Cavings Analysis:

A Key to Managing Wellbore Instability in Real Time

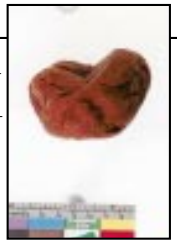
Cavings

Cavings are rock fragments produced by wellbore instability and transported to surface in the drilling mud.

Typical cavings are centimeter sized fragments, but can range from 1mm to more than 10 cm.

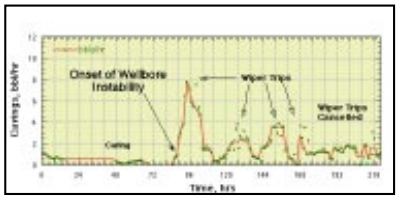
Small cavings, called "coffee-ground cavings" can form from disaggregating of larger water-sensitive shale cavings.

Larger cavings are typically produced from naturally fractured formations. Such cavings are bounded by natural fracture planes.



Cavings Analysis

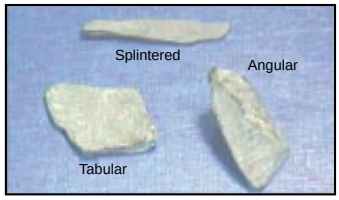
Cavings Rate Monitoring



Monitoring the volume of cavings versus time
- provides an early warming of wellbore instability
- signals need to improve hole cleaning
- indicates which drilling practices destabilize the wellbore

Cavings Morphology

Interpretation of cavings morphology
- helps determine cause of wellbore failure
- helps determine optimal remedial action

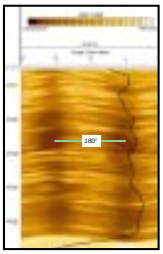


Angular Cavings

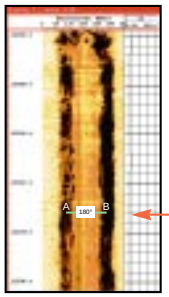
These multifaceted rock fragments result from shear failure of the wellbore.

Key Characteristics
- facets are ***newly created*** fracture surface
- facets may be curviplanar
- facets are nonparallel
- failure-two regions on the wellbore separated by 180°

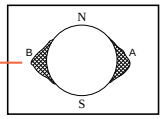
Borehole Images illustrating sections of wellbore that have suffered shear failure (dark bands A and B) which are the sources of angular cavings. RAB* (Resistivity At Bit) images allow diagnosis of wellbore failure while drilling.



RAB while-drilling Image



UBI* after-drilling Image

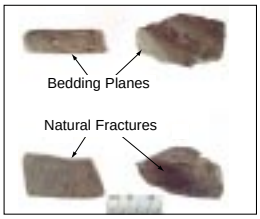


Schematic borehole cross section (looking down hole) showing locus of shear failure where angular cavings originate (A and B).

Remedial Action
- if mud weight close to Pp: raise mud weight
- if mud weight close to fracture pressure
  - maintain mud weight
  - decrease fluid loss
  - manage hole cleaning

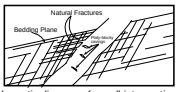
Platy/Tabular Cavings

These cavings are rock fragments bounded by preexisting planes of weakness.

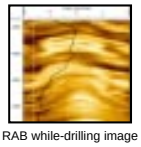


Key Characteristics
- majority of caving surfaces represent preexisting planes of weakness
- one or more parallel surfaces are common
- surfaces tend to be relatively smooth and planar
- failure initiates on high side of wellbore when well is nearly parallel to a plane of weakness

RAB while-drilling image



Schematic diagram of a well intersecting pre-existing planes of weakness (bedding, fractures). Platy-blocky cavings originate on high side of the hole due to gravitational instability.



RAB while-drilling image

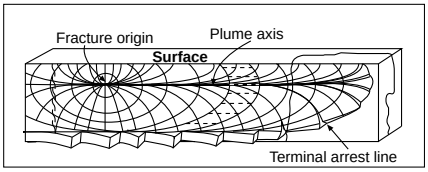
UBI after-drilling image

Borehole images illustrating damage on high side of wellbore. RAB image (left) damage (dark region) is centered on high side (u). UBI image (right) high side damage is oriented 330°.
Note: High side damage is well developed when wells are deviated along bedding or fracture dip direction.

Remedial Action
- maintain mud weight
- minimize fluid loss coefficient of drilling mud
- use crack blocking additives
- avoid back reaming
- manage hole cleaning
- avoid excessive rpm and drillstring vibrations
- employ gentle drilling practices

Splintered Cavings

These elongated platy rock fragments result from tensile failure of the wellbore. Splintered cavings are believed to form as a poroelastic response to drilling too fast through low-permeability shale or drilling underbalanced.



Surface structures commonly associated with extension (mode 1) fractures (after Kulander and Dean, 1985).

Key Features
- typical lithology: low-permeability shale fragments
- caving surfaces show plume structure indicative of tensile failure
- entire circumference of wellbore may be damaged

Remedial Action
- raise mud weight
- reduce rate of penetration

Food for Thought

- More than one type of caving (mode of instability) can be produced in a single openhole section. The driller must determine which mode of failure is most problematic and take the appropriate remedial action.
- It is important to respond to sudden changes in cavings rate. A small constant volume of cavings production is worth monitoring but may not require immediate remedial action.
- The use of cavings morphology to diagnose wellbore failure cavings is relatively new. When interpretation of cavings is problematic, e-mail a digital image of the cavings to a geomechanics specialist. Include a coin or ruler for scale and, if possible, locate the source on a (RAB, UBI, FMI*[Fullbore Formation MicroImager]) borehole image or on an oriented 4-arm or 6-arm caliper.
- Issue a digital camera capable of producing a sharp image of a U.K. 1 pound coin or a U.S. quarter dollarto the mud logger.

Please e-mail images and or questions about cavings analysis to
Richard Plumb (plumb@sugar-land.oilfield.slb.com) or
Stephen Edwards (sedwards@sugar-land.oilfield.slb.com)

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Oilfield Services

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