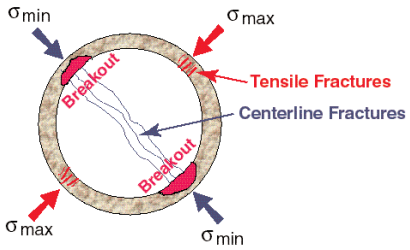
Understanding induced fractures on borehole images and core

Induced fractures can be distinguished from natural fractures by their geometry, and relationship to the borehole. Where breakouts are present, identifying induced fractures is often easier, as breakouts and induced fractures are related to the same *in-situ* stress conditions.

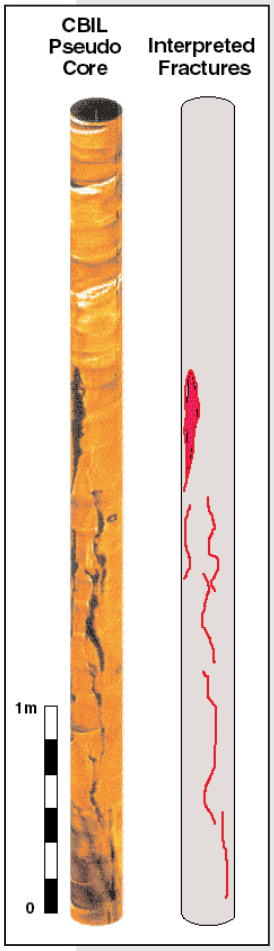
How to distinguish induced fractures from natural fractures

- Induced fractures are always open
- Natural fractures can be closed, partially or fully open, or mineralized
- Hydraulically induced fractures tend to be restricted to tensile parts of the borehole wall which are 90° from breakouts
- Petal fractures form ahead of the drill bit in compressive areas where breakouts develop
- Natural fractures are often symetrically developed on each side of the borehole
- Petal and centerline fractures are nearly always symmetrical, but hydraulic fractures are usually asymmetrical.

In the majority of well locations, one of the three principle stresses is oriented vertically, requiring the other two stresses to be horizontal. Breakouts form in response to the minimum stress (σ_{min}) and maximum stress (σ_{max}) components in the borehole. Induced fractures tend to form perpendicular to the least principle stress, so that well developed, borehole-parallel induced fractures form when σ_{min} is perpendicular to the borehole. Hydraulic, centerline and tensile fractures tend to be inclined to the borehole when σ_{min} is inclined to the borehole, although they may not form perpendicular to σ_{min} in this case.



The stress relationship in a borehole cross section, and the expected position of breakouts in tensile and centerline-induced fractures.

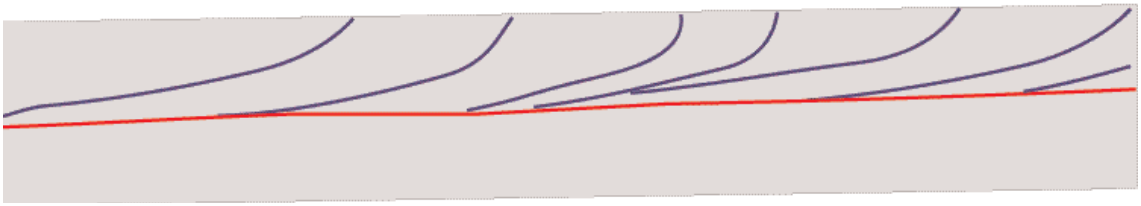


Pseudo core generated from image data can also be used to interpret fracture type and geometry

Induced fractures on core

Petal, centerline and petal-centerline fractures are visible on cores — they are the only induced-fracture types which are formed prior to the removal of borehole material during drilling.

Fractured sandstone core



Interpreted fractures on sandstone core

Petal-Centerline Fracture

Petal Fracture

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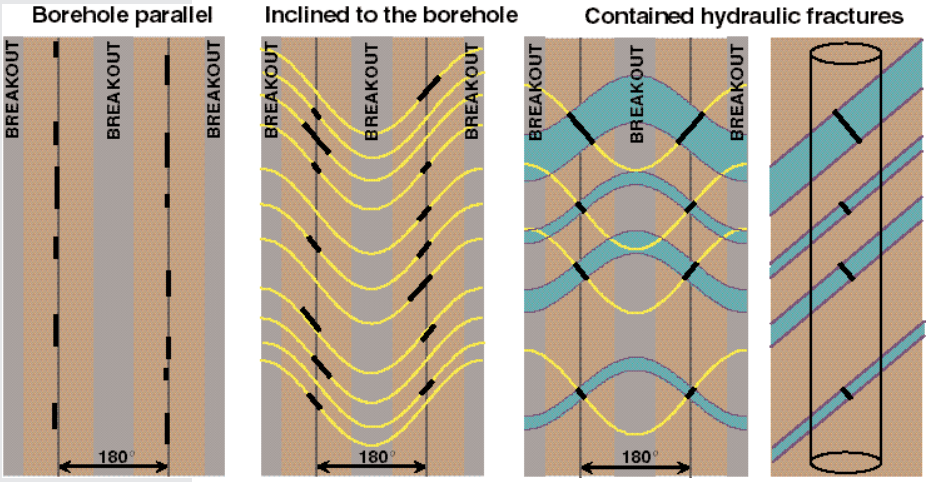
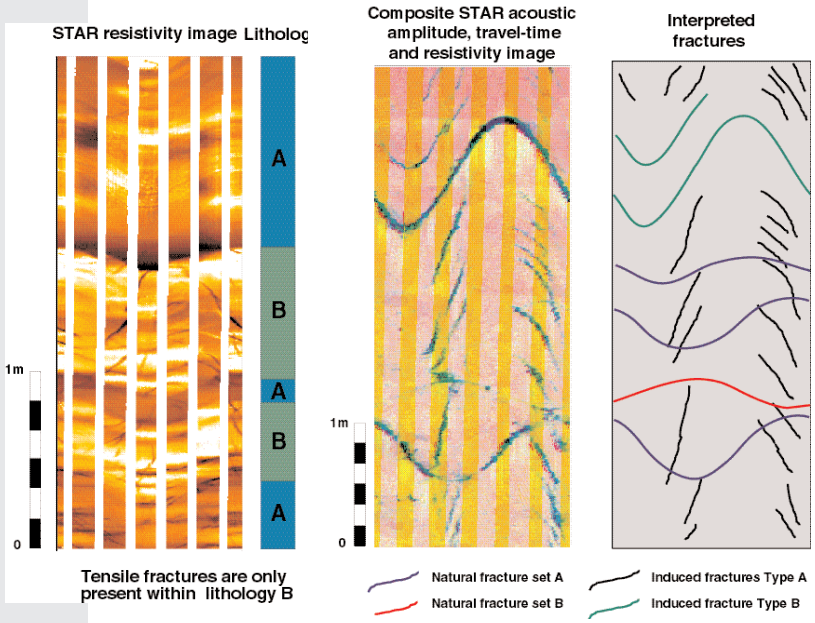
Hydraulic and tensile wall fractures

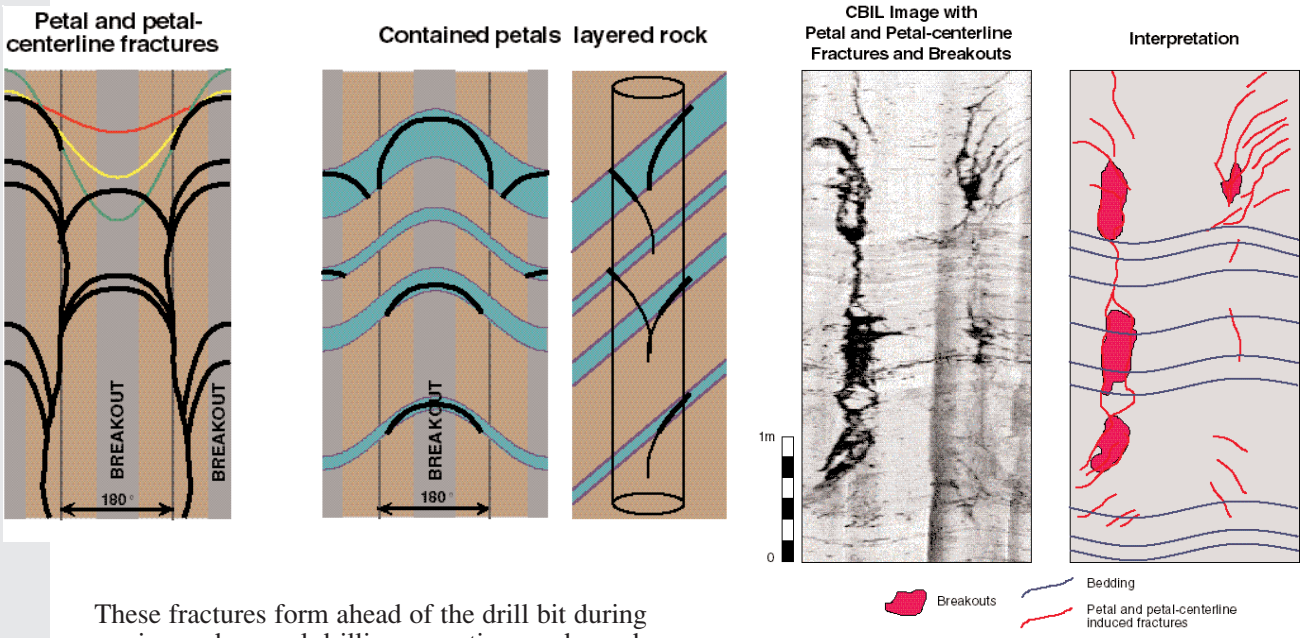




Hydraulic fractures form when the pressure of the drilling fluid exceeds the minimun stress plus tensile strength components. These fractures can propagate far from the borehole wall with an adequate fluid supply. If hydraulic fractures develop due to excessive mud weight, significant mud losses may occur and the fracture can resemble well-developed centerline fractures. Locally developed hydraulic fractures are usually a result of overdriven turbo drills.

Tensile wall fractures form due to inwards buckling of the borehole wall under the influence of stresses concentrated on the borehole wall and thermal contraction due to cooling from the drilling fluid. These fractures form perpendicular to the minimum stress component rotated 90° from breakouts. Tensile wall fractures may have complex geometry and do not propagate far from the borehole because the generating stresses only exist near the borehole wall.

Petal and petal-centerline fractures



These fractures form ahead of the drill bit during coring and normal drilling operations and are characterized by highly non-planar geometry. They normally extend beyond the final borehole diameter and correlate between core and image logs. The direction of fracture propagation is always downhole. Petal fractures form immediately ahead of the drill bit as a result of excessive bit weight. Centerline fractures propagate ahead of the drill bit. If breakouts are present, it is often impossible to identify centerline or petal-centerline fractures as the fractures coincide with the breakout orientation.

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