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Geotechnical Prospects of Geological Sequestration of Carbon Dioxide in Deccan Trap of Central India

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Abstract

The enhanced use of fossil fuels and burning of hydrocarbon for advancing prosperous society induces pronounce rise of carbon dioxide (CO_2) concentrations in the atmosphere. The carbon dioxide (CO_2) is one of the major constituents of green house gases. Thus the higher concentrations of such greenhouse gas has resulted numerous serious complexities in constancy of environmental equilibrium. The geological sequestration is appears to be one of the most conspicuous and enduring options in diminishing the concentration of CO_2 in the atmosphere to avoid major biological disorders and ecological imbalances.

The enormously large and considerable thick deposits of Deccan Trap comprises of sandwiched boles lenses and pockets, overlying massive tholeiitic basalt, underlying vesicular basalt and surface exposure of some amygdaloidal basalt with dolerite dykes. These seem to be pertinent to allow the disposal of huge quantity of CO_2 liberated from the different industries, domestic use and transportation, etc. These tend to avoid additional concentration of CO_2 in the atmosphere following the carbonation reactions of CO_2 with calcium oxides (CaO) and magnesium oxide (MgO) present in basalt and bole beds- equations (1) and (2):
$CaO + CO_2 = CaCO_3 + Energy \ldots$ (1)
$MgO + CO_2 = MgCO_3 + Energy \ldots$ (2)

The energy released in the equations 1 and 2 substantiate the energy required with the energy produced by burning of the coal (C) (Equation 3).

$C + O_2 = CO_2 + Energy \ldots$ (3)

The basalt of Deccan Trap shows considerable concentration of MgO as 6.20wt% and Cao as 9.4% with Rc = 26 and RCO_2 as 7.1.

Besides the chemical stability of CO_2 in the form of carbonates, the mechanical stability of reservoir as well as seal or cap-rock beds is of prime concerns to sustain with the injection induced developed pore-pressure and up thrust pressure for minimum retention periods and post-injection changes. Hence the geotechnical feasibility of the sites is also one of the critically important aspects of sequestration to ensure the long term safety of the storage structures.

The geomechanical studies performed on the rocks of Deccan Trap of the area exhibits the compressive strength ranging from 88.58 to 128.57 MPa, tensile strength ranging from 8.42 to 12.34 MPa, shear strength ranging from 26.87 to 58.78 MPa and modulus of elasticity ranging from 8.52 to 5.52 GPa. The compressive strength of overlaying massive basaltic strata on bole bodies shows the values of compressive strength to be

128.57MPa, tensile strength to be 12.34MPa, shear strength to be 58.78MPa and modulus of elasticity to be 8.52GPa. The underlying vesicular basalts with fused one side opening towards depths (bottom side) exhibits compressive strength to be 88.58 MPa, tensile strength to be 8.48 MPa, shear strength to be 26.87 MPa and modulus of elasticity to be 5.52 GPa. The amygdaloidal basalt shows compressive strength to be 92.57 MPa, tensile strength to be 8.86 MPa, shear strength to be 31.24 MPa and modulus of elasticity to be 6.56 GPa. The saturated massive basalt with acidic water exhibits compressive strength to be 119.25MPa, tensile strength to be 8.05 MPa, shear strength to be 53.68 MPa and modulus of elasticity to be 8.12 GPa. The saturated vesicular basalt with acidic water shows compressive strength to be 82.73 MPa, tensile strength to be 8.01MPa, shear strength to be 25.86 MPa and modulus of elasticity to be 6.05 GPa while saturated amygdaloidal basalt with acidic water imparts compressive strength to be 88.57 MPa, tensile strength to be 8.04 MPa, shear strength to be 24.21 MPa and modulus of elasticity to be 6.01GPa.

Hence, the different kinds of overlying and underlying basaltic beds of boles appears to be sufficiently capable to withstand with CO_2 gas and CO_2 liquid pressures due to low differences in the strengths parameters of saturated basalts and bole beds as both reservoir and cap rocks, hence the basaltic rocks associations in Deccan Trap can be considered as an appropriate reservoir and seal system (or cap-rock) for efficient storage of CO_2. In addition, the modulus of elasticity of basalts indicates low values of failure strain developed during deformations which is an additional supports to the strong stability of basalts. Besides these, the high porosity (25% to 30 %) and permeability (1.8x 10¬-2 m/s) of boles and low porosity (5%) and permeability (2.34x10-12 m /s) of overlaying and underlying basalts (except vesicular basalt) are found to be pertinent to allow the easy flow CO_2 gas and liquids within the bole beds both for promotion of change of gas phase of CO_2 in liquid and dilution of supra-critical CO_2 liquid due to sufficient 8%-10% moisture contents of the bole beds.

The minor fractures and joint boundaries encountered in basaltic strata require some additional treatments to enhance the sealing capacity of overlying massive basaltic mass through controlled grouting by cement and chemicals. The boles encased within basaltic strata of Deccan Trap can be considered prospective for geological sequestration of CO_2.

In addition, the hardened bole beds with precipitated carbonates also minimize the local subsidence problems on other hand. However, more experimental works, field demonstrations and modeling are still the requirement for proper planning and design of disposal of CO_2 in bole and basaltic strata as a permanent solution.