Electrical Resistivity Measures in Cohesive Soils for the Simulation of an Integrated Energy System Between CCS and Low-Enthalpy Geothermal

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ABSTRACT

This work has focused on the possibility of being able to consider the behavior of the caprock, such as a layer of cohesive soil that absorbs and transfers the displacement due to the expansion of the aquifer subject to the action of the flow of CO$_2$ at high pressure, but lower than the overburden of the geological formations overlying the caprock. Assuming a caprock saturated unconfined laterally, which drains over time overpressure neutral interstitial fluid present in the matrix of cohesive soils, it has been calculated at the rate derived from the elastic yielding of consolidation theory and compared this value with the one obtained by applying a coefficient of consolidation built on the theory of the “double layer”. This theory also known as the Gouy-Chapman (1910) was applied to the prediction of the behavior of cohesive soils where it conducted a micro-mechanistic approach. From the design point of view, the second part of the study simulate the possibility of combining in a single integrated system, the injection of CO$_2$ in deep saline aquifers to generate a range of pressures that facilitates the upgrade of geothermal fluids from geological formations that constitute the caprock or any porous aquifers overlaid with the aquifer reservoir. The uptake of these fluids promotes dissipate excess pressure and at the same time the settlement of primary consolidation of the formations overlying the aquifer subjected to the vertical elastic displacement. Preserves itself, in this way, the balance of the system and shows how the CCS can have a double purpose: on the one hand reduce the emission of CO$_2$ into the atmosphere, and the other end to provide a energy contribution with the exploitation of a source of renewable energy.

Keywords: Caprock, Electrical Resistivity Measures, Ionic Concentration n(∞), Primary Consolidation, U Neutral Pressure

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1. INTRODUCTION

In this paper we discussed the contribution that the Carbon Capture and Storage (CCS) can make to the development of an integrated energy system doubly careful to safeguard the environment. It is conceived for the combined use of geothermal fluids as a source of energy as a result of storage of CO$_2$ in the deep layers in place of issue of the same gas in the atmosphere. Because this system can find real application it is necessary that some structural-geological conditions are met. It is essential that there is the presence of an aquifer saturated permeable to porosity, which represents the complex hydro-geological suitable to contain CO$_2$, buffered at the top by a waterproof geological formation called caprock, extended up to the surface (land surface) or alternating layers less permeable or secondary saturated aquifer with the role reservoirs of geothermal fluids. A schematic and simplifying (in nature the structural conditions can be much more complex—Figure 2) is that of Figure 1. From the results of the geo-mechanical and fluid dynamic simulations developed in accordance with the theory of Terzaghi (1925) and Gouy-Chapman (1910), it can be said as the injection of CO$_2$ in deep saline aquifers to generate a pressure field throughout the aquifer, without exclusion of that part of the same aquifer is not yet affected by the advance of the CO$_2$ plume. The geo mechanical analysis compares these two theories which provide the behavior of cohesive soils from the standpoint of macro mechanistic (Terzaghi, 1925) and micro mechanistic (Gouy-Chapman, 1910), using different soil parameters for acquisition and processing. The interstitial overpressure generated together with the elastic deformation induced in the aquifer reservoir, is transmitted as a uniformly distributed load at the interface between the aquifer and caprock, causing in the fluid contained in the geological layers overlying the aquifer a range of pressures varied with distance from the point of load application (Figure 1). Because of the hydro geological properties of these impermeable formations, characterized by a very low value of permeability of the order of $10^{-15}$-$10^{-17}$ m$^2$, this overpressure is not quickly dissipates over time. The low transmissivity, i.e. the reduced tendency to dissipation of overpressure, causes the vertical displacement of the aquifer–caprock system, result of the elastic deformation of the aquifer subject to the pressure of injection of CO$_2$. The direct uptake of fluids, then, is necessary so that another way to banish the overpressure generated by the injection of CO$_2$ with the result to preserve the structural balance of the aquifer-caprock.

In the presence of an impermeable layer as the caprock, the fluid contained in it is stored

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*Figure 1. One-dimensional model simplified of CO$_2$ injection in an aquifer-caprock system (from ERSE, 2010)*
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