Bore Hole Seals

Introduction

Overarching Questions

1. What materials and processes have been developed for sealing, and used to seal, boreholes under representative conditions?

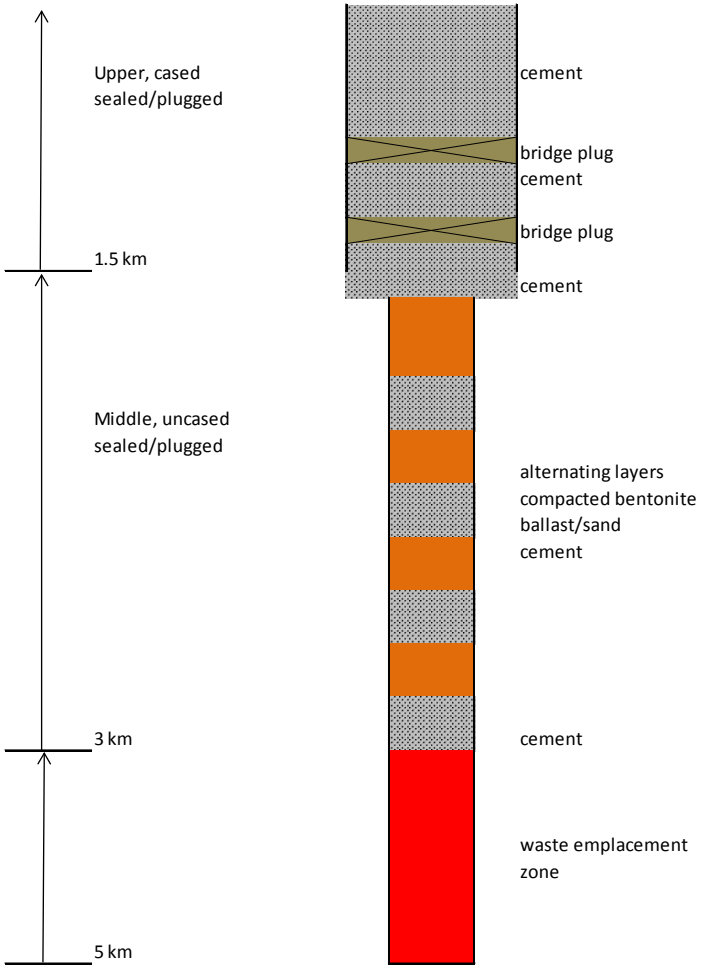
2. What evidence is there for the long-term effectiveness of borehole seals?

3. How can we predict the long-term performance of seals?

4. What level of performance of a borehole seal is critical to the safety of deep borehole disposal?

Three Well Sections of Concern

1. The deep repository for the waste.
2. Intermediate depths that may be influenced by well bore heating and fluid percolation.
3. The upper well bore where the final seals between the surface are made.



Innovation

1. Several different groups have studied and are studying these problems.
2. Seal innovations are many and will be discussed today.
3. Modeling of the seals has been done that suggests long term stability.
4. Life of material analogs exist.

Well Bore Seals from an Oil and Gas Perspective

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Well Bore Seals

- Well bores must be sealed –
- On the outside of the steel casing that is placed in the well.
- Inside the well when the well is abandoned.
- Seals must be designed as a part of the well bore architecture.

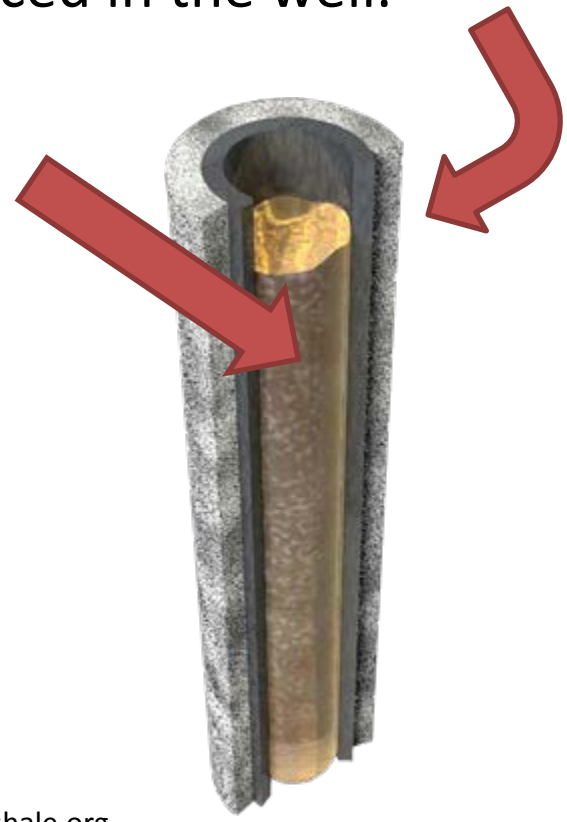


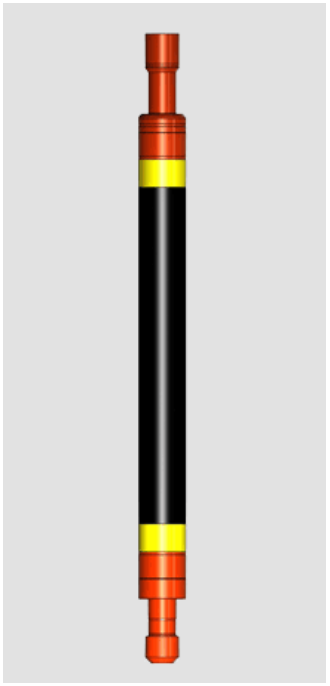
Image from exploreshale.org

Traditional Well Bore Seals

- Traditional seals have been made of Portland Cement with appropriate additives.
- It forms a low permeability solid that establishes strength and resists corrosion if correctly formulated.
- If properly used it forms adequate bonds with the casing and the rock.

Mechanical Well Bore Seals

- Mechanical seals such as packers with plugs and bridge plugs are also used internal to the well.
- External casing packers are used to separate portions of the well bore outside the casing when cement is not used.
- Expandable casing can be used as a seal.



Images from Youtube, Halliburton, and poss.com

Seal Failure

- Seals can fail due to:

1. Channels caused by poor cementing practice.
2. Exceeding the mechanical seal strengths.
3. Cement exposure to fluids that degrade the quality of the solid.
4. Failure of external casing packers or bridge plugs.

- All of these failures promote a flow channel outside the casing.

Plug and Abandonment

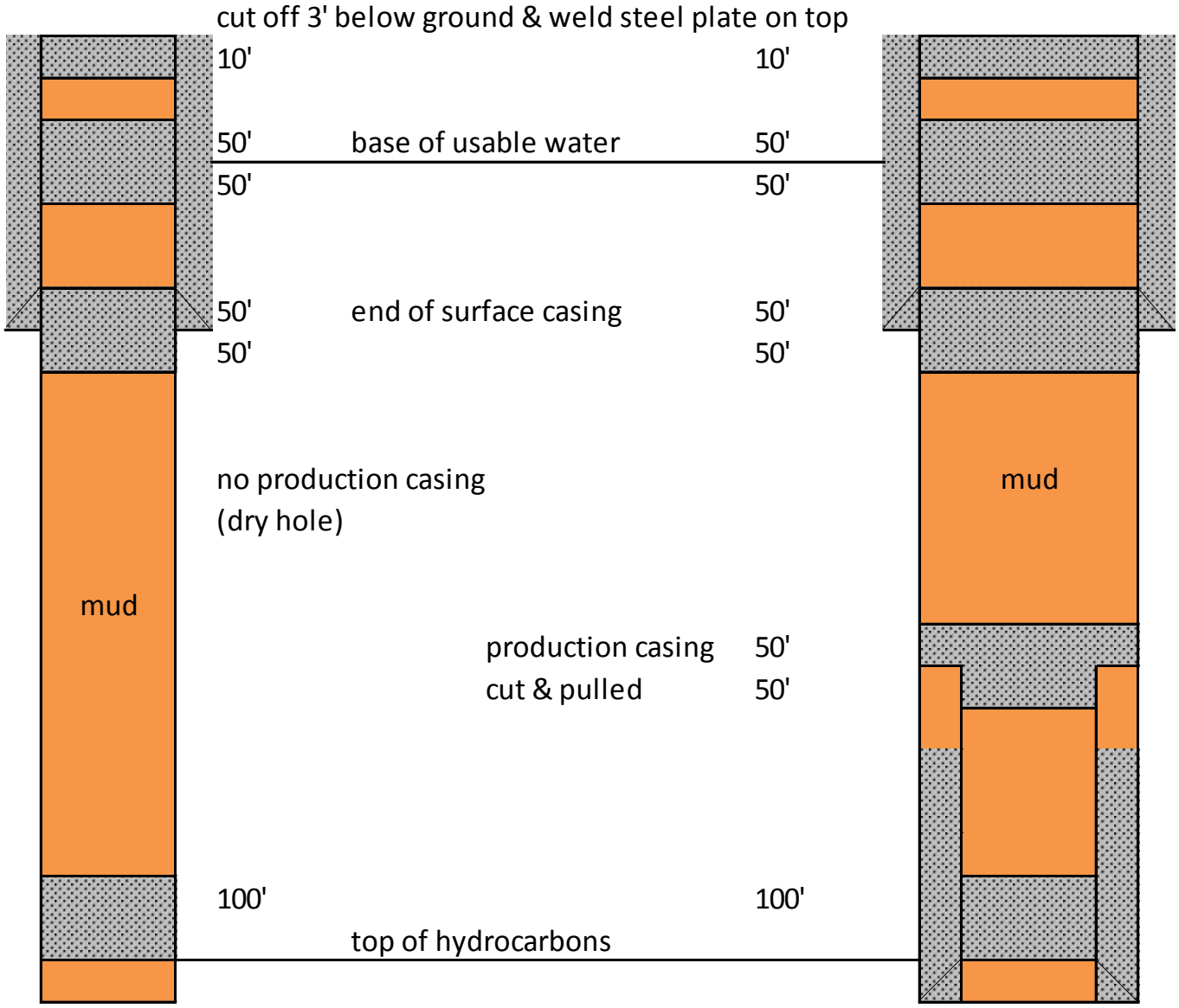
- At the end of the life of a well it is plugged with a variety of seals that are placed in the well as specified by the governing body.

- Generally a seal is placed to separate oil and gas reservoirs from other layers and to separate geologic intervals and the base of the usable quality water.

- The seals are made by the placement of cement perhaps supported by a bridge plug during the time required for the cement to set.

- The mechanical bridge plug is not considered the permanent part of the plug – the set cement forms this plug.

Examples of Plug and Abandonment



Cement Alternatives

- Portland cement with blast furnace slug produces a stronger more resistant cement for certain applications.
- Blast furnace slag can be used to convert clay base drilling muds to a cementitious material. This might be useful above the cement in the portion of the well to be left full of mud.
- Modified chemically bonded phosphate ceramics. These have been tested in geothermal wells in Indonesia.
- Temporary plugs made of barite have been used to isolate high pressure zones from weak layers. This is a dense, low permeability mass, but it does not fuse or react to form a solid.
- Temporary plugs made of compacted bentonite clay have been used to isolate water flows in a well. This plug can establish ionic bonds, but these are easily broken.

Seal Testing

- Regardless of the type of seal it can be tested with pressure.
- A positive test is pressure placed on top of the plug and held for a reasonable time to verify no leak from above.
- A negative test is a reduction of pressure above the plug to verify no flow from below.
- External seals can also be investigated using a cement bond log.

The Use of Cement

- General guidelines for the use of cement are:

1. Use enough cement – more is better.

2. Use cement that will provide the strength and life dictated by the well conditions of fluid type, pressure, and temperature.

3. Use good cementing practices when placing the cement and allowing it to cure.

Cement Life

- Cement or cement alternatives can have a long life if the general guidelines for creating the seals are followed.

- Analogs for cement life of 2,000 years are the Roman coliseum and aqueducts.