M.Geo.239 “Fluids in the crust”

MSC course, Geoscience Master, Georg-August-Universität Göttingen

Winter semester 2019-2020

Instructor: Elco Luijendijk, room 122 in the structural geology department, +49-(0)551 39 14269, eluijen@gwdg.de

Office hours: Preferably afternoons (13:00-17:00)

Course contents

Module LV1: Lectures, 2 SWS

This module introduces fluid flow in the crust and the interaction of fluids with geological processes such as heat flow and deformation. The lecture part of the course (LV1) first introduces the basic physics of crustal fluid flow, heat flow and deformation. We will subsequently study fluid flow systems at a range of scales and settings, including the potential of fluid flow through the lower crust, regional flow in sedimentary basins and orogens and localized hydrothermal systems in faults. The course includes a critical review of case studies from the recent scientific literature.

Module LV2: Exercises, 3 SWS

LV2 consists of exercises where we will learn to set up and evaluate simple numerical models of fluid and heat flow in excel and Python. We will learn to use hydrogeological datasets such as pressure and temperature data to constrain these models. As a final part of the exercises we will combine models and data for a case study of choice on crustal fluid flow.

Grading

The overall grade for M.Geo.239 consist of 50% of the grade for the exam (module LV1) and 50% of the grade for the exercises (module LV2). For the exercise module each of the exercises will count equal towards your grade.

Rationale and aims

This course was designed to provide you with broad knowledge on the role of fluids in geological processes, which is relevant to many other parts of geosciences in your MSc. curriculum. This course was designed to also teach core scientific concepts such as how to critically evaluate model studies and compare models and geoscience datasets. In addition, this course provides key background information and skills for future research or industry work on topics such as geothermal energy, oil & gas exploration and radioactive waste storage. And finally, the course was also designed to make you with the scripting language Python. Scripting languages like Python or Matlab have emerged as key tools in research or industry work.

Learning outcomes

After completing this course you will

1) Have learned what factors control fluid flow in the crust and how fluid flow systems evolve over geological timescales
2) Have learned how fluid flow affects geological processes, such heat flow and deformation.
3) Have the ability to construct simple models of fluid and heat flow in excel or Python
4) Be able to use hydrogeological data to evaluate conceptual or numerical models of fluid and heat flow
5) Have learned to critically evaluate scientific literature and model studies of fluid and heat flow

Reading material

The course includes reading material that provides additional information on the material that is discussed during the lectures. The reading material will also be useful for the exam practice questions and some questions during the exam will also be based on this. The reading material includes:

1) Selected chapters from Ingebritsen, Sanford & Neuzil (2006) Groundwater in geological processes. A copy of this book is available in the library. Copies of the relevant chapters will be available on stud.ip

2) Selected scientific papers on fluid and heat flow in the crust. See the lecture schedule for more details. Copies of the papers will also be made available on stud.ip

Practice questions

You will receive a set of practice questions for the exam as a handout and as a pdf on stud.ip. There are approx. 3 to 4 questions for each lecture. We do not have a lot of time to go through these questions during the lecture hours. However, I strongly recommend that you complete the exam practice questions on your own. Doing so will make the exam much easier and more importantly you will learn much more from the course and will be able to do simple calculations to study fluid & heat flow processes in your future research or industry career. I am available for helping out with the questions in the afternoons (13:00-17:00), at office 122 in the structural geology department.

Important dates

First exam: ***Monday 10 Feb 2020, 10:15-11:45***, room MN01

Second exam: ***Wednesday 8 April 2020, 13:15-14:45,*** room 131

Deadlines for handing in exercises: **see exercise schedule below**. Deadline for the last exercise is **21 February 2020**

Schedule

Lectures (LV1)

Lecture number	***Date***	***Theme***	***Lecture title***	***Reading material***
1	23/10/2019	Introduction	Introduction and overview of fluids in the crust	
2	30/10/2019	Fluid flow basics	Where can we find fluids? Fluid volumes and fluxes in the crust and mantle	Cathles (1990)
3	06/11/2019	Fluid flow basics	Diffusion laws and fluid flow basics	book section 1.1 and 1.3
4	13/11/2019	Fluid flow basics	Permeability	Ingebritsen and Gleeson (2015), book section 1.2 and 1.3
5	20/11/2019	Fluid & heat flow	Terrestrial hydrothermal systems. Lecture by Sarah Louis instead of Elco Luijendijk	
6	27/11/2019	Fluid & heat flow	Physics of fluid flow, heat and solute transport	book section 1.4 and 1.5
7	04/12/2019	Driving forces	What drives crustal fluid flow? Topography-driven flow	Garven (1995)
8	11/12/2019	Driving forces	Convection	
9	18/12/2019	Driving forces	Compaction-driven flow	book section 11.1
10	08/01/2020	Fluid flow & deformation	Faults	
11	15/01/2020	Fluid & heat flow	Crustal heat flow	book section 8.1
12	22/01/2020	Fluid & heat flow	Oceanic hydrothermal systems	book section 13.1-13.5
13	29/01/2020	Fluid flow & deformation	Fluid flow and deformation	
14	05/02/2020		Review of course material and exam preparation	
	10/02/2020		***Exam***	

Exercises (LV2)

Tutorial number	***Date***	***Exercise***	***Deadlines***	***Remarks***
1	25/10/2019	Exercise 1: Making your own groundwater model in excel		
2	01/11/2019	Exercise 1, continued		
3	08/11/2019	Introduction to Python and exercise 2a: Model groundwater flow using Python		
4	15/11/2019	Exercise 2a, continued		
5	22/11/2019	Exercise 2a, continued		supervised by Sarah Louis
6	29/11/2019	Exercise 2b: Model crustal heat flow	***exercise 1***	
7	06/12/2019	Exercise 2b, continued		
8	13/12/2019	Exercise 2b, continued		
9	20/12/2019	Exercise 3: Model a 2D heat and fluid flow problem of choice	***exercise 2a***	work at home session
10	10/01/2020	Exercise 3, continued		
11	17/01/2020	Exercise 3, continued	***exercise 2b***	
12	24/01/2020	Exercise 3, continued		
13	31/01/2020	Exercise 3, continued		
14	07/02/2020	Exercise 3, continued		
	21/02/2020		***exercise 3***	

Note, the schedules may still change. Any updates will be posted on stud.ip