Fractures – an overview

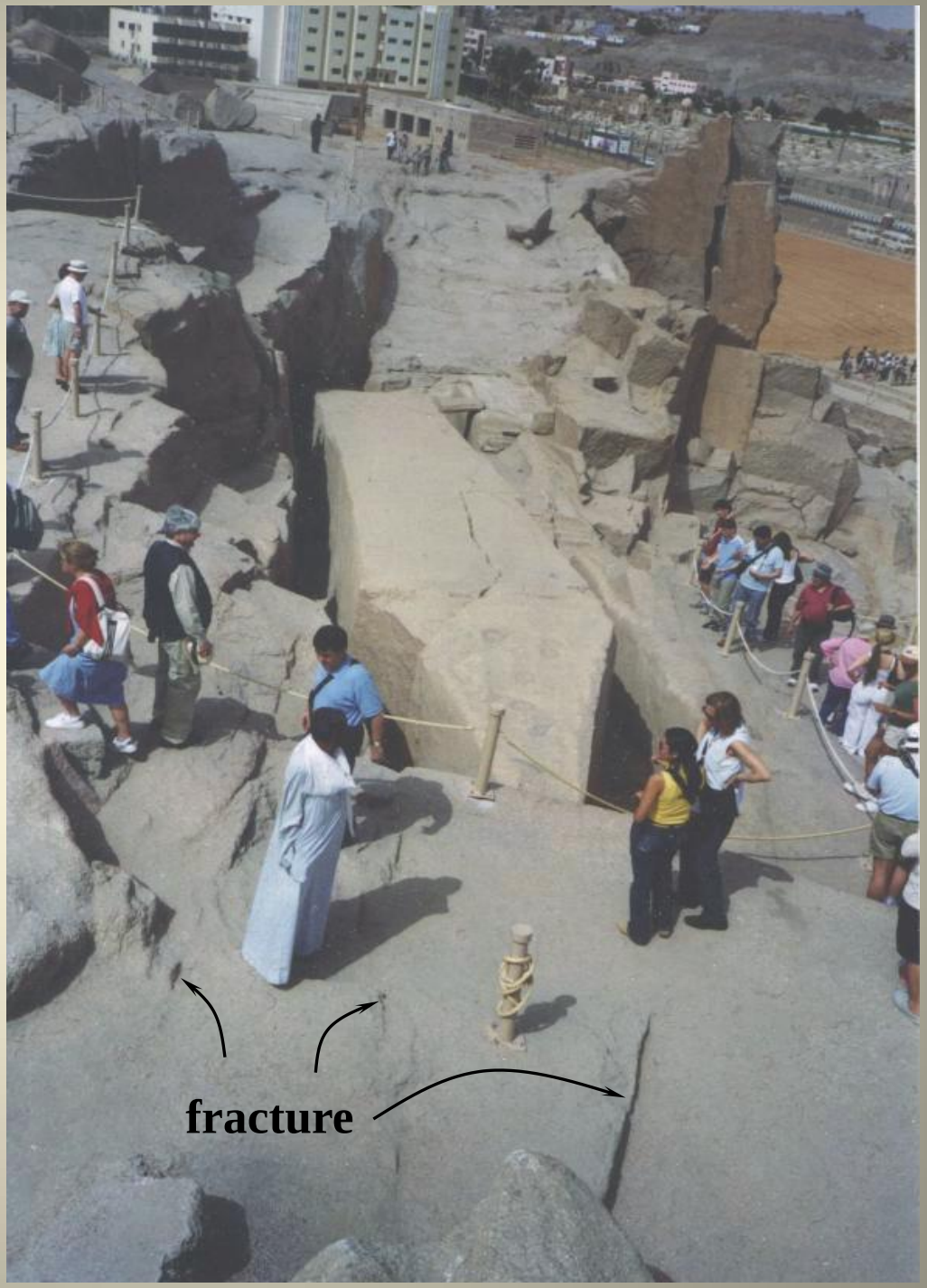
Paul MacKay

Aswan Dam, Egypt

Obelisk Quarry

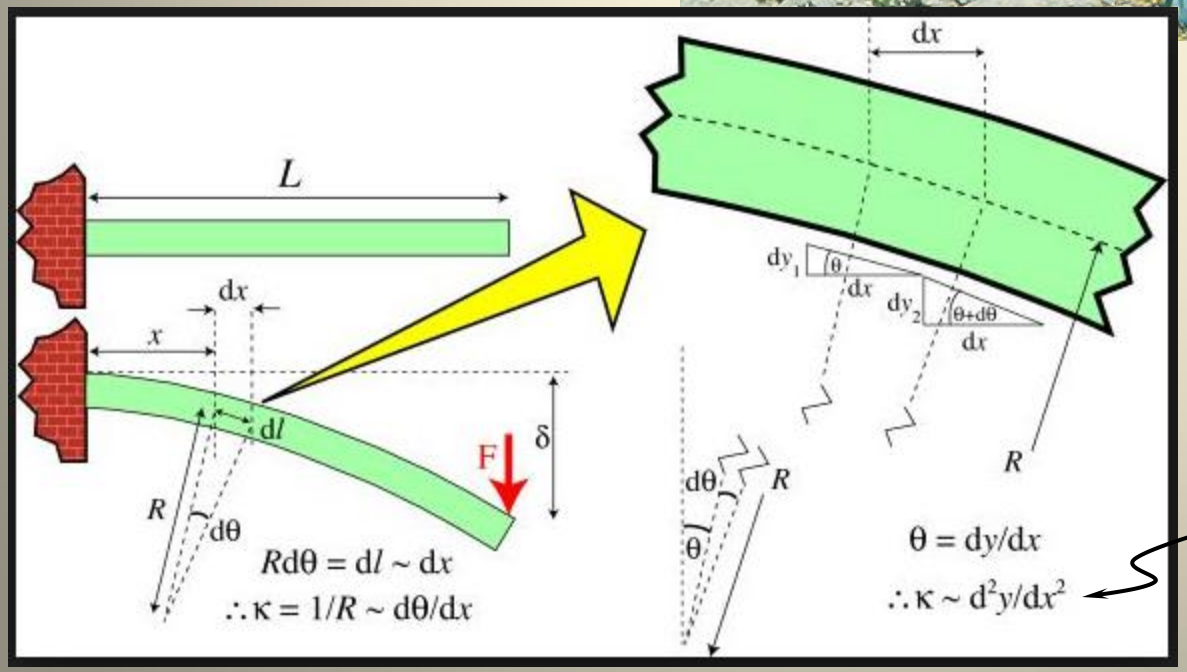
- circa 1500 BC
- Largest known obelisk
- 43 m long
- ~1,200 tons

- Likely took advantage of the natural fracture system



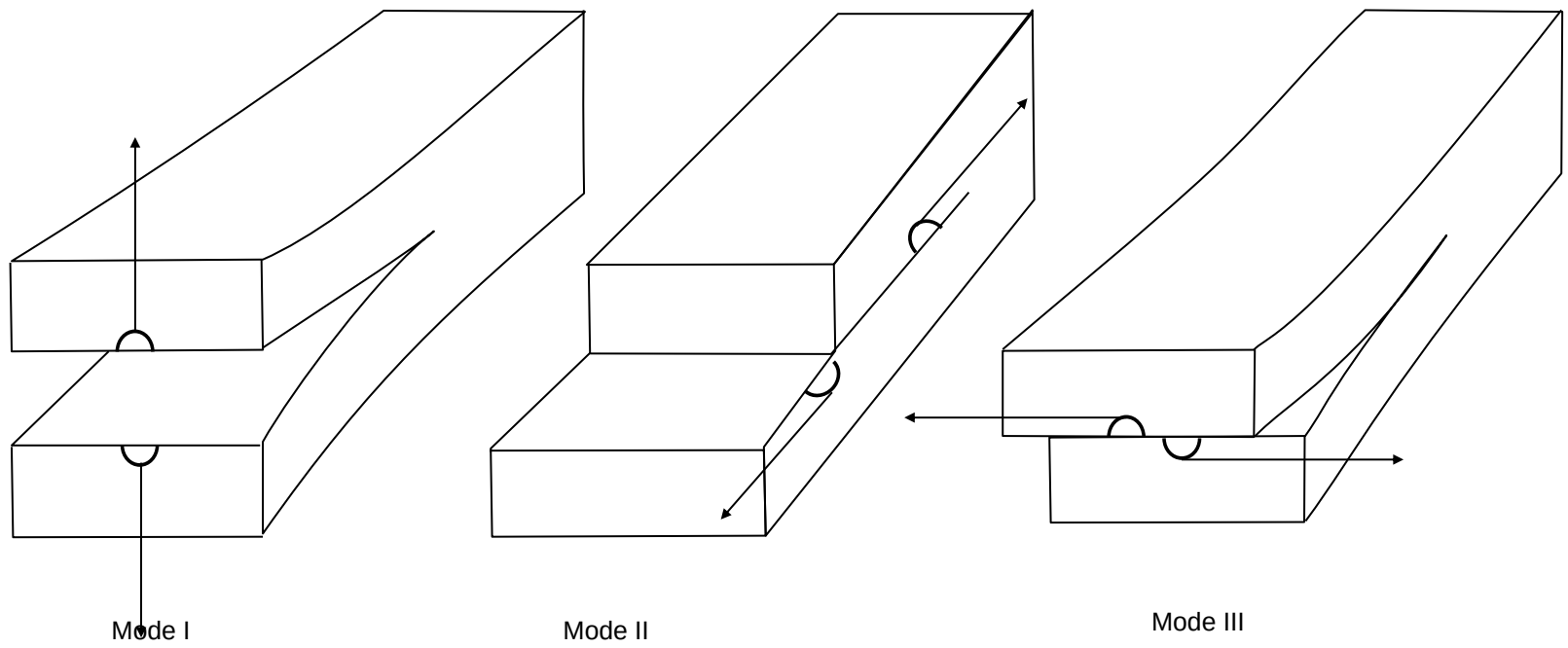
Bending Moment for a Beam

- Fractures were related to the bending moment
- Fluid Pressure not considered
- Strain path not considered



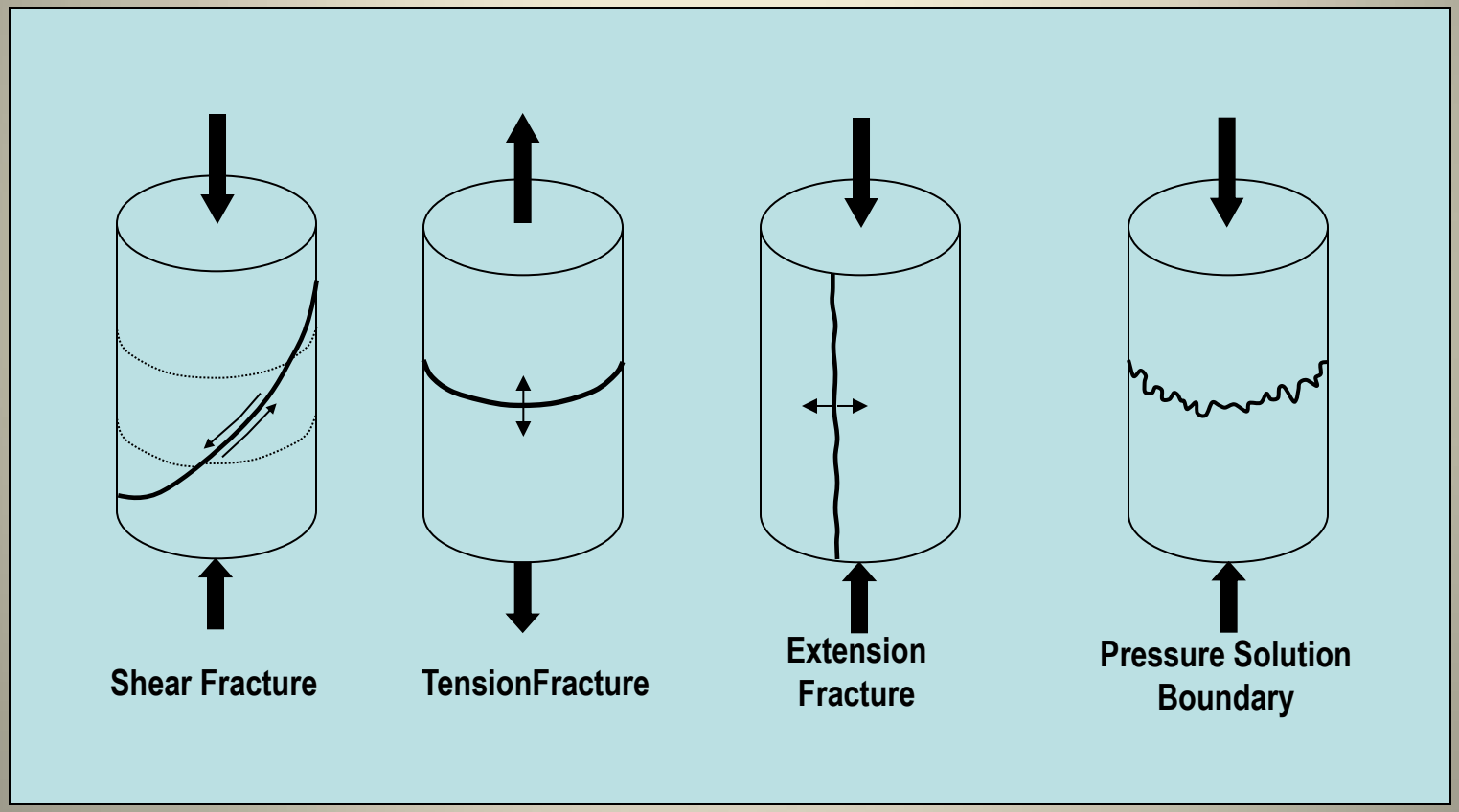
Beam curvature

Fracture Modes

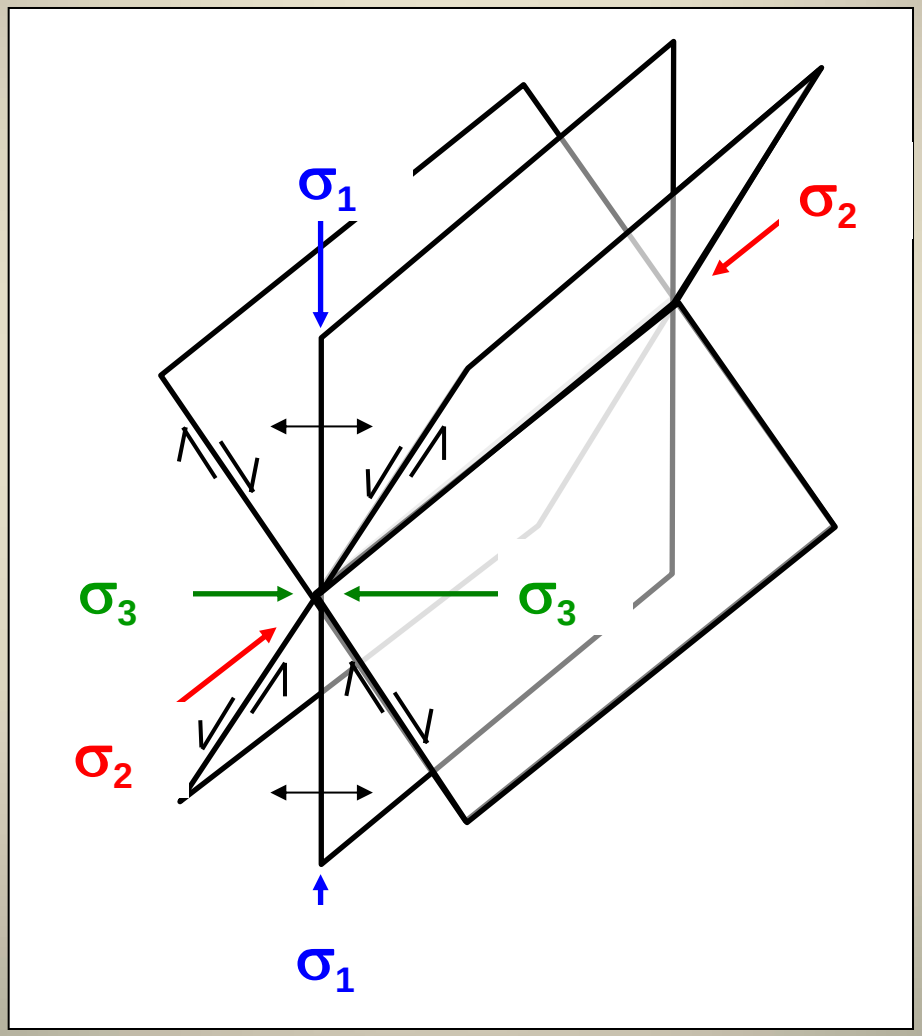


After Jamison

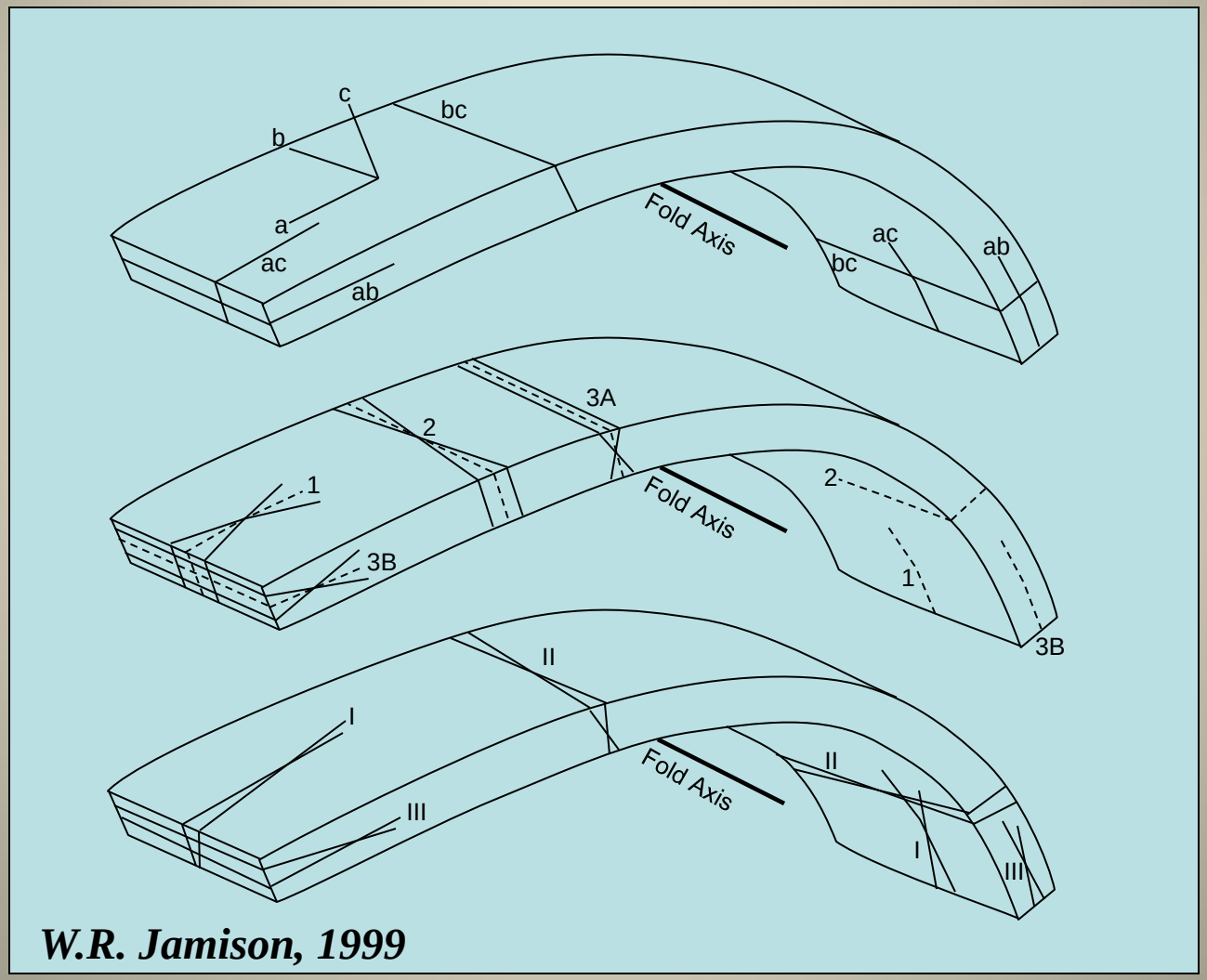
Types of Fractures



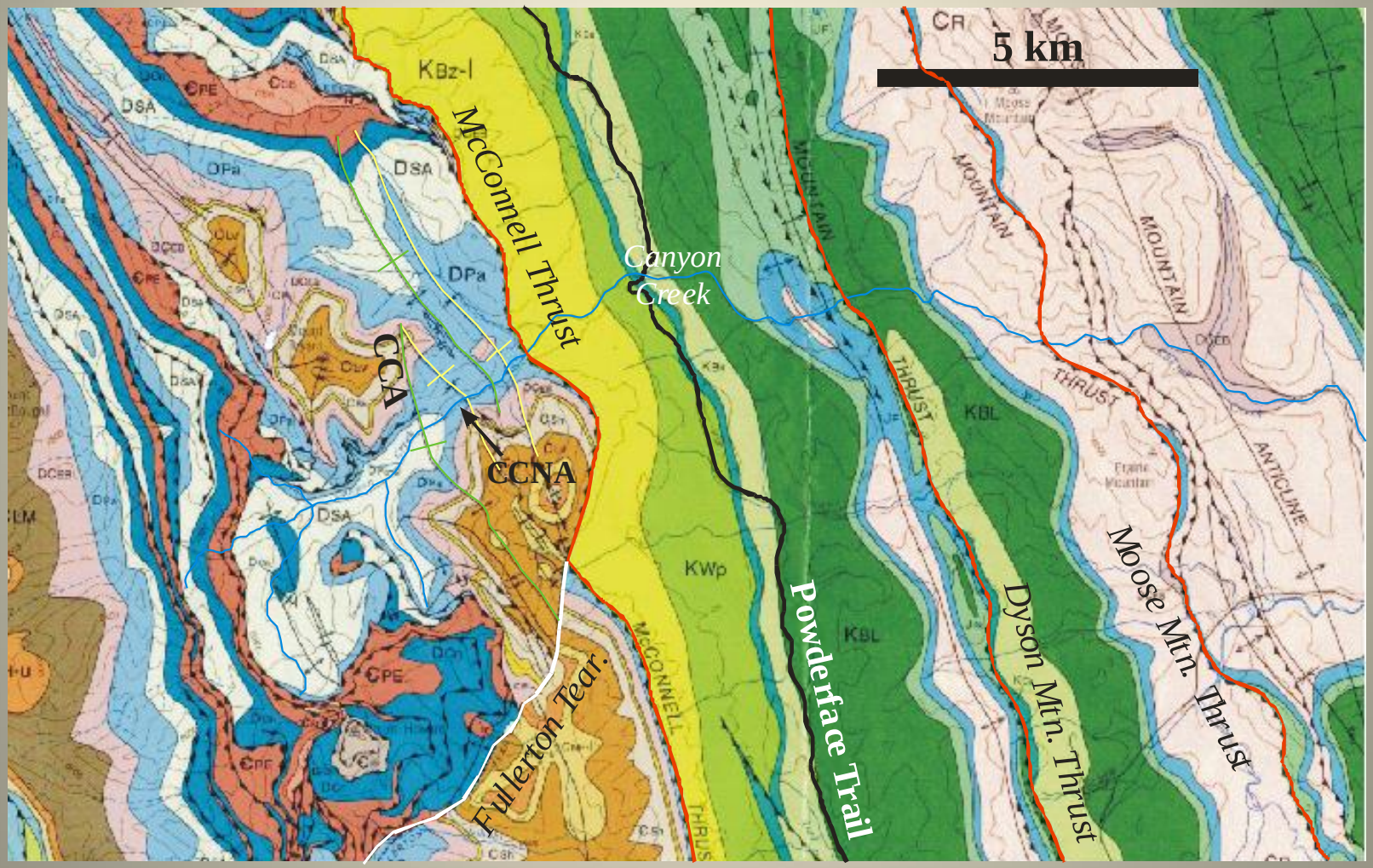
Stress conditions associated with fractures



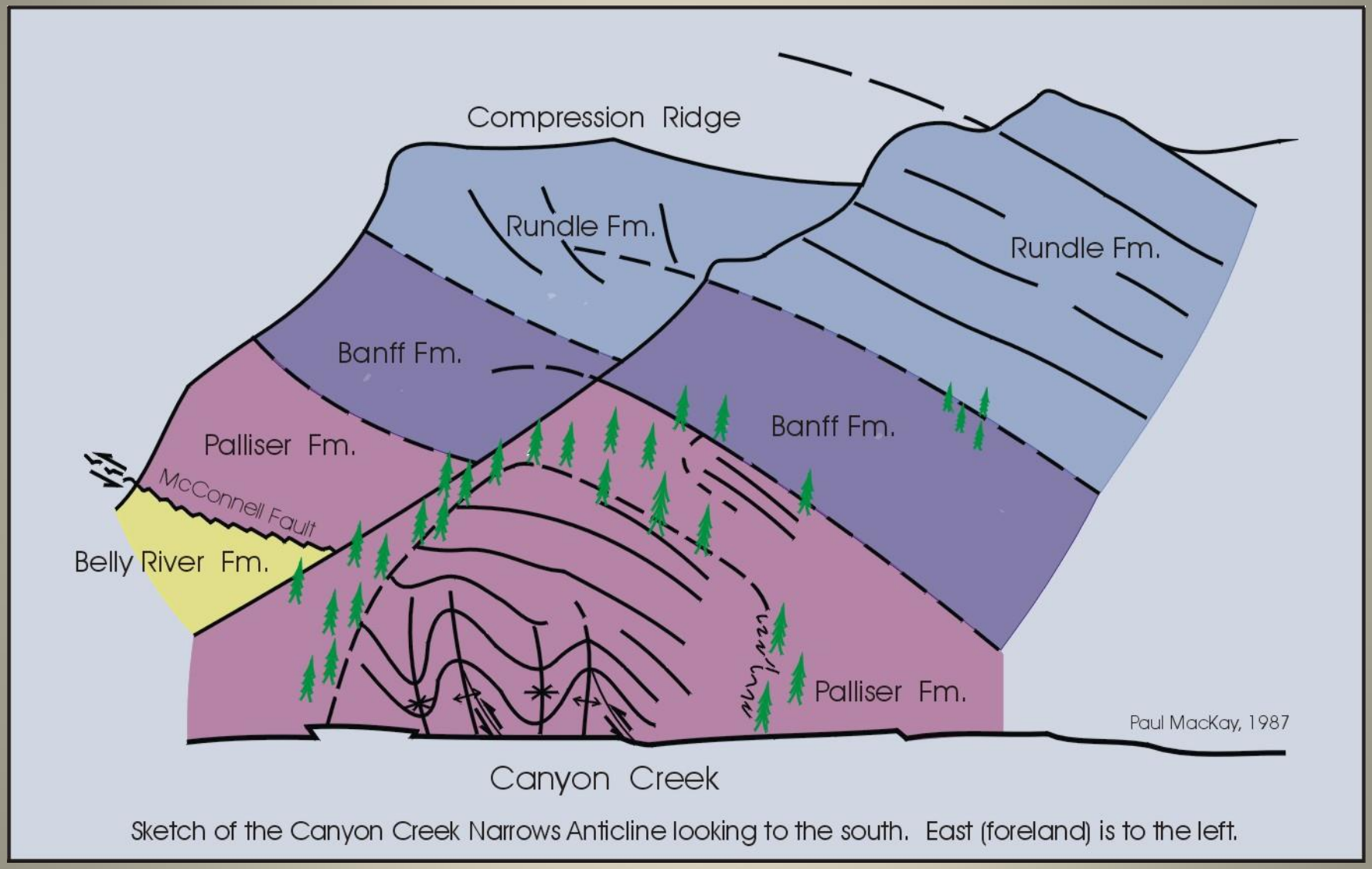
Fractures associated with folds



Canyon Creek
Surface Geology

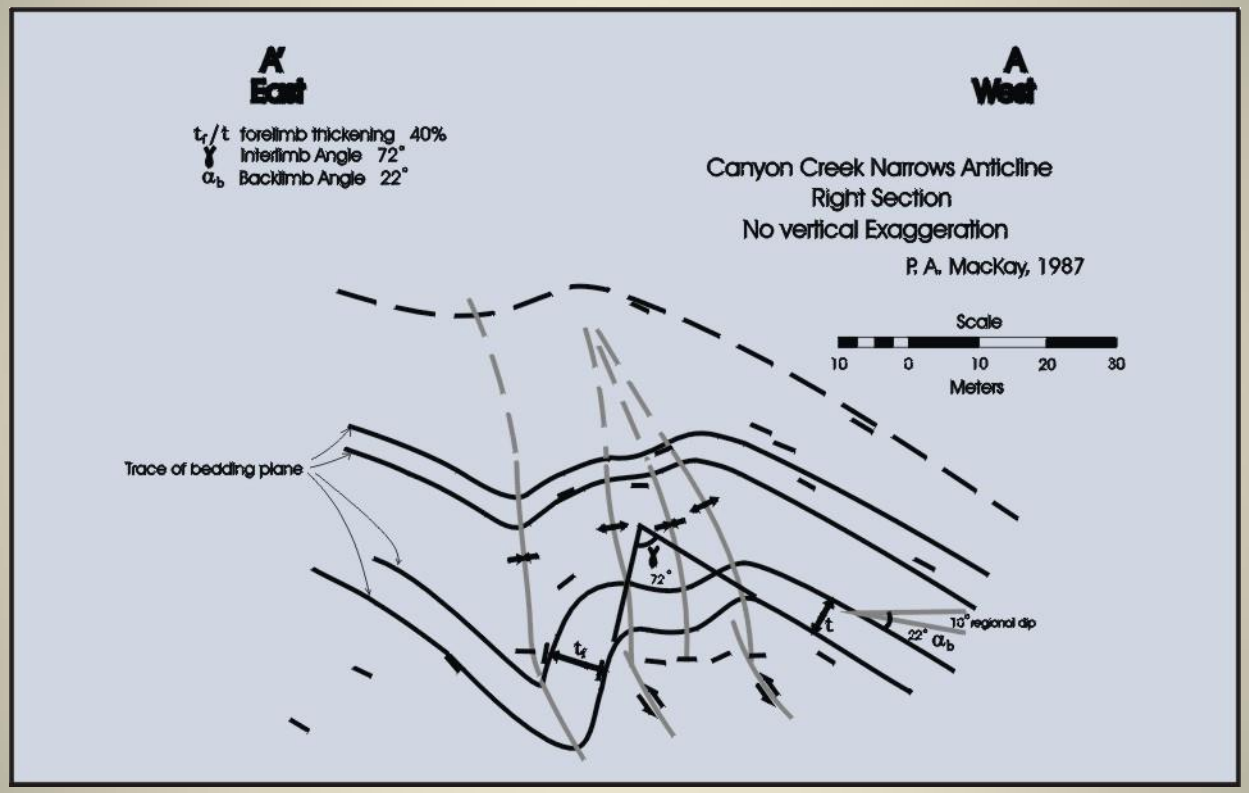


Fold in the Palliser Fm (Wabamum) – Canyon Creek



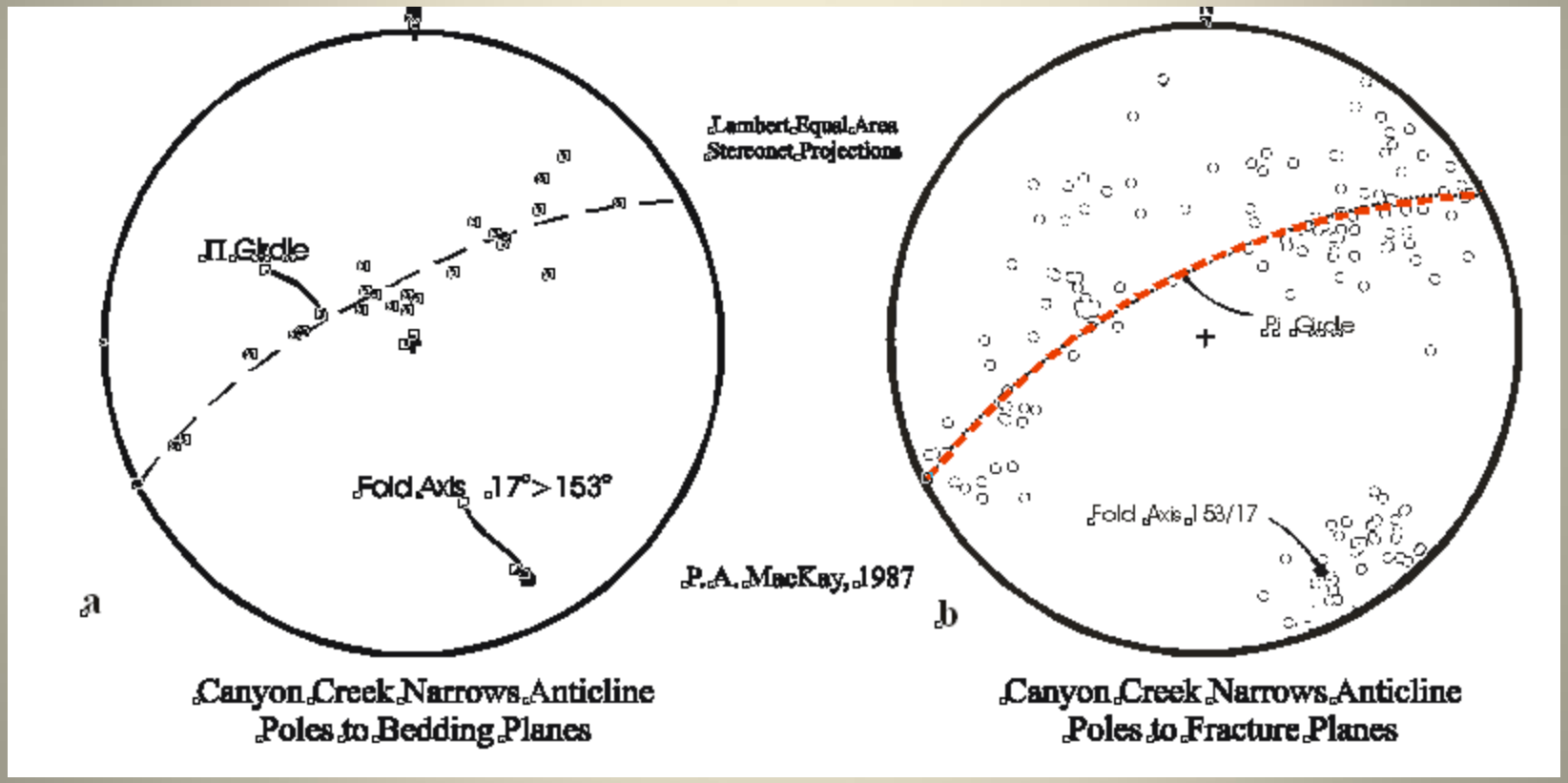
Sketch of the Canyon Creek Narrows Anticline looking to the south. East (foreland) is to the left.

Folded Palliser (Wabamum) – Canyon Creek



Folded Palliser (Wabamum) – Canyon Creek

Canyon Creek
Poles to bedding and fractures



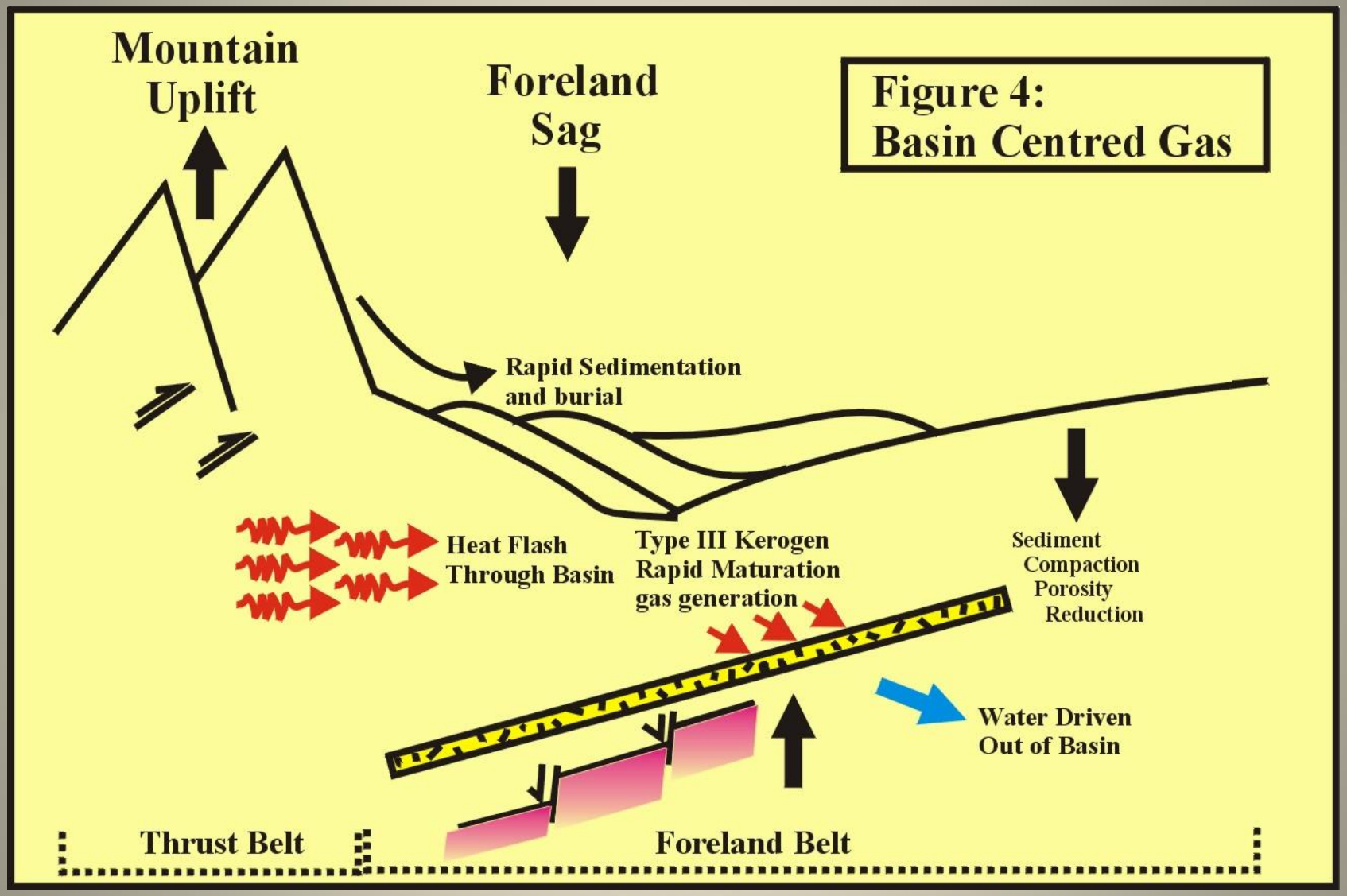
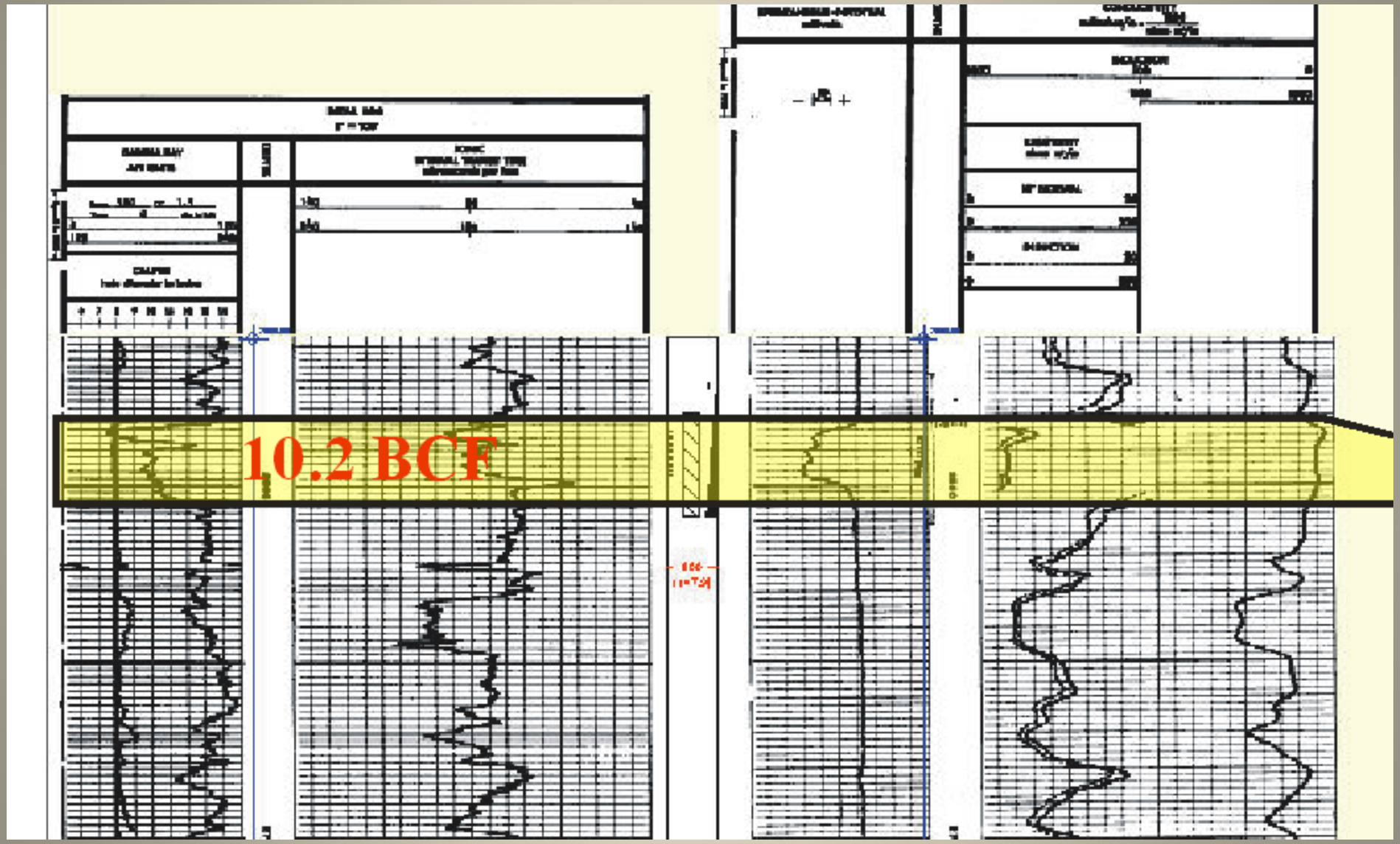
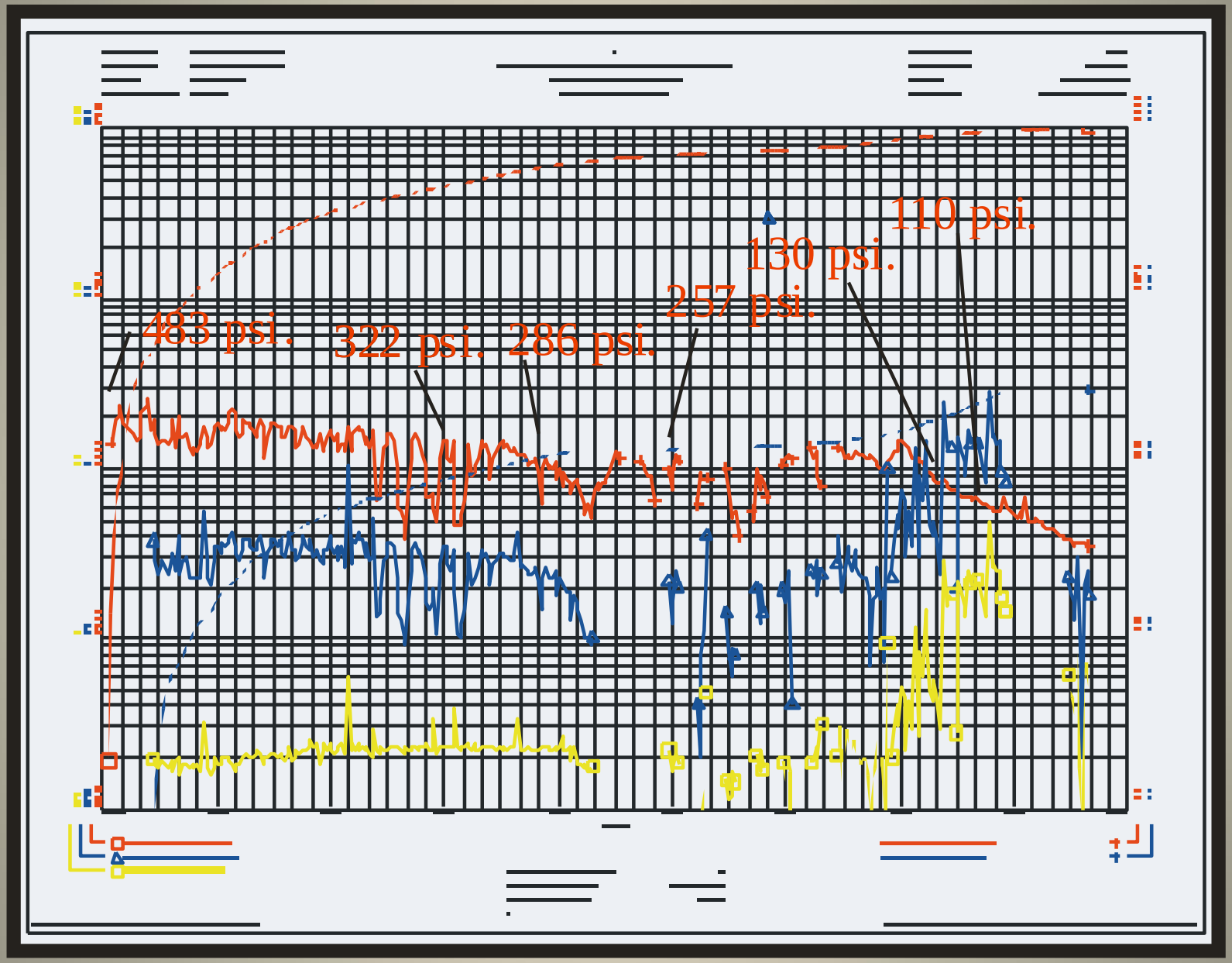


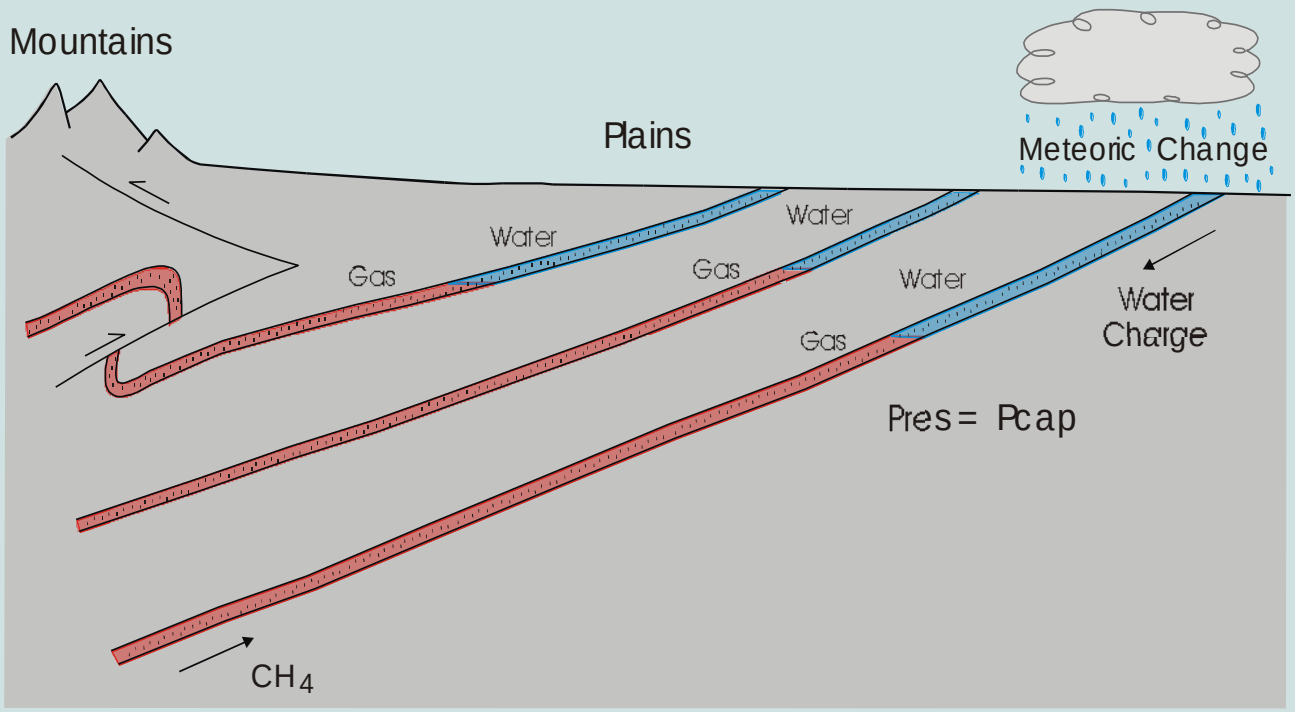
Figure 4:
Basin Centred Gas
Mountain
Uplift
Foreland
Sag
Rapid Sedimentation
and burial
Heat Flash
Through Basin
Type III Kerogen
Rapid Maturation
gas generation
Sediment
Compaction
Porosity
Reduction
Water Driven
Out of Basin
Thrust Belt
Foreland Belt

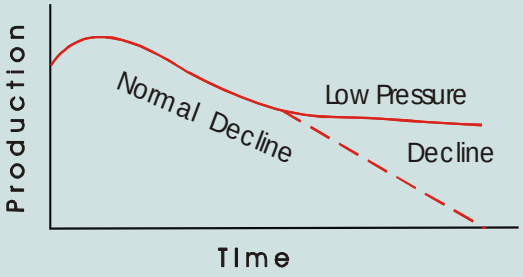
Sandstone
Shale/Siltstone

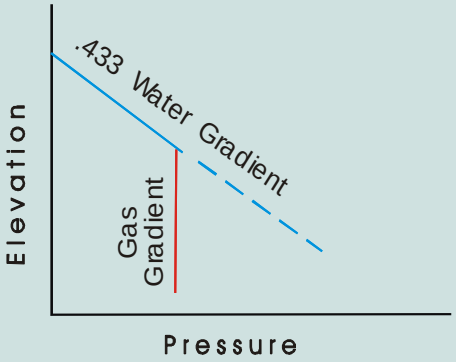
Place holder for horizontal well


10.2 BCF

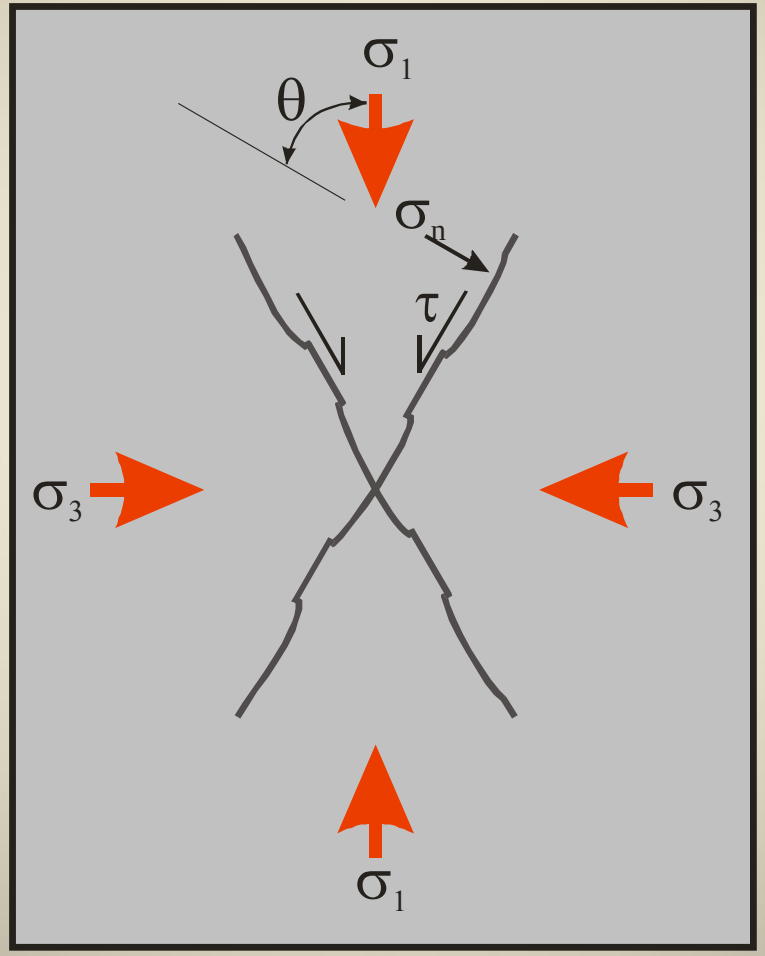

483 psi.
322 psi.
286 psi.
257 psi.
130 psi.
110 psi.


Mountains
Plains
Meteoric Change
Water
Water
Gas
Gas
Water
Gas
Water
Charge
Pres = Pcap
CH4

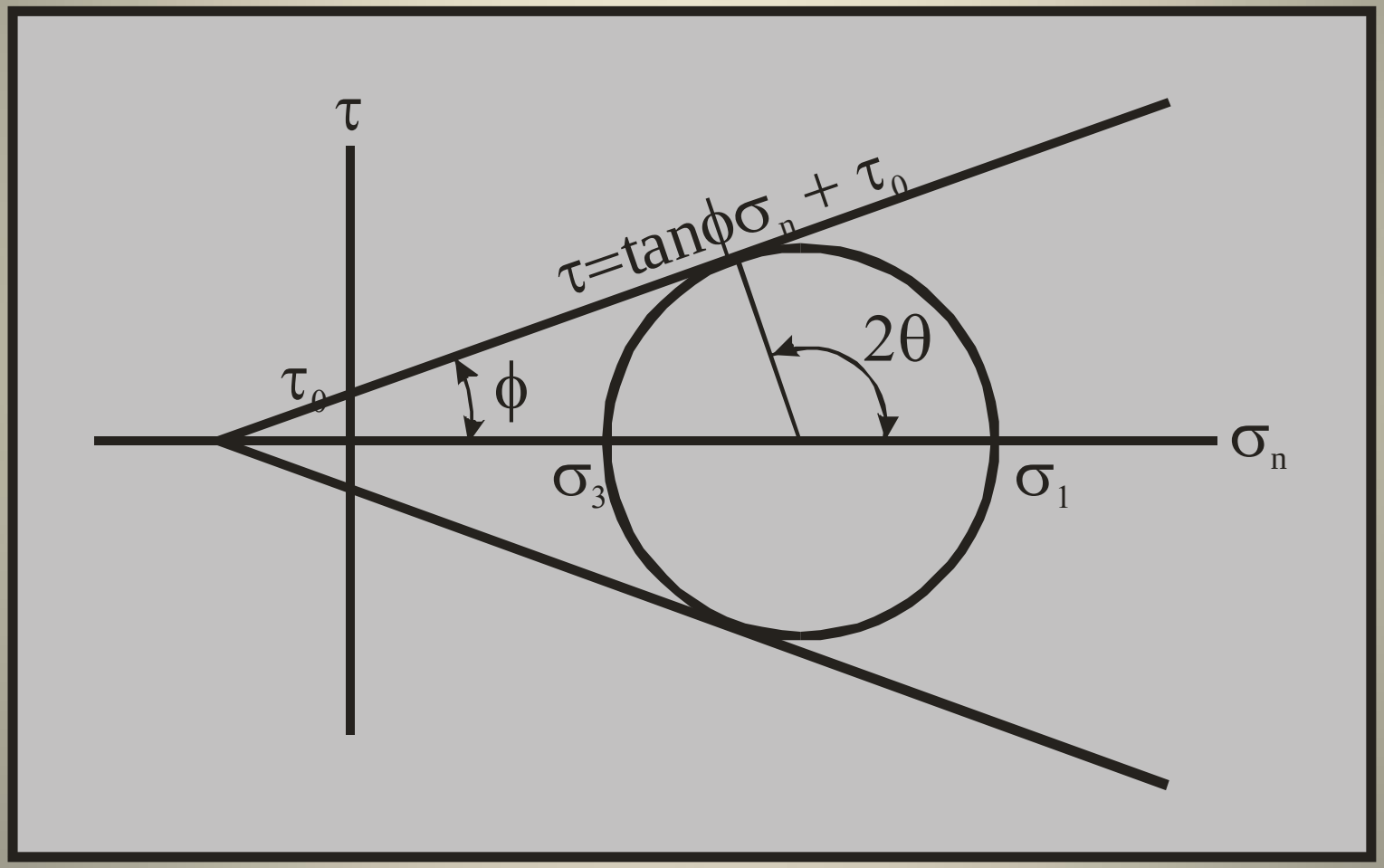

Production
Normal Decline
Low Pressure
Decline
Time


Elevation
.433 Water Gradient
Gas
Gradient
Pressure

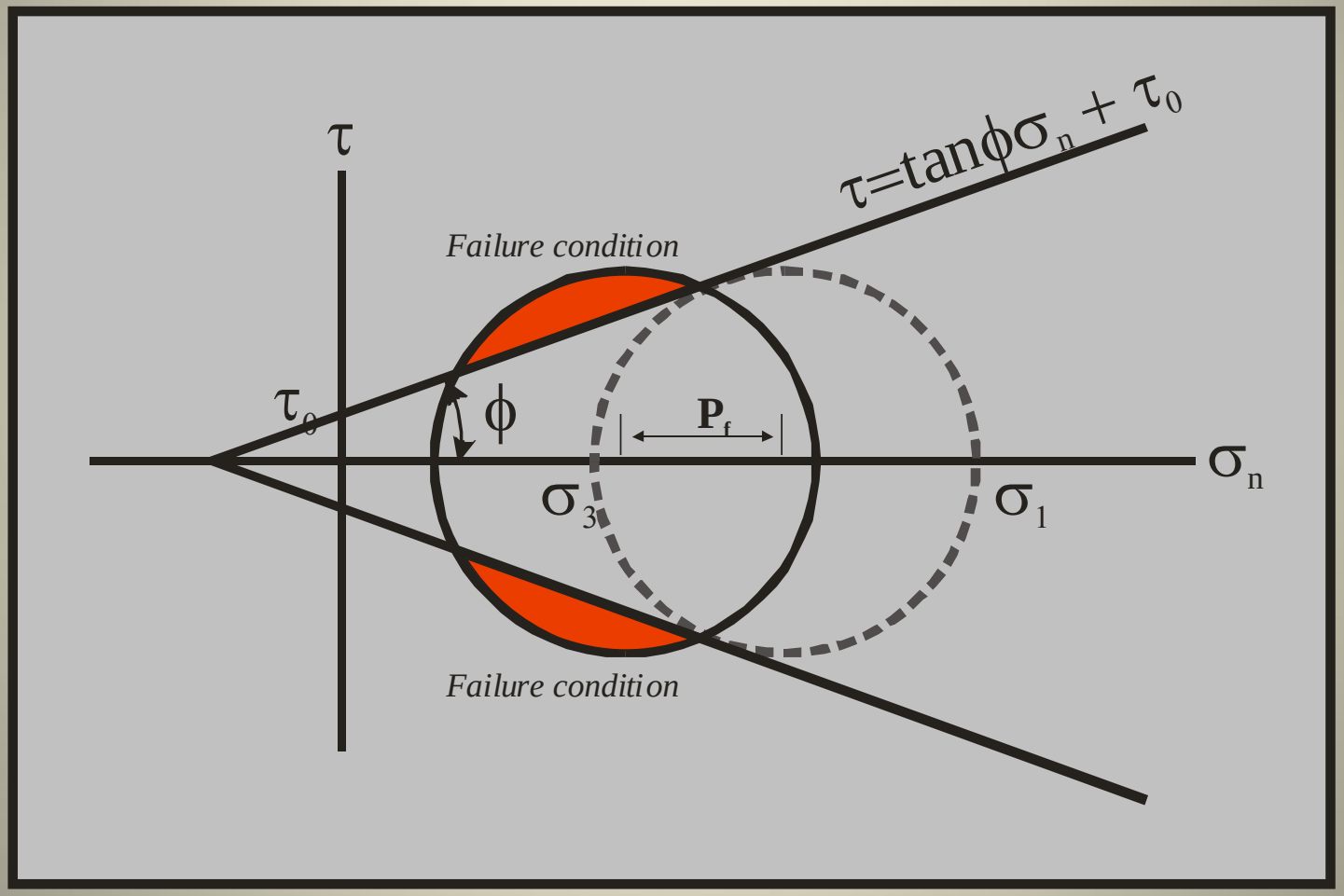
How do faults form?



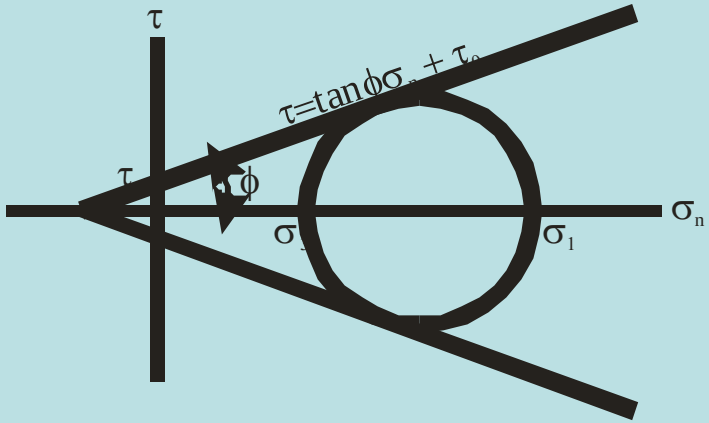
Mohr Diagram



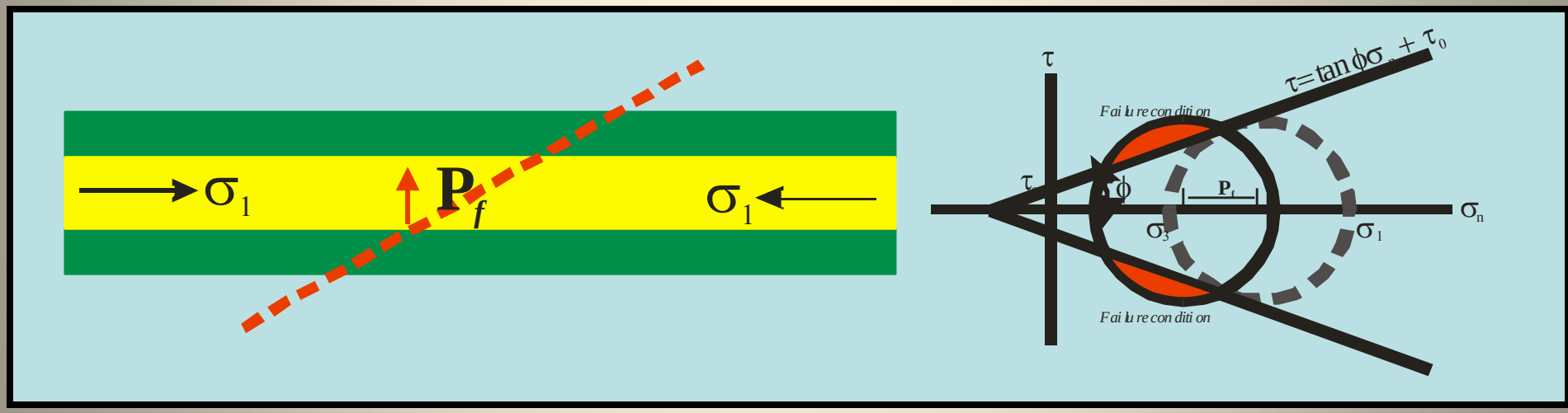
Role of Fluid Pressure



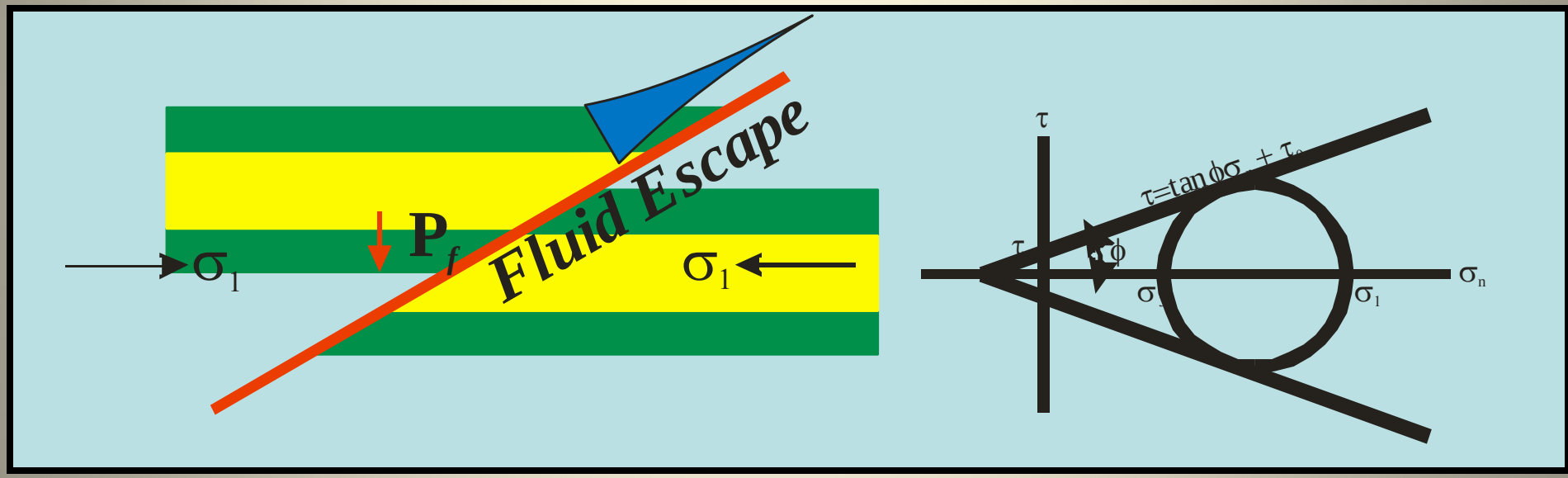
Strata is critically stressed



Strata is critically stressed
Fluid pressure increases
(hydrocarbon generation?)



Strata fails and releases fluid
Original fluid pressure is restored
Strata is critically stressed

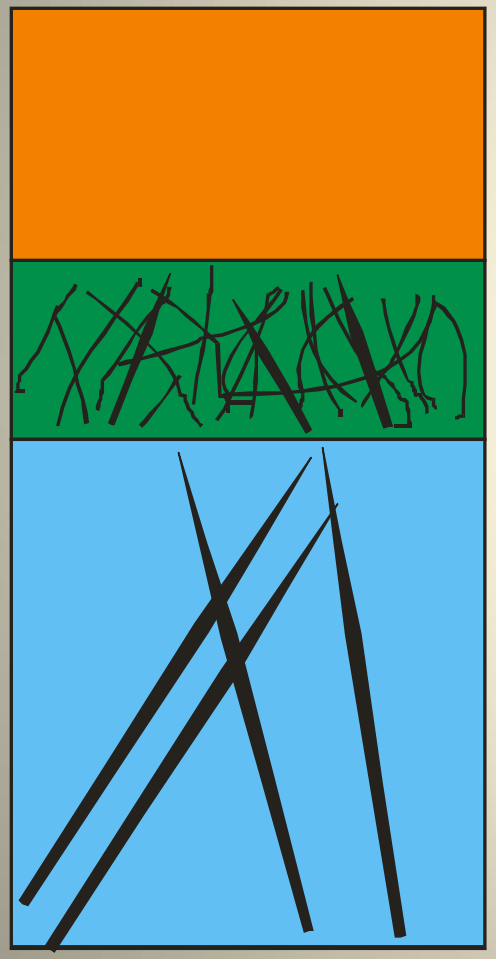


How do faults seal?

- **1/ Fault gouge along fault reduces permeability – primary**

- **2/ Juxtaposition of tight impermeable strata against reservoir rock – secondary**

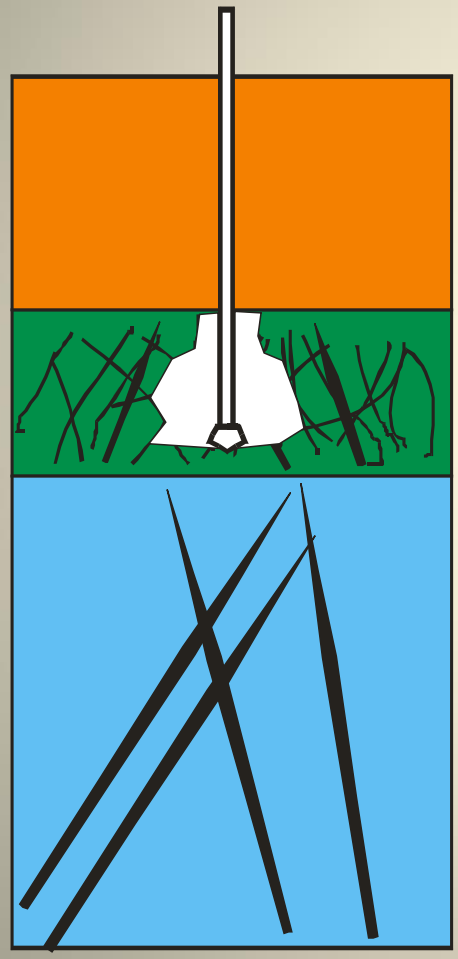
Drilling Issues Associated with Fractured Reservoirs



Fractured Organic Shale

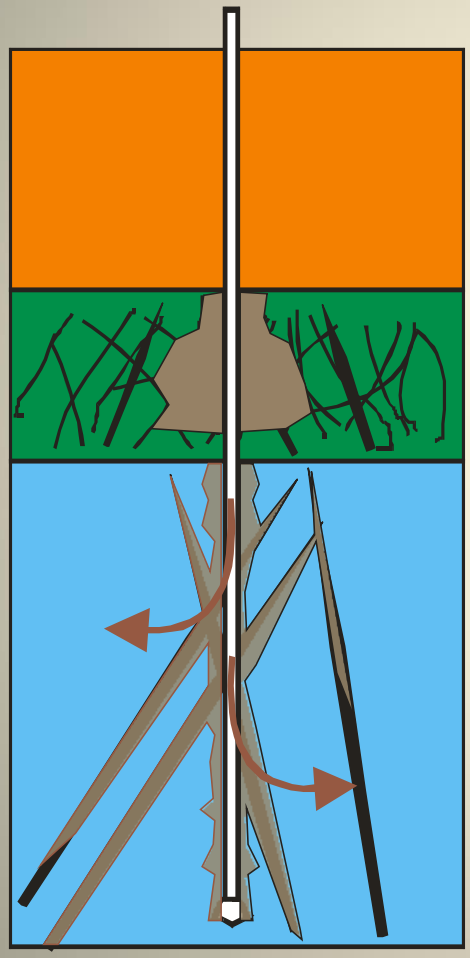
Fractured Reservoir

Drilling Issues Associated with Fractured Reservoirs



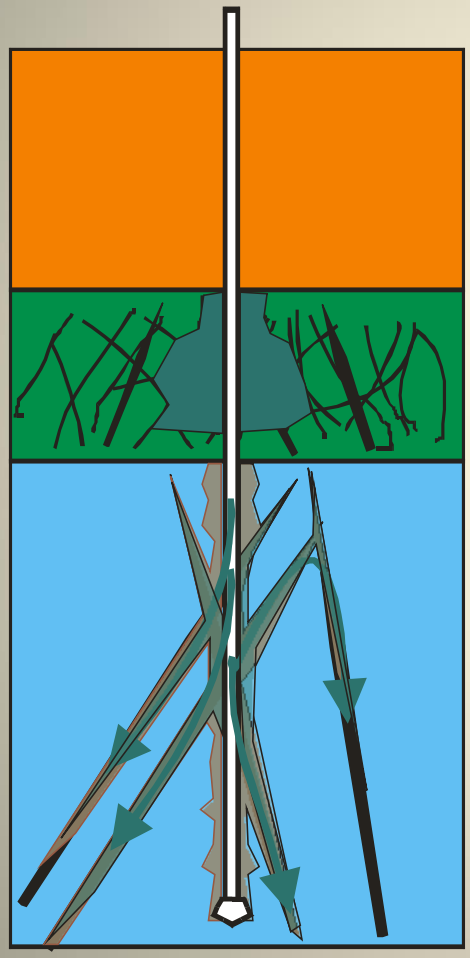
- Drill bit penetrates the fractured shale and the shale begins to collapse releasing gas into the well
- Response to increase gas in the mud is to weight-up.
- Zone appears over-pressure because it is taking on gas
- Increase weight until gas is no longer coming into well
- Well is over-balanced but not losing mud to the formation because the shale is tight and the fractures are not effective

Drilling Issues Associated with Fractured Reservoirs



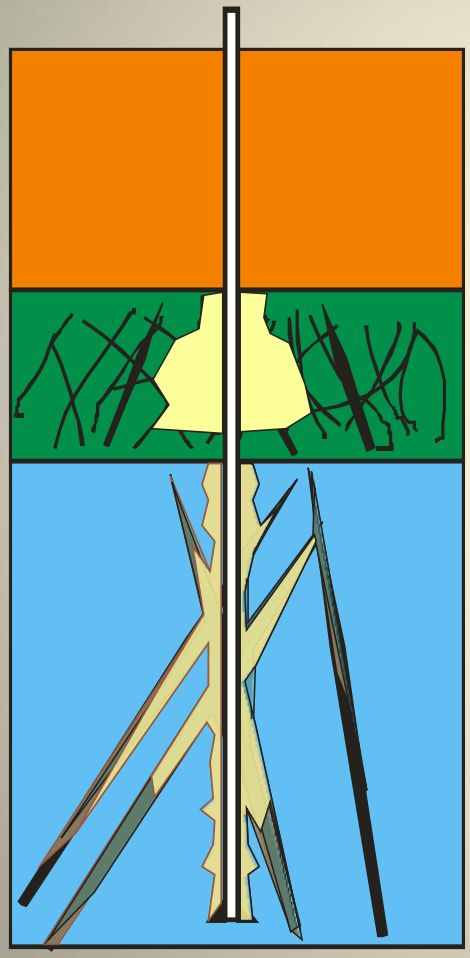
- Drill bit enters normally pressured reservoir and begins to lose mud to the formation
- The increased mud weight accelerates the mud loss and a loss circulation situation develops

Drilling Issues Associated with Fractured Reservoirs



- Loss Circulation material is mixed into the mud and pumped into the formation
- Due to the nature of the fracture shape the LOC material does not pack off at the wellbore interface but penetrates into the formation
- Eventually the LOC material is effective at stopping the loss of drilling mud but the damage to the formation is deep and along the best permeability pathways

Drilling Issues Associated with Fractured Reservoirs



- The well is cased and the cement is circulated.
- The high weight cement (SG=1.8) is overbalanced to the reservoir and additional cement pushes into the fractures within the reservoir causing further damage