Well stimulation

Well stimulation

Well stimulation is an oil and gas term for using high-pressure water and sand to crack a rock formation deep underground. By pumping this fluid into a drilled well, we are able to open up tiny fissures, up to several tenths of an inch wide, which then allow oil and natural gas resources trapped in tight rocks to flow back through our pipes and up to the surface, where we capture them for energy use.

All forms of well stimulation help to open channels in the formation, so that oil and gas can flow to the wellbore more easily.

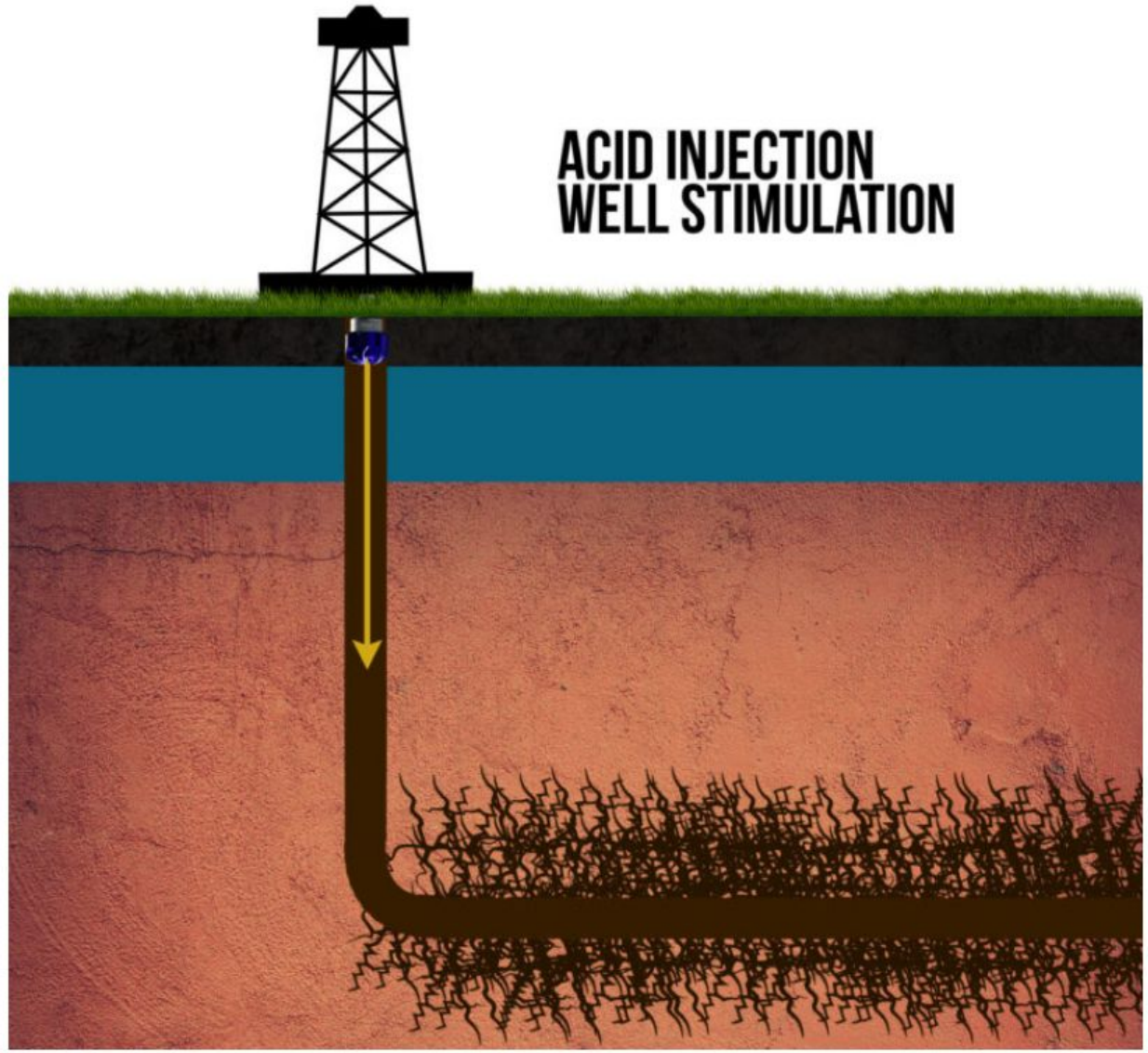
Most Common Methods of Well Stimulation

- Acid injection or Matrix acidizing
- Hydraulic fracturing
- Explosives

Most modern well stimulation is done through hydraulic fracturing, as the technique has proven to be more efficient, effective, and safe than older methods.

Acid Injection or Matrix acidizing

- Acid stimulation is where an acid is pumped down hole.
- The acid dissolves minerals and calcareous deposits that would otherwise impede (затруднять) hydrocarbon flow.
- The porosity within the formation is enlarged, allowing for increased fluid passage.
- The most common type of acid used is hydrochloric acid (HCl).
- Careful consideration must be taken to not damage the steel casing and well equipment when using acid.

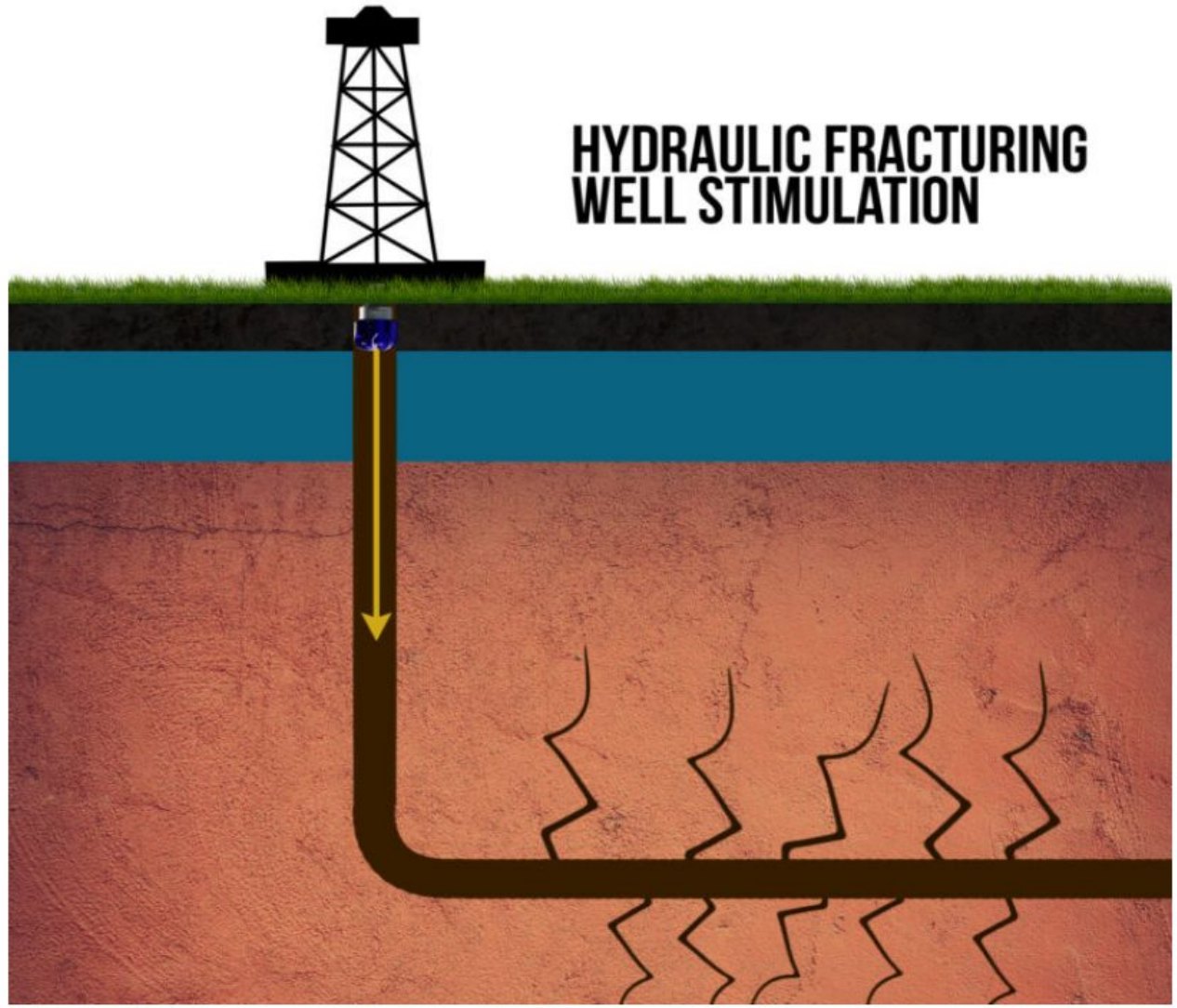

ACID INJECTION
WELL STIMULATION

Hydraulic Fracturing

Hydraulic fracturing well stimulation requires a fluid to be pumped down hole at extremely high pressure. The fluid pressure forces the producing formation to fracture, crack, and break. These fractures allow hydrocarbons to easily pass to the wellbore. When a well is “fracked”, and the hydraulic fluid pressure is reduced, the cracks tend to close and return to their original state. To maximize oil production a proppant or sand is pumped down hole while the well is being fracked. The proppant makes its way into these tiny fractures within the formation. As the pressure is reduced, the fractures are held open by the proppant, which is now within the fractures. The hydrocarbons now have a much easier path to the wellbore.

Some research shows that production can increase 30 times when hydraulic fracturing has been used. Retired wells can be fracked to revitalize and increase production, giving them a second life before they are decommissioned.

It is the least popular well stimulation method because it involves risks.

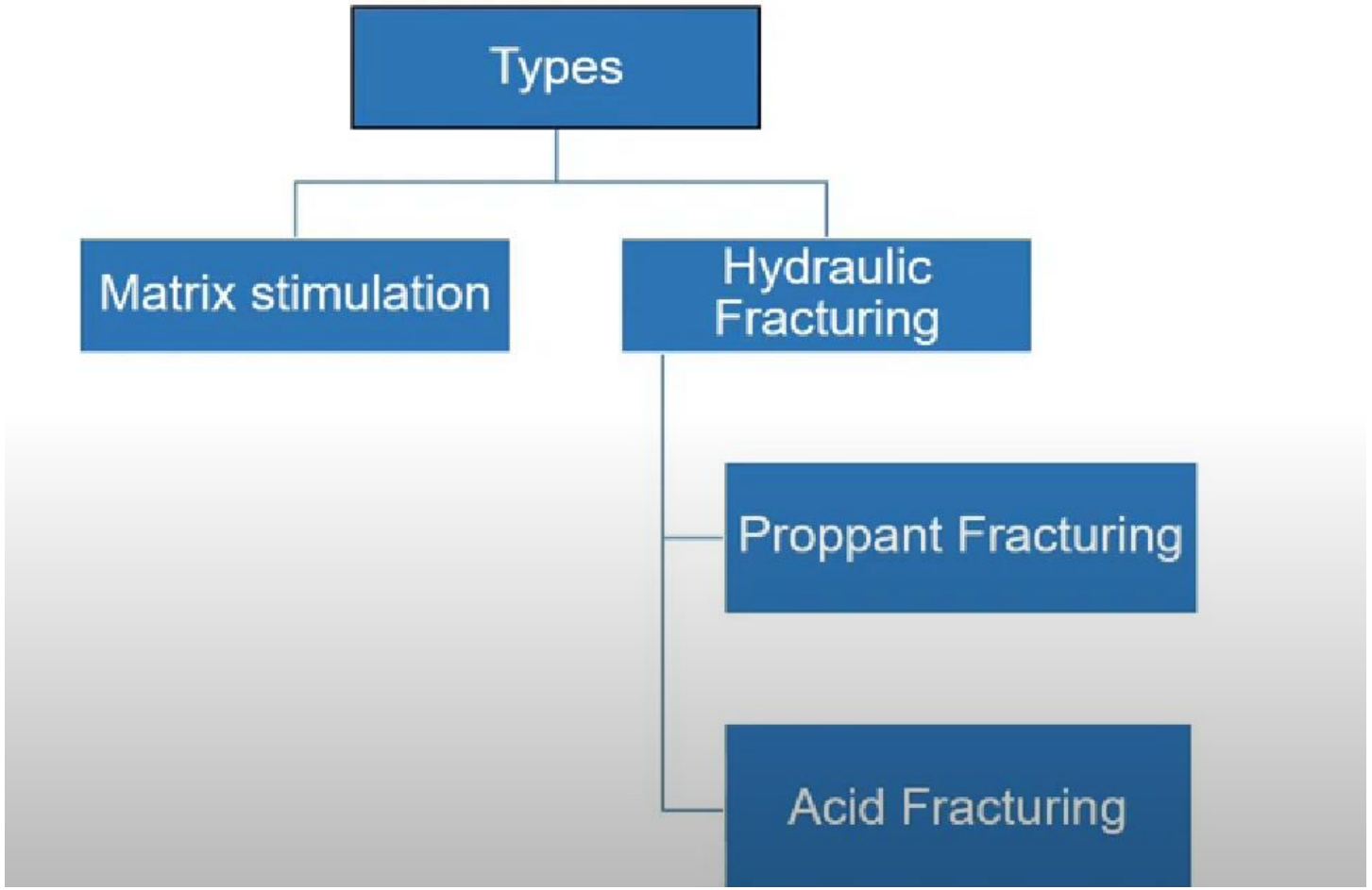


What is Hydraulic Fracturing Well Stimulation

Explosive Well Stimulation

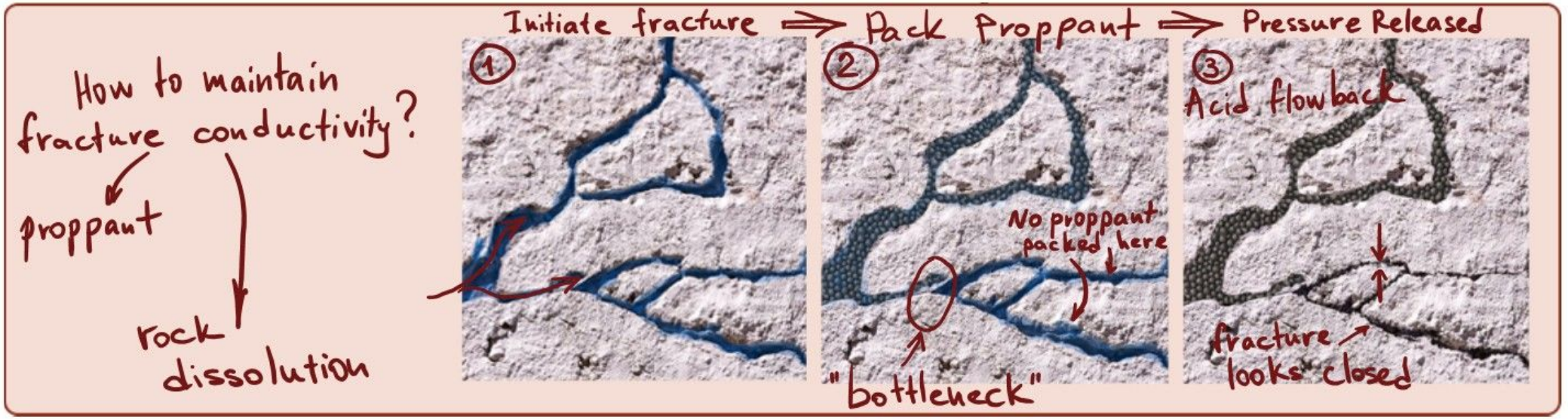
- Explosive well stimulation requires the use of chemical explosives.
- This is commonly known as well shooting.
- Explosives detonated downhole create an energized pressure wave which travels through the fluid in the well.
- The fluid moves into and breaks up the formation.
- Explosive is the simplest form but has been proven the be the least accurate and effective of all methods.
- It can also cause localized damage to the well if not executed properly.
- It is the least popular well stimulation method because it involves risks.

Well stimulation



Proppant fracturing

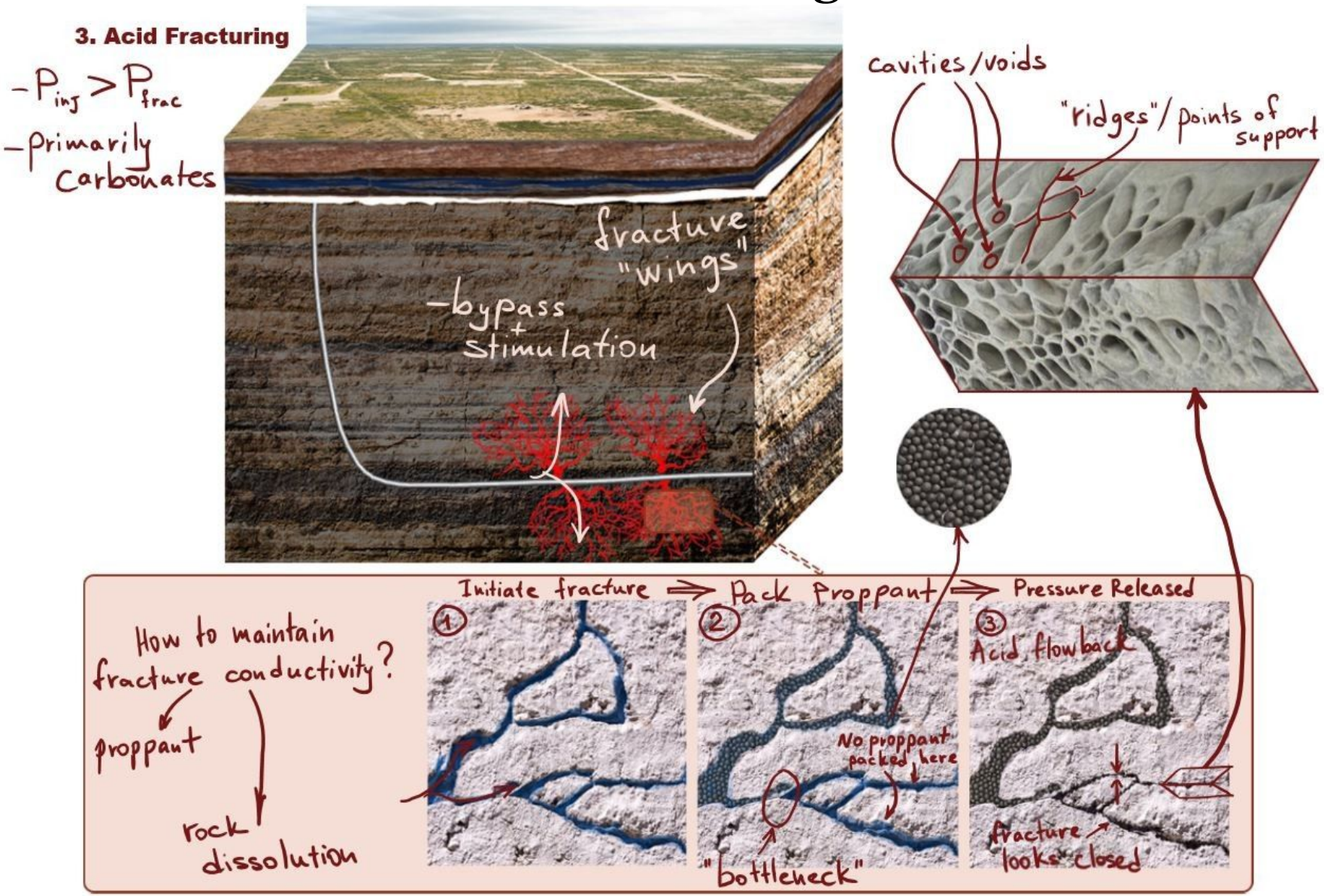
- First, we pump acid or some viscous fluid to raise the pressure and open the fracture (**Figure 5**). But remember that if we stop the injection – pressure will drop down and fracture will close. Therefore, traditionally before releasing the pressure, we prop the fracture with sand or similar material called proppant, to keep the fracture open, and maintain its conductivity.
- Often times there would be some fracture wings that we can't effectively pack with proppant. And once pressure is released, the fracture will close. If proppant was placed in the fracture then conductivity will be maintained to be high, and if there is no proppant then we might lose that conductive pathway because the fracture will be completely shut.



Acid fracturing

- In “Acid Fracturing” treatment, acid is intentionally pumped at a pressure above formation fracturing pressure. Such treatments are primarily used in carbonates.
- In this case, we bypass the formation damage and stimulate the undamaged formation at the same time.
- This technique is an alternative to both matrix acidizing and hydraulic fracturing. In a way, our objective is similar to these traditional techniques because we want to maximize the stimulated reservoir volume. Therefore, we create long, open, conductive channels from the wellbore, extending deeper into the formation. However, there is a big difference from traditional hydraulic fracturing – and this difference is about the way we create and maintain fracture conductivity.

Acid fracturing



Matrix acidizing

- The second type of acid treatments is “Matrix Acidizing” (Figure 3). In this case, we inject acid through the perforations in the formation. Injection pressure is below fracturing pressure. Our goal here is to improve permeability in the near-wellbore region. The way we reach this goal would depend on the reservoir mineralogy.
- For example, in a sandstone reservoir – our goal is to remove the damaging material. It can be certain minerals or other solid particles and fines that are blocking pore throats and pore spaces between grains of sand. Acid is injected to flow through the pore network and dissolve these materials that plug the porous media.
- And in a carbonate formation, our goal is to bypass the damaged zone. We do this by dissolving rock and creating these channels, called wormholes. To form these branches and channels, we have to choose the right acid and injection rate, but ultimately, we want to extend these wormholes from perforations beyond the near-wellbore zone. This would create a conductive pathway for our hydrocarbons to flow through.

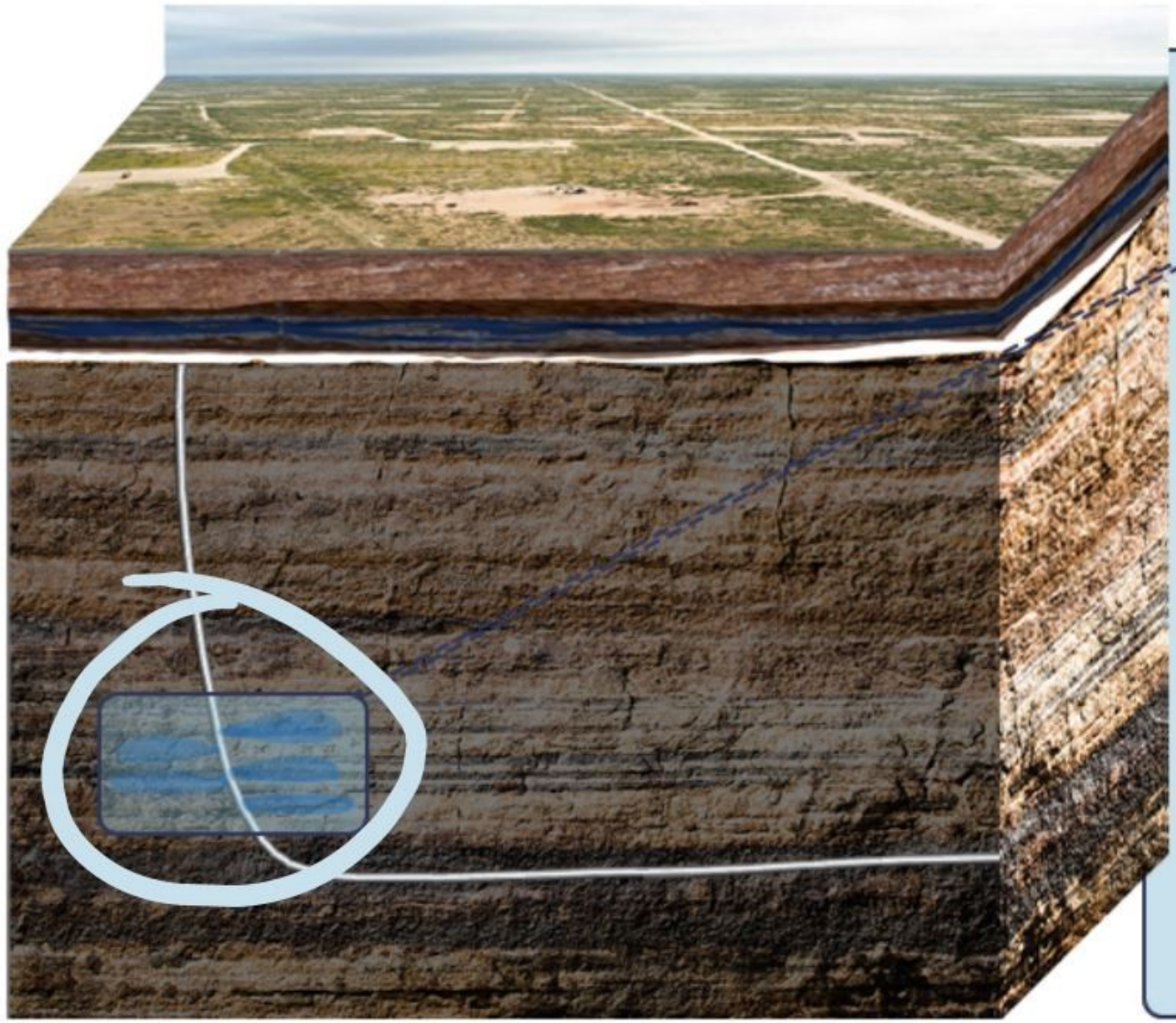
Matrix acidizing

Matrix acidizing is a well stimulation technique that tries to increase the flow of oil or gas from reservoir rocks by dissolving the formation matrix and establishing new channels. It involves the injection of acid, typically hydrochloric acid, into the reservoir formation at high pressure. The acid reacts with the rock, primarily carbonate formations, and dissolves the minerals, thereby creating wormholes or channels that connect the wellbore to the reservoir. This process effectively increases the permeability of the reservoir and enhances production rates.

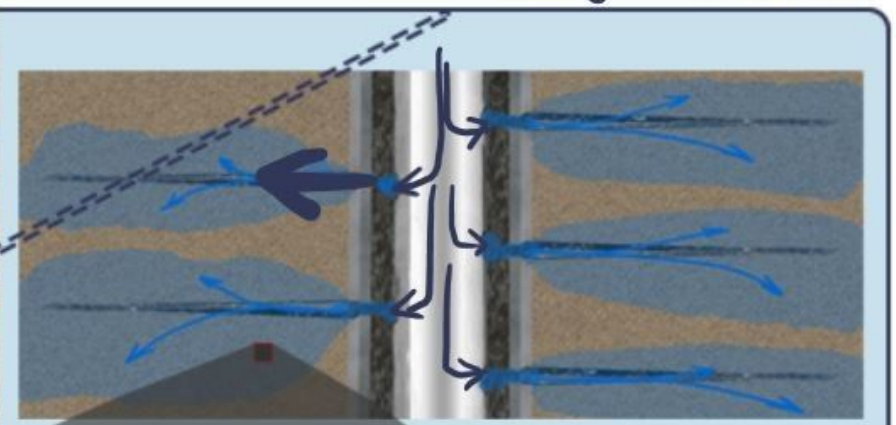
Before conducting matrix acidizing, a thorough evaluation of the reservoir formation is essential. This evaluation includes analyzing well logs, core samples, and production data to determine the rock type, mineral composition, and permeability of the formation.

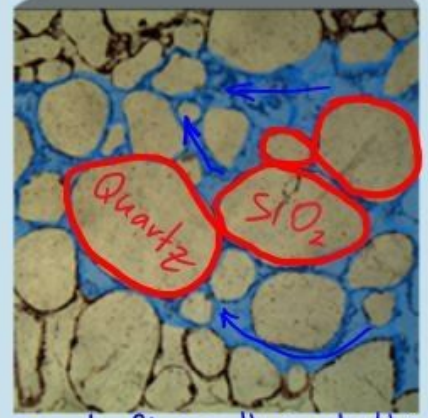
As the acid contacts the rock formation, a chemical reaction occurs, dissolving the carbonate minerals present in the reservoir matrix. This reaction creates channels and enlarges existing pore spaces, enabling improved fluid flow.

2. Matrix Acidizing

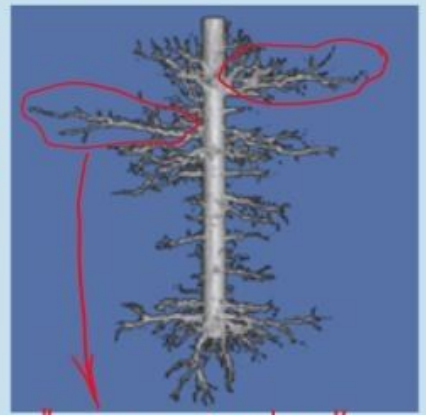


$P_{inj} < P_{frac}$





acid flows through the porous media
⇓
remove the damage

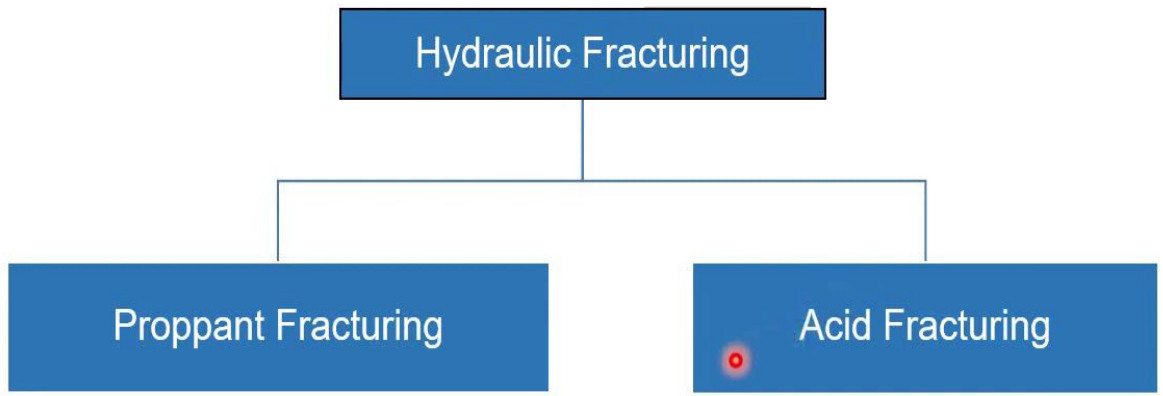


"wormholes"
⇓
bypass the damage

Sandstones vs Carbonates

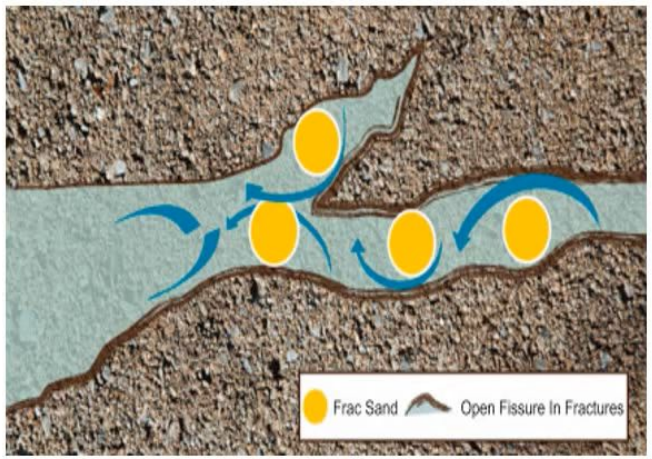
Hydraulic Fracturing

- Hydraulic fracturing is a well-stimulation technique used commonly in low-permeability rocks like tight sandstone and shale etc. to increase the flow of oil and gas reservoir towards well. Hydraulic fracturing involves injecting a mixture of water, sand, and chemicals under high pressure ($P_{inj} > P_{frac}$) into the formation.
- The objective of hydraulic fracturing for well stimulation is to increase well productivity by creating a highly conductive path (compared to reservoir permeability) some distance away from the wellbore into the formation.



Types of Hydraulic Fracturing

- Proppant Fracturing: During proppant fracturing sands and proppants are pumped into the formation to keep the fractures open. Proppant fracturing is performed in sandstone reservoirs.
- Acid Fracturing: During acid fracturing, acid is injected ($P_{inj} > P_{frac}$) into the formations which generate the conductivity channels by etching the formation and thus producing wormholes. Acid fracturing is performed in limestone reservoirs.



Matrix Stimulation

- Matrix stimulation also known as matrix treatment or matrix acidizing is a process of injecting a fluid into the formation, either an acid or solvent at pressure below the fracturing pressure ($P_{inj} < P_{frac}$), to improve the production or injection flow capacity of a well.
- Main objective is to cure the damage and achieve initial permeability.
- Could be performed both in sandstone and limestone reservoirs.

Hydrostatic Pressure

The hydrostatic pressure is the pressure created by a column of fluid due to its density and vertical height. This type of pressure always exists and may be calculated whether the fluid is static or flowing. It can be calculated using the following relationship:

$$\mathbf{Hp = MW \times 0.0519 \times TVD}$$

Hp is the hydrostatic pressure in psi, MW is the mud density in lbs per gallon, and TVD is the True Vertical Depth in feet, i.e. the vertical distance from the depth reference level to a point on the borehole course.