Applicability of bentonite as alternative plug material for oil and gas well abandonment

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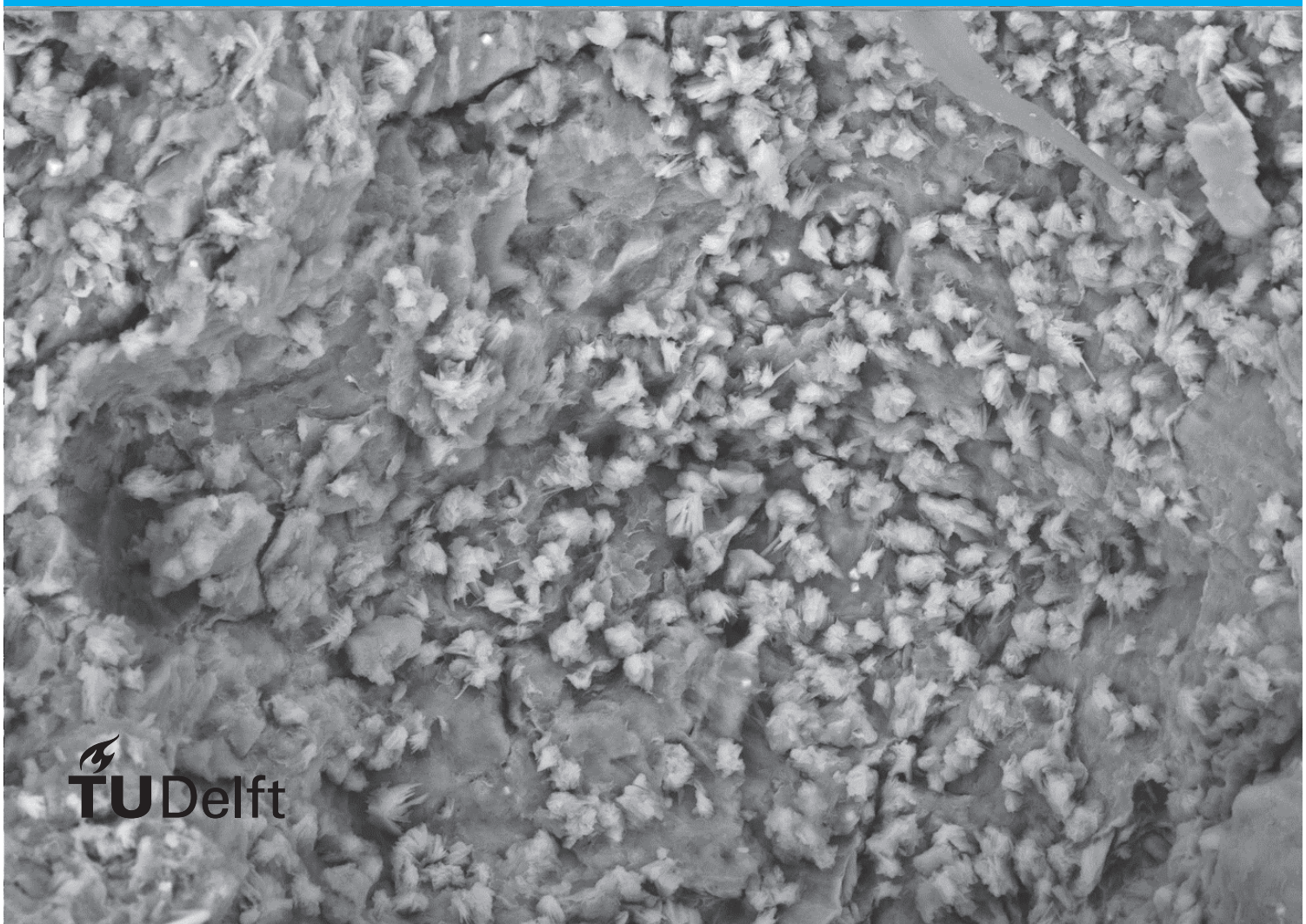

TU Delft

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by

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Abstract

Oil & gas wells are plugged and abandonment when have reached the end of their production life-cycle or are discovered dry during exploration. It is estimated that currently 20-30 million oil & gas wells are waiting to be permanently decommissioned world wide. The maturation of the oil & gas industry will only continue to increase the amount of wells to be abandoned going forward in to the future. Although effective and efficient, the conventional use of cement for the plug & abandonment of wells proves to be associated with certain limitations.

Bentonite is being considered as an alternative material for plug and abandonment. Bentonite is a clay which is known for its high swelling capacity, with a potential volume increase up to 300% upon hydration. Additionally, saturated bentonite has a low water permeability and a self-healing capacity. Evaluating bentonite as an alternative sealing material is important to determine its applicability to oil & gas wells. An abandonment plug has to be able to mechanically withstand pressure differentials resulting from remaining or recharged reservoir pressures whilst preventing the resulting fluid migration, ideally for an indefinite amount of time. An assessment of the different gas migration mechanisms through a bentonite plug is considered in this study.

Four possible gas migration mechanisms through bentonite were identified: advective-diffuse, visco-capillary , dilatant pathway formation and macroscopic tensile fracturing flow. Two of these mechanisms are relevant for the evaluation of a bentonite plug; visco-capillary and dilatant pathway formation flow or a combination of both. From experimental work it has been observed that gas migration commences at a differential pressure which is in the same range as the swelling pressure produced during the hydration of the bentonite plug. The magnitude of the plug swelling pressure is influenced inversely by the free swelling space and proportionally by the dry density of the bentonite plug. When hydrating bentonite material is fully confined, the gas breakthrough pressure is determined by the dry density of the bentonite plug. In the case of a plug comprising of compacted bentonite pellets a maximum dry density of 1000 kg/m^3 can currently be produced; this results in gas breakthrough pressures in the range of 2-5 bar.

Experimentally it was observed that a permeability of 20 nD at a pressure differential of 20 bar was observed in a bentonite plug comprising of hydrated granular bentonite material; a permeability which is as low as a cap-rock. This results highlights the potential of bentonite as a sealing material, but practical operational considerations have to be taken before this can be achieved in oil & gas wells.

These results indicate that it is currently not practical to use bentonite as pressure bearing abandonment plug. Further knowledge is required regarding; the pressure-time dependency of the gas permeability; sensitivity of the bentonite swelling pressure to water salinity; and the impact to the bentonite plug quality over prolonged exposure to high temperatures.