



Annulus Leak Detection and Well Repair in a Class I Well

*GWPC 2020 UIC Conference - San Antonio, TX
February 17, 2020*

Safety Moment

—Allergies

—*Airborne – Weather Events and Seasonal*

- General awareness
- Pollen count
- Antihistamines



Introduction



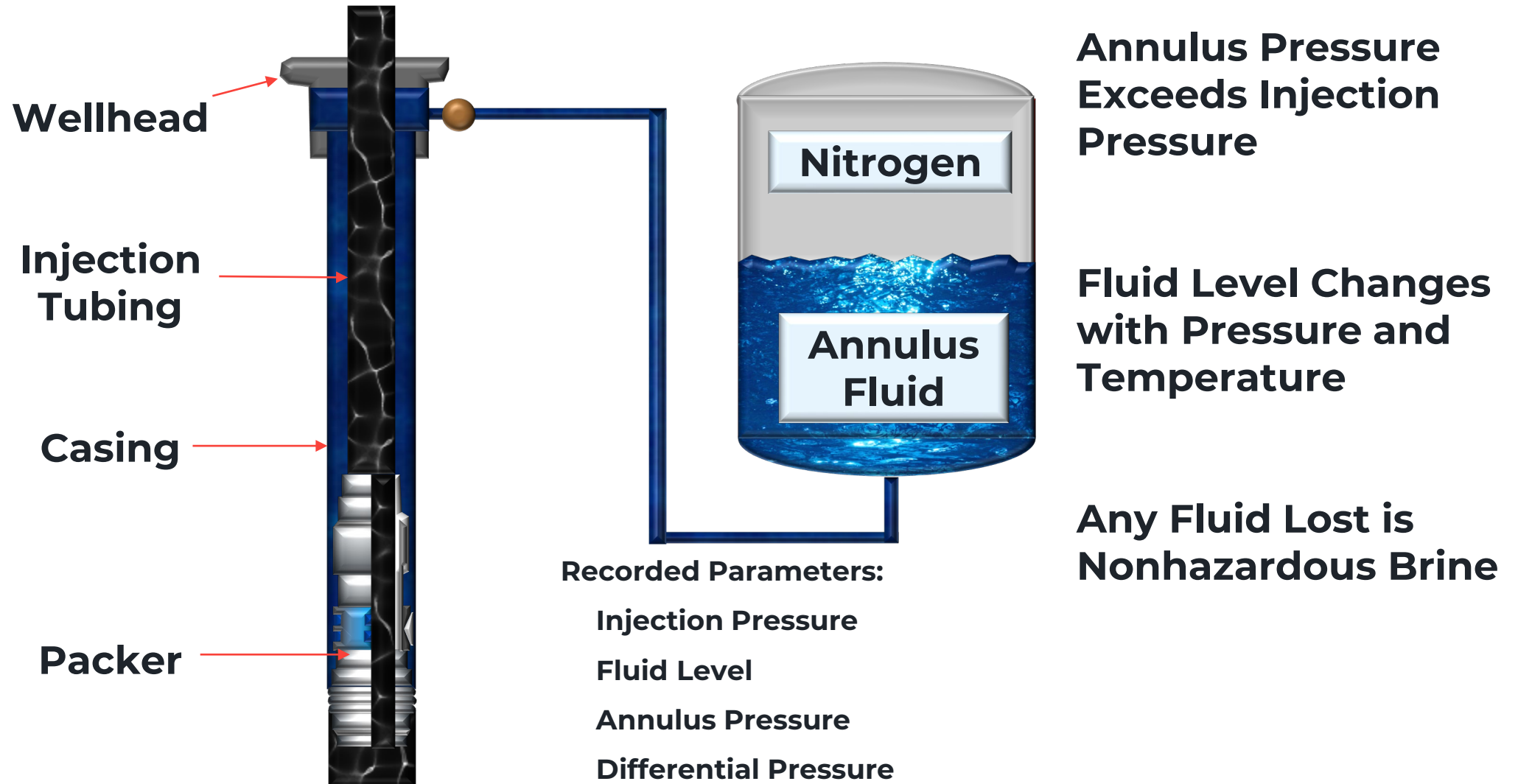
- Lead Engineer and Project Manager at WSP for 10 years
- Worked on 30+ Class I wells in permitting, MIT, well repair, drilling, and completions.

Presentation Agenda

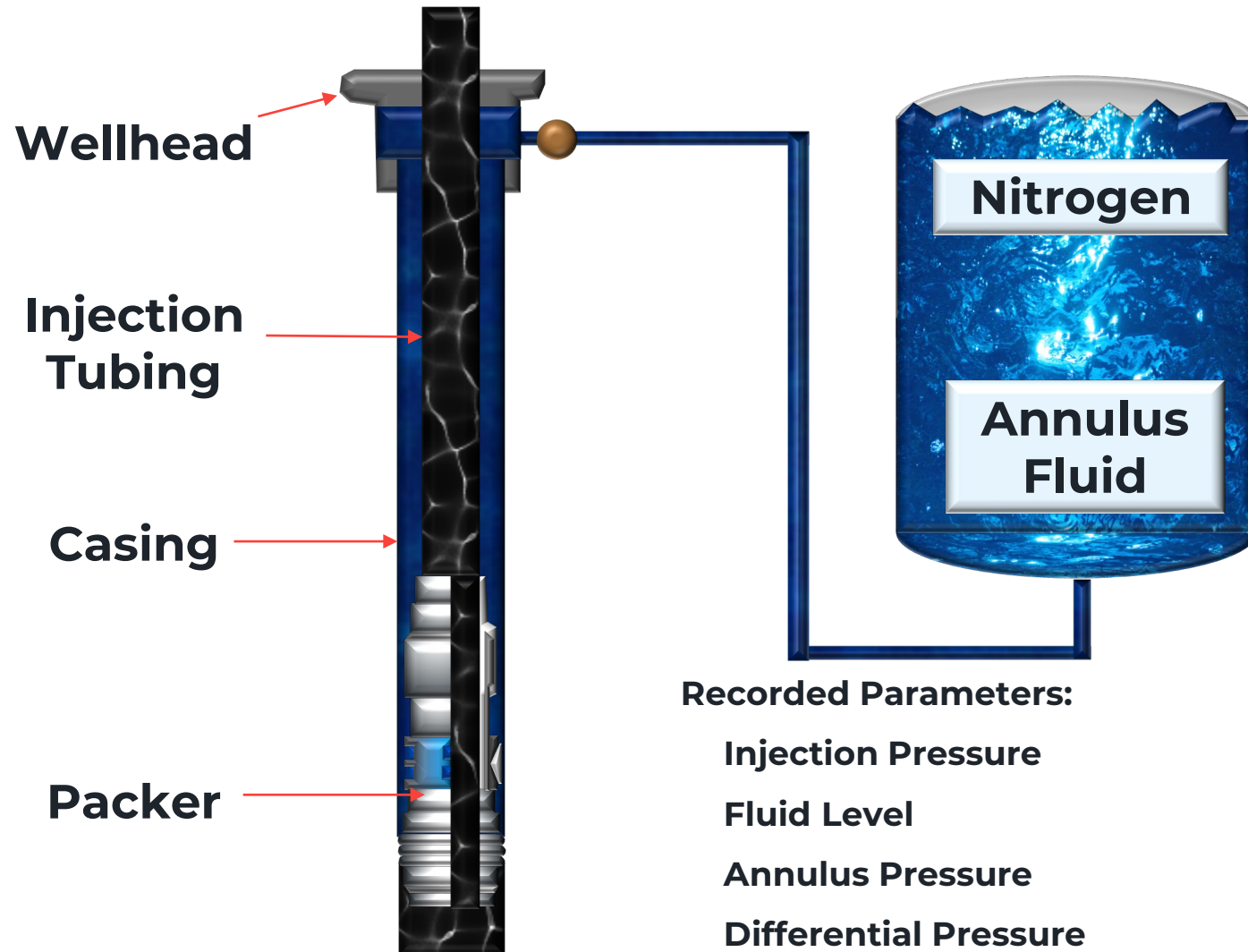
- Annulus leak detection
- Leak Determination
- Well Repair
 - Removing and replacing Tubing/Packer*
 - Determining casing leak*
 - Installing Liner
 - Sidetrack

Annulus Leak Detection

Well Annulus Monitoring System (WAMS)



Well Annulus Monitoring System (WAMS)



Annulus Volume

- Temperature effects

- Only a few gallons of water cooling down can cause a significant decrease in annulus pressure due to compressibility.*

- Compressibility of fluid example:

- 7" X 4-1/2" casing-tubing annulus with packer set at 5000 ft. Volume = 140 bbls*

- Reduction in annulus pressure of 50 psig caused by reduction of 1.03 gallons in the annulus.*

- $C_w = 3.5 \times 10^{-6} \text{ psi}^{-1}$

Leak Determination

- Tubing leak

- Tubing pressure and casing pressure will typically equalize*

- Casing leak:

- Annulus pressure will drop to 0 psig*

- WAMS unit not able to maintain pressure due to fluid loss -- dependent on size of casing leak*

Tubing Leak

Remove Injection
Tubing

Ground Level

Changing Tubing String and Packer

- Un-sting from packer

Base of USDW

Surface Casing and Cement

Confining Zone

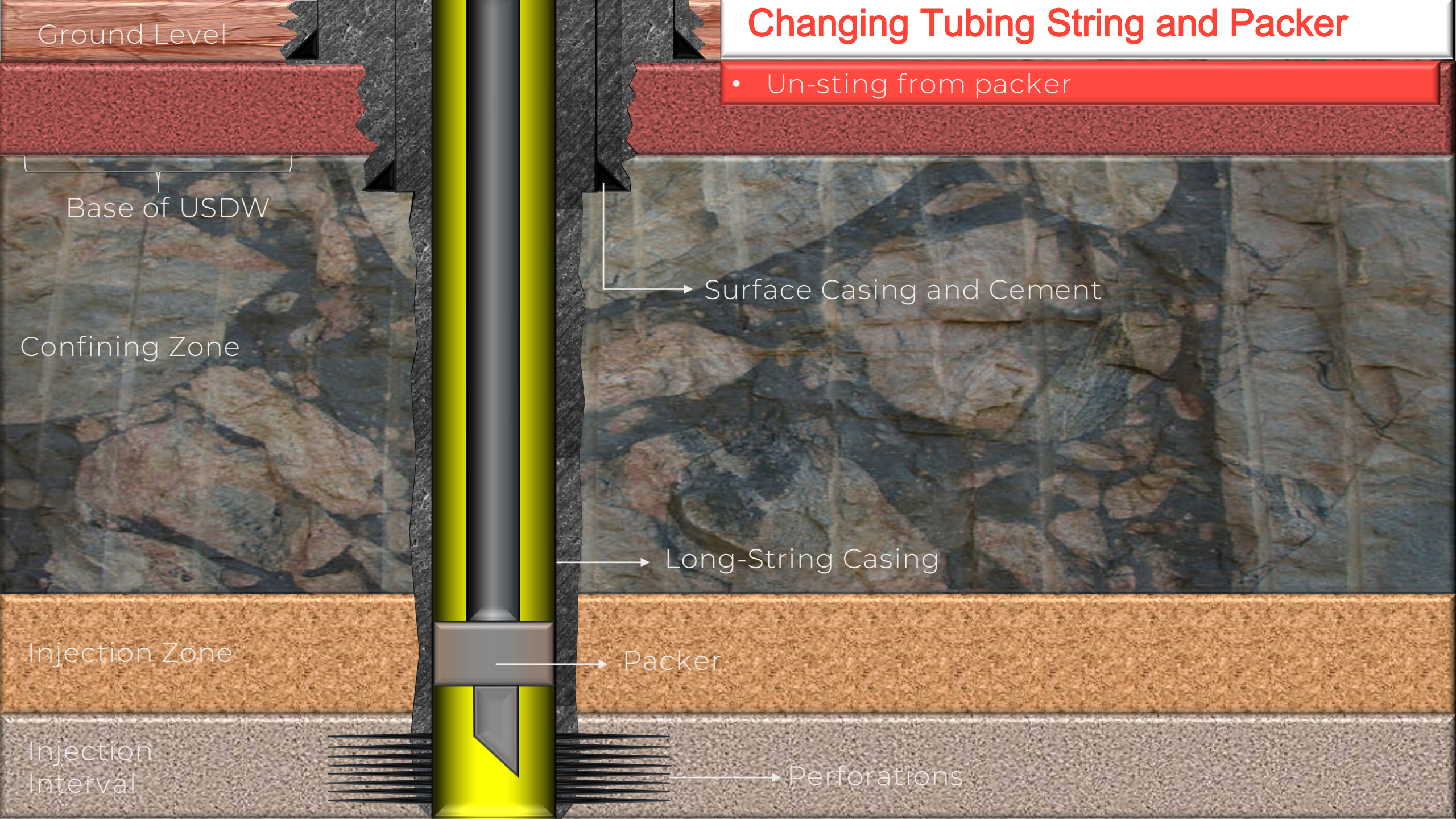
Long-String Casing

Injection Zone

Packer

Injection Interval

Perforations



Ground Level

Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool

Base of USDW

Surface Casing and Cement

Confining Zone

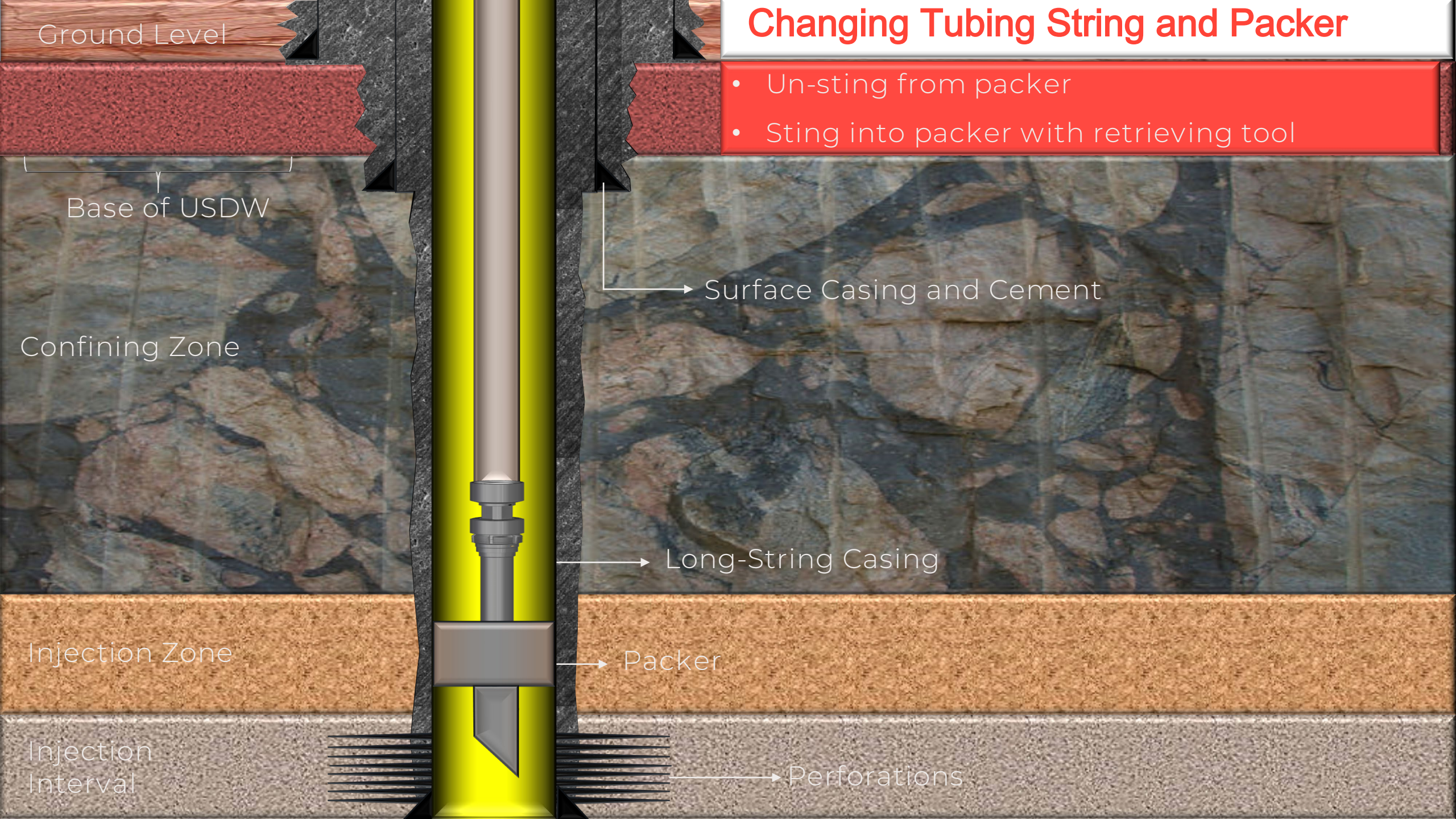
Long-String Casing

Injection Zone

Packer

Injection Interval

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

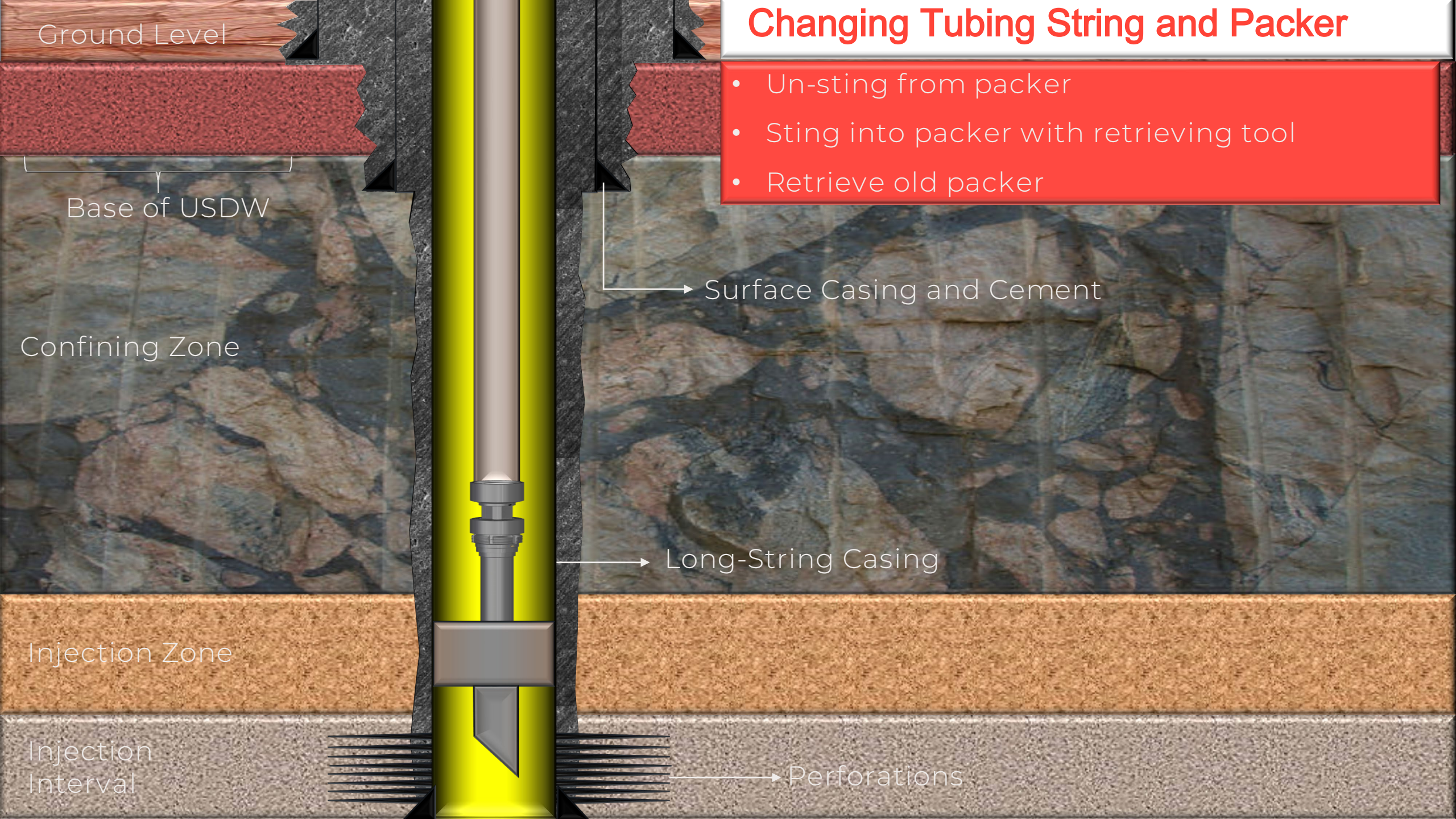
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer

Surface Casing and Cement

Long-String Casing

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

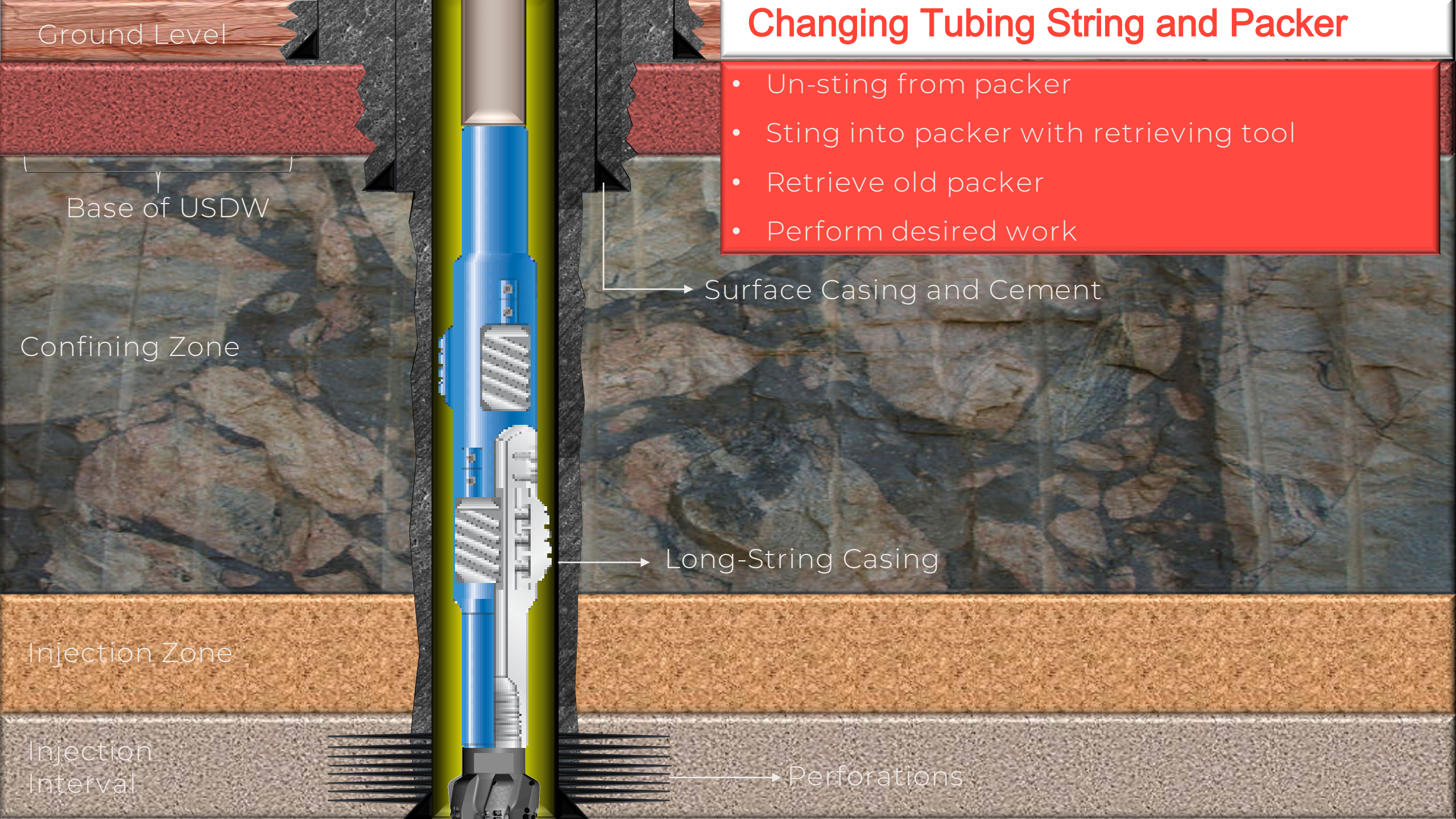
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work

Surface Casing and Cement

Long-String Casing

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

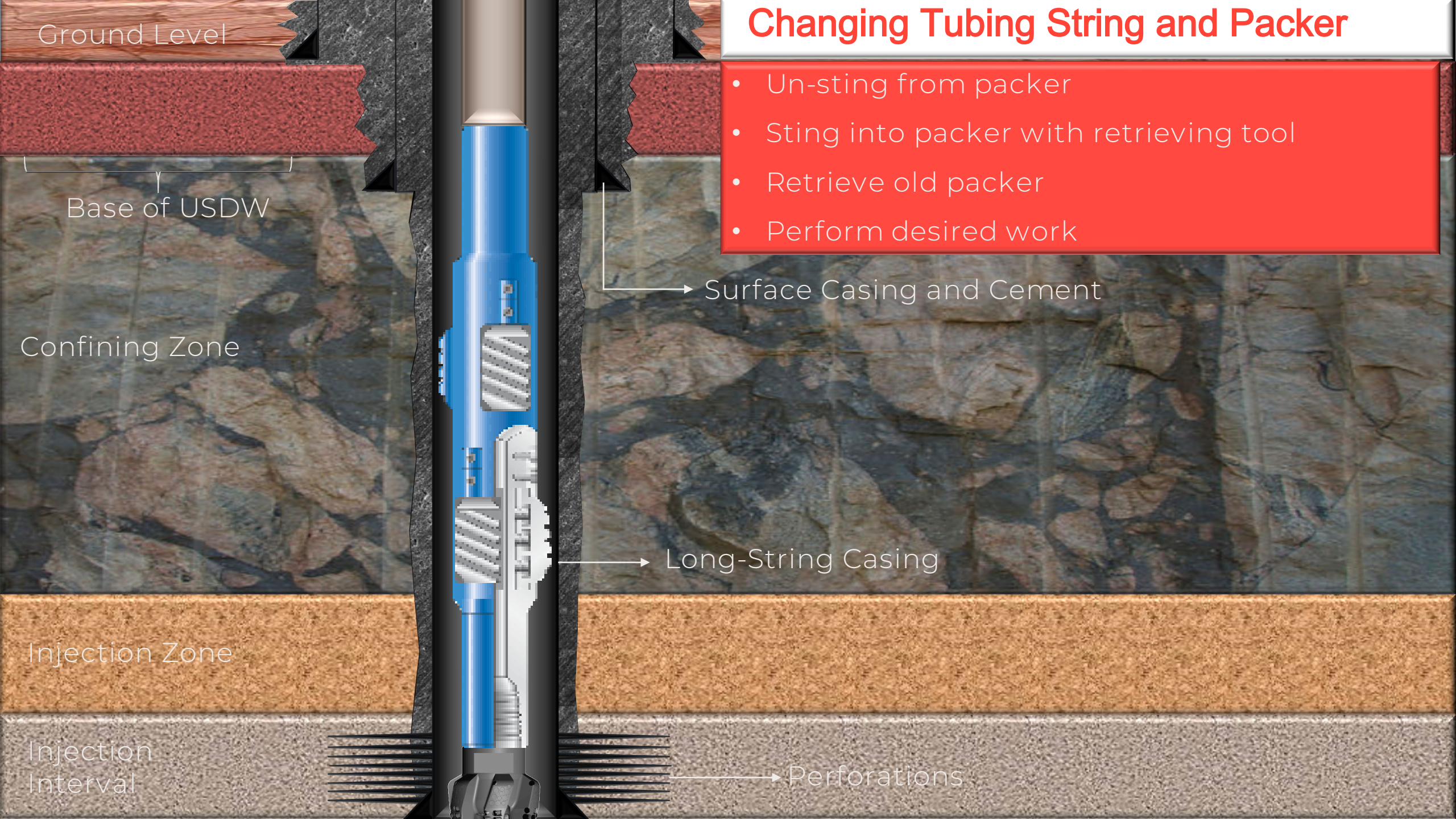
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work

Surface Casing and Cement

Long-String Casing

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

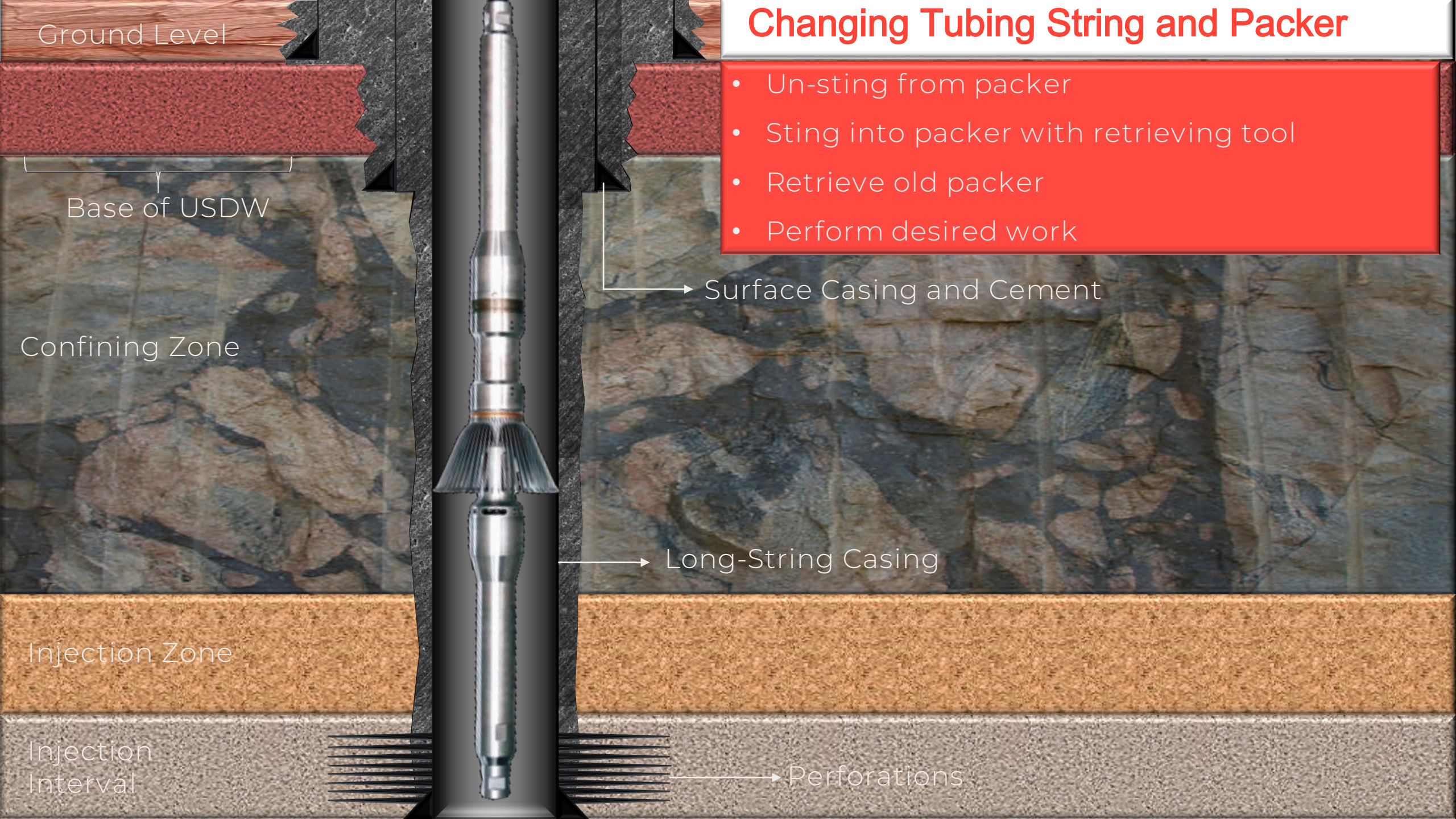
Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work

Surface Casing and Cement

Long-String Casing

Perforations



Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work

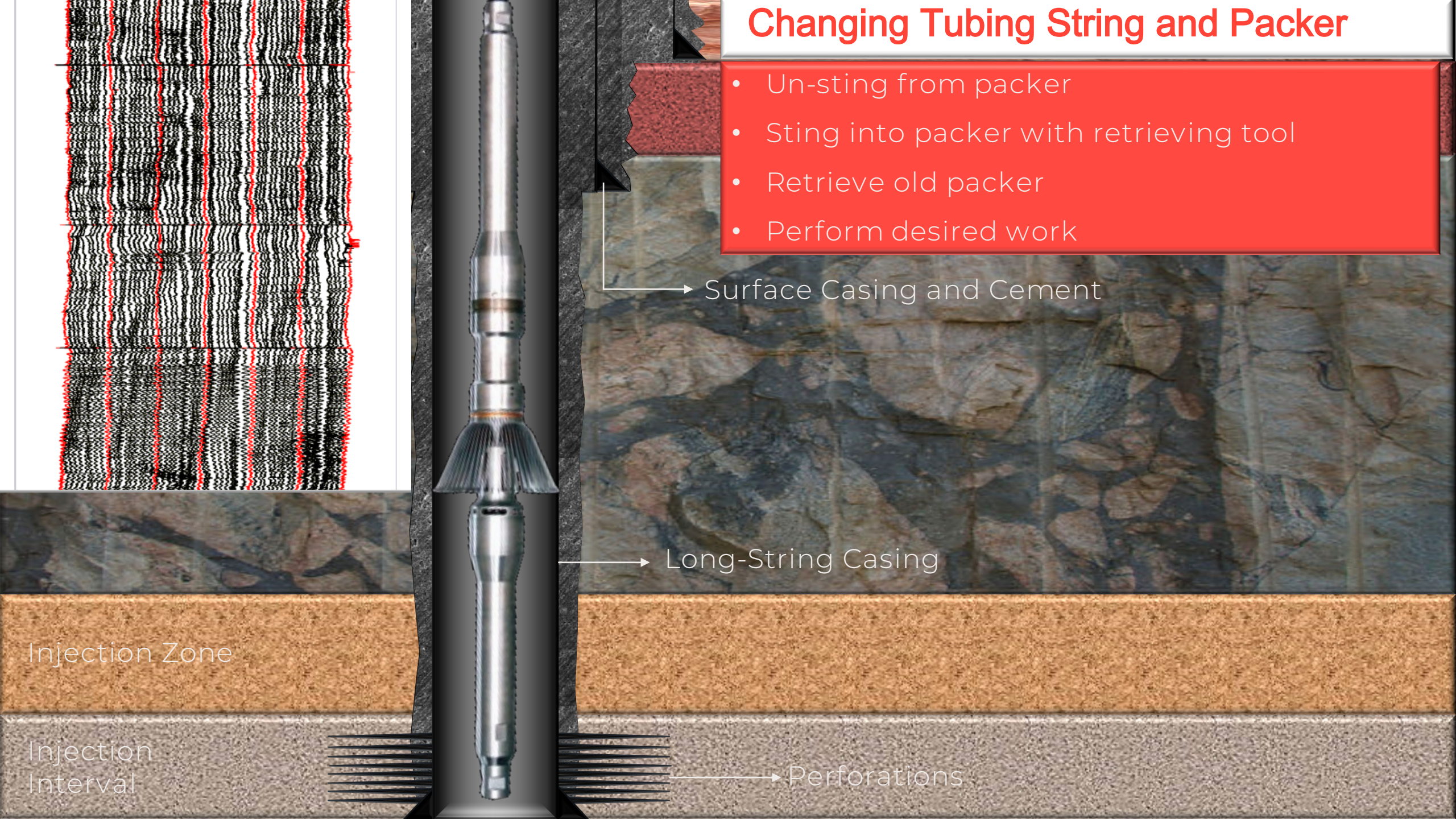
→ Surface Casing and Cement

→ Long-String Casing

Injection Zone

Injection Interval

→ Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Long-String Casing

Packer

Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer

Perforations

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Long-String Casing

Packer

Perforations

Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer
- Set new packer

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Long-String Casing

Packer

Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer
- Set new packer
- Remove setting tool

Perforations

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Long-String Casing

Packer

Perforations

Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Perform desired work
- Run in new packer
- Set new packer
- Remove setting tool
- Stab into packer with new tubing

Casing Leak

Installing Liner

Ground Level

Base of USDW

Confining Zone

Injection Zone

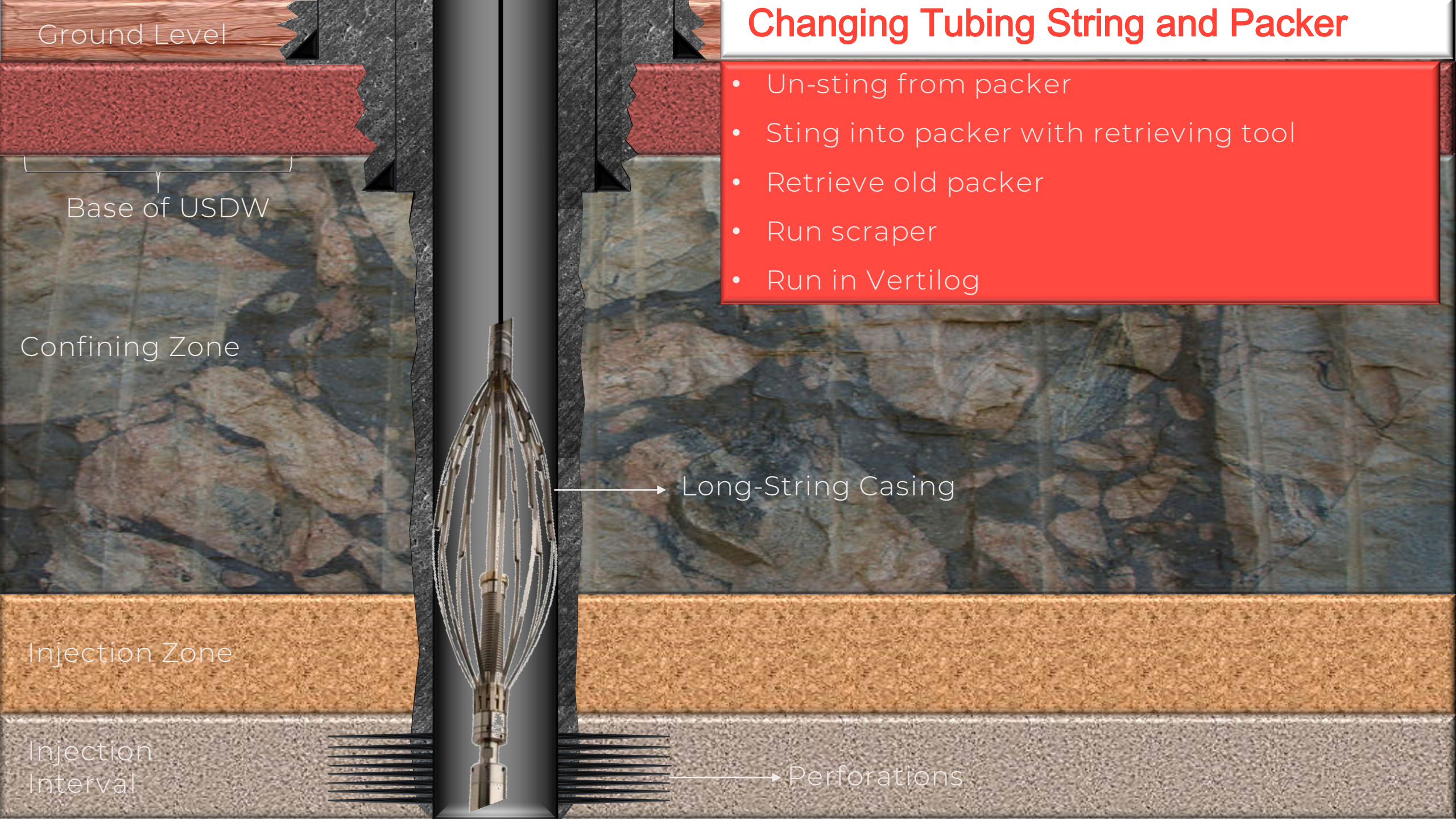
Injection Interval

Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog

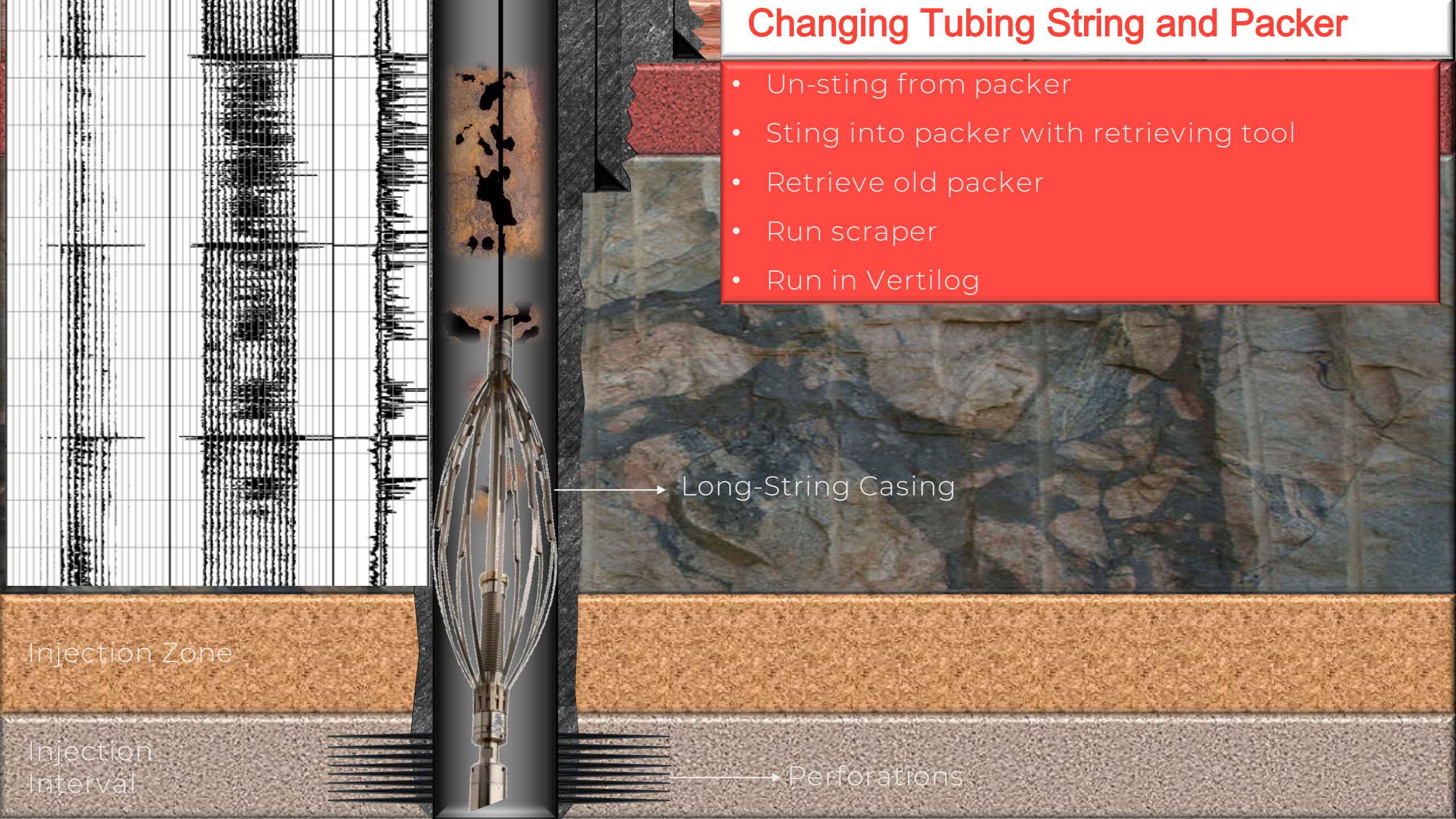
Long-String Casing

Perforations



Changing Tubing String and Packer

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog



Long-String Casing

Perforations

Injection Zone

Injection Interval

Installing Liner

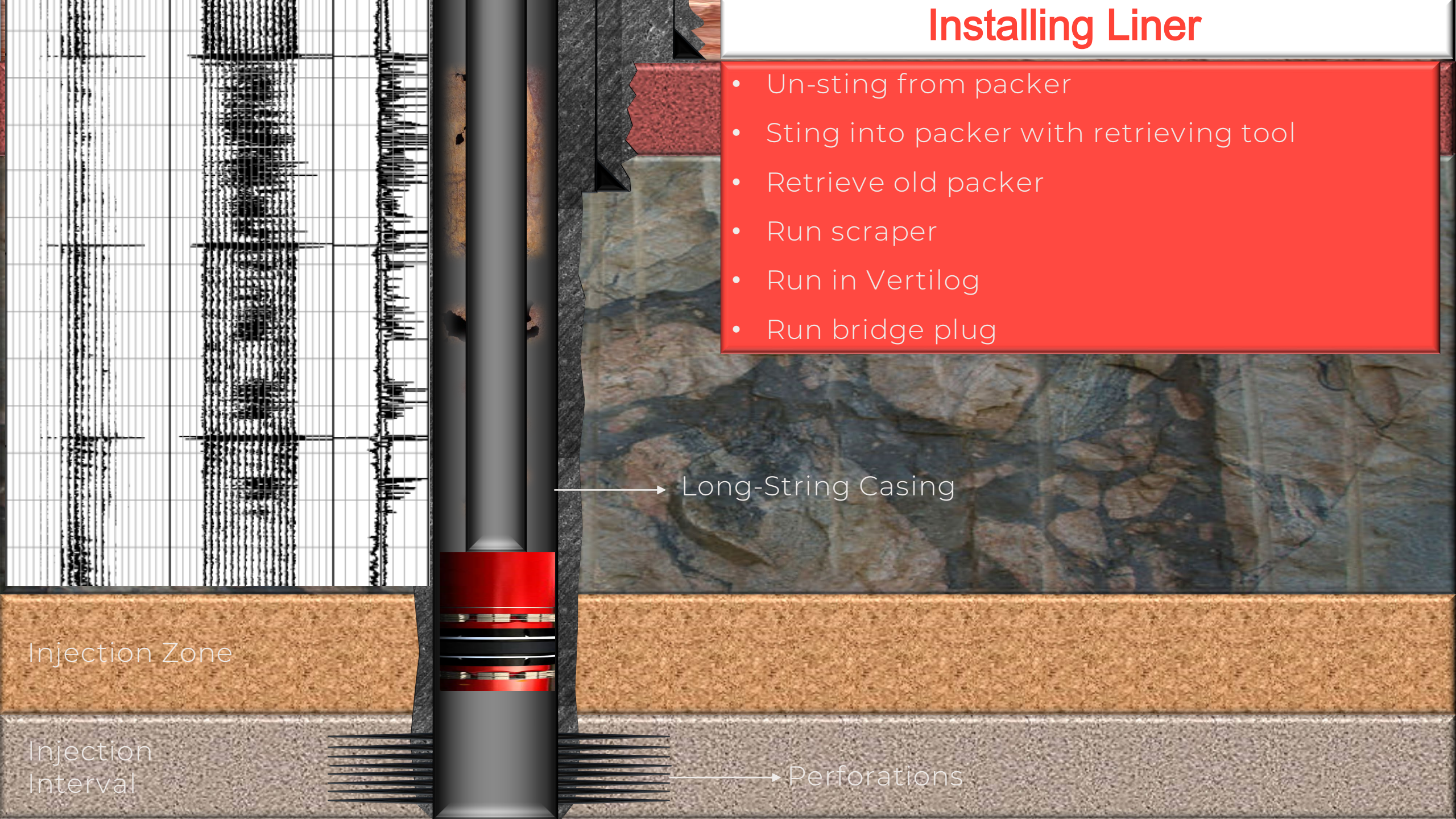
- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug

Long-String Casing

Injection Zone

Injection Interval

Perforations



Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole



Injection Zone

Injection Interval

Long-String Casing

Perforations

Ground Level

Base of USDW

Confining Zone

Injection Zone

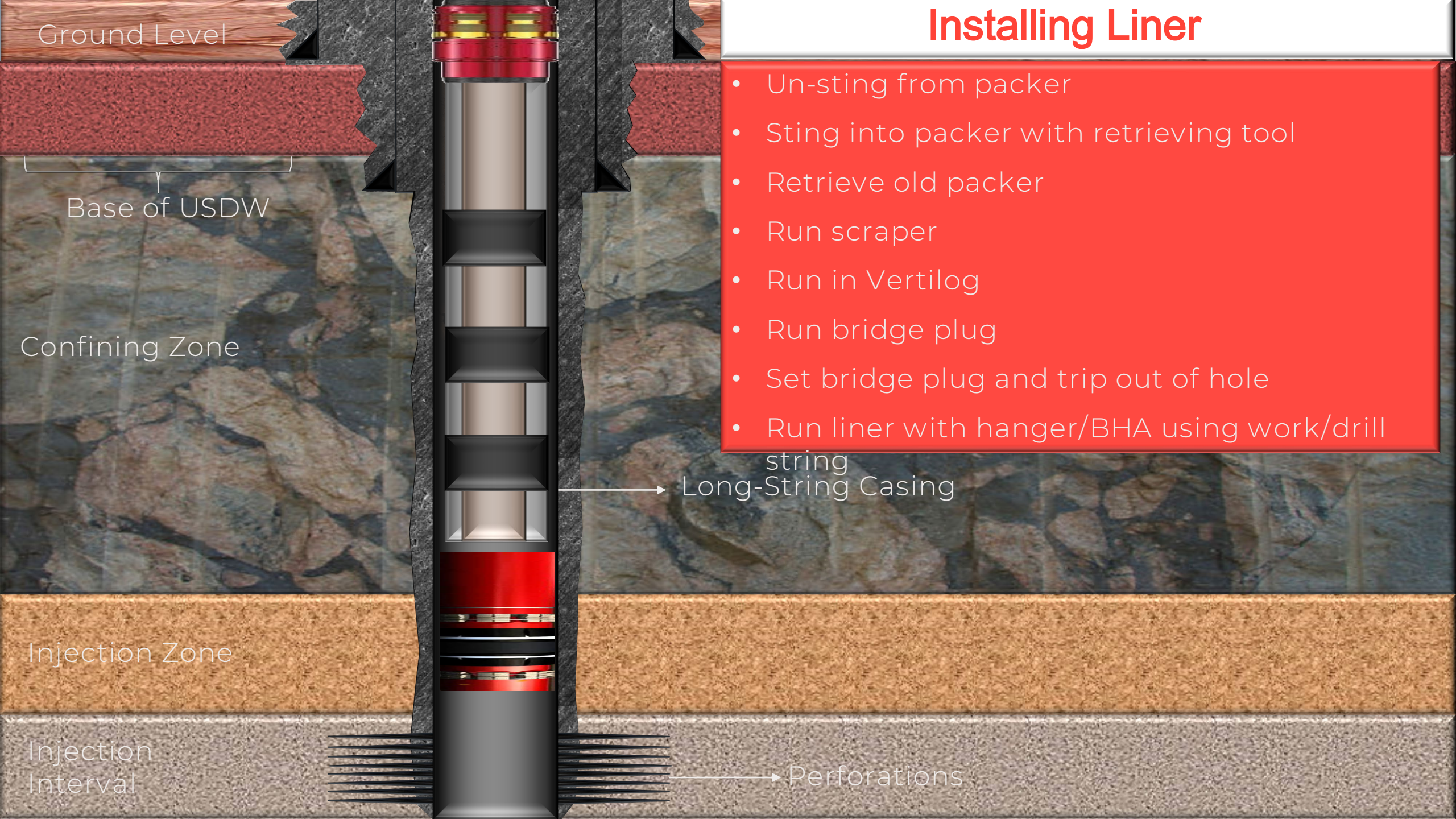
Injection Interval

Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill

Long-String Casing

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Perforations

Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Perforations

Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Perforations

Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug
- Allow cement to set and trip out hanger setting tools

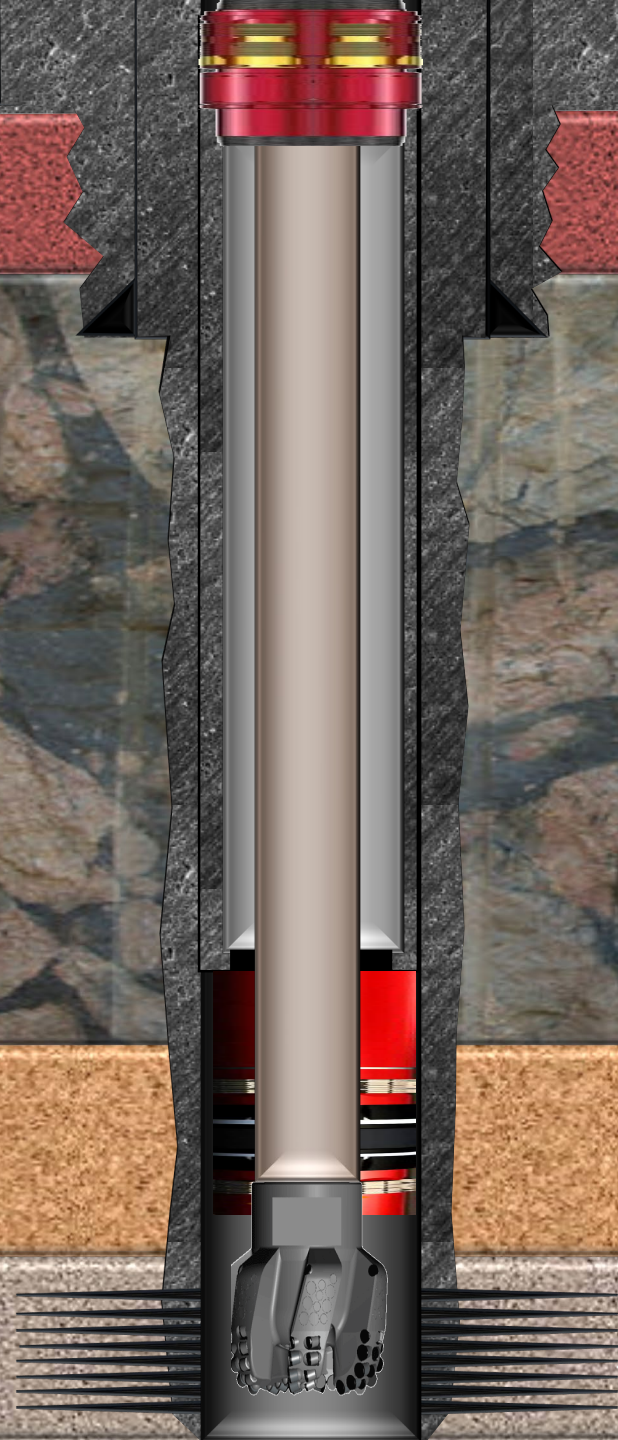
Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval



Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug
- Allow cement to set and trip out hanger setting tools
- Drill out cement and plug.

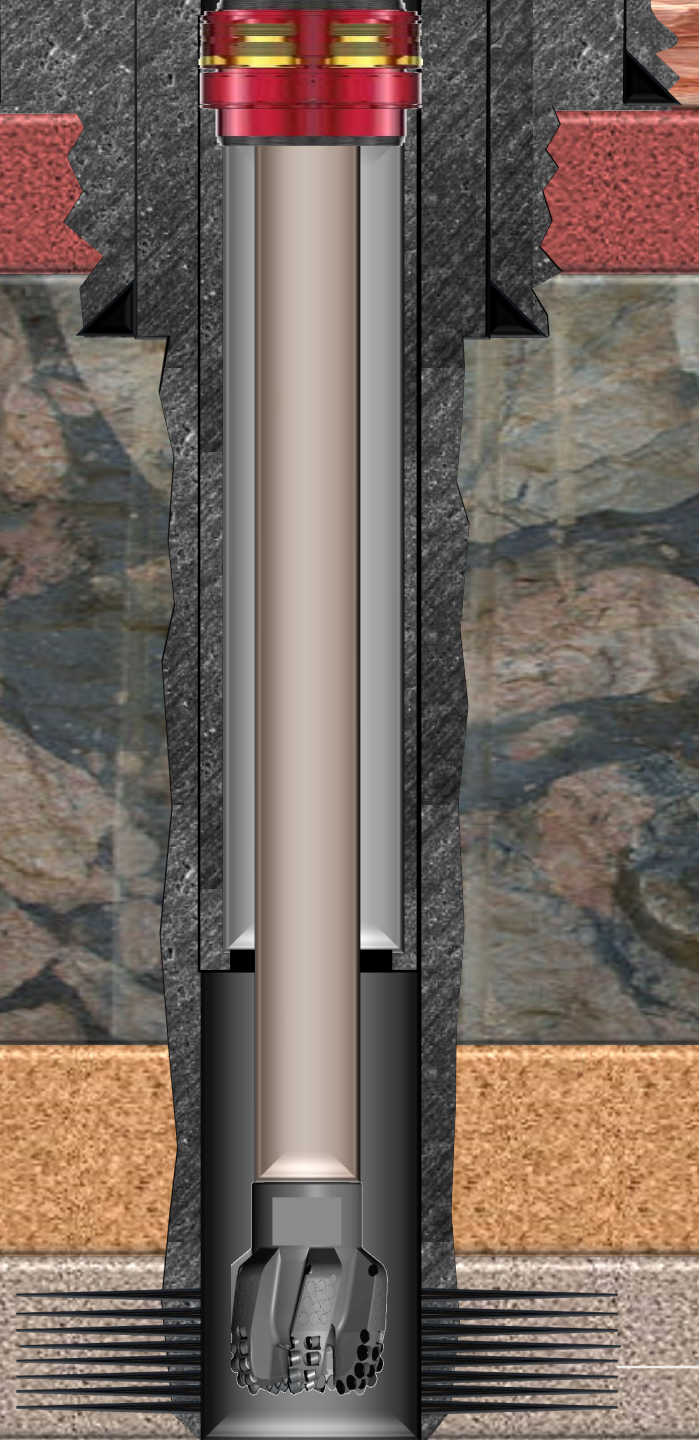
Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval



Installing Liner

- Un-sting from packer
- Sting into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run bridge plug
- Set bridge plug and trip out of hole
- Run liner with hanger/BHA using work/drill string
- Cement Liner in place, monitor pressure
- Drop plug
- Allow cement to set and trip out hanger setting tools
- Drill out cement and plug.
- Trip out of the hole
- Perforations

Ground Level

Install new packer and tubing

- Run in new packer

Base of USDW

Confining Zone

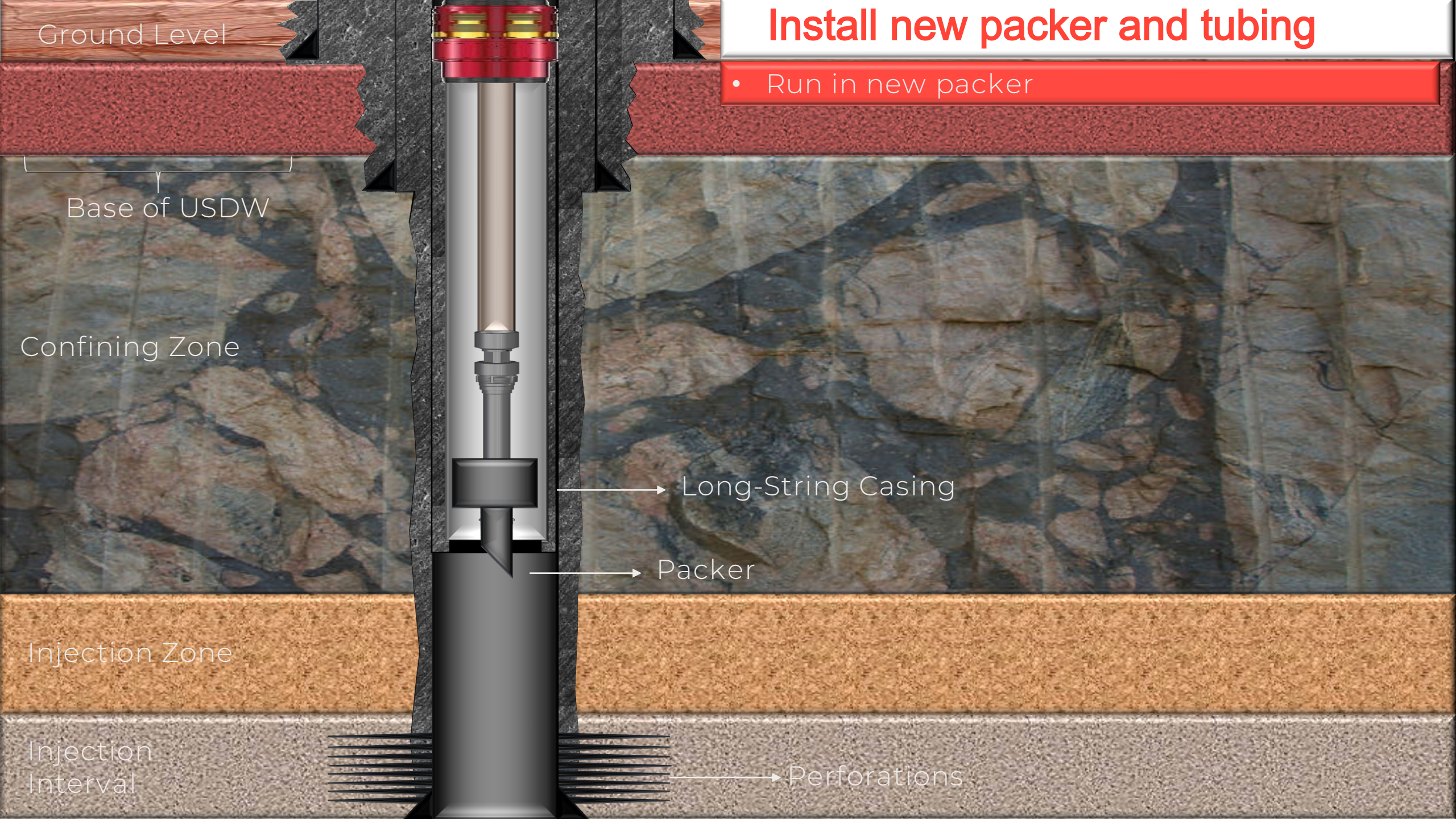
Long-String Casing

Packer

Injection Zone

Injection Interval

Perforations



Ground Level

Install new packer and tubing

- Run in new packer
- Set new packer

Base of USDW

Confining Zone

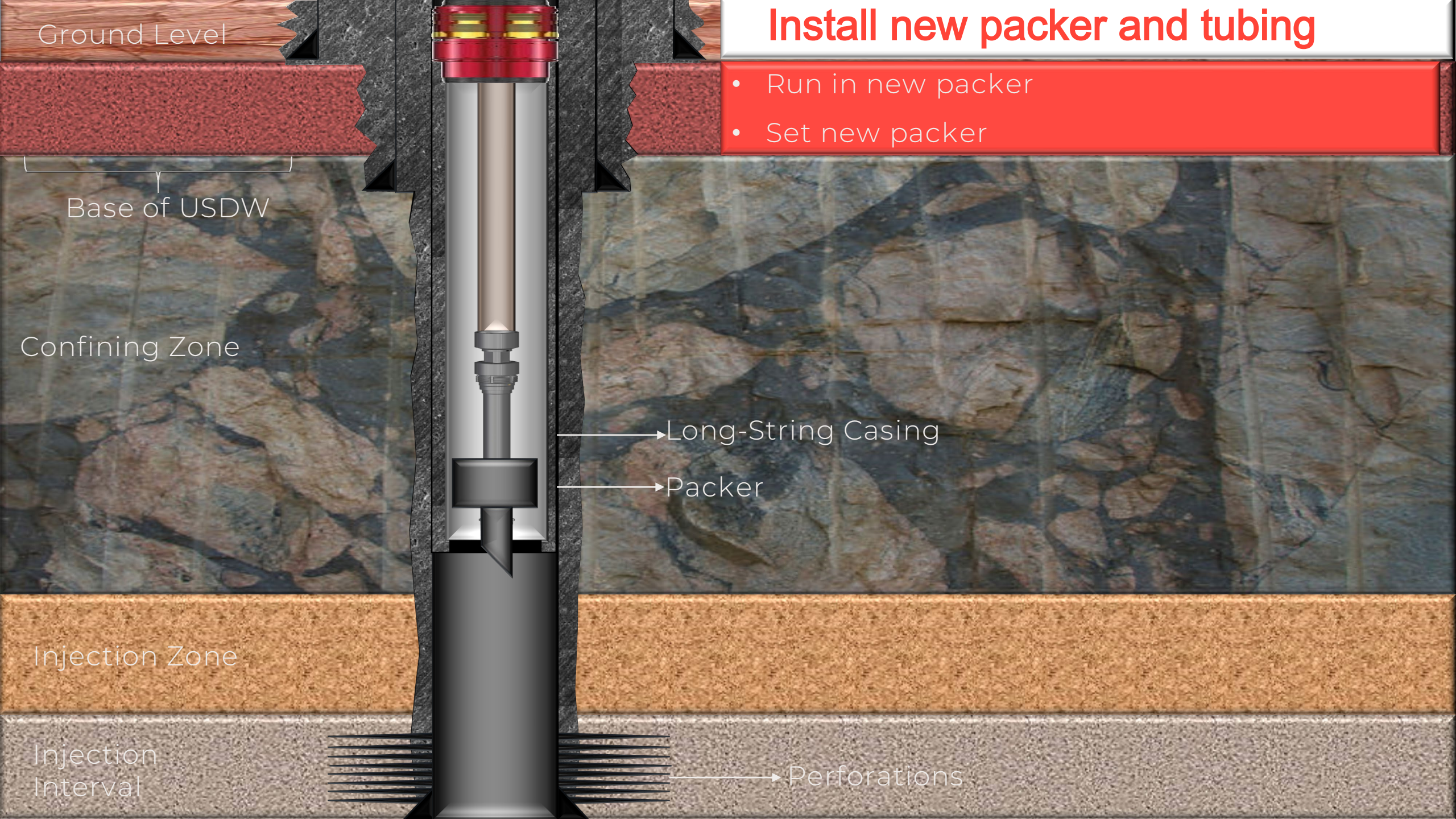
Long-String Casing

Packer

Injection Zone

Injection Interval

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

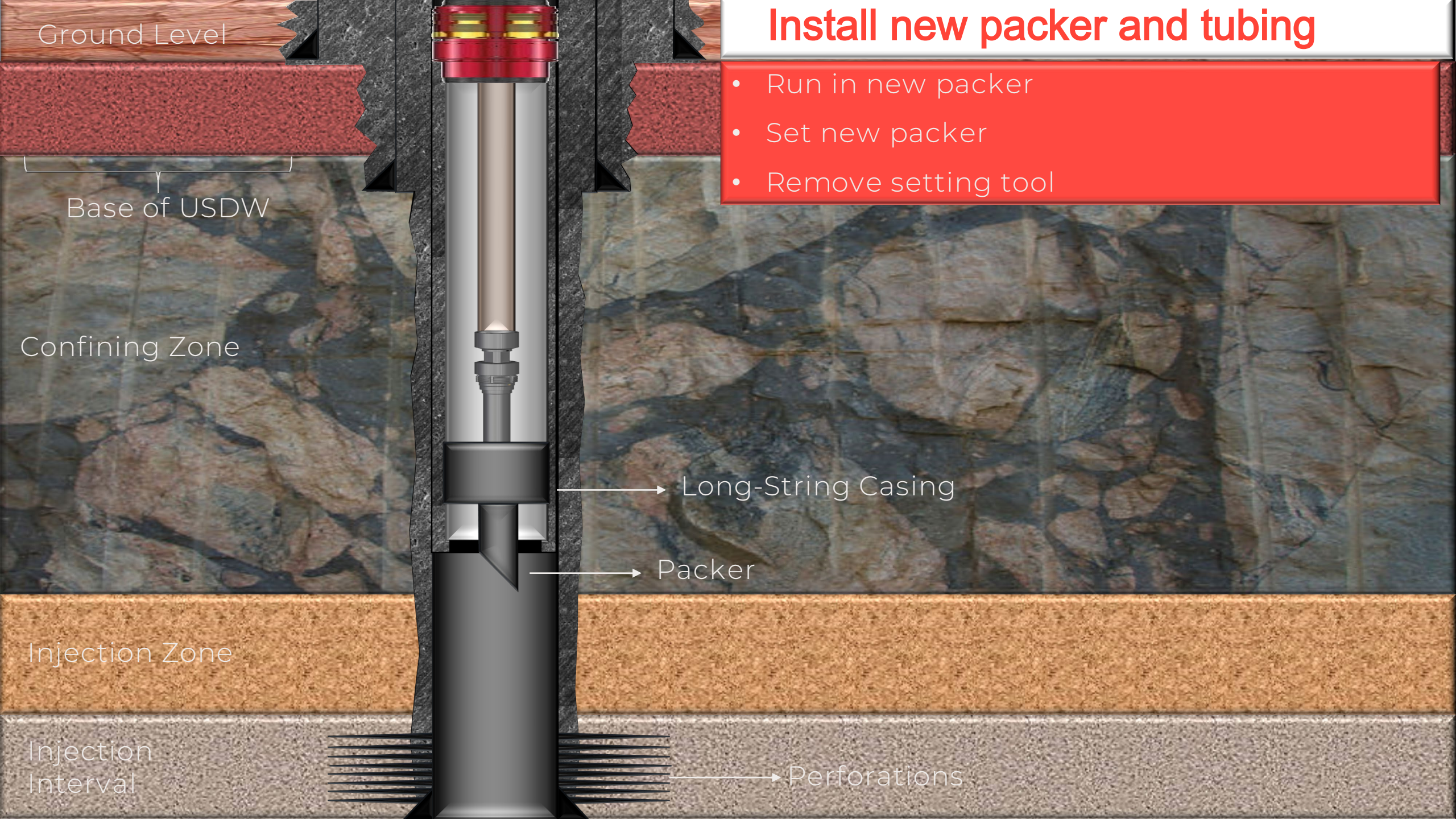
Install new packer and tubing

- Run in new packer
- Set new packer
- Remove setting tool

Long-String Casing

Packer

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

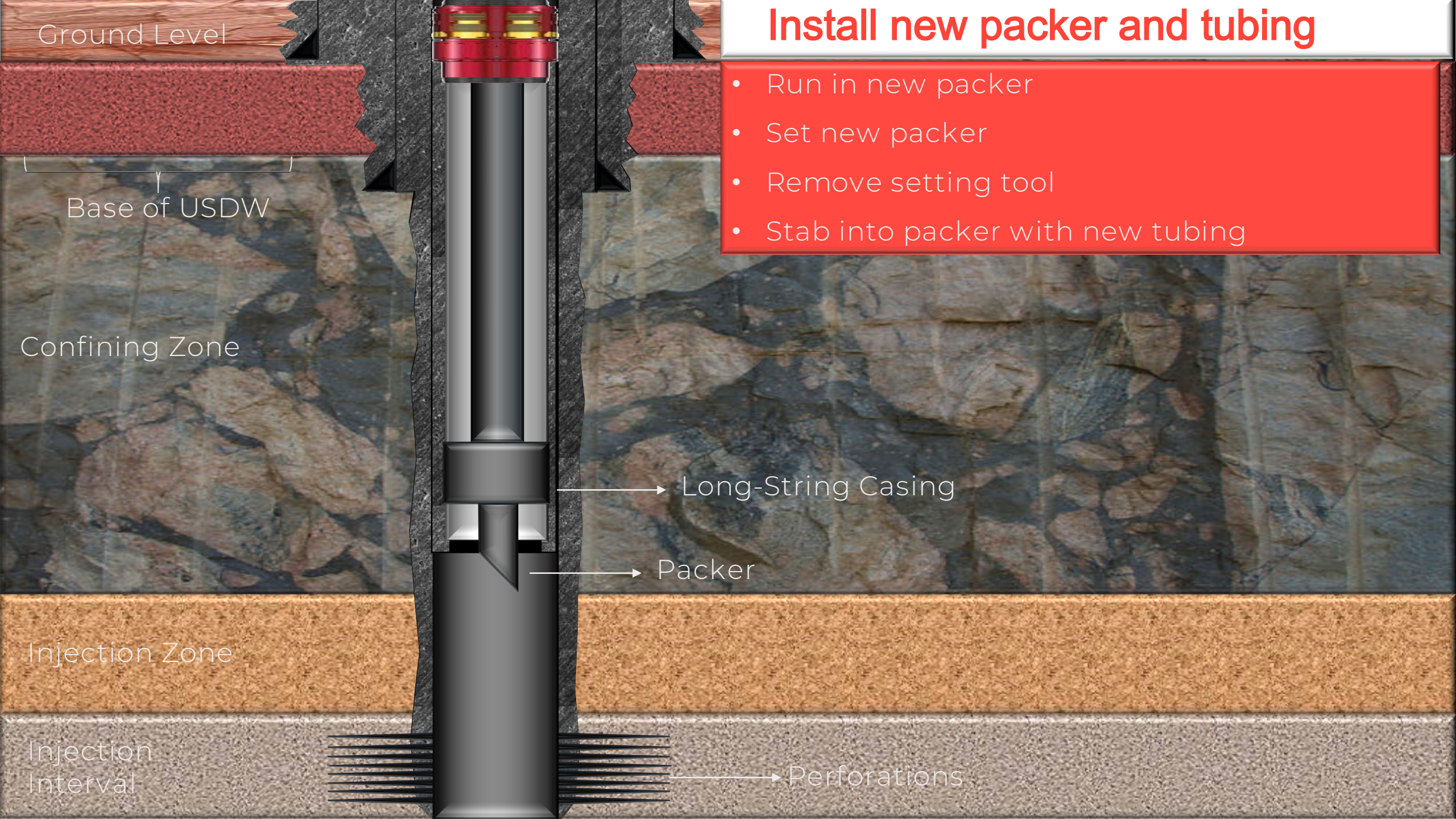
Install new packer and tubing

- Run in new packer
- Set new packer
- Remove setting tool
- Stab into packer with new tubing

Long-String Casing

Packer

Perforations



Casing Leak Sidetrack

Ground Level

Base of USDW

Confining Zone

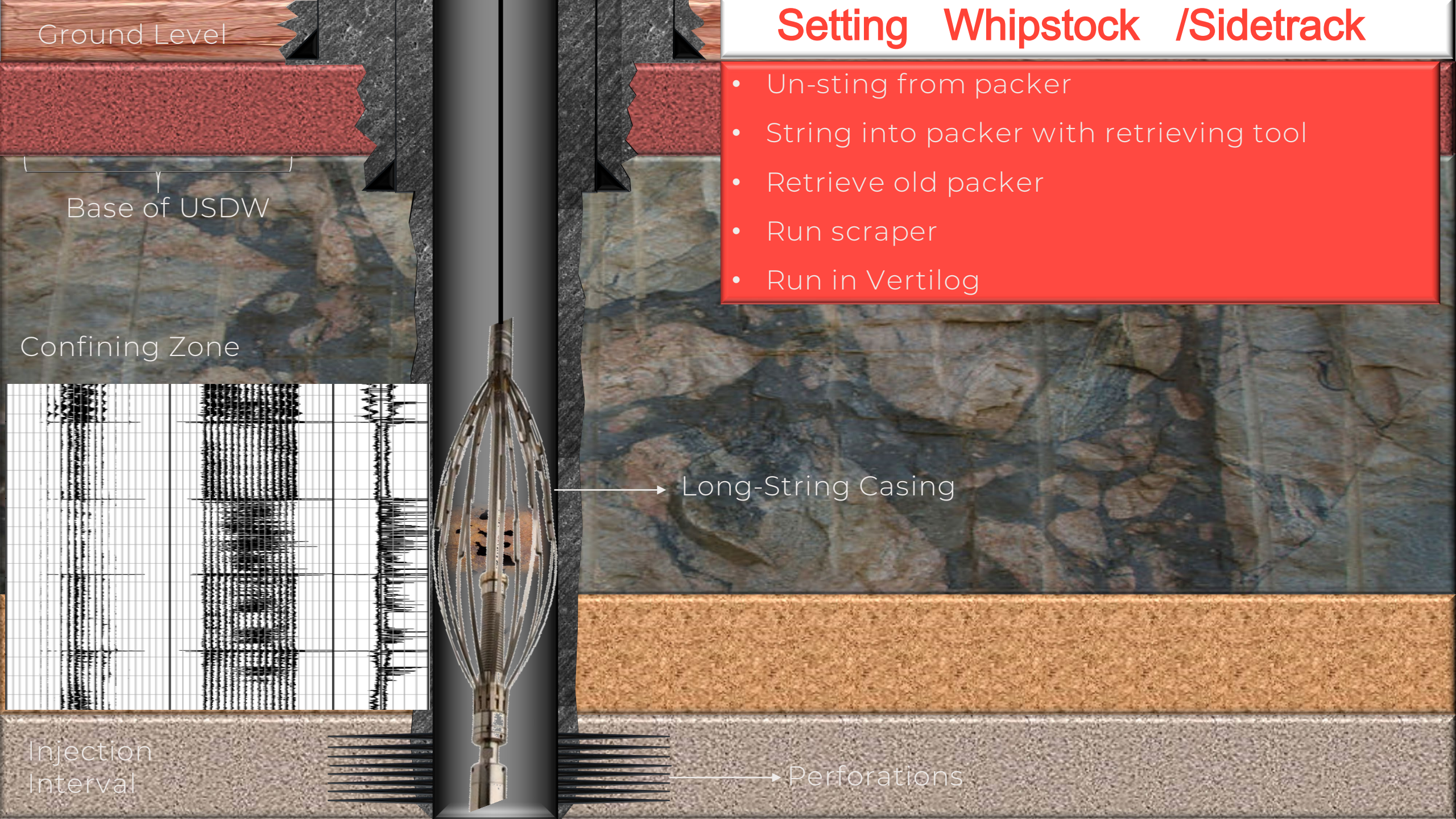
Injection
Interval

Setting Whipstock /Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog

Long-String Casing

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Long-String Casing

Perforations

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly

Ground Level

Base of USDW

Confining Zone

Injection Zone

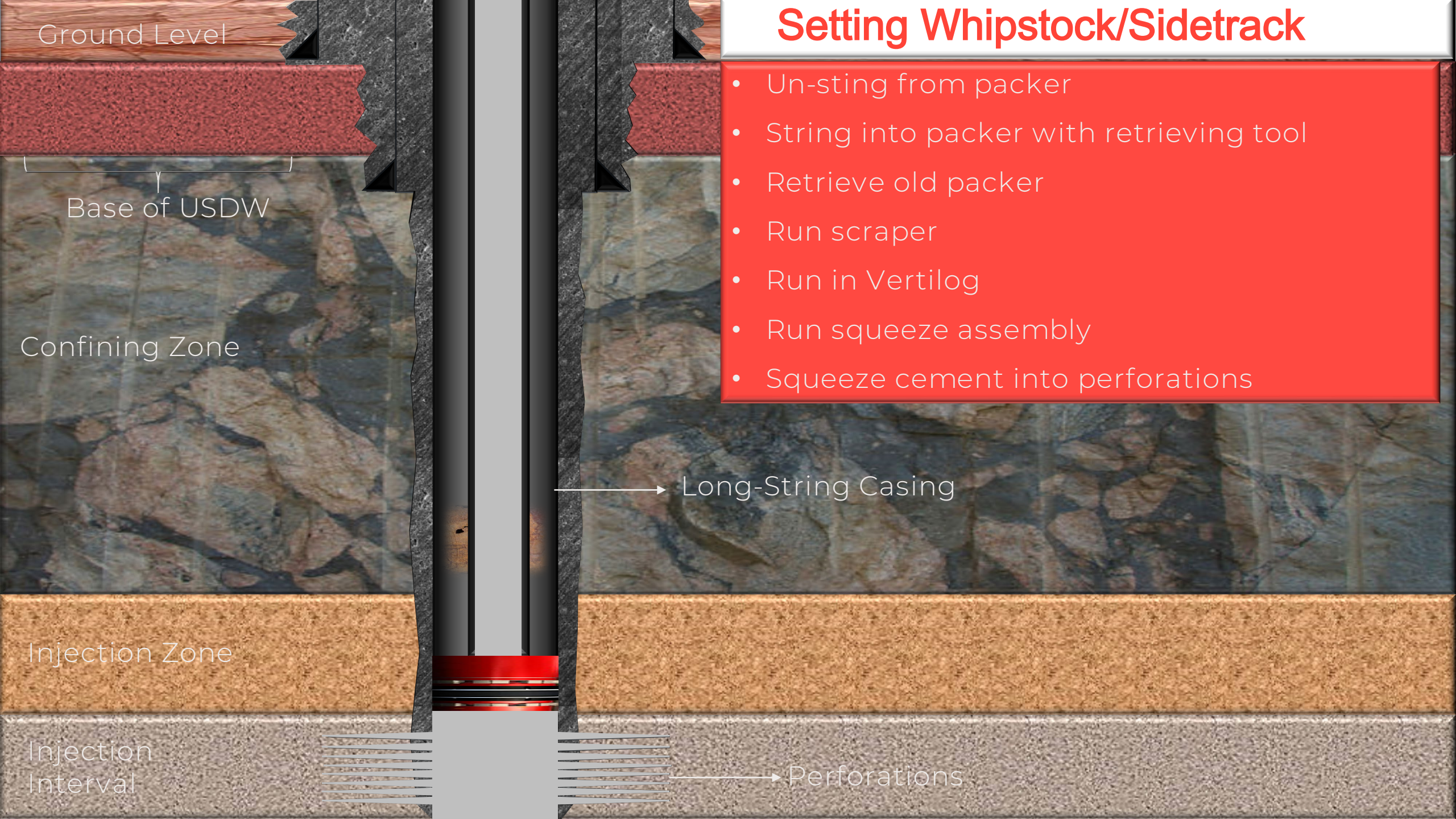
Injection Interval

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations

Long-String Casing

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string

—————→ Perforations



Ground Level

The diagram shows a vertical cross-section of a wellbore. At the top, a wooden-textured layer represents the ground level. Below it is a red, textured layer. A bracket labeled 'Base of USDW' spans the width of the wellbore just below the red layer. The main body of the wellbore is filled with a dark, textured material. Below this is a light blue vertical column representing the wellbore fluid. At the bottom of the wellbore, there is a red and black assembly. Below the wellbore is a brown, textured layer, and at the very bottom is a grey, textured layer. Labels on the left side of the diagram include 'Ground Level', 'Base of USDW', 'Confining Zone', 'Injection Zone', and 'Injection Interval'.

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.
- Run in open ended above damaged casing

Perforations

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.
- Run in open ended above damaged casing
- Set balanced cement plug at damaged casing

Perforations

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and flush work string
- Release from cement retainer and trip out of hole and wait 12 to 24 hours on cement.
- Run in open ended above damaged casing
- Set balanced cement plug at damaged casing
- Allow 12 - 24 hours to set and trip out of hole

—————> Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Un-sting from packer
- String into packer with retrieving tool
- Retrieve old packer
- Run scraper
- Run in Vertilog
- Run squeeze assembly
- Squeeze cement into perforations
- Maintain pressure on squeeze and allow 12 - 24 hours to set
- Release from cement retainer and trip out of hole
- Run in open ended above damaged casing
- Set balanced cement plug at damaged casing
- Allow 12 - 24 hours to set and trip out of hole
- Trip in with work string and locate top of cement, ensure a hard tag.

Ground Level

Setting Whipstock/Sidetrack

- Run in with whipstock

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Perforations



Ground Level

Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool

Perforations



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
- Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.



Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
- Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.
- Repeat milling window to remove burrs and to ensure window is clear. Continue circulating out metal shavings (circulation fluid not shown for demonstration purposes)

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock /Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
- Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.
- Repeat milling window to remove burrs and to ensure window is clear. Continue circulating out metal shavings (circulation fluid not shown for demonstration purposes)
- Trip out of hole with milling assembly and trip in with bit. Drill sidetrack



The diagram shows a vertical wellbore in a cross-section. The wellbore is lined with a dark material. A whipstock setting tool is shown at the top of the wellbore, with a red whipstock being set. Below the whipstock, a side track is being drilled, indicated by a red line. The wellbore is surrounded by different geological layers: a brown layer at the top, a grey layer below it, a blue and white patterned layer, a brown layer, and a grey layer at the bottom. Labels on the left side of the diagram identify these layers: 'Ground Level' at the top, 'Base of USDW' below it, 'Confining Zone' below that, 'Injection Zone' below that, and 'Injection Interval' at the bottom. The right side of the diagram has a red background with white text listing the steps for setting the whipstock and drilling the side track.

Ground Level

Base of USDW

Confining Zone

Injection Zone

Injection Interval

Setting Whipstock/Sidetrack

- Run in with whipstock
- Orient whipstock and set whipstock
- Trip out with whipstock setting tool
- Trip into hole with mill and start milling window. Circulate hole to clean out metal shavings. Ditch magnets in possum belly are a must.
- Repeat milling window to remove burrs and to ensure window is clear. Continue circulating out metal shavings (circulation fluid not shown for demonstration purposes)
- Trip out of hole with milling assembly and trip in with bit. Drill sidetrack
- Proceed with completing sidetrack

QUESTIONS AND COMMENTS

Thank you!

wsp.com

