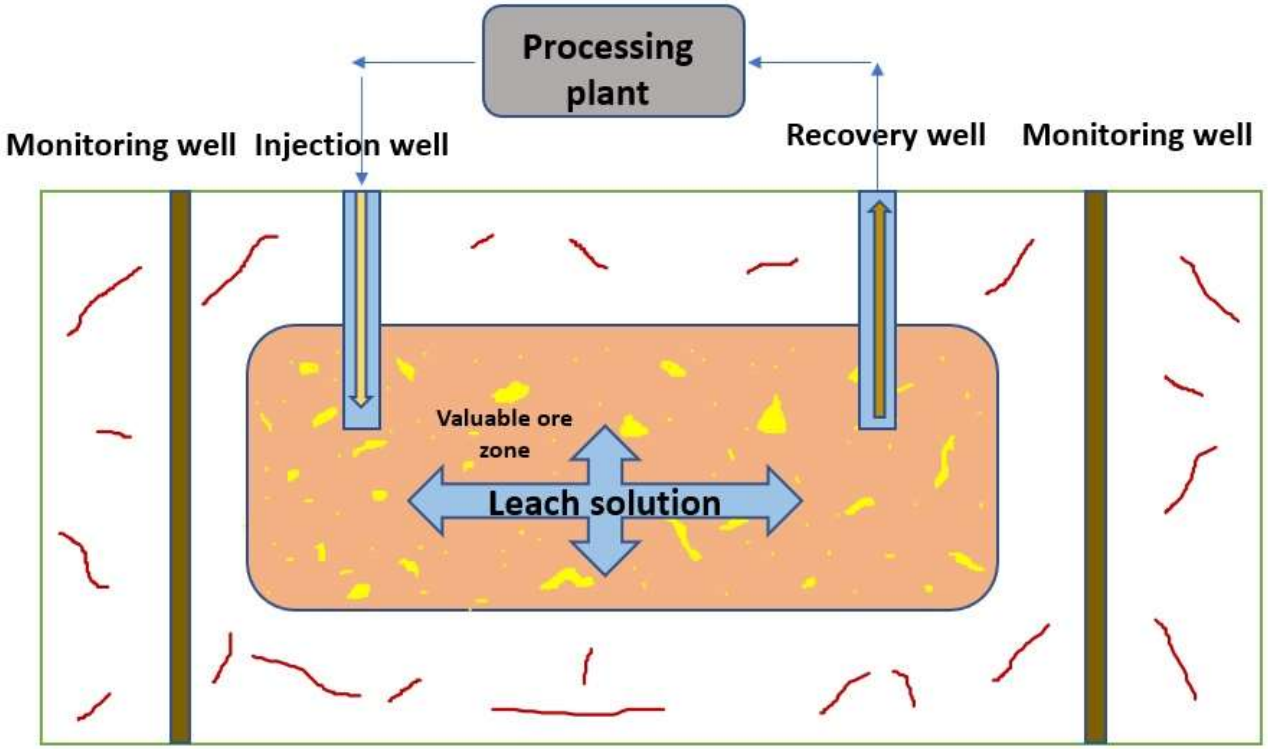
Review of fracturing techniques (microwaves, high-voltage pulses and cryogenic fluids) for application as access creation method in low-permeability hard rocks for potential in situ metal recovery

Sahar Kafashi

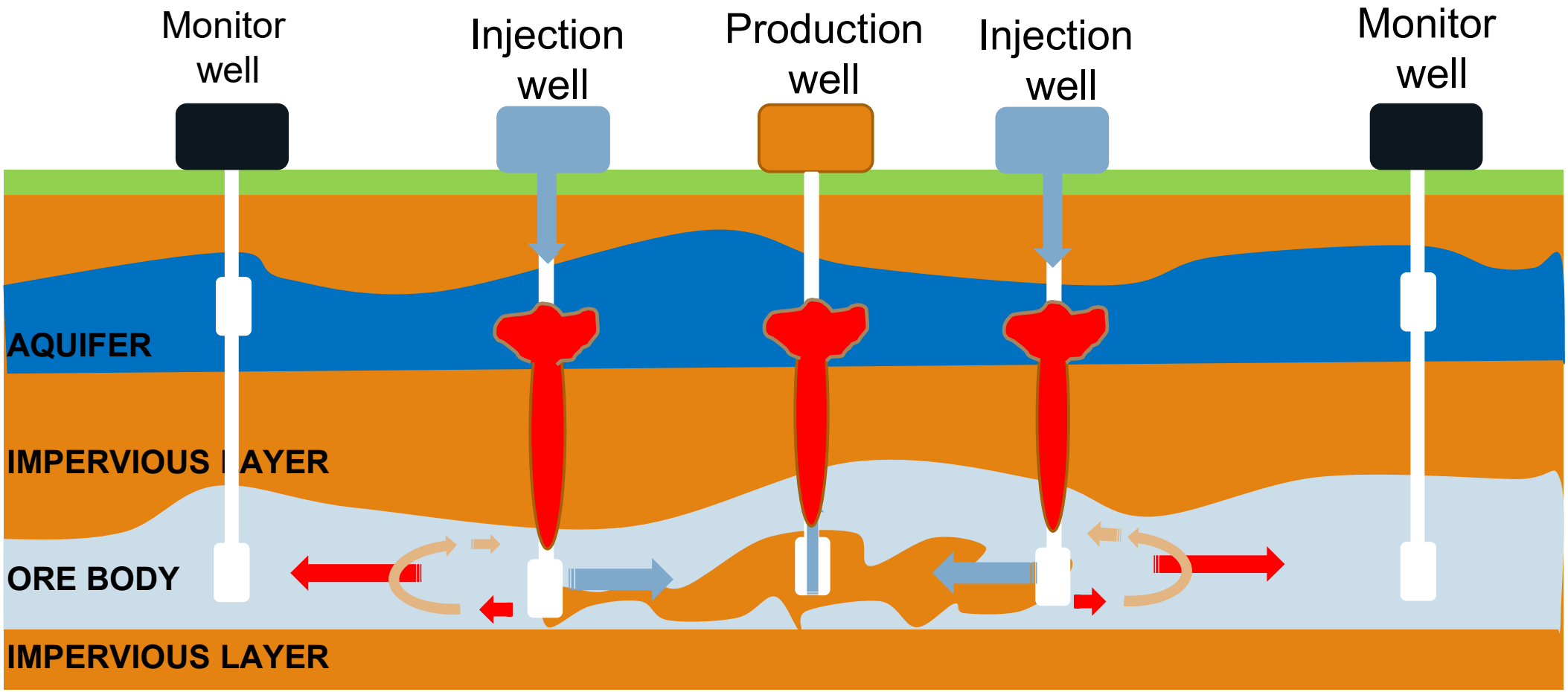
Murdoch University

kafashi.sahar@murdoch.edu.au

In situ leaching

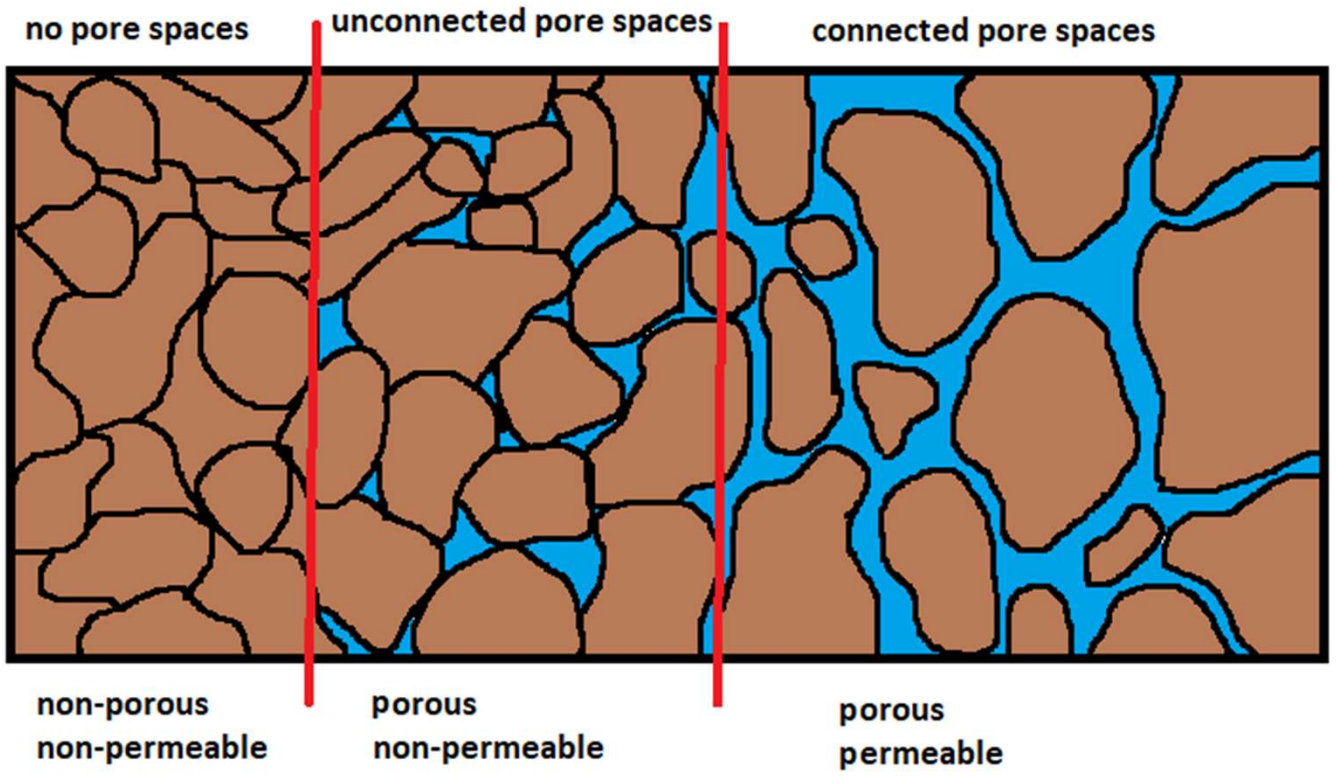


ISR lends itself to the commercial recovery of soluble salts and uranium from permeable, readily leachable “palaeochannel” deposits. However, no commercial processes exist currently for the in-situ recovery of copper, gold and nickel, Zinc and Silver as these commodities often exist in compact, impermeable rock.


Monitor well
Injection well
Production well
Injection well
Monitor well
AQUIFER
IMPERVIOUS LAYER
ORE BODY
IMPERVIOUS LAYER

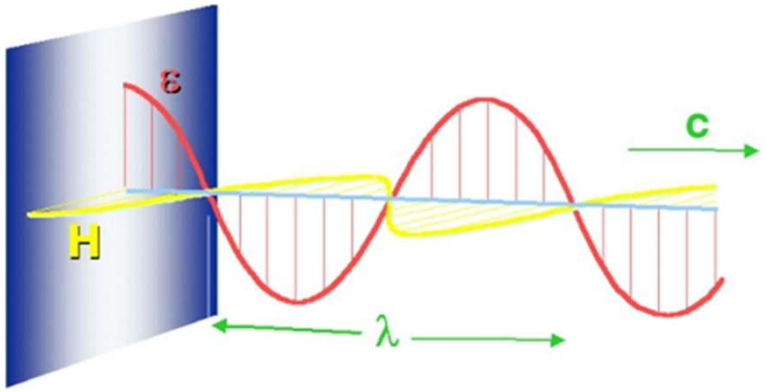
Access Creation

- Why we need for access creation in low-permeability hard rocks for in situ leaching



Microwave fracturing

Microwaves have extensive usage in processing engineering materials from assisting in comminution to leaching them.



leaching

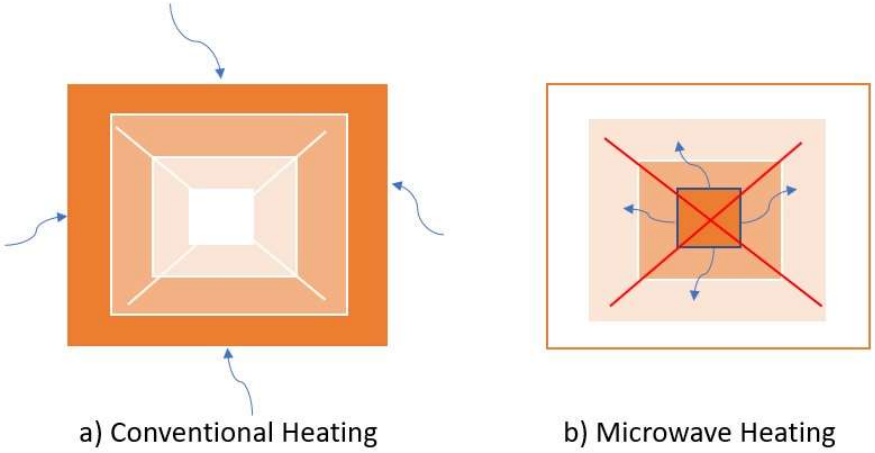
- ✓ Increasing surface area of material
- ✓ Oxidizing Mineral's surface
- ✓ creation of large convection thermal currents
- ✓ Heating

assisting in comminution

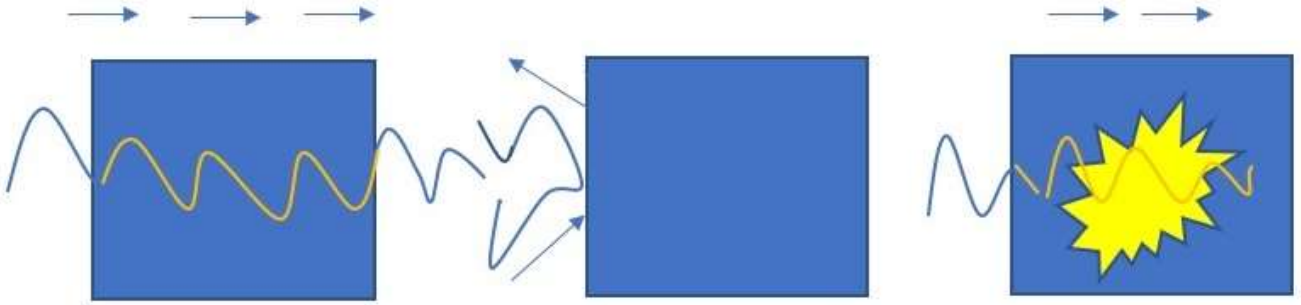
Heating

- ✓ Reduce in mechanical strength (point load index) which renders the ore more amenable to comminution

Microwave fracturing

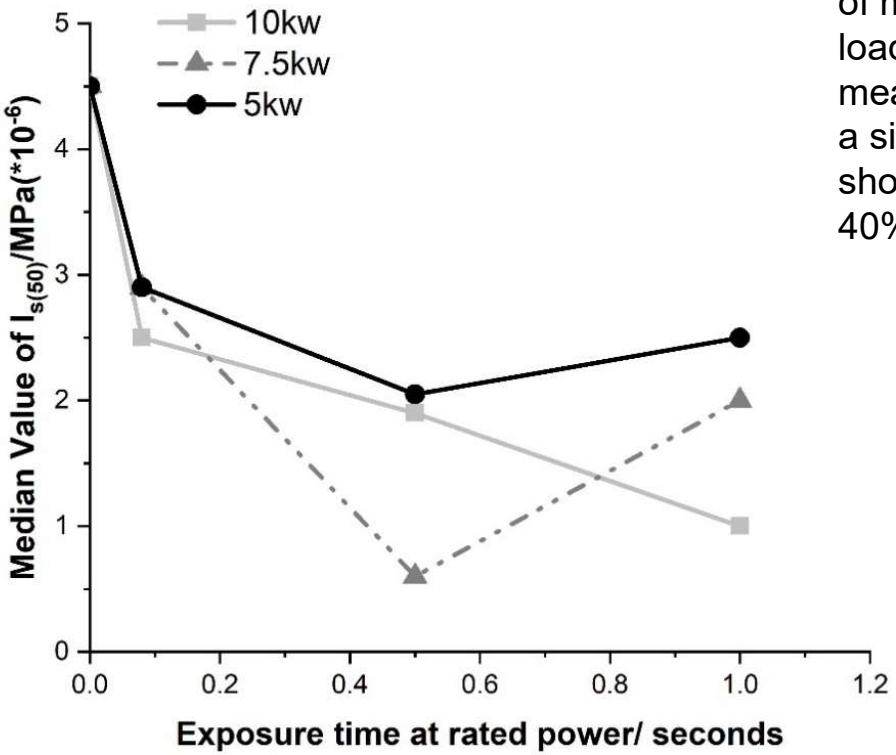


In conventional heating, the material surface gets heated first. Subsequently, heat transfers inside the material by conducting or convection; however, in microwave heating, heat is generated internally within the material by molecular interaction and volumetric heating is achieved in a short time.



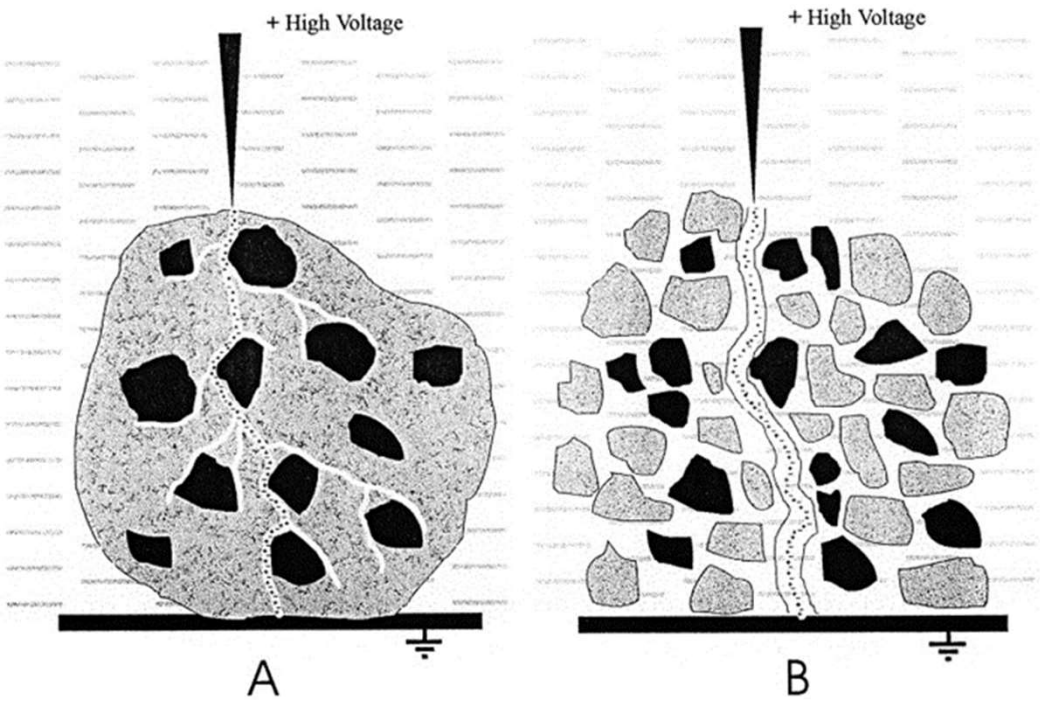
a) Transparent b) Reflector c) Absorber

Microwave fracturing



Kingman et al. (2004) carried out tests to measure the influence of microwave power density on change in ore strength. Point load index and drop weight tests were two procedures used to measure this effect. It was shown that microwave treatment has a significant effect on the strength of the ore, with exposures as short as 0.1 s reducing the point load index by approximately 40% (Figure 5).

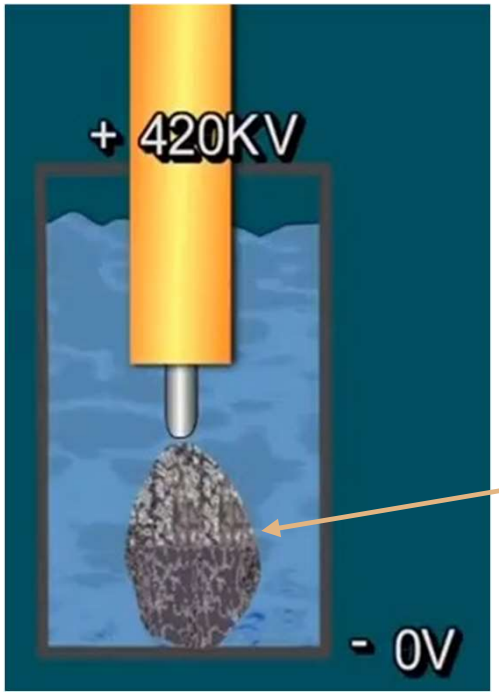
High Voltage pulse fracturing



SELFRAG machine is one of the High Voltage (HV) braking machines that uses HV pulse generators to apply extremely energetic electric discharges to solids placed between two electrodes which disintegrate and/or weaken the particles' structure by strong tensile forces due to the differences in mechanical or electrical properties of different components.
The water acts as a special electrical insulator to prevent electrical discharge occurring outside the rocks.

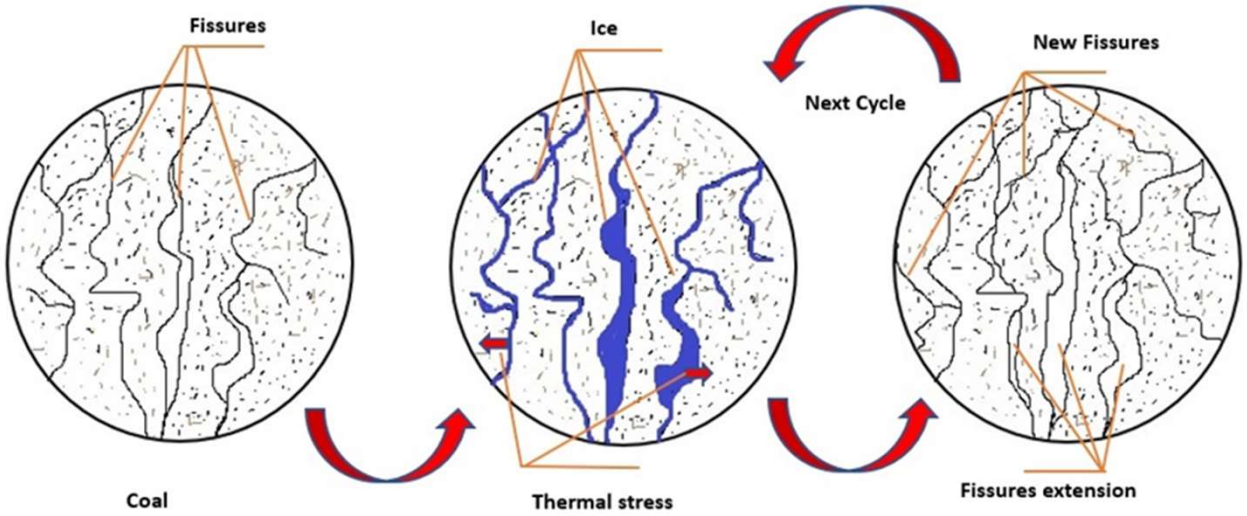
Due to different conductivity of material, current flows differently within that and heats them, and then thermal gradient causes breaking the material.

High Voltage pulse fracturing

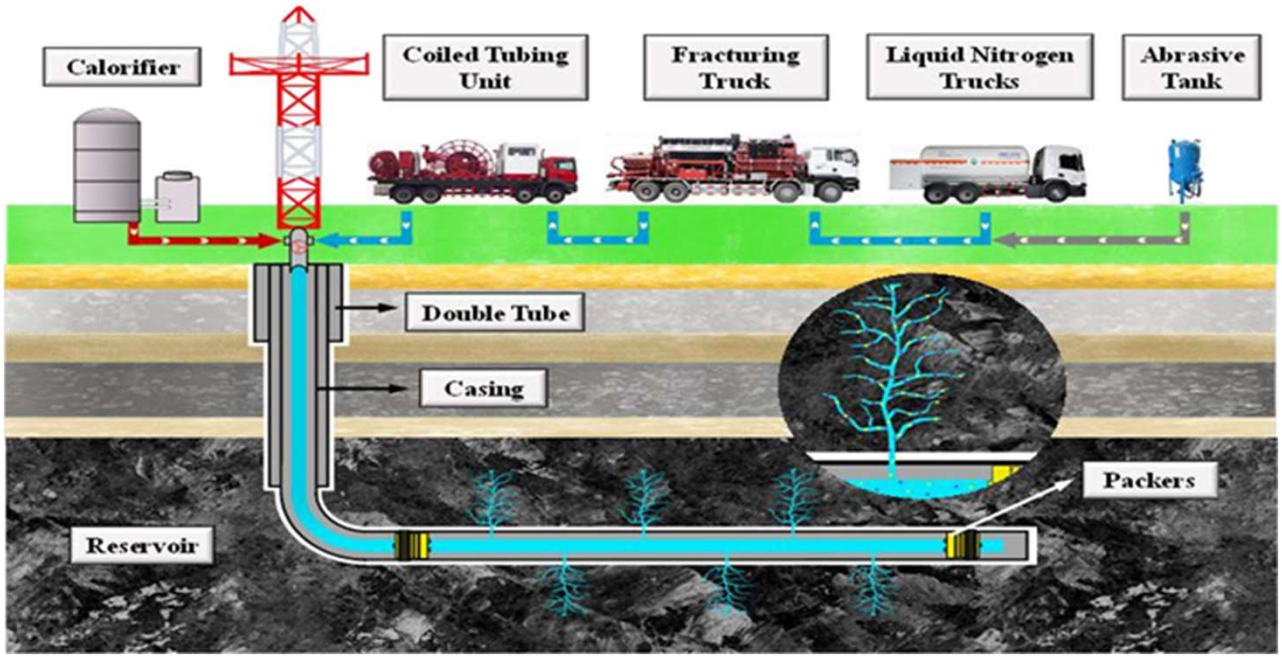


Cryogenic fluid fracturing

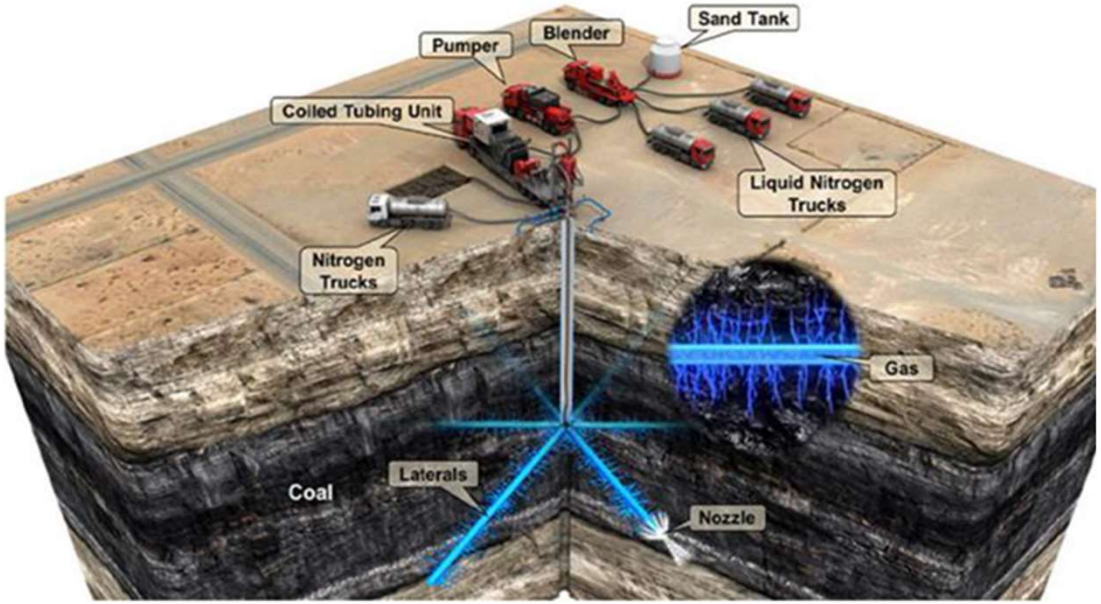
Rapid cooling of a rock surface results in a non-uniform temperature distribution, which builds considerable thermal stresses. These stresses are due to tension on the surface of the rock and compression in center of its body.



Cryogenic fluid fracturing



Cryogenic fluid fracturing



Conclusion

MW, HV and CF may be promising technologies to increase the permeability of hard rocks, such as copper- and gold-bearing ores, and thereby create access for lixiviants and promote mass transfer in ISR processing. This review focused on factors that could be important for application of the three methods in ISR environments.

All three methods MW, HV and CF, are rapid and environmentally friendly fracturing methods that are potentially applicable in ISR systems. These three methods can be used for access creation as well as for selective separation minerals grain separation and to improve leaching.