Course Structural Geology and Tectonics
(GEO3-1307 – de Bresser)

Practical 2: "To invest or not to invest" – a case study on strain analysis
Friday February 22nd 2019

Aim of this mini-project is to practice the application of various ways of quantifying strain (strain measurement techniques, use of deformation and strain tensors), and to use the methods to test (conceptual) models. In the end, it should allow you to do meaningful predictions. The project should be approached as real-life example where you (in a team of two) can demonstrate your professional skills. Note, however, that the project is fully artificial.

Background:

Oil company Pecten Oil owns a license for exploration of Block C16 (Fig. 1). As part of the deal with the local government, it was agreed to drill at least one exploration well within block C16. The exact location for drilling has not yet been picked. However, it has become clear that the drilling program will require a substantial financial investment. In order to reduce the financial risk, Pecten Oil invites other oil companies to join the program (a so-called 'farm-in offer'). In exchange for taking part of the risk, the partners will benefit from any profit in case of success.

Oil company Anglia Petrol is interested in the offer. Before stepping in, however, they want to carry out their own (independent) analysis of the hydrocarbon potential of Block C16.
This is where your help is required. Your team is asked to advice Anglia Petrol whether or not to join drilling operations. In other words, you are expected to assess the chances of successful drilling.

Regional geology

1. Regional geological studies have made clear that the chances for hydrocarbon (oil/gas) source rock to be present are good. Oolitic fossil-rich limestones are expected to be potential reservoir rocks, effectively sealed by an evaporitic sequence.

2. From the interpretation of seismic sections, it appeared that the oolitic limestones in the subsurface of Block C16 are folded on a relatively large scale, with symmetrical fold geometry and an interlimb angle of about 90° (Fig. 1). The interpretation of Fig. 1 also shows the supposed location of the hydrocarbon source rock and seal. An east-dipping zone crosscuts the folds; this zone has been interpreted as a shear zone.

Field data

1. On some distance east of Block C16, the folded limestones are exposed in the field. Deformed fossils and ooids were used to obtain data on the strain distribution in the folds. Results are given in Fig. 2. The amount of strain parallel to the fold-axis appeared to be negligible. In addition, on the scale of the folds no evidence was been found for any volume change during deformation.

2. West of Block C16 the shear zone crops out in the field. Observations on tension gashes in the shear zone are shown in Fig. 3. Also indicated is the presence of various (crystalline) dikes in the exposure.

Laboratory data

1. The oolitic limestone has been experimentally studied in the famous Rock Mechanics Laboratory of the department of Earth Sciences of Utrecht University. That work made clear that the limestone can only be a suitable hydrocarbon reservoir if it is heavily fractured on a small (i.e. grain-) scale. Such microfractures appeared to develop if the strain ratio R increased above 2.4. In contrast, the evaporitic sequence only fractured at a strain ratio above 6.0.

2. Analysis of the burial history of the hydrocarbon source rock resulted in an estimate of the timing of oil/gas generation; this happened about 10 million years ago.

3. Geochronological work on samples of the crystalline dike in the shear zone (from the field area west of Block C16) suggested that the shear zone was active in the time period from 12 to 6 million years ago.

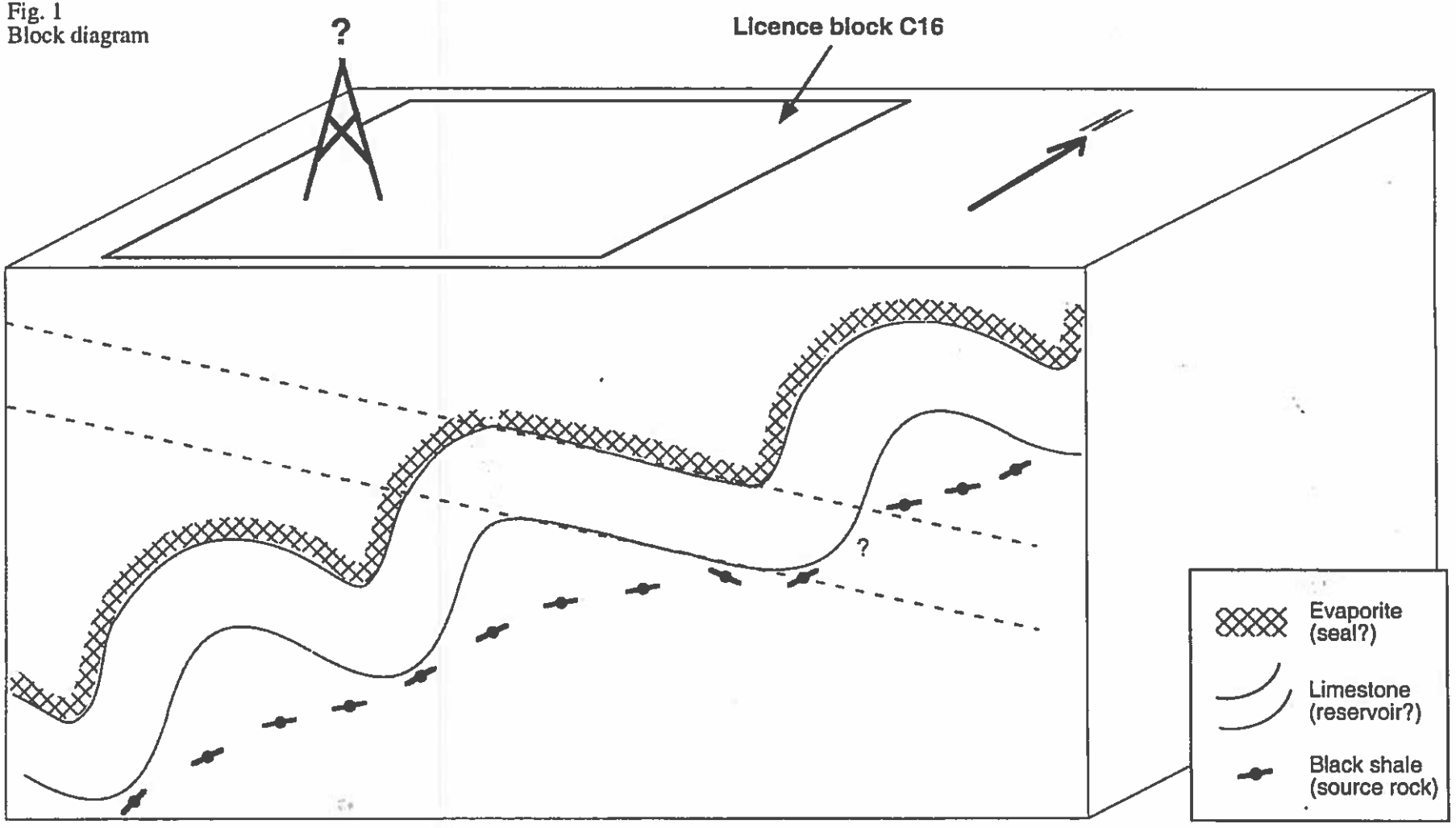
Your advice

Use the above information to prepare a sound advice to Anglia Petrol: should they react positive or turn down the farm-in offer of Pecten Oil?

First, try to define which questions you would like to be answered to get to a well-founded advice. Further, ask yourself whether you have enough data at your disposal to be able to answer all these questions. Then, carry out the analysis. Work in teams of two. A couple of (expensive) independent consultants will be available to answer questions.

Deliverable: Present a short report in which you summarize your analyses (i.e., results of the various steps) and give a well-founded advice. Include a detailed explanation of how you got to this advice.
Dead line: Friday March 1st, 11.00 hr. Hardcopy only.

Fig. 1
Block diagram



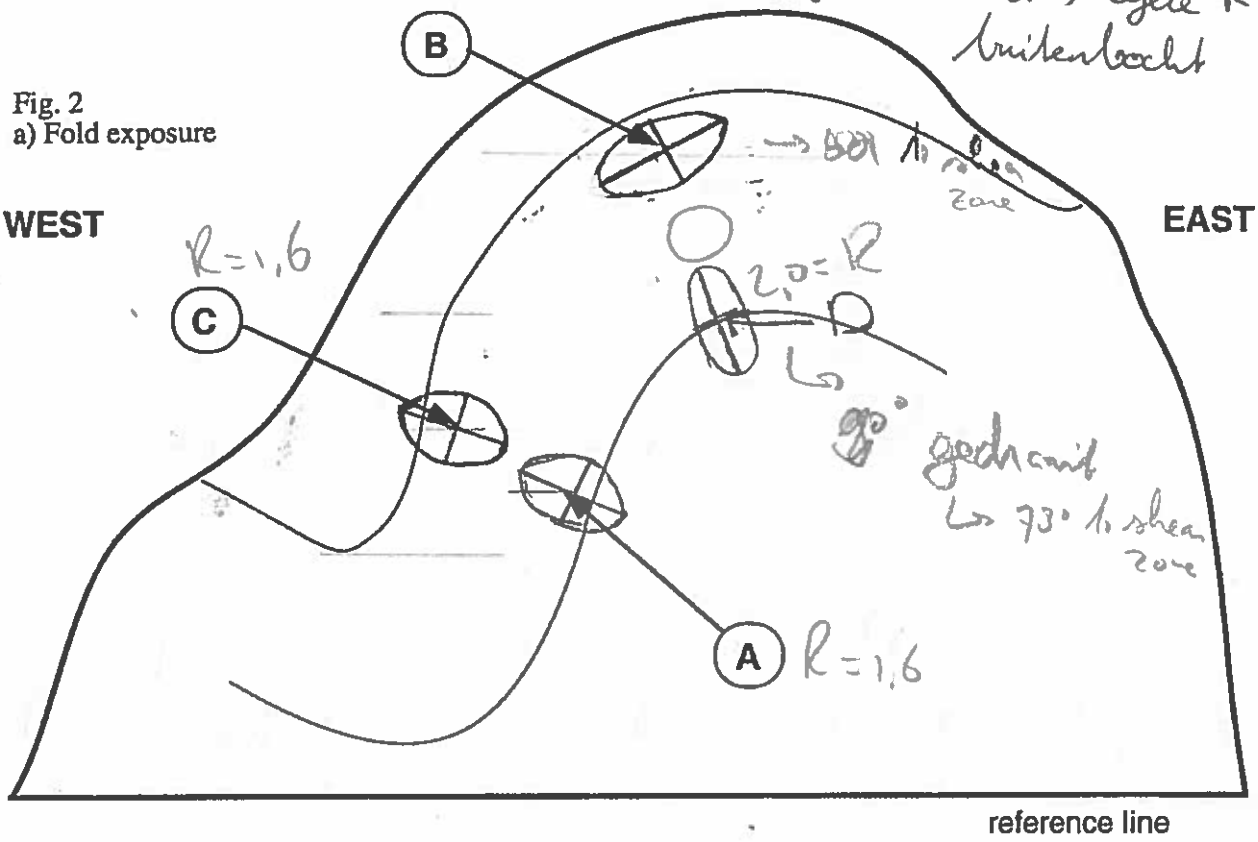


Fig. 2
a) Fold exposure

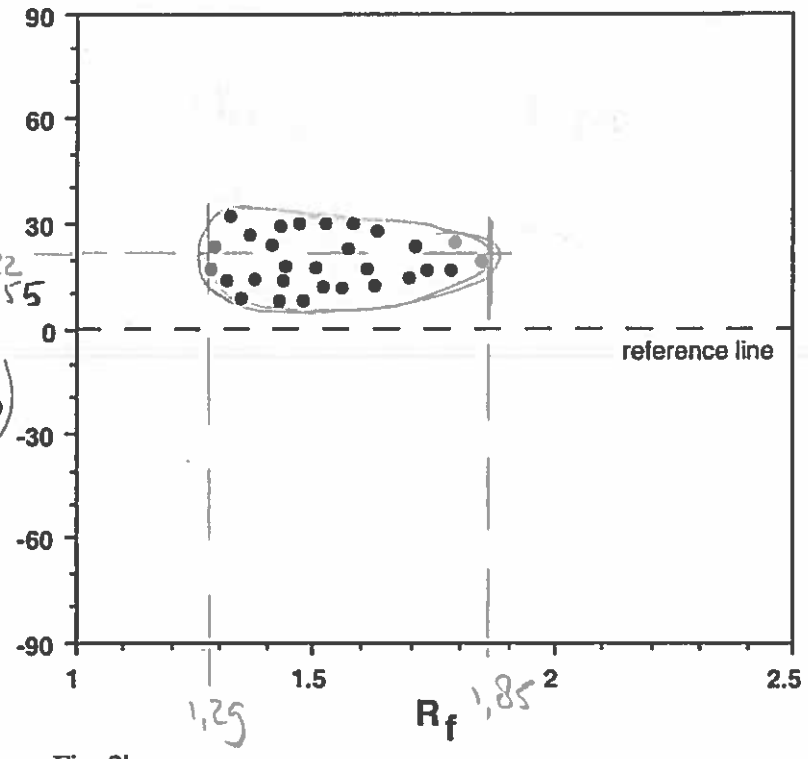


Fig. 2b
R_f - ϕ' diagram oolitic limestone
positive ϕ' are measured clockwise

2,11 0,22

9,875 0,55

1,16 0,38

0,5 1,05

B

Bulen: R = 5,6

D

Binnen: R = 2,

2,4<R<6 0

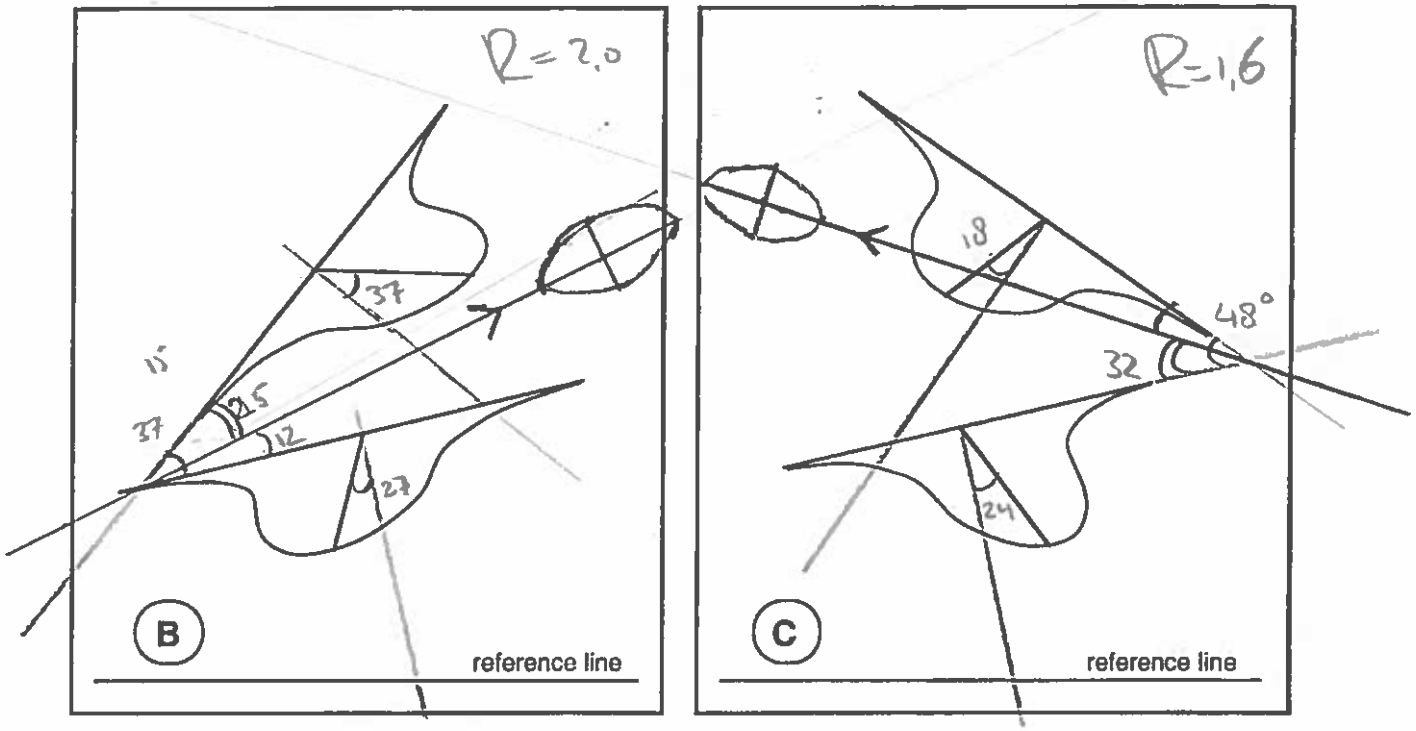


Fig. 2c
Deformed fossils on locations B and C

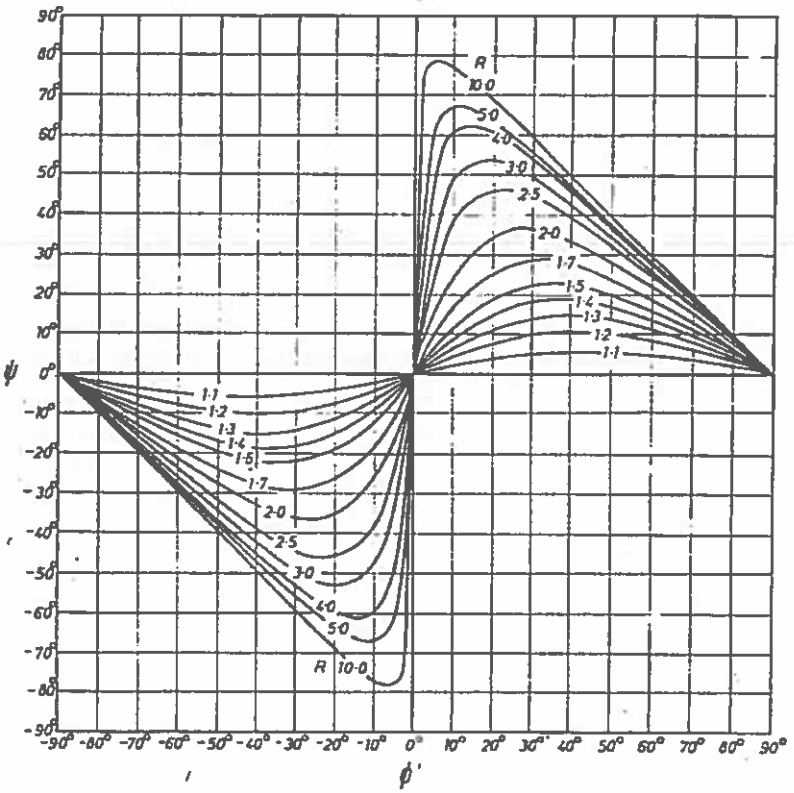
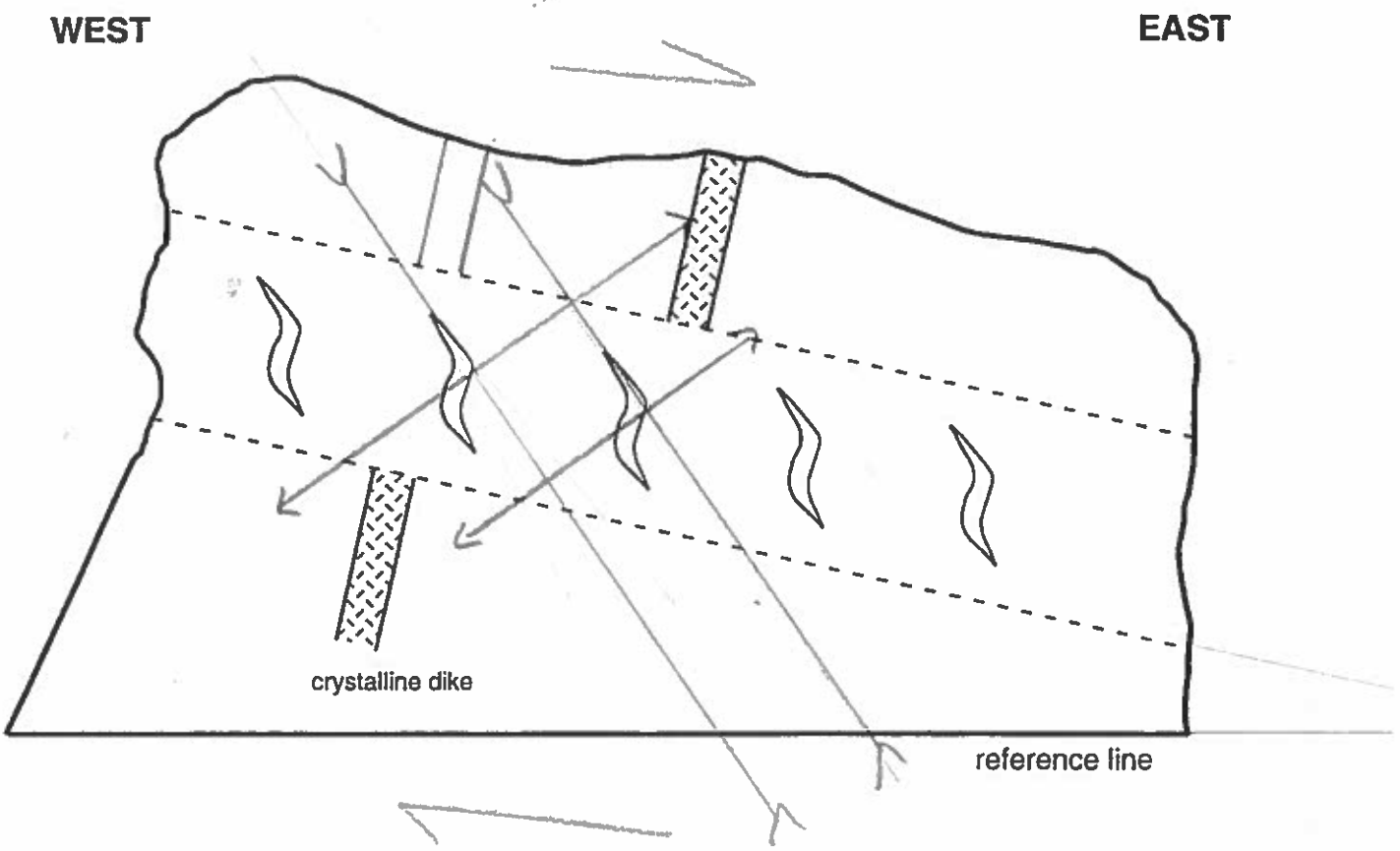


Fig. 2d
Breddin graph

3,4 cm displacement

Fig. 3
Shear zone exposure



$$F_{ij} = \begin{pmatrix} 1 & 1,21 \\ 0 & 1 \end{pmatrix}$$