Sediment Heterogeneity and Sand Production in Gas Hydrate Extraction

Daini-Atsumi Knoll, Nankai Trough, Japan

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The possibility of commercial natural gas production from gas hydrates has been tested by researchers and industry for more than ten years. Depressurisation of gas hydrates in porous and permeable sandstones has successfully produced water and natural gas. However long term sustainable production is still elusive. Catastrophic sand production into the wellbore has terminated at least three of the significant depressurisation trials including the 2013 trial at the Daini-Atsumi knoll, Nankai Trough, offshore Japan.

Sand production is generally thought to be the result of mechanical and hydrodynamic instability, however it appears the failure mechanism is not the same for all reservoirs and the location of reservoir porosity and pressure on the normal compression line for sands could be a controlling factor. Sand production in reservoirs at shallow depths and low confining stresses (less than 10 MPa) are likely to be influenced by fluid flow effects like those described by the Shields (1936) diagram. The relative density of the formation may also affect the nature of the sand production in these reservoirs.

The Daini-Atsumi knoll is a structural high on the outer ridge of the Kumano forearc basin, offshore Japan. Hydrate saturations of 50 to 80 % occur within three geological units of the Middle Pleistocene Ogasa group. This group is made up of deep water sediments including sediment gravity flow deposits distinguished by alternating silt and sand layers. The presence of these alternating layers could have influenced the sand production seen during the trial.

This reservoir heterogeneity at the 2013 Daini-Atsumi knoll gas hydrate production trial site was characterised using the descriptions of geological units, analogues and statistical techniques. Scenarios of this heterogeneity were tested in a high pressure plane-strain sand production apparatus. The results of these tests suggest the boundary shear stress of the fluid on the grains is a significant control on sand production for the Daini-Atsumi Knoll reservoir and the layering and grainsize structure of the sediments encourages sand production. Relative density of the sediments appears to impact the nature of the sand production where denser sediments show more localised movement. These results indicate that even minor weaknesses in sand control devices will result in uncontrollable sand production rates from the Daini-Atsumi Knoll gas hydrate reservoir. Managing the fluid flow rate in the reservoir and selectively completing coarser grained zones at the base of sand layers could help limit sand production in future trials.