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MAINTAIN OF ENVIRONMENT FROM AFFECTION OF CO_2 - A REVIEW

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Abstract: Maintain environment is priority to any plan in human life. It is aimed to review of injection, storage and leakage monitoring of CO_2 by using experimental, numerical and analytical data. The mineralogy, chemical composite, lithology, seismic wave propagation, small earthquake, accelerating natural earthquake, thermal stress-strain modeling, ground movement level and risk assessment in this industry and fault activation have been discussed. It expects to better understand problems and research requirements related to this industry.
Keywords: Environment; seismic zone; lithology; stress; risk assessment

1. INTRODUCTION

To maintain environment from CO_2 injection method is practicing. The CO_2 inject into subsurface has to be maintain from leakage to the surface and contaminate to any natural resource due to exploration or extraction. The CO_2 has been created from industrial activities or natural environment. The main propose of CO_2 monitoring is human health. The CO_2 monitoring has to be done during injection and storage phase.

To solve global warming problem carbon dioxide reduction technology has shown attracted worldwide attention (Lee et al., 2012). To reduce emission of greenhouse gases which burning from fossil fuels in atmosphere the geological CO_2 storage is recognize as an acceptable method (IPCC., 2005; Förster et al., 2006). The first CO_2 injection and storage into saline aquifers was in Canada on early 1990 (Michael et al., 2010). The CO_2 capture and storage (CCS) are subdivided in several distinct realms which are (i) quantity of CO_2 in atmosphere (ii) capacity of CO_2 in overburden (including faults and wells) (iii) reservoir with appropriate seals (iv) and time for storage (P. Winthaegen, 2005). The suitable deep of geological formations should be more than 800 m which is saline aquifers, depleted oil and gas fields or coal beds (Holloway, 1996; IEA, 2004, 2006). But sometimes depth is around 630 m (Andreas, 2008). And the site geological allowed to be more near surface and made more project economic effective. This processes are require experimental and modeling studies for analyzing leakage risk assessment as well as groundwater and minerals contamination due to any possible reason.

For near accurate CO_2 injection and storage monitoring in saline aquifers many research project in around the world especially in USA (Frio), Australia (Otway), Japan (Nagaoka), and Algeria (In Salah) and Germany (Ketzin) are going on (Michael et al., 2010). The research on CO_2 storage for deformation of the reservoir zone has been modeled by using seismic data (D.J, White., 2011). And Rock and fluid physics measurements and modeling have been used for evaluation of CO_2 for controlling P-wave and S-wave velocity (Davie et al., 2003). The numerical models are used to understand geological monitoring and storage operation for injection 18,000 t of CO_2 in saline aquifer at Ketzin (Würdemann et al., 2010). And numerical simulator has been practiced for explanation water-rich brine phase, CO_2-rich phase and dissolution of both these components in the phases. (Assteerawatt et al., 2005). To identify fluid origin and obtain constraints on fluid movements within the crust in petrology field natural tracers has been used (Ballentine et al., 1991; Wilkinson et al., 2008). The geochemical model for the hosting aquifers has been used to reconstruct the pre-injection reservoir chemical composition, evolution of the system during injection and measure the geochemical trapping mechanisms for over 100 years and validate of simulation in short term of 3 years (Cantucci et al., 2009). The finite-difference elastic-wave-equation scheme has been used to estimate synthetic seismograms (Cheng, 1994; Kamm et al., 1996). The monitoring and verification of CO_2 storage reservoirs has successfully been implemented at Sleipner (Arts et al., 2004 a,b, 2008). The gravity surveys and electrical resistance tomography surveys are two other methods for CO_2 monitoring. Smith et al., (2001) indicated economic and engineering aspects of CO_2 storage and injection. The studies show that deep saline aquifers have the acceptable capacity for CO_2 storage (Bachu., 2003; Bradshaw et al., 2007). And for any CO_2 capture and storage (CCS) project the sedimentology, structural geology, fluid flow, reservoir characteristics and modeling, geophysical modeling and interpretation, mathematical modeling, mineral reactions, geochemistry, geomechanics, petrophysics and marine geology sciences as well as biological processes are required for storage performance, seal properties, monitoring techniques, operational aspects and marine environment (Eyvind Aker et al. 2011; Borm., 2005). The main objectives are monitoring CO_2 injection, storage and leakage in deep at seismic zone as well as analyzing seismic wave propagation and estimate liquefaction magnitude near surface by using numerical and analytical investigation. The CO_2 confide durability and stopping leakage are important in this reconnaissance.

2. DISCUSSION

2.1. CO_2 injection and storage

The CO_2 capture and storage (CCS) is a greenhouse gas mitigation technology (Korbul, 1995). After CO_2 capture it will be transporting by pipeline or shipping to a suitable site for injection into an underground geological formation for long term storage (IPCC, 2005). The CO_2 is injected for enhanced oil recovery (EOR) operations worldwide especially in the Permian Basin of west TX, USA (Hsu, 1995), and also CO_2-enhanced gas recovery (EGR) as well as CO_2-enhanced coal-bed methane recovery (ECBM) extensively have been used (Yangyang, 2012). To monitoring CO_2 injection in subsurface electrical sounding methods has been discussed (Ramirez, A., 2003). The electrical resistivity can be imaged due to availability of metal-cased boreholes (Daily, W et al., 2004). And according to Albright, J.C. (1986) assumed CO_2 is increased resistivity. One of the commercial-scale CO_2 storage is started at In Salah, Algeria (Riddiford et al., 2003). The CCS cost can be reduced in introducing technology low consumption energy in whole of this process.

2.2. CO_2 leakage

The CO_2 leakage may be expected from some storage sites if extensively applied CO_2 injection technology (Holloway et al., 2006), and it is possibility of leakage to ocean and/or atmosphere (West et al., 2003), and from other hand soil gas measurements shown leakage is through narrow gas vents and CO_2 is migrating in this process only from small area of leakage at the surface (Beaubien et al., 2008). The acceptable leakage level is in range from 0.001% per year around 1% over 1000 years to 0.01% per year which is equal 1% over 100 years (Bowden., 2005), and more than this level of CO_2 leakage can have harmful effect on the atmosphere or local marine and terrestrial ecology as well as directly hazardous to man (Williams, SN., 1995). And it is require investigating for better understanding CO_2 leakage possibility during natural hazard especially earthquake and contaminate to the extractable natural resources. It can be understood the strata permeability and porous has direct correlation with CO_2 leakage. Eyvind Aker et al., (2011) mentioned high permeable fault plane is measurable by using InSAR even outside the reach of the injected CO_2 plume. In this regard Klinginger (2006) presented an investigation for carbon dioxide propagation in the subsurface which is depending on the rock permeability. Andreas, (2008) explained that increasing temperature caused decreasing density and viscosity and resulted in vertical migration CO_2 and also thermal arrival time depending on the sweeping efficiency. Onuma, T. in (2009) developed method and concept to explain CO_2 potential leakage during injection and reservoir and later Eyvind Aker et al. (2011) used finite element model for surface heave for injection and model test at In Salah, Algeria.

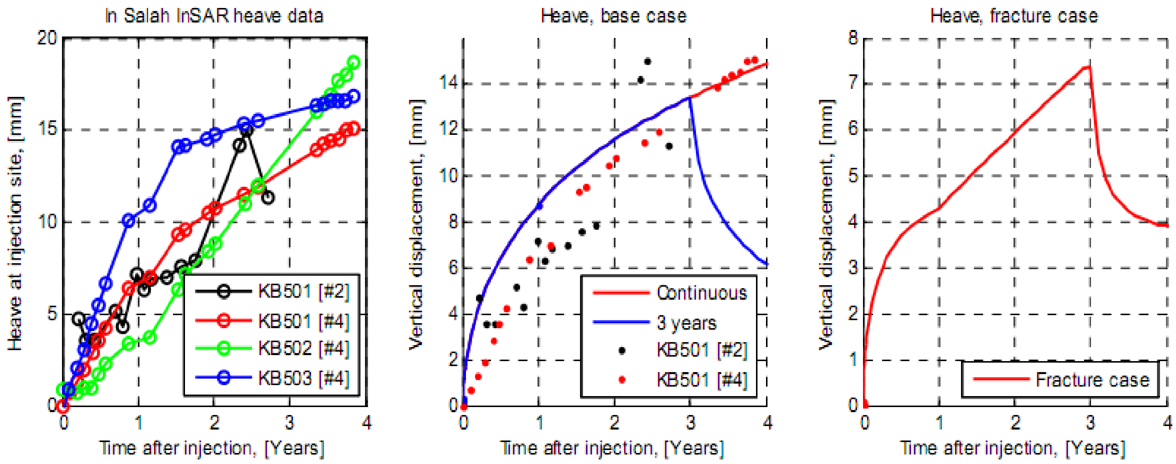

Figure 1. Left: Measured heave data at the injection wells from two different references (Onuma, T. 2009; Rutquist, J. 2009). Centre: Close-up (0-4 years after injection) of surface heave (modelled Base case; line) compared with measured data for injection well KB501(dots). Red curve is from continuous injection and blue curve when injection is stopped after 3 years. Right close-up (0-4 years after injection) of surface heave (Fracture case) (Eyvind Aker et al. 2011)

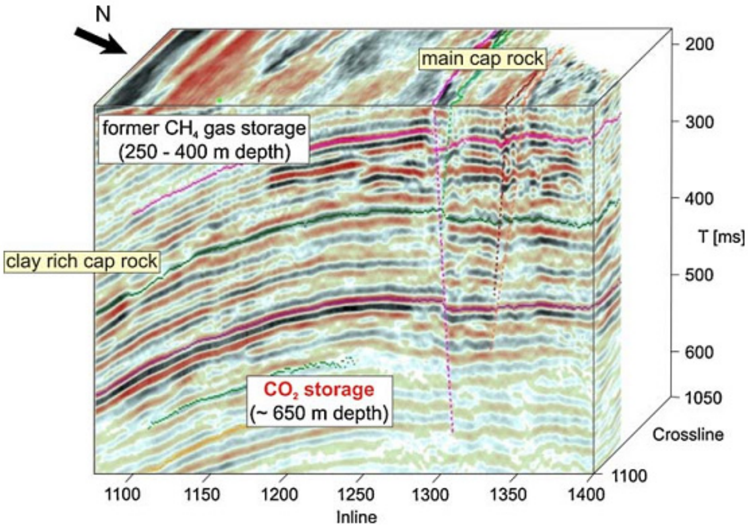

Figure 2. Cross-section derived from3D seismic tomography showing the abandoned gas storage, the fault structure, cap rock, and reservoir (Juhlin et al., 2007; Hilke., et al. 2010)

The figure 1 has been indicated the reduction of heave during 3 years for three different projects. It is requiring more investigation under considering different factors included sedimentology, structural geology, fluid flow behaviour, reservoir characteristics, mineral reactions, geochemistry, geomechanics, petrophysics and marine geology for middle period and long term. The figure 2 is indicated 3D seismic data and geological models are used for assessing fundamental stratigraphic imaging of the geological structure to minimize CCS risk and accurate identify gas storage formation. (Juhlin et al. 2007; Hilke, et al. 2010). The CCS risk assessment is depend on site characteristics, data accuracy, assessing future direct and indirect potential problems, project cost, project feasibility and application of management art, all these process require computer modelling and imaging before performance. The result of CCS will be in acceptable level if all stage of risk management performed perfectly through near accurate computer simulation.

Tohidi, et al. (2010) present an excellent research on CO_2 self-sealing mechanism to minimize risks leakage at ocean and atmosphere. Suebsiri, et al. (2006) identified hidden CO_2 emission from the recycle process and it make complicate the actual CO_2 is stored. Hassanzadeh., et al. (2009) has been indicated that well geometry, injection time, injector distance from the sources are important factors and at any project have to be designed separately.

2.3. Mineralogy and Chemical composite

The stratigraphic trapping, capillary trapping, solubility, relative permeabilities hysteresis and mineral trapping are various types of CO_2 underground trapping are occurred (Oloruntobi and LaForce, 2009; Solomon, 2007; Flett et al., 2004), subsequently mineralization and CO_2 dissolves in water forms several types of minerals (Bachu et al., 1994; Calabrese et al., 2005), which multi-mineral reactive is a difficult parameter to be measured (Xu et al., 2007). The dissolving CO_2 in deep where groundwater not presence mineral trapping may take place for several thousand years (Ennis-king; 2003). The CO_2 can dissolves in water and reacts with minerals and caused carbonate mineral like dawsonite ($NaAl(OH)_2CO_3$) (Eyvind Aker et al., 2011), and impacts on deep subsurface microbial ecosystem and biogeochemical process (Julia M, West et al., 2011). And also microbe could be affected by injected CO_2 while it could survive exposure due to its physical and chemical properties (Werner, BG., 2006). Among the all point have been mentioned there scope for assessing feasibility of microbes utilising CO_2 as an energy source (Julia M, West et al., 2011). The CO_2 leakage mechanism is depending on chemistry and mineralogy (Scherer et al., 2005). And CO_2 injection has influenced on cement sealing properties and clarified typically crack resulted carbonation (Eyvind Aker et al., 2011). According to G, Rimmele (2008) some cement carbonation reaction occurs only at surface of the plug in the presence of the acid gas. Brandvoll (2009) is identified CO_2 spreads into cement along crack and pores and caused carbonation in deep after 40 days of exposure. The degassing magma is zone caused more energetic emissions (Holloway et al., 2006), and created CO_2 and subsequently migrates to the Earth's surface and is emitted through volcanic (Baines, 2004). And also the CO_2 can migrate through natural fracture networks in the rock strata, and/or through the matrix of porous and permeable sedimentary rocks (Czernochowski-Lauriol; 2003). And mixing CO_2 with water causes gas hydrates, the freezing of water, and corrosion (Austegard et al., 2006), and leads to increase leakage possibility. Tohidi et al. (2010) have been indicated that the sandy sediment morphology, grain cementation are important factor in leakage level and reducing CO_2 migration rate. Another factor for controlling gas hydrate formation may be marine organic which is reported by Saito and Suzuki (2007).

2.4. Small earthquake and accelerating natural earthquake

The CO_2 migrant mechanism helps in identify best storage location and depends on fault lithological (A, Annunziatellis, 2008) and lithology controls injected seal quality for many years (Zhou et al., 2004). The seismic data has been collected in from of P and S - wave inversion. The investigation shows that the pore pressure and CO_2 degree of saturation have been changed in reservoir zone (D.J, White, 2011). The application of inversion procedure has been indicated by (Cole, S et al., 2002) and (Lumley, D et al., 2003). The impedances has been inverted instead of travels time and amplitudes (Meadows, M., 2008). Migrating gas can result in seismic responses (Schroot, 2003). In sandy sea bed sediments gas emerges as bubbles (Hovland, 1985), Under low permeability condition CO_2 looses more energy than compare to high-permeable cases and also lower CO_2 viscosity leads to higher injection pressure (Andreas., 2008) this process under saturated condition reduces subsoil liquefaction resistance it means that the CO_2 leakage is an element accelerates liquefaction phenomenon and also increasing CO_2 temperature helps in acceleration uplift force. According to Lindeberg., (2003) and thermal conductivity may changes with CO_2 degree of saturation during injection (Hilke, et al. 2010). Under the applied geological constraints, effective storage capacity of the reservoir increases with increase heterogeneity, whereas the injectivity decreases. (Lengler et al., 2010). Where fluid moves from the reservoir to the wellhead, both pressure and temperature decreases and changes in the fluid chemistry (Quattrocchi et al., 2006b), and the Geomechanical stress decreases as pore fluid pressure decreases.

2.5. Thermal stress-strain modelling

Development model for geological storage and numerical codes helps to problem description (Class, 2009) The permanent temperature monitoring in gas-hydrate bearing sediments at around 1200 m depth has been investigated (Henninges, 2005). And also temperature monitoring in the subsurface fiber-optic distributed temperature sensing (DTS) cables can be used (Bielinski, 2008).

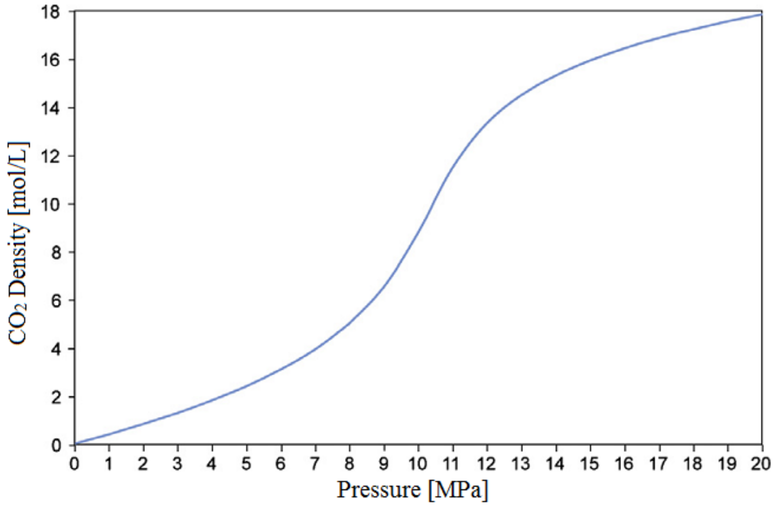

Figure 3. Variation of CO_2 density in mol/L with pressure between 0 and 20 MPa. (Lemmon et al., 2010)

3. RESEARCH PRIORITY AND SUMMERY

- ✓ The leakage, storage and injection monitoring of CO_2 for minimizing environment pollution and/or using stored CO_2 in future industry has been studied.
- ✓ The leakage of CO_2 causes extensive corrosion if contaminate to water (Austegard et al., 2006).
- ✓ Analyzing potential leakage of CO_2 using finite element model, soil mineralogy and lithology for numerical and analytical modeling to asses CO_2 behavior when fault is subject to seismic wave and CO_2 confide with stress as well as analyzing effect of CO_2 on seismic wave propagation.
- ✓ Possibility of small earthquake or accelerating natural earthquake because of CO_2 storage.
- ✓ Analyzing geological stress-strain behavior in concern to CO_2 behavior and possibility of ground movement level as well as fracture or fault activation.
- ✓ Analyzing potential leakage of CO_2 due to failure of seal materials, geological characteristics and mineral trapping.
- ✓ Near accurate well modeling and reservoir geometries are needed for improving storage safety (Hassanzadeh., et al. 2009).

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