1

Objectives

- Learn how fluid flow systems evolve over geological timescales
- Learn how fluid flow affects geological processes such heat flow and deformation
- Learn to construct simple models of fluid & heat flow
- Learn to combine models and hydrogeological data to study fluid and heat flow
- Learn to look critically at scientific literature on fluid flow

2

Schedule

- 14 x 2 hour lectures on crustal fluids (LV1)
  - Wednesdays, 10:15-12:00, room 131
- 14 x 3 hour exercises on combining simple models and crustal fluid flow datasets (LV2)
  - Fridays, 12:15-15:00, MN13

3

Work plan LV1

- 2 hour lectures
- Includes exam practice questions. Not graded, but highly recommended
- Lecture schedule in syllabus and on stud.ip

4

Work plan LV1

- 1st part (Oct-Dec): Lectures on the basic background of crustal fluids
- Where can we find fluids in the crust?
- How does fluid flow? Basic flow laws
- and why? Driving forces of fluid flow: topography, heat, tectonic forces....
- How fast? Permeability of porous rocks and fractures
- How do we study fluid flow? Numerical models and isotope, geochemical or temperature datasets
- 2nd part (Jan-Feb): lectures on various crustal fluid flow themes:
  - Fluid flow and heat flow in the crust
  - Fluid flow, faults and deformation
  - Regional-scale fluid flow systems
  - Continental and oceanic hydrothermal systems

5

Work plan LV1

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	Crustal heat flow -> Lecture by Sarah Louis instead of Elco Luijendijk	book section 8.1
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	Oceanic hydrothermal systems	book section 13.1-13.5
12	22/01/2020	Fluid & heat flow	Continental hydrothermal systems	
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***	

6

Work plan LV2

- 3 hours of lectures per week:
  - ~0.5 hr of explanation, background of exercises
  - ~2.5 hrs of exercises.
  - We will work together on the exercises in class
  - Working together is encouraged, but exercises are graded individually
  - Deadlines: 2 weeks after last session for each exercise (see syllabus for details)

7

Work plan 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		Work at home session
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

8

Work plan LV2

- Exercise 1: Make a simple numerical model in excel
- Exercise 2: Make a simple but more powerful model of groundwater flow and heat flow in python
- Exercise 3: 2D fluid & heat flow model of topic of choice.
- Still subject to change, topics so far:
  - Use temperature data to quantify the history of fluid flow in a hydrothermal system in Beowawe, Nevada, the Aachen hot spring or a volcanic hydrothermal system in Guadeloupe
  - Model regional groundwater & heat flow in the Upper Rhine Graben

9

Course material

- Lecture slides, available on stud.ip after each lecture
- Selected scientific papers, also on stud.ip
- Chapters from: “Groundwater in geological processes” by Ingebritsen, Sanford and Neuzil.
- Copy available in library or from me.
- Plus scans of chapters on google drive (cannot post on stud.ip unfortunately or I will go to jail)

10

Homework?

- LV1: read chapters of groundwater in geological
- processes handbook or scientific papers before lectures.
  - ~ 5 relatively short papers plus 4 book chapters (this may change…)
- LV2: Exercises done together in classroom
- Practice questions: highly recommended to work through these during the lecture series (and not only 1 day or the night before the exam)
- And of course: study for the exam

11

Grades

- LV1: exams on 10 feb. 2020 and 8 april 2020
- LV2: Hand in final exercise 2 weeks after last session (21 Feb. 2020)
- Final grade: 50% LV1, 50% LV2

12

Fluids in the news

- At the start of each lecture we will discuss news items on crustal fluids/groundwater from newspapers, popular science magazines, blogs, etc…
- If you find something interesting, send a link to the item, plus a link to the scientific paper behind the news item (if available) the day before the lecture, so I can include it
- 2 news items = bonus point of 0.7 for exam grade

13