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Basic Physics of Geological Carbon Storage

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SUMMARY

In 1937 and 1940 two basic treatises on fluid flow in the subsurface were published. Muskat, 1937, shaped the development of reservoir engineering while Hubbert, 1940, introduced the physically consistent Theory of Force Potentials to petroleum exploration and hydrogeology. Two decades later, the development of the advanced hydrogeological methods of gravitational Groundwater Flow Systems (Tóth, 1962) were based on Hubbert's Force Potential.

Muskat's, 1937, methods lead to very successful and prosperous hydrocarbon productions. They are based on continuum mechanics [energy related to volume] and are physically inconsistent. In petroleum production, the actual flow paths are not of great importance as long as the hydrocarbons and other fluids enter the production wells. The same is applicable for EOR. The large scale injection of CO₂, however, will remove the sink conditions of hydrocarbon production and EOR application and replace it with source conditions causing long term rise of the pressure potential. From the source injection wells the CO₂ will flow along pathways which cannot be determined by using methods based on Muskat [1937]. Methods based on Hubbert's Force Potential [energy related to mass] and gravitational Groundwater flow systems are, however, particularly suitable for the determination of the flow paths for hydrous fluids, hydrocarbons and CO₂ on their migration away from the CO₂ injection sites. In this context the presentation will show why off-shore injection encounters hydrostatic conditions while on-shore injection will encounter hydrodynamic conditions.

The presentation will address the interplay between gravitational, pressure potential and capillary forces. It will also shed light on the role, within Carbon Sequestration, of so-called Buoyancy Forces, of pressure potential forces, of the physics of the occurrence of Buoyancy Reversal (Weyer, 1978) and how all these conditions can be beneficially applied in carbon sequestration.

References

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