Changes of Permeability as a Result of Hydrate Dissociation in Sand-Clay Sediment from Qilian Mountain Permafrost, China

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Introduction

Gas hydrates are solid crystalline compounds that confine gas molecules in cavities composed of water molecules[1]. They occure at all continental margins and in permafrost regions. Due to the enormous amounts of methane (CH_4) bonded in the hydrate, it is considered as a promising energy resource for the future and worth exploiting.

Permeability is a key factor describing the efficiency of gas production from natural gas hydrate reservoirs[2-4]:

- ❖ Control fluid migration
- ❖ Determine indirectly the accumulation and distribution of gas hydrates
- ❖ Affect ability and efficiency for gas production.

In this study, we investigate the changes of permeability during gas hydrate formation and dissociation processes in sand-silt core samples from Qilian Mountain Permafrost (QMP).

Fig. 1 Burning of methane hydrate sample in the lab

Location of sample collection

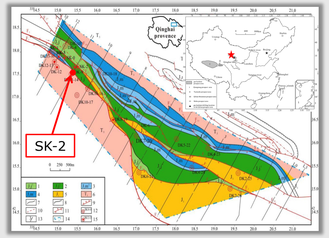

Fig.2 The simplified tectonic map of Sanlutian of Muli Basin, Qilian Mountain permafrost and wells location[5]

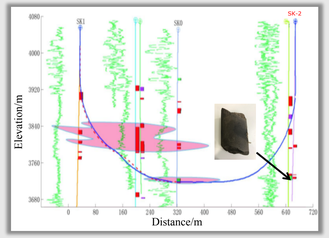

Fig. 3 Schematic diagram of trial production well SK-0, SK-1 and SK-2 In QMP[6]

Borehole SK-2:

- Muli coalfield, Qinghai province, northwest China
- One of the horizontal butted trial-production wells
- Fracture-filling and pore-filling gas hydrate
- Grey mudstone and fine-grained sandstone

Samples from SK-2:

- 355 m below the surface
- Beneath the gas hydrate-bearing intervals

Sample Preparation and Experiments

1. Properties of sample matrix

- Pore sizes: 0.1-10 μm (Mercury Intrusion Porosimetry)
- Particles sizes: 0.01 -30 μm (MIP)
- Mineral components: quartz, feldspar, plagioclase, mica, kaolinite and ankerite/ siderite (SEM, EDS, XRD)

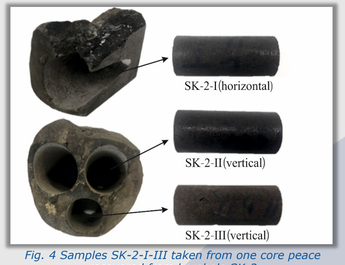

Fig. 4 Samples SK-2-I-III taken from one core peace recovered from borehole SK-2

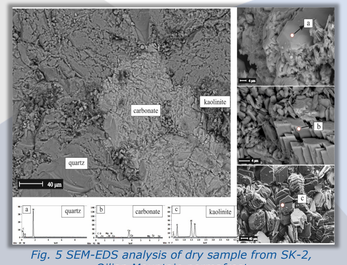

Fig. 5 SEM-EDS analysis of dry sample from SK-2, Qilian Mountain permafrost

2. Preparation

- Dry sample saturated with 5 wt% KCl
- Confining pressure: 6 MPa
- Initial temperature: 274 K

3. Hydrate formation

- Sample pressurized with CH_4 gas at 5 MPa
- Temperature: 274 K
- Time for formation : 6 days
- Hydrate saturation: calculated on basis of the amount of gas collected after dissociation

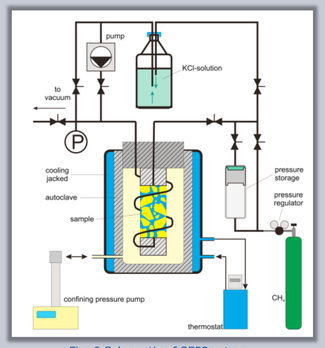

Fig. 6 Schematic of SEPP setup

4. Permeability measurements

- Calculation: Darcy's Law
- Fluid injection: 5 wt% KCl solution
- Injection circle rates: 0.5, 1, 2, 3, 4, 3, 2, 1 and 0.5 ml/min respectively.
- Injection duration: each rate for 5 minutes.
- Permeability tests :

Test 1: initial measurement
Test 2: after long time brine injection
Test 3: after gas injection
Test 4: after ice formation and melting
Test 5: after alternating pure water and brine injection
Test 6: after hydrate formation and dissociation

Results and Conclusions

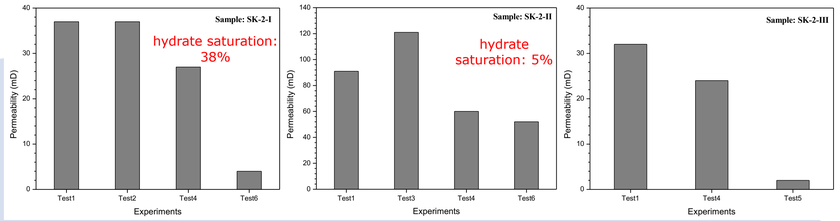

Fig. 7 Permeability measurement results for sample SK-2-I-II-III

- Irreversible damage of permeability after hydrate dissociation in the sediments
- Water and gas fluid dynamics are not the main reasons for the decrease of permeability
- At higher hydrate saturations, hydrate dissociation induces a stronger decrease in permeability

❖ **Pure water released from hydrate dissociation leads to permeability decrease**
❖ **Permeability decrease by hydrate dissociation is related to hydrate saturation**

- Small particles migrate from the sample onto the filter paper which has been attached on outlet side of the sample surface during permeability measurements
- Not only clay, but also quartz and carbonates involved in the fine migration

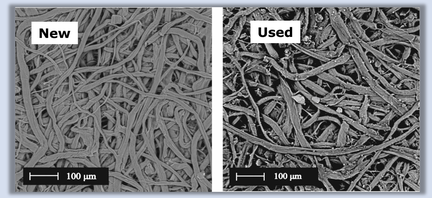

Fig. 8 SEM micrographs of the filter paper before and after reservoir formation damage of sample SK-2-I

❖ **Release of fresh water from hydrate dissociation induces[7]:**

1. **decrease of salinity**
2. **increase of double layer thickness**
3. **increase of repulsive of the electrical charge for small particles**
4. **release of fine particles**

References

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