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Study Guide

Regional thermo-tectonic modelling of sedimentary basins

A GEOCAP WP1.01-1.02 joint short course.

Development and use
This course is developed by the Tectonics Group, Department of Earth Sciences, Utrecht University, in close co-operation with GEOCAP partners at TNO, Utrecht. Developers are dr Damien Bonté (UU), dr Fred Beekman (UU), prof.dr Jan-Diederik van Wees (UU/TNO), prof.dr Sierd Cloetingh (UU), and postdoctoral researchers and PhD students of the UU Tectonics Group. This course is developed as part of the 'train-the-trainers' component of the GEOCAP work packages 1.01 and 1.02, and funded by the GEOCAP program.

Course contact persons:
- Dr Damien Bonté: d.d.p.bonte@uu.nl (course lecturer)
- Dr Fred Beekman: fred.beekman@uu.nl
- Prof.dr Jan-Diederik van Wees: Jan_Diederik.vanWees@tno.nl

This course is closely related to the WP1.01-1.02 training course on “Geothermal assessment in sedimentary basins for low/medium enthalpy resources”, which will be given in Bandung in the week before this course.

Abstract
The main objective of the course is to provide an in-depth understanding of the geodynamic processes, thermo-mechanical boundary conditions and rock properties that control and affect the thermo-tectonic evolution of sedimentary basins. The acquired knowledge will provide a solid foundation to better assess the potential of low-to-medium enthalpy geothermal systems in sedimentary basins.

Target group and prerequisites
The target groups of this course are practitioners (industry, ministry) and trainers / lecturers (academia). Those wishing to enroll should hold at least a BSc in geology, geophysics, geochemistry or comparable. Moreover, affinity with geothermal exploration is another prerequisite, evidenced for industry participants by several years of work in geothermal exploration, and for academic participants by successful completion of a MSc level geothermal exploration course.

Content
This advanced geothermal exploration course (PhD/MSc level) consists of topical lectures and related exercises (both paper and computer). Lectures and exercises each comprise approximately half of the course time, and will be given in alternating time blocks of 1-1.5 hours. In addition, selected papers may be given to read as homework during the course.
The last day of the course will be devoted to a synthesis of the course, comprising an overview of the presented topics and a group discussion on the importance and relevance for regional geothermal resource assessment in low-to-medium enthalpy sedimentary basin systems.

This advanced course (PhD/MSc level) comprises a series of lectures and connected exercises on the thermo-tectonic evolution of sedimentary basin systems. Focus will be on those aspects that are

of most and immediate importance for geothermal exploration and resource assessment of low-to-medium enthalpy sedimentary basins, such as present in The Netherlands.

Below a *preliminary* day-to-day overview of the lectures and exercises.

Day 1: Geodynamic processes and thermal evolution of the crust and lithosphere.

- General introduction to geothermal energy in sedimentary basins
- Overview of geodynamic processes involved in basin formation
- Steady-state and transient geotherm in crust and sediments
- Role of thermal conductivity and heat production on geotherm
- Exercise: modelling and parameter study of the geotherm in crust and basins

Day 2: Thermal evolution of sedimentary basins

- Basin classification (extensional / foreland / intraplate)
- Thermo-mechanical evolution of sedimentary basins
- Rheological controls
- Exercise: modeling the thermo-tectonic post-rift evolution of an extensional basin. Assessing the impact of thermally controlled rheology on crustal temperature and basin geometry

Day 3: Thermal evolution of extensional sedimentary basins (NL case study)

- Thermo-tectonic evolution of an extensional sedimentary basin
- Thermal characterization
- Assessing borehole temperature data
- Temperature maps from borehole data
- Exercise 1: Gathering and correction of BHT temperature data
- Exercise 2: BHT-based temperature modeling

Day 4 (morning): Resource in place

- Interactive exercise on the characterization of the resource in place (spreadsheet)

Day 4 (afternoon): EGS in extensional sedimentary basins

- Fundamentals of Enhanced geothermal systems (EGS)
- Influence of regional stress fields
- Assessing the state of stress on faults (i.e. risk of induced seismicity)

Day 5: Synthesis

- Review of key concepts introduced in the course
- Relevance for regional geothermal resource assessment in low-to-medium enthalpy sedimentary basin systems in Indonesia.
- Feedback from the attendees

Learning outcomes

At the end of the course, the participant will have:

- Obtained an understanding of the fundamental aspects of the thermo-tectonic evolution of sedimentary basin systems.
- Obtained an in-depth understanding of the evolution of the geotherm in and below sedimentary basins.
- Learned what crustal rheology is and how this affects the thermal structure of basins
- Learned how to compile and combine borehole temperature data, and how to use this data to construct temperature maps of sedimentary basins
- Learned about the importance and role of regional stress fields for EGS systems

Course structure
In the first four days, the course consists of topical lectures and related exercises (both paper and computer). Lectures and exercises each comprise approximately half of the course time, and will be given in alternating time blocks of ¼ lecture day. In addition, selected papers may be given to read as homework during the course.
The last day of the course will be devoted to a synthesis of the course, comprising an overview of the presented topics and a group discussion on the importance and relevance for regional geothermal resource assessment in low-to-medium enthalpy sedimentary basin systems.

Teaching and learning methods
See under course structure.

Study load

Activity	**Number of hours**
Self-study of the materials and the assignments	4
Lectures	16
Supervised practicals	16
Project based learning	0
Preparation for assessment	0
Field work	0
Total	36

Assessment
The assessment of the course is based on class assignments. Assignments will be carried out by teams of two students to stimulate mutual discussion and sharing of knowledge and expertise. Teams will be formed at the start of the course. Team assignments will have to be handed in on a day to day basis, or as instructed by the course lecturer. The assignments will be graded as “completed” or “not completed”. Feed-back on the assignments will be given during the course by the lecturer.
At the end of the course, a certificate will only be given to each participant when all assignments have been handed in and graded as “completed”.

Study materials
- Reasonably modern laptop/notebook, running MS Windows (2007, 2010).
- Standard office package like MS Office or LibreOffice/OpenOffice (both freeware), including a spreadsheet program and a document editor.

Teaching materials
Handouts of the course lectures, exercises and model answers will be made available to the participants during the course.