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Storage of CO_2 and generation of alkalinity from reaction of fly ashes with flue gas

M. Back (1), K. Vosbeck (2), M. Kühn (3), S. Peiffer (1), H. Stanjek (2) and C. Clauser (3)

(1) Hydrology, University of Bayreuth, Germany, (2) Clay and Interface Mineralogy, RWTH Aachen University, Germany, (3) Applied Geophysics, RWTH Aachen University, Germany (martin.back@uni-bayreuth.de / Phone: +49-921-552170)

The reduction of anthropogenic CO_2 in the atmosphere is of paramount importance for the future world climate. Various available options for the sequestration of CO_2 in the subsurface have been proposed and discussed.

Within the research project CO_2Trap, funded by the German Federal Ministry of Education and Research (BMBF under grant 03G0614A-C) we evaluate a novel approach of CO_2 sequestration that is based on the combination of CO_2storage and geothermal energy production. The crucial reaction is the dissolution of anhydrite and subsequent precipitation of calcite (see also Vosbeck, this conference). This process of mineral trapping however requires alkalinity which we attempt to generate with alkaline fly ashes from the coal burning industry.

Because of their high acid neutralization capacity (ANC) and high reactivity lignite fly ashes are well suited for CO_2-binding within short reaction times. Chemical and mineralogical investigation proved that the basicity of the ashes stems mainly from the presence of the alkaline elements Ca and Mg (up to 55 w %), bound in fine-grained oxides and hydroxides (e.g. lime, portlandite).

CO_2-binding reactions in aqueous solution are investigated using a continuously-stirred tank reactor that enables bubbling of CO_2 into the suspension of water and fly ash. The process controlling parameters are studied by varying p_{CO2}, liquid-solid-ratios, purging rates of CO_2, temperature and stirring rate. Prior to the ash addition into the reactor, the water was tempered at 25°C and pre-equilibrated with a certain p_{CO2}.

The experimental results show a rapid uptake of CO_2 especially in the first 20 minutes of reaction, which makes the process feasible for a technical realisation. A CO_2-binding potential of 2 mmol CO_2 per g ash was measured in experiments during 1 h of reaction time. Thus, this process could neutralize at least 0.5 % of CO_2 emission from lignite coal burning plants. This value can certainly be increased by optimizing the process variables (e.g. temperature) and by utilizing comparable alkaline materials like steel slag.

Beside the formation of alkalinity in solution, experimental results prove effective carbonation of fly ashes with flue gas. Carbonation process seems to be a further promising option for CO_2-binding and is considered within this project.

Germany was the leading lignite coal producer in 2004, representing 20 percent of the global production. 167.4 Mio t/year was thereby used for power generation. Round about 10 % of the coal accumulates as fly ash during the combustion process, what means that they are available in great amounts near large point sources of CO_2.The economical potential of the suggested process is therefore significant in terms of emission trade.