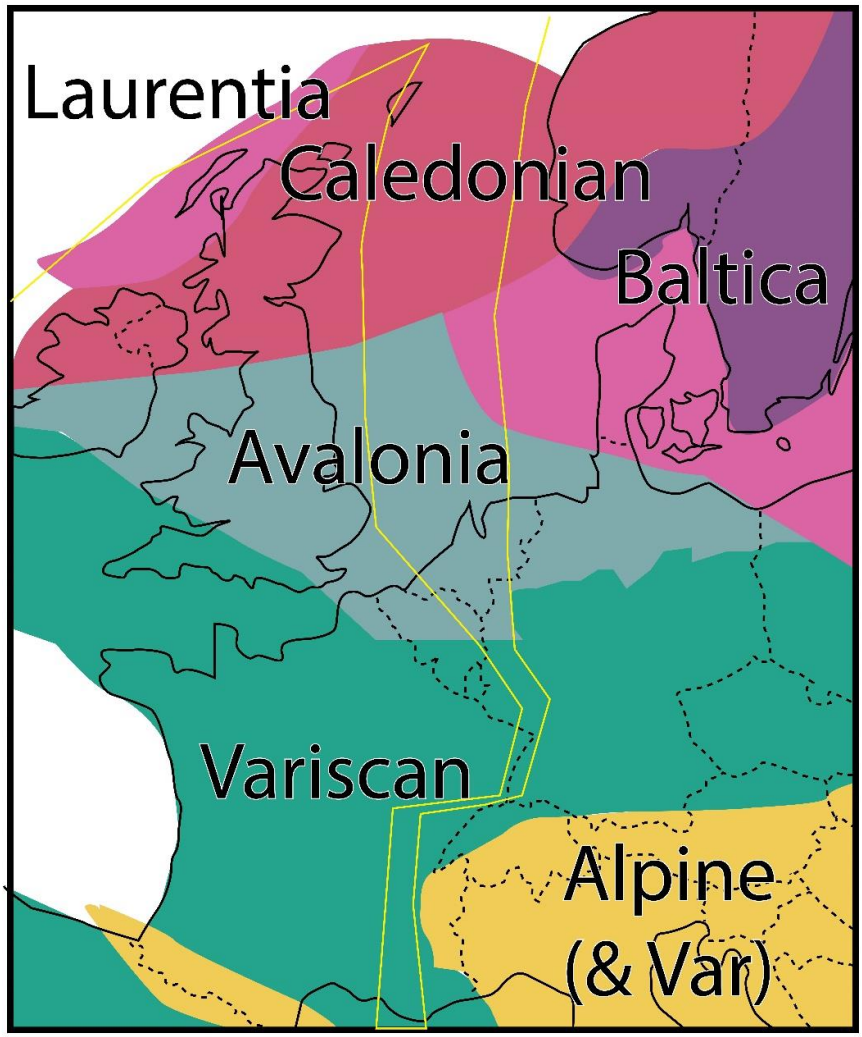
Answers exam 16 april 2019 Geology NW Europe



1. On this map, mark which areas were affected by the three main orogenic phases, give their name and indicate when they occurred. Also mark the areas that underwent extension.

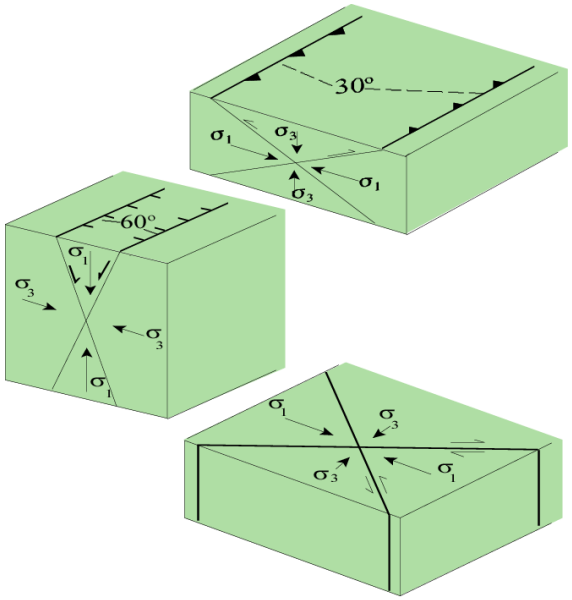
   Caledonian orogeny: Laurentia collided with Baltica and Avalonia at the end of the Silurian.

   Variscan orogeny: Gondwana collides with Laurasia during the Devonian/Carboniferous: involves everything south of Avalonia

   Alpine orogeny: Africa moves N, Italy and Iberia collide, marked area could extend a bit further N:

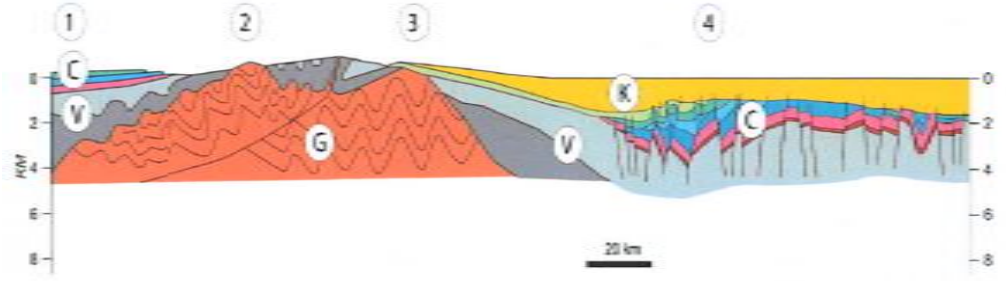
   Extension: yellow lines European rift zone: Rhone Graben, Rhine Graben, North Sea Basin, and let's not forget the Atlantic!

2. The three main tectonic regimes (ext/contr/strikeslip)are all the result of relative plate movements and all have a distinctive stress pattern that is associated with them. What are these patterns and how do they lead to the typical fault patterns associated with each regime. Can you give an example of how it is possible we sometimes find structures associated with one regime in an area that is undergoing another regime?



This figure almost tells it all. Faults are the result of differences of principal stresses, and with the orientation of the stress field we get different faults and a different tectonic regime: extension: sigma1 vertical, contraction: sigma3 vertical, strike slip: sigma 2 vertical. Faults always form at an angle of roughly 30 degrees to sigma1, with sigma2 in the faultplane. Thus we get faults with dips of about 30 (thrusts/contraction), 60 (normal/extension and 90 degrees (strike slip). Because the Earth is heterogeneous, one can find different faults in the wrong setting (normal fault in strike slip, etc), or older structures can find themselves in reactivated areas, the possibilities are endless

3. Study this cross section:



Where do you think this section is located? Please describe the geologic history of this section, paying attention to the different phases of sedimentation and deformation. Can you add any geographic names (numbers)? Can you indicate approximate ages?

You're looking at a section from northern France (left) to the center of the Netherlands (right)

History:

- *deposition (Early Paleozoic) and deformation of G (Caledonian Orogeny)*
- *erosion*
- *deposition of V (Devonian & Carboniferous) and deformation in south (Variscan Orogeny)*
- *erosion*
- *deposition of C (Mesozoic), with extension in the right side*
- *uplift and ersion in the right hand side*
- *deposition of K (Cenozoic) in the N, uplift and erosion in the south*
- *1 would be France/S-Lux/Paris Basin*
- *2 Ardennes/Wallonia*
- *3 Brabant Massif/Flanders*
- *4 North Sea Basin/West NL Basin/ Netherlands*

Multiple choice questions (one correct answer, each 1/2 of a point):

4. During fieldwork you find a fault with 200 m displacement along dip. How long do you think it is along strike at the very least?
   a. 40 m
   b. 400 m
   c. 4000 m, length of fault is between 20 to 110x the displacmeent
   d. 40000 m

5. Which statement is correct?
   a. The Caledonian Orogeny occurred during the Silurian and was caused by the collision of Baltica, Avalonia and Laurentia
   b. During the Devonian and Carboniferous, a series of trans-and regressions resulted in a varied deposition in Belgium, ranging from continental deposits to coral reefs.
   c. The Variscan Orogeny started during ~~the Permian~~ ***Carboniferous****, and involved Belgium and all of Europe south of it.*
   d. Since the Permian, Belgium eroded to a peneplain, which was partly uplifted in the Cenozoic, and erosion of the rivers present on the plain formed the valleys and hills we now find in the Ardennes.

6. Which statement is not correct?
    a. With extension tectonics, we may observe the following structures: volcanism, uplift, ophiolites, domino faulting, low angle faults
    b. With contraction tectonics, we may observe the following structures: ramp and flat structures, ~~flower structures~~, duplexes, fractures, thrust faults
    c. With strike-slip tectonics, we may observe the following structures: riedel faults, pull-apart basins, horizontal slicken sides, anticlines, conjugate faults.
    d. With salt tectonics, we may find the following structures: anticlines, diapirs, welds, reservoir seals, domino faulting.

7. The following lines indicate the ages of the subsequent layers that were found in different wells, going from top to bottom. Which of these wells probably contains a normal fault?
    a. Holocene, Pleistocene, Pliocene, Miocene
    b. Devonian, Silurian, Ordovician,Cambrian.
    c. Oligocene, Eocene, Cretaceous, Jurassic ***Paleocene is missing***
    d. Triassic, Permian, Carboniferous, Devonian

8. Assuming global warming as predicted by most scientists continues into the long term future, then earth scientists working in the Delft area in about 20 million years will probably find above the layers of the Anthropocene:
    a. a transgressive sequence, going from coastal sands to deeper marine shales and limestones. ***Warmer: sea level rise***
    b. a regressive sequence, going from coastal sands to fluvial clays and coal.
    c. a deformed sequence consisting of folded layers as a result of continued deformation due to higher temperatures.
    d. an erosional sequence, with large parts of the Anthropocene being eroded by the activity of large rivers and wave actions due to extreme rainfall.

9. Which is wrong? Extensional fractures can form in different ways:
    a. *Due to faults, where they will be parallel or ~~at rights angles~~* ***60 degrees*** *to the faults*.
    b. Due to folding, where they can be parallel to the fold axis, but may have lots of different orientations.
    c. Due to cooling, where they try to have three directions, each at 60 degrees to the others.
    d. Due to regional stress, where they will form parallel to σ_1.

10. Which is wrong?
    a. Brent is the name of one of the first offshore oil field in the UK, located in extensional tilted blocks
    b. The Schoonebeek oil field has the Coevorden formation as a source, the Bentheimer sandstone as reservoir and the ~~Zechstein salt~~ ***shales*** *as seal*
    c. The Groningen gas field has the Carbonifeous coals as source, the Rotliegend as reservoir and the Zechstein as seal
    d. Many of the gas and oil fields in the North Sea area are located in reservoirs formed by domino faulting

11. If a limestone has a coefficient of internal friction of 26 degrees, at what angle relative to sigma 1 do you think a fault will form?
    a. 26
    b. 30
    c. 32 Calculate this for yourself!
    d. 52

12. Which statement is wrong?
    Volcanism can occur in different tectonic settings:
    a. Along Mid Oceanic Ridges, where it results in the formation of new oceanic crust
    b. In and along rift basins, where the relatively thin magma can result in basalt flows
    c. Above subduction zones, where the thick andesitic magma leads to very violent explosions
    d. Above hotspots, ~~where the expulsion of water from the crust leads to large eruptions~~, forming volcanic islands.