Carbondioxide injection in coal seems for sequestration and enhanced methane production

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Aanleiding

Coal seams are a potential supplier of methane gas and can be used to store CO_2 at the same time. This can be done by using the Enhanced Coalbed Methane (ECBM) process. In order to be able to use these coal seams for the storage of CO_2 and enhance the production of methane, the mechanisms by which the coal seams adsorb, retain and store these gasses need to be understood.

Methode

The coalbed is considered as a system which is being influenced by the presence of deposited coal including the presence of minerals. In order to create a process design and to be able to test and evaluate the ability of reservoir simulators to model these processes, a full understanding of the reservoir dynamics must be achieved.
The relatively low concentration of CO_2 in coal beds compared to the original composition of the injected gas raises questions regarding the long-term stability of CO_2 in coal beds. This study to a certain extent investigates, as to whether reactions with CO_2 can occur in coal at reservoir temperature.

Resultaten

The chemical reactions involving CO_2 cannot be ruled out since the CO concentrations are different in a N_2 and an O_2 atmosphere. The presence of O_2 has been detected and is possibly not an outcome of physic-sorption. The term 'chemical involved' cannot be specified in detail due to the limited amount of experimental data. However the claim is pertinent that chemical reactions involving CO_2 are present, even at low temperatures of 70° C. Thus contrary to the common treatment of storage, utilizing CO_2, the reactivity of CO_2 cannot be neglected a priori and appears to be relevant.

<u>Using industrial flue gas instead of pure CO_2 (Mazumder et al., 2006B)</u>
A number of conditions are given for which the rate of adsorption and recovery are determined.

	Dry coal	Wet coal
100% CO_2	The rate of adsorption and recovery are determined for different pressures	
Flue gas[1]		

The adsorption rate for the different gasses and different coal blocks is determined and can be summarized as follows:

	Dry coal	Wet coal
100% CO_2	Highest amount of adsorption	Lesser amount of adsorption then compared to dry coal
Flue gas[2]	Low amount of adsorption	

When comparing CO_2 with CH_4, CO_2 is best absorbed in all cases. The influence of water is only a limiting factor when pure CO_2 is injected. When varying the pressure of the injected flue gas a number of conclusions can be drawn:

- When increasing the pressure, the amount of adsorbed CO_2 increases;

[1] Flue gas is directly captured at the end of the chimney and is composed of 10,9% CO_2, 0,01% CO, 9% H_2, 3,01% CH_4, 3% O_2, 0,106% SO_2, the remaining substance is N_2.
[2] Flue gas is end-of-pipe gas consisting of 10,9% CO_2, 0,01% CO, 9% H_2, 3,01% CH_4, 3% O_2, 0,106% SO_2, de rest is N_2.

- When recovering substances from the coal bed, it is noted that when decreasing the pressure, more CO_2 and CH_4 is released;
- Flue gasses can be injected directly in coal seams and can act as a filter for cleaning flue gasses.

The cleat network (Mazumder et al.,2006C)
As the cleats provide conduits for fluid flow, its network in coal seams play an important role in the production of methane. The permeability depends on a number of factors: cleat size, -spacing, - connectedness, aperture, degree of mineral fill, patterns of preferred orientation. A methodology for determining the cleat spacing is being proposed which uses Gaussian Point Spread Function. With this method the cleat apertures were measured using images from CT scans. The peak height and missing attenuation measurements were used to generate the aperture distribution. A method to determine the cleat orientation and cleat spacing distribution from CT scans was developed. Combining these techniques gives a better understanding of the cleat framework. Up-scaling to coal seams is not possible.
Furthermore, no method can be exact in the sub-pixel level due to the fact that pixels are not a physical domain. At best the error in the approximations can be reduced by choosing the right method.

The swelling of coal and its effect on cleat permeability (Mazumder at al., 2006D)
The cleat permeability of coal is the most important determinant for producing CH4 from coal beds. This permeability can change due to the swelling of coal which in turn is caused by injecting CO_2. The influence of the swelling of coal caused by injecting CO_2 on the cleat permeability is investigated. The major conclusion of the performed experiments is that injection of CO_2 in coal seams results in volumetric swelling. This injection has a profound effect on the fracture porosity and permeability of the coal. Because of changes in the porosity and permeability in coal seams, the transportation process should be dealt with in much detail since the decrease in porosity and permeability can result in serious injectivity problems near the well bore.

The production of CH4 from a coal bed over time
The production of methane from a coal bed can vary over time. Therefore, understanding the mechanisms of adsorption, retention and accumulation of methane gas within coal seams is important for the exploration and assessment of coal bed methane.
Therefore two techniques have been used to estimate coalbed methane production (production decline technique and material balance and flow equation techniques.
Coal reservoirs can be characterized using mathematical models. Well-to-ell interference effects can greatly improve the economic recovery of gas from water saturated coal seams. Coupling material balance methods with flow equations makes it possible to predict future production rates. Reservoir simulation is applicable to all stages of the well life; however, it’s most useful in areas where an abundance of reservoir data have been generated and well test data are available.

Meer informatie
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Meer informatie over de disseratie (2007) via:
http://www.nwo.nl/nwohome.nsf/pages/NWOP_5WBFEY