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Structural Analysis of Deformed rocks (GEO4-1411) --- Exam 03-02-2005

Time: 09.00 – 12.00 hr.
Place: AW – C.008

Answer 4 out of the 5 questions

Question 1 – On inhomogeneous and homogeneous deformation of rocks

a) Describe what is meant with "lobe and cusp structures". Also, list (and explain!) what factors determine the geometry of these structures.

b) Classical buckling theory ('Biot') predicts folding with a dominant wavelength. What factors control wavelength according to this theory, and how do they do this? You may want to use theoretical relationships (equations) to underpin your answer. Is this theory generally accepted?

The homogeneous deformation of an experimentally deformed rock-analogue material is described by the following Velocity Gradient tensor **L**:

$$\mathbf{L} = \begin{pmatrix} 3x10^{-11} & -2x10^{-11} \\ -6x10^{-11} & -3x10^{-11} \end{pmatrix} \quad [s^{-1}]$$

c) Explain briefly what a Velocity Gradient tensor is, and why it might be useful to analyse deformation of (rock) materials in terms of 'flow'.

d) Make a Mohr circle representation of **L**. Label all axes and explain what the intersections of the Mohr circle and the axes mean. Also, determine the mean instantaneous stretching rate and the vorticity of flow.

e) Fig. 1.1 is a drawing of the flow pattern of material particles as observed in the experiment. Can **L** be the correct tensor for this flow pattern? Give arguments.

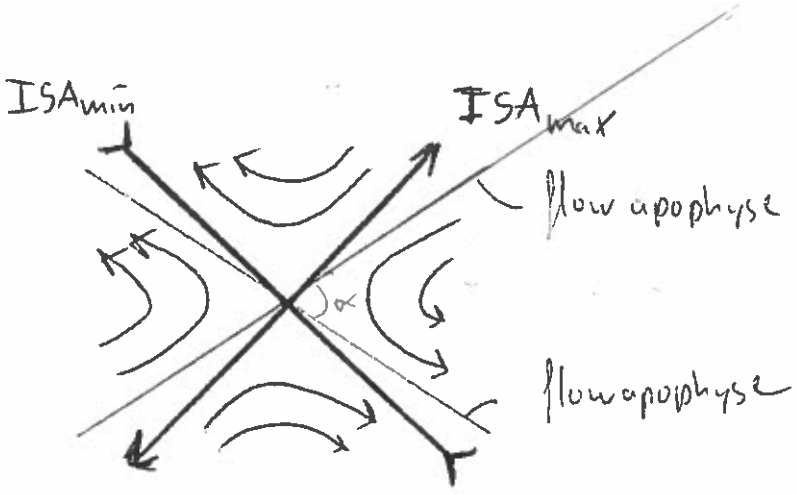

Fig. 1.1

Question 2 – On mechanical instabilities and structure development

a) Explain the essential characteristics of an unstable deformation process and explain why rock materials with a near Newtonian rheology are less prone to localized deformation than those with a non-linear rheology.

b) Describe the main characteristics of the following structures observed in deformed rocks (illustrate with simple diagrams) and offer an explanation of how these structures can develop:
- Folds
- Stylolites in impure limestones

c) Define the term "ductile shear zone" from the point of view of a structural geologist working in the field.
- Go on to use the concept of "positive feedback" to outline the different ways in which ductile shear zones can dynamically localize in a deforming rock mass.
- What features might you look for in the field to determine how a given ductile shear zone formed (i.e.localized).

Question 3 On paleostress Analysis

a) Explain briefly what the basic assumptions are behind stress analysis using fault slip data. What is the role of the 'stress shape ratio' in this respect?

b) Let's assume that you are given the task to map faults in a complexly fractured area, with the aim to analyse the stress history. Present a plan of your approach to the project; what to look for in the field, what approach to follow in the data analysis?

c) Give a general overview of the pros and cons ('voors en tegens') of determining stress using crystallographic (e-)twins in calcite.

Fig. 3.1 (from Stipp *et al.*, 2002) shows flow stresses calculated from recrystallized grain sizes (natural quartzites deformed at known temperature *T*) using different piezometric relations (laboratory calibrated). GBM, SGR and BLG refer to different recrystallization mechanisms.

d) Give a summary of the various ways in which the diagram can be interpreted. Start by explaining what a recrystallized grain size – stress piezometer is.

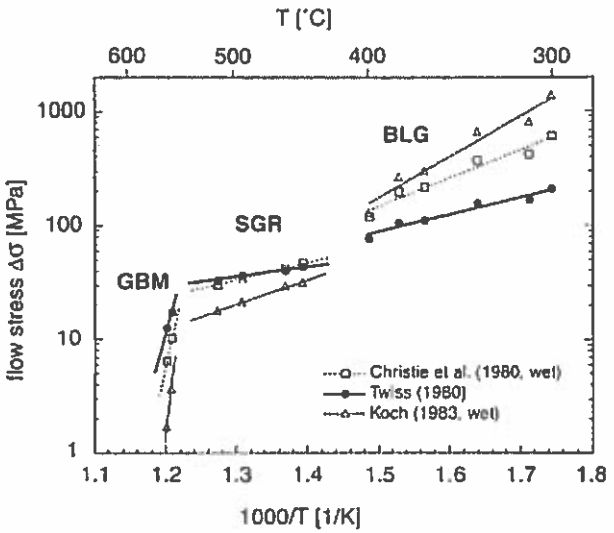

Fig. 3.1

Question 4 On the analysis of tectonic histories

a) Describe two cases where "polyphase" deformation structures, like re-folded folds or boudinarged folds, can be formed during a single progressive deformation.

b) Discuss how folds and faults formed by soft-sediment deformation can be distinguished from tectonic structures formed after the rocks were lithified.

c) Give definitions for the following terms: magmatic flow, sub-magmatic flow and sub-solidus flow.

d) How can you use structural analysis of foliation and lineation patterns to distinguish if a granodiorite intrusion into a sequence of peltic sediments was syn-tectonic or post-tectonic? Figure 4.1 shows the foliation and lineation pattern of the Andorra pluton in the central Pyrenees. Was this pluton syn-tectonic or post-tectonic?

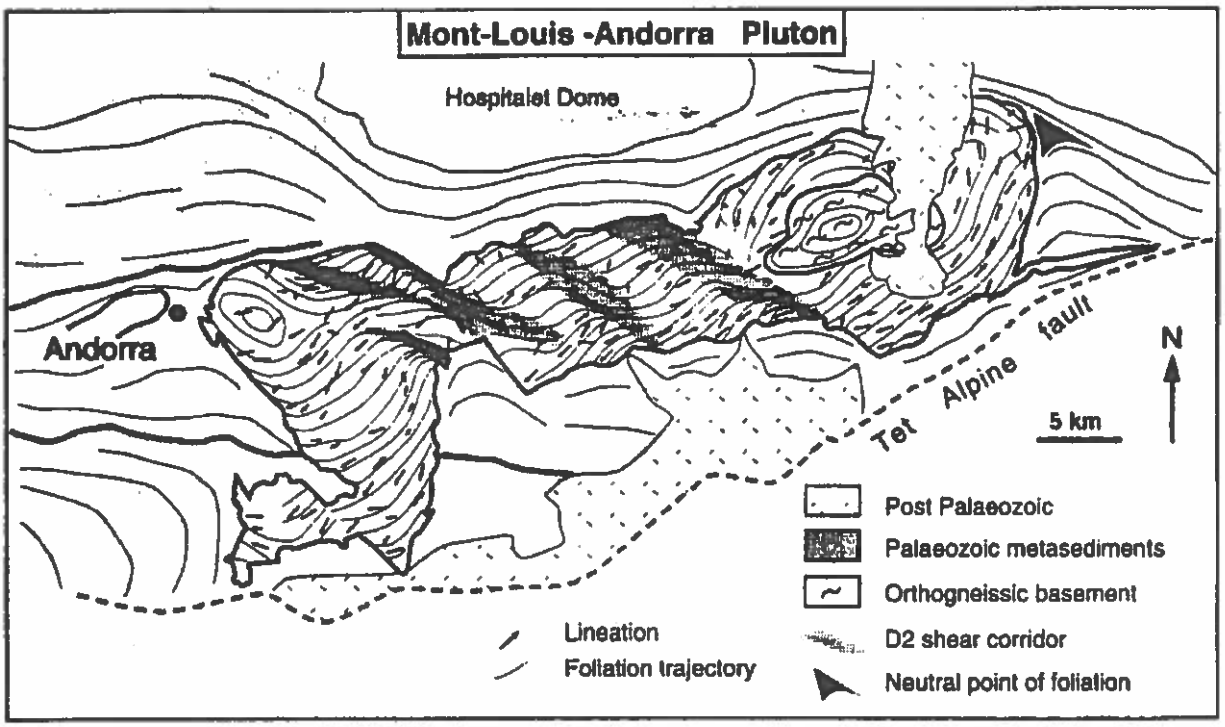

Fig. 4.1