Structural Geology and Tectonics GEO3-1307 – Intermediate test

Date: Wednesday March 13th 2013
Time: 13.30-15.00 hr.

Please read the complete exam before starting. Ask any language-related question. Always explain how you got to the answer. Be creative and good luck!

DON'T FORGET to hand-in Figs. 1 and 2 after you have finished the test.

Question 1: Quantification of strain

Close to the village of El Chive in southern Spain, deformed Paleozoic limestones and conglomerates have been found that are folded into hundred-meter-scale folds with a horizontal fold axis (Fig. 1a: perpendicular to the fold axis). There is evidence for a small component (5%) of extensional strain parallel to the fold axis. The limestone contains deformed fossils (Fig. 1b) as well as stylolites (solution surfaces). These stylolites run through both the matrix and the fossils, and indicate a volume change of 17%. The conglomerate contains deformed quartz pebbles. The R_f-ϕ' method (Fig. 1c) would be a good method to determine the strain of the pebbles in the conglomerate.

a) Determine the strain ratio of the deformed fossils (Fig. 1), taking all three fossils into account.

b) Why is the Breddin graph method not suitable to determine the strain of deformed pebbles?

c) Assume i) that the fold mechanism was buckling by flexural shear, ii) that the strain in the pebbles is the same as in the fossils of the limestone, and iii) that the initial shape ratio (R_i) of all pebbles was 1.15. Use Fig. 1c to predict as accurate as possible how the distribution of R_f-ϕ' measurements would be. Hand-in the figure.

d) - Quantify the strain of the limestone in 3 dimensions by giving values for the three principal strains.
- Illustrate the type of strain that you obtain in a suitable Flinn diagram.

e) The tensor that is believed to describe the deformation of the fossils in the limestone layer (in the plane of section) is given below. Analyze the tensor in order to check if your results of a) and d) are consistent with the predictions of the tensor.

$$F_{ij} = \begin{pmatrix} 0.3 & 0.7 \\ -0.6 & 1.2 \end{pmatrix}$$

STUDENT: Noah Lik

Antwoordmodel **TUSSENTOETS GEO3-1307** (Structural Geology & Tectonics) HdB 13-3-2013

QUESTION 1

a)	4	4	R = 2.56 for the fossils
	4	3	Two fossils on one side of Breddin graph, onde on the other. Correct angles
b)	6	1	Breddin graph is based on change in symmetry - that is not what pebbles show (ellipsoids)
c)	3	3	Flexural shear: so orientation long axis in congl. same as in limestone: @72 degr with horizontal ref line
	3	3	Strain in pebbles same as in fossils: so R=2.56
	3	3	Ri=1.15: use formuleas for Rs and Ri to determine Rfmax=2.94 and Rfmin=2.23
	3	3	Draw on Fig 1c, at phi=-72 and using Rfmax and Rfmin
d)	3	3	S2=1.05 (5% extension parallel to fold axis)
	3	3	S1*S2*S3=0.83 (volume decrease since stylolites)
	3	3	S1=1.42, S2=1.05, S3=0.56 (some points if calculations right but assumptions wrong) 1.42/0.56 = 2.5
	3	3	LN (S1/S2) = 0.30, LN (S2/S3) = 0.83; data point right of plane strain line
e)	2	2	Determination of G (0.45 -0.51 / -0.51 1.93)
	4	4	Determination of eigenvalues (2.09 / 0.29)
	2	2	Ratio of principal stretches = 2.68, roughly ok
	4	—	Deformed block drawn OR strain axis determined
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QUESTION 2

a)	2	1	if you know type of faults
	2	2	if there is a characteristic L/T ratio (area, type of fault)
	2	—	if the throw gradient is more or less constant
	3	—	then you can predict the length of the fault for a given throw
b)	3	3	Faulted basement
	3	2	Salt layer with varying thickness (2), no faults (1)
	3	3	Listric normal fault (north), covered by base Albian
	3	2	Listric normal fault (middle), cuts through Albian
	3	3	Normal fault (south) linked to basement fault, cutting through salt, covered by Top Inferior oolite
	3	3	Thickness variation Triassic-Inferior oolite, to South
	3	—	Hanging wall anticlines
	3	2 1	Crestal collapse faults
			(be creative) / bonus
c)	5	5	Rifting (basement), before salt deposition
	8	4	Rifting (sediments), accomodated by decollement on salt
	4	1	Inversion (limited)
50		70	

FINAL:

75