

**Structural Geology and Tectonics GEO3-1307 – Intermediate test**

Date: Wednesday March 11<sup>th</sup> 2015

Time: 15.15-16.45 hr. (1.5 hr)

Place: Ruppert Rood

**House rules:**

- You may not leave the room during the first 30 minutes of the exam.
- Latecomers will be admitted until 30 minutes after the start of the exam
- All electronic equipment needs to be switched off (including phones!!), except for equipment which the examiner has allowed.
- Put coats and bags on the floor. Bags need to be closed.
- If you need to use the toilet, you have to let the invigilator know. Leave your mobile phone behind. You cannot go to the toilet after the first student has left the exam.

Please read the complete exam before starting. Ask any language related questions. Then, answer the two questions (they are worth 50 points each). *Always explain how you came to your answer.* Be creative and good luck!

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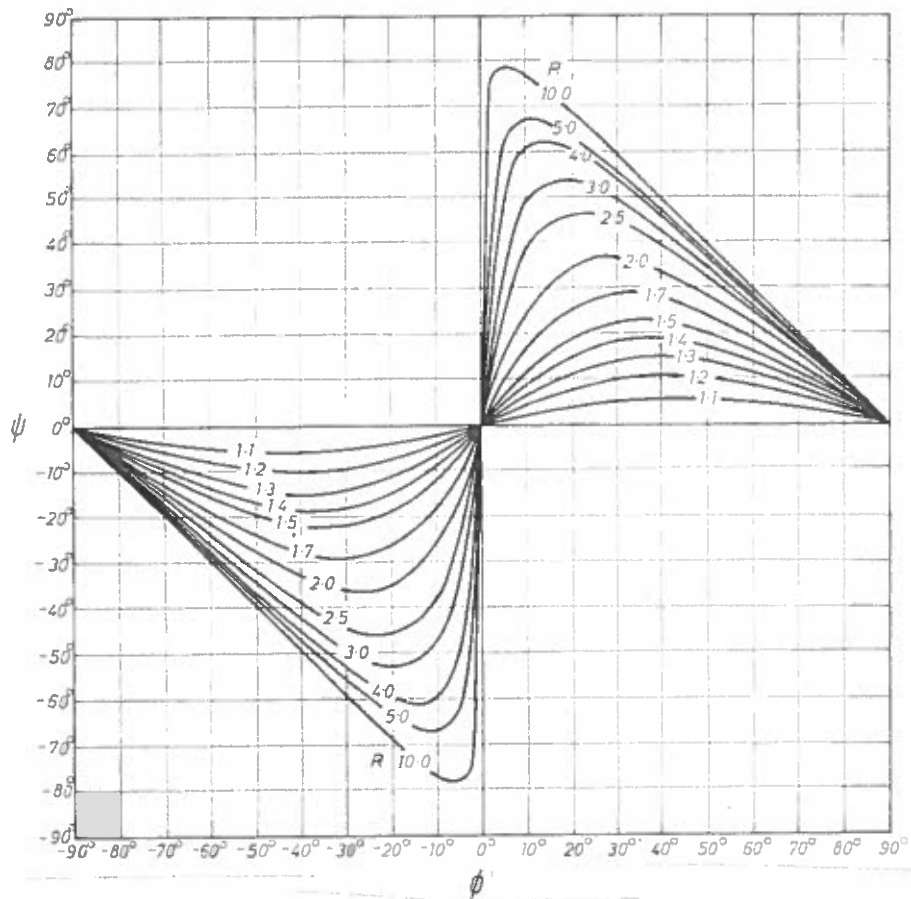
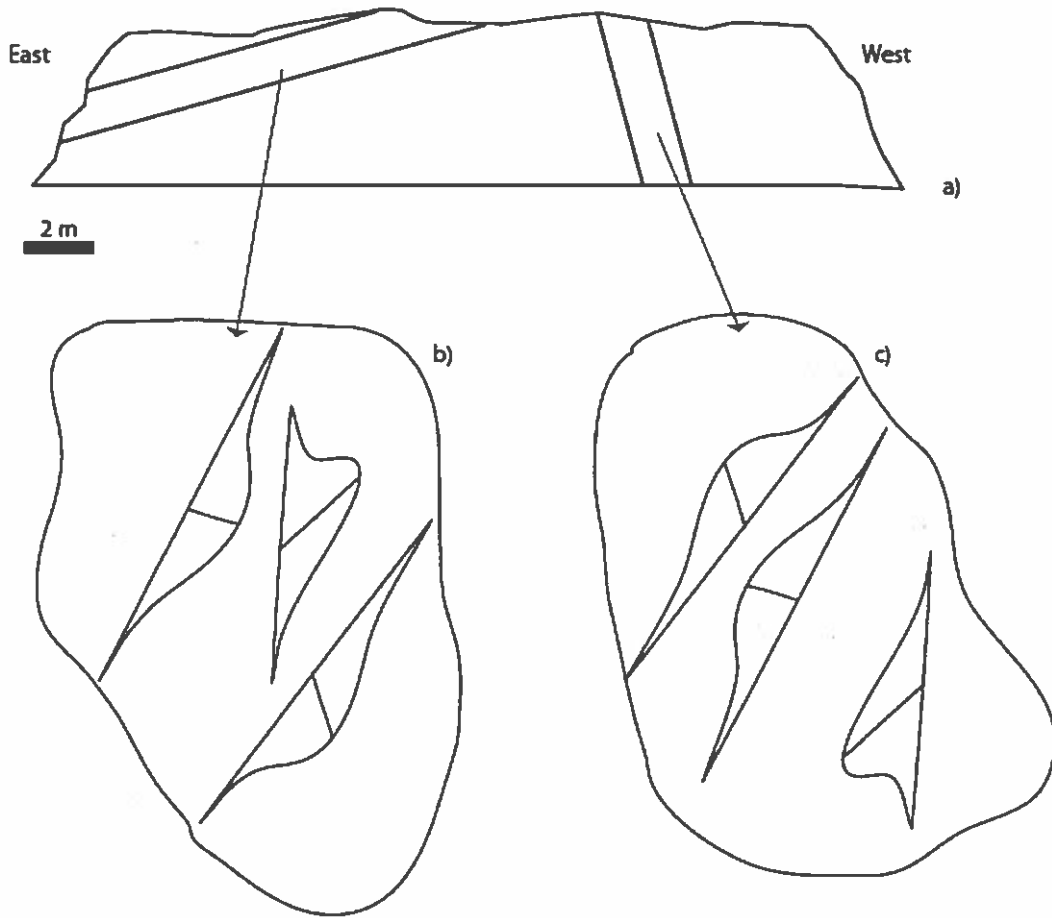
### **Question 1: Quantification of strain**

A talented structural geologist from Leuven University, Belgium, has investigated folded limestones in the southern part of the Ardennes (Fig. 1). The folds have an horizontal fold axis. The limestones show many deformed fossils. The deformation of these fossils has been quantified using the Breddin graph method. The fossils look slightly elongated in North-South sections through the rock. This elongation has been quantified to be 5%. The layers visible in the outcrop are full of solution features. They indicate a 10% volume change during folding.

- a) (6 points) The structural geologist apparently did not choose to apply the centre-to-centre (or Fry) method. Why not?
- b) (10 points) Determine strain ratio  $R$  of the deformed fossils for both limbs of the fold. Also determine the orientation of the long and short axes of the 2D strain ellipse and put these on Fig. 1a. Make sure that you HAND-IN the figure after having finished the exam.
- c) (6 points) Directly below the limestone layer, there is a layer with deformed pebbles. The initial shape ratio  $R_i$  of the pebbles was found to be 1.5. Design an  $R_i$ - $\phi'$  graph that is consistent with this value for  $R_i$  and for the strain ratio  $R$  found for the eastern limb at question 1b. (in case you do not have an answer for  $R$  at b), take  $R=2.0$ )
- d) (6 points) What can you learn from the analysis of the outcrop with respect to the fold mechanism? Explain your answer.
- e) (8 points) Quantify the strain of the limestone in 3 dimensions by giving values for the three principal strains.
- f) (12 points) The tensor that is believed to describe the deformation of the western limb of the folded limestone is given below. The base of the limestone is used as reference line (so *not* the horizontal!). Analyze the tensor in order to check if your results of b) are consistent with the predictions of the tensor.

$$F_{ij} = \begin{pmatrix} 1 & -1.1 \\ 0.1 & 0.9 \end{pmatrix}$$

Figure 1



### Question 2: Faults and structural styles

Fig. 2 shows a cross-section through a complex geological structure NNW of the outer Hebrides (Møller Hansen & Cartwright, 2006).

Fig. 3 shows a length-throw profile for a normal fault in the Phitsanulok basin, Thailand (after Morley *et al.*, 2007). The throw is given for four individual layers along the strike of the fault (oldest: “base syn-rift”, youngest: “intra Yom”).

- (8 points) Define what is meant with a “Structural Style”.
- (10 points) The structural style of Salt Tectonics consists of a series of often complex structures. Explain in a few sentences why salt moves and develop such complex structures.
- (12 points) Make a clear list of *observations* for the cross-section of Fig. 2. Use numbers, colors or other annotations to relate your observations to specific parts of the section. HAND-IN the figure after having finished the exam.
- (10 points) Analyze the observations presented at c): what Structural Style are we dealing with? Explain your answer
- (10 points) Analyse Fig. 3 and give an interpretation of the character of the length-throw profile.

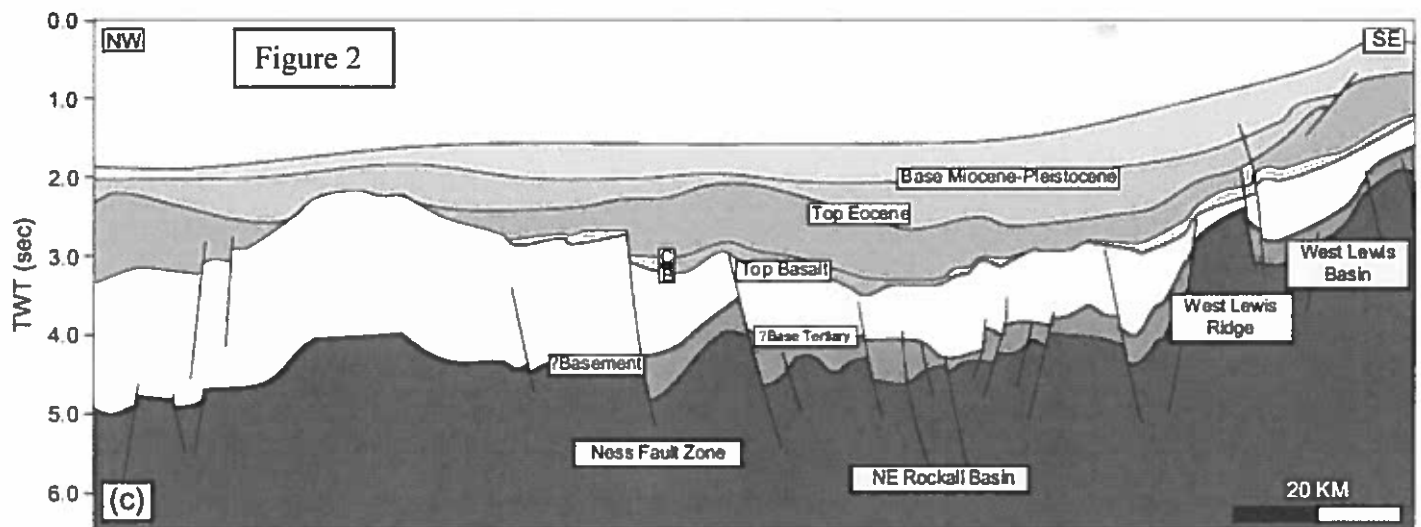


Figure 3

