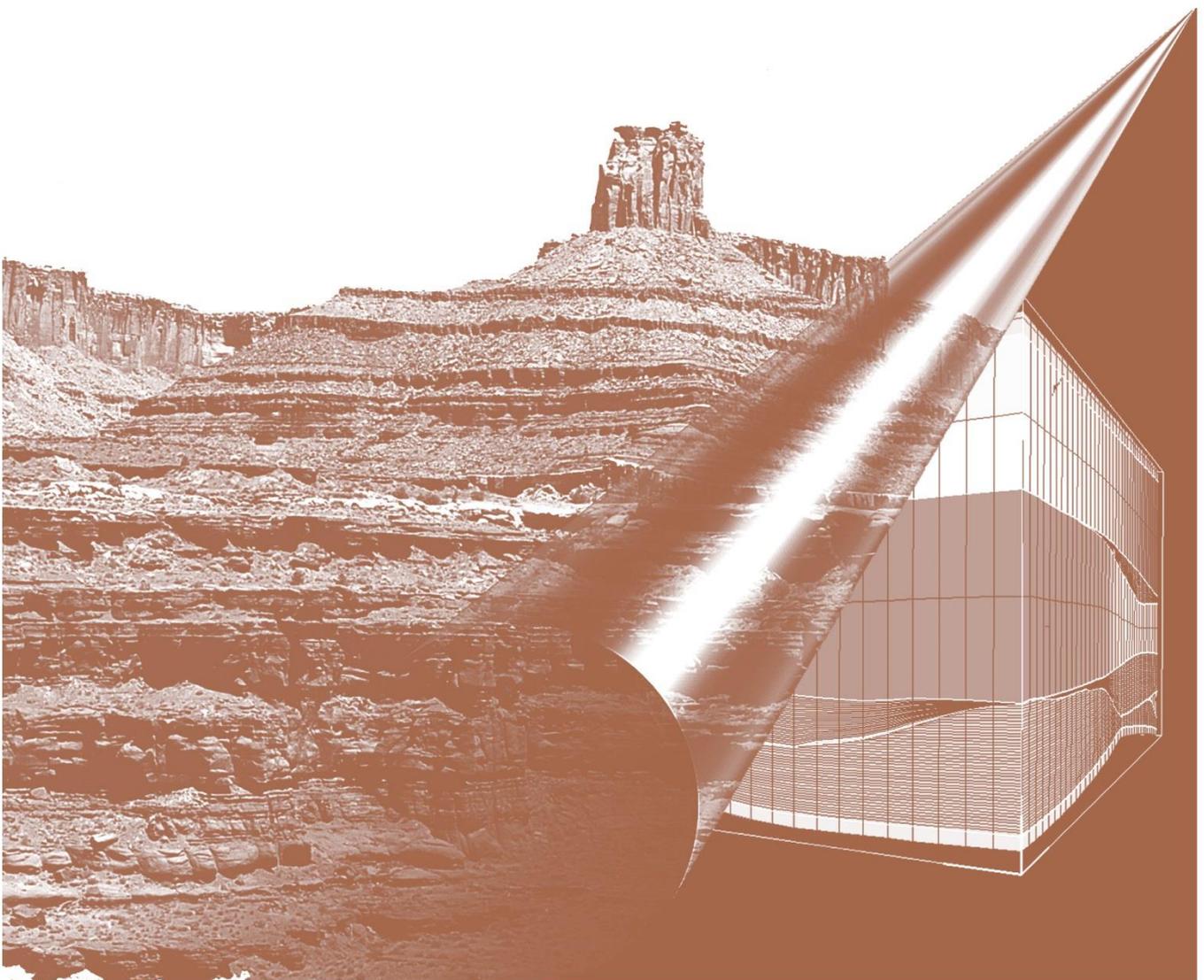
The Centre for Technical Geoscience is a national research school based in Delft. It offers a curriculum of graduate courses, which are especially dedicated to the PhD students of the participating institutions but also available to external participants.

Participants within CTG are:

- TU Delft
  - Faculty of Civil Engineering and Geosciences
  - Faculty of Applied Sciences
- Utrecht University
  - Faculty of Geosciences

Detailed information can be found on the CTG website:  
[www.ctg.tudelft.nl](http://www.ctg.tudelft.nl)

## CENTRE FOR TECHNICAL GEOSCIENCE



## GRADUATE COURSES IN TECHNICAL GEOSCIENCE

**COURSE PROGRAMME  
2018 – 2019**

The Delft-based Centre for Technical Geoscience is a national research school with a curriculum aiming at enlargement and integration of skills and knowledge in four main geo-disciplines:

- Wave field imaging
- Applied geology
- Stress and deformation
- Flow and transport
- Geodesy, Atmospheric Science and Remote Sensing

### **COURSE SCHEDULE 2018-2019**

CTG's standard curriculum comprises various courses that are programmed over a two years period. For the course year 2018-2019 the scheduled courses are presented in this brochure. Additional courses might be planned during the year, please check our website or contact us to be put on the mailing list.

#### ***Introduction courses***

14 Jan - 18 Jan	tg030	Introduction to transport in porous media with applications in reservoir engineering and geo-environmental engineering by Prof.Dr. J. Bruining
28 Nov - 20 Dec	tg032	Seismic data processing: theory and practice by Drs. P. Gerritsma
Spring 2019	tg038	Seismic data and their physical information content by Dr. G. Drijkoningen & Dr. D.J. Verschuur
13, 20 & 27 March	tg046	Introduction to Hydrogeochemical data mining and forensic hydrology utilizing hydrochemical fingerprints by Prof.Dr. P.J. Stuijzand

#### ***Advanced courses***

June 2019	tg131	Advanced wave theory for geoscientists by Prof. C.P.A. Wapenaar
April/May 2019	tg136	Programming with MPI by Dr. J.W. Thorbecke
6, 7 & 8 March 2019	tg503	Introduction to seismo-acoustic waves in the Earth's spheres by Prof.Dr L. Evers

## COURSE DESCRIPTIONS

### COMPACT INTRODUCTION COURSES

#### **tg030 Introduction to transport in porous media with applications in reservoir engineering and geo-environmental engineering**

Lecturer: Prof.Dr. J. Bruining, Dr. Hamidreza Salimi (Panterra)

Entrance requirements: MSc level in science or technology

Course format: 5 full days of lectures and computer exercises; we will use COMSOL 5.4 to illustrate applications of porous media flow in petroleum and environmental engineering. It is necessary to take your laptop with you with COMSOL 5.4 and Excel installed. COMSOL 5.4 will be made available by COMSOL with a license of a few weeks

Course date: 14-18 January 2019

GS credits: 5

Scope: Covers the scientific and engineering principles of flow in porous media. The topics covered are fundamentals of single-phase flow, multi-phase flow in porous media, relative permeabilities for primary/secondary drainage and imbibition (first three days), and practical applications concerning reservoir-fluids properties, material-balance principles and reservoir-pressure interpretation (last two days). The successful course participant will understand the concepts and methodologies that are used currently in petroleum and environmental engineering and the tools to perform an Exergy Return on Exergy Invested (ERoEI) analysis.

#### **tg032 Seismic data processing: theory and practice**

Lecturer: Drs. P.H.A. Gerritsma

Entrance requirements: MSc level in science or technology

Course format: 8 times of 4 hours of lectures

Course date: 28, 29 November, 5, 6, 12, 13, 19 & 20 December 2018

GS credits: 4

Scope: Seismic data processing typically consists of a sequence of specific processes where each process has a number of alternative implementations. This course gives an overview of the processes that are common in seismic data processing and discusses for each process the theory of the different implementations together with their practicality and inherent assumptions. The course starts with those topics of "digital signal processing theory" that are relevant for seismic data processing: Fourier and Laplace transform, linear systems, sampling, z-transform, inverse filtering and least-squares filters. The topics of seismic data processing are: static corrections, velocity analysis and stacking, deconvolution, signal-to-noise enhancement techniques, multiple elimination, migration, dmo and velocity model building. The course contains many examples and exercises and there will be ample opportunities for interaction. At the end of the course the participants will have obtained a thorough understanding of the theory and practice of seismic data processing.

#### **tg038 Seismic data and their physical information content**

Lecturer: Dr.ir. G. Drijkoningen and Dr.ir. E. Verschuur

Entrance requirements: This course is aimed at PhD students who are not doing research on a purely seismic/geophysical topic but still are working with seismic data and models. Basic knowledge of linear algebra and differential equations is required. Furthermore, basic knowledge on Matlab is required, because the exercises as used in this course will be done in Matlab. A Matlab primer will be made available for the newcomers to Matlab. Participants are required to prepare for this course by doing a Matlab exercise in advance that will bring them to the required starting level. A laptop with Matlab installed is necessary. If you don't have this facility, please let us know so we can try to arrange an alternative.

Course format: 8 times of 4 hours of lectures

Course date: Spring 2019

GS credits: 4

Scope: The aim of this course is to learn what information can be obtained from seismic data, purely from a physical perspective. This information can be data (e.g., an image) or models (e.g., the velocity model). The course covers the following issues:

- \* Structural information: migration and the effects on seismic imaging
- \* Velocity information: velocity models, obtained from tomography, migration, full-waveform inversion and log data; differences and accuracy between the different velocity models
- \* Impedance information: impedance inversion on post-stack data
- \* Angle-dependent impedance information: AVO and inversion

- \* Rock-physics models used for seismic interpretation, including fluid replacement
- \* Stress-change and saturation-change information due to production/injection: time-lapse seismic and its inversion

In all these items both forward modeling and inversion play an important role. Both are seen as necessary parts. Still, inversion theory is not seen as an objective of this course. Each lecture will be followed by a Matlab exercise. Thus, the participants learn about seismic data and their information contents (e.g., models) passively, via the lectures, and actively, via the computer exercises.

### **tg046 Introduction to Hydrogeochemical data mining and forensic hydrology utilizing hydrochemical fingerprints**

Lecturer: Prof.dr. P.J. Stuijzand

Entrance requirements: BSc level in science or technology, backgrounds in water quality aspects recommended

Course format: 3 full days of lectures and computer exercises; homework and reading assignments will complement the lectures. We will use various hydrogeochemical programs such as HGC, Reactions+, TRANSATOMIC and Unmix to illustrate how field and lab data can be elaborated to yield useful information. It is necessary to take your laptop with you, with Excel 2010 or higher installed

Course date: 13, 20 & 27 March 2019

GS credits: 3

Scope: Covers the whole sequence of data collection, data control and elaboration up to data interpretation and building converging evidence. The following topics will be addressed: mapping of hydrochemical systems, tracer types, the power of multitracing, active and passive tracing, unmixing solutes, combination of closed-form analytical solutions of groundwater and pollutant transport with hydrochemical evidence, chemical mass balances, and selected case studies. Provides a broad exposure to the different aspects and possibilities of applying hydrochemical information for solving hydrological disputes (some of which in court). The successful course participant will understand concepts and methodologies in hydrogeochemistry that are currently used in hydrology, water management, environmental geosciences and environmental engineering.

## **ADVANCED COURSES**

### **tg131 Advanced geophysical imaging in complex media**

Lecturer: Prof.dr.ir. C.P.A. Wapenaar & Prof.dr.ir. J.T. Fokkema

Entrance requirements: MSc level in science or technology

Course format: 10 days of lectures, assignments and presentations.

Course date: June 2019

GS credits: 5

Scope: Subjects that will be handled include:

- Unified treatment of acoustic, elastodynamic and electromagnetic wave theory
- Unified reciprocity and representation theorems
- Applications in multiple elimination, wavefield decomposition, time-reversed acoustics, seismic interferometry, Marchenko imaging, and much more.....

Students are expected to present and discuss a paper from the recent literature at the end of the course

### **tg136 Programming with MPI**

Lecturer: Dr. J.W. Thorbecke (j.w.thorbecke@tudelft.nl)

Entrance requirements: programming with C or Fortran on Linux Course. You need to bring a laptop

Course format: 4 times of (2 hours of lectures + 2 hours of exercises), in total 16 hours

Course date: April/May 2019

GS credits: 2

Scope:

- > + Understand the basic functionality of MPI.
- > + Compile and run MPI programs.
- > + Write MPI programs with point to point communication and collective operations.
- > + Learn how to set-up domain decomposition and IO within MPI.
- > + Combine MPI with OpenMP and vectorised kernels to match modern compute architectures.

### **tg503 Introduction to seismo-acoustic waves in the Earth's spheres**

Lecturer: Prof.dr. L.G. Evers, Dr. S. Shani-Kadmiel, Dr. P.S.M. Smets

Entrance requirements: MSc level in science or technology

Course format: 3 times of 4 hours of lecture and exercises.

Course date: 6, 7 & 8 March 2019

GS credits: 2

Scope: This course is an interactive introduction to seismo-acoustic waves in the Earth's spheres (geo, hydro, cryo & atmo). Our primary aim is array processing and data interpretation, providing hands-on experience by use of Jupyter (IPython) notebooks.

We focus on small arrays, up to a dozen of sensors, as used by the International Monitoring System (IMS), which is being established as a verification measure for the Comprehensive Nuclear-Test-Ban Treaty (CTBT). The IMS consists of a global network of seismometers, hydrophones and microbarometers that constantly monitor the underground, oceans and atmosphere for potential nuclear test explosions. Sensor arrays facilitate the ability to resolve the wave vector and increase the detectability of a propagating coherent signal.

In this introductory course, we explain the basic principles of arrays and array processing techniques. Moreover, we will demonstrate, by various case studies, how array processing results can be used to study the characteristics of transient events, continuous sources of ambient noise, and how these contribute to the understanding of geophysical processes in the Earth's spheres. Sources and processes of interest are earthquakes, (underwater) volcanic eruption, ice-related signals from e.g. calving and changes in the spheres of propagation like temperature. The three main topics are:

1. Basics of planar arrays and processing
2. Transient events
3. Continuous signals (ambient noise)

Key points: Signal and Array processing, Signal characterization, Data interpretation

---

## GENERAL INFORMATION FOR COURSE PARTICIPANTS

### Application

Six weeks before start of a course an announcement with further information and the possibility to register will be sent to all CTG members and interested colleagues. Registered persons will receive a confirmation two weeks before the start of the course. After the course, the participants are requested to fill in an evaluation form. Successful participation will be confirmed by a certificate. All external course participants should complete the application form which is available on request and on our website and send this at least two weeks before the starting date of the course.

### Costs

For PhD students of CTG and related MSc students, the courses are free of charge. For PhD and MSc students from other groups, we charge €50,- per GS point (1 point = 8hr work load) + €50,- administration costs. For course participants from institutes or firms we charge a fee of €1000,-. Discounts can be discussed for external course participants who are affiliated to CTG.

### Graduate School and/or CTG Certificate

Each PhD candidate of Delft University of Technology automatically becomes a member of the TU Delft Graduate School (GS; <http://www.graduateschool.tudelft.nl/>). The GS' Doctoral Education programme consists of three categories: 1. Discipline-related skills; 2. Research skills; 3. Transferable skills. All CTG courses can be added as a discipline related course. The minimum number of GS credits for discipline-related courses you should receive is 15. We strongly advise you to take most courses within the first two years of your PhD study, thus benefitting most of it. PhD students of TU Delft who are enrolled in the GS will obtain a Doctoral Education certificate stating all courses they followed. After finalizing a course, all participants receive a CTG certificate. If you are a member of the GS, you can add this to your GS account.

### Location

If not otherwise stated, all courses are scheduled at the Department of Geoscience & Engineering in Delft. A route description can be obtained from our website.

### Accommodation

Individual hotel accommodation during a course can be arranged by the secretary. The costs of such accommodation are for the course participant.

### Contact

Centre for Technical Geoscience - Faculty of Civil Engineering and Geosciences - Department of Geoscience & Engineering - Stevinweg 1 - 2628 CN Delft - [www.ctg.tudelft.nl](http://www.ctg.tudelft.nl). For information on our course programme, please contact Marlijn Ammerlaan, ✉ [m.j.m.ammerlaan@tudelft.nl](mailto:m.j.m.ammerlaan@tudelft.nl) - ☎ +31 (0)15 2781423