

# A New Water Extraction Method to Generate and Control Water Reservoir in Planetary Environments

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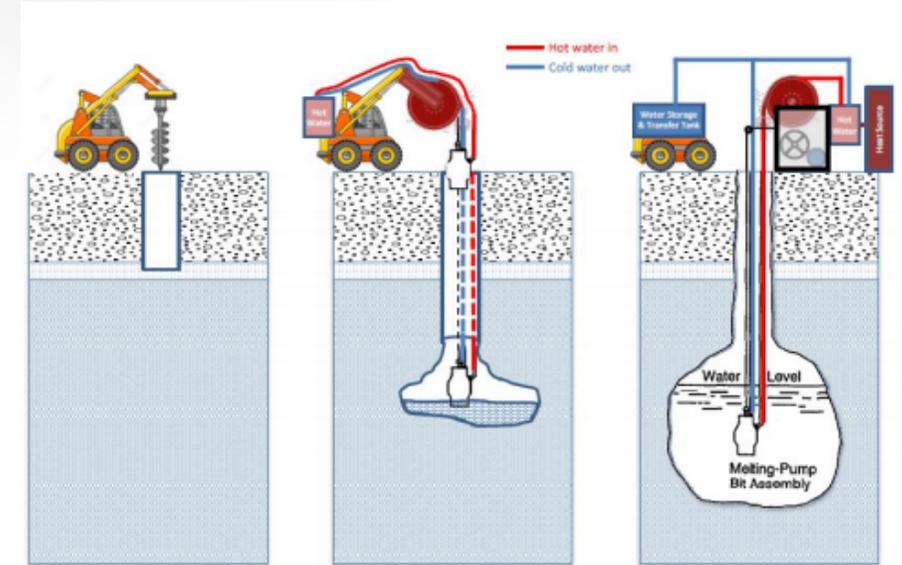


# In situ water extraction concepts



Sublimation of icy regolith on the Moon with Thermal Mining

Sowers, et al., 2018



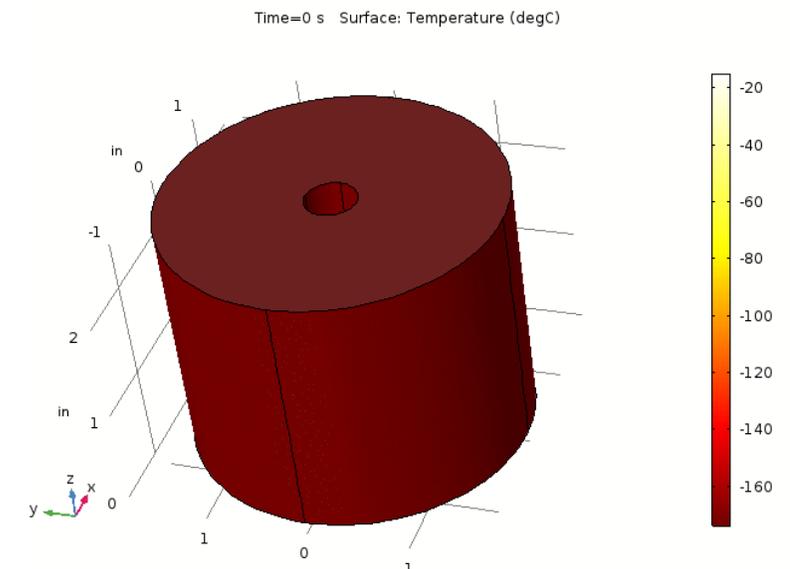
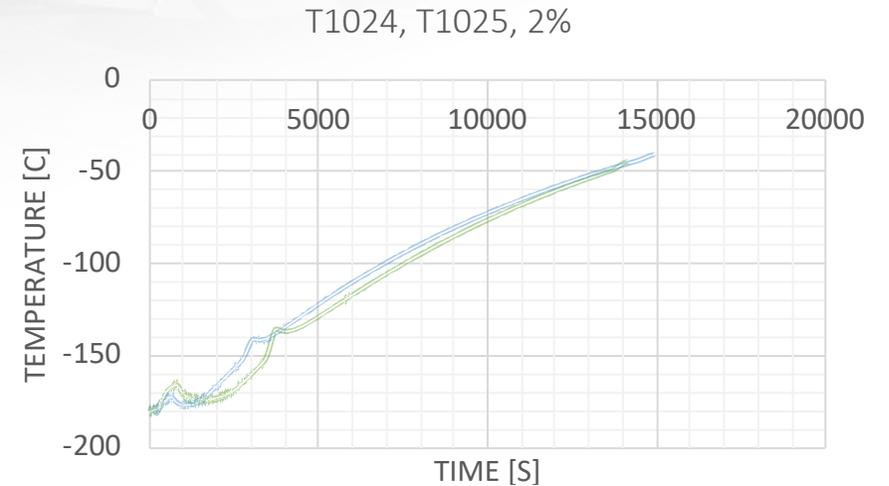
Melting of ice sheets in Antarctica or Mars with Rodwell

Linne et al., 2017

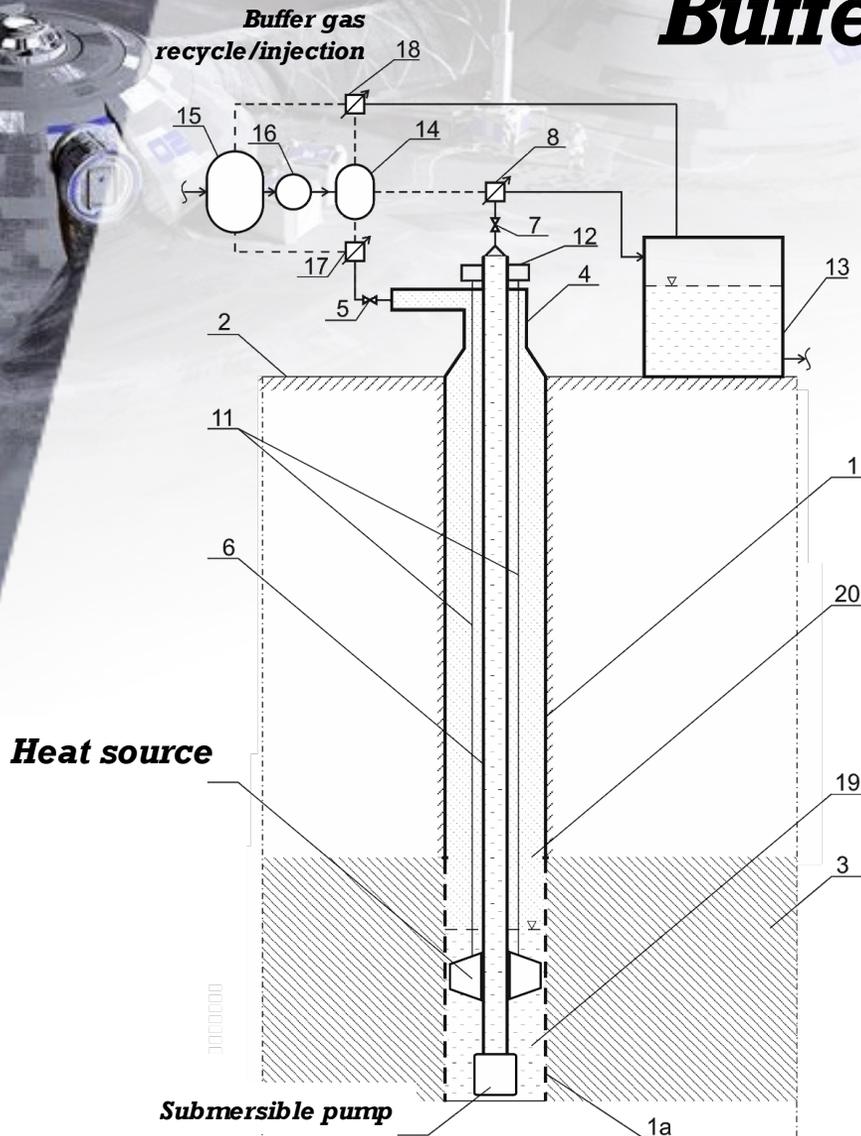


# The tyranny of icy regolith heating

1. Any method has in common:
  - Phase change(s)
  - Heat and mass transfer
2. Extraction method for a certain ice deposit has to be tailored for:
  - Ice content and geology
  - Energy and consumables constraints
3. Ice heating in a planetary environment is a slow and energy intensive process



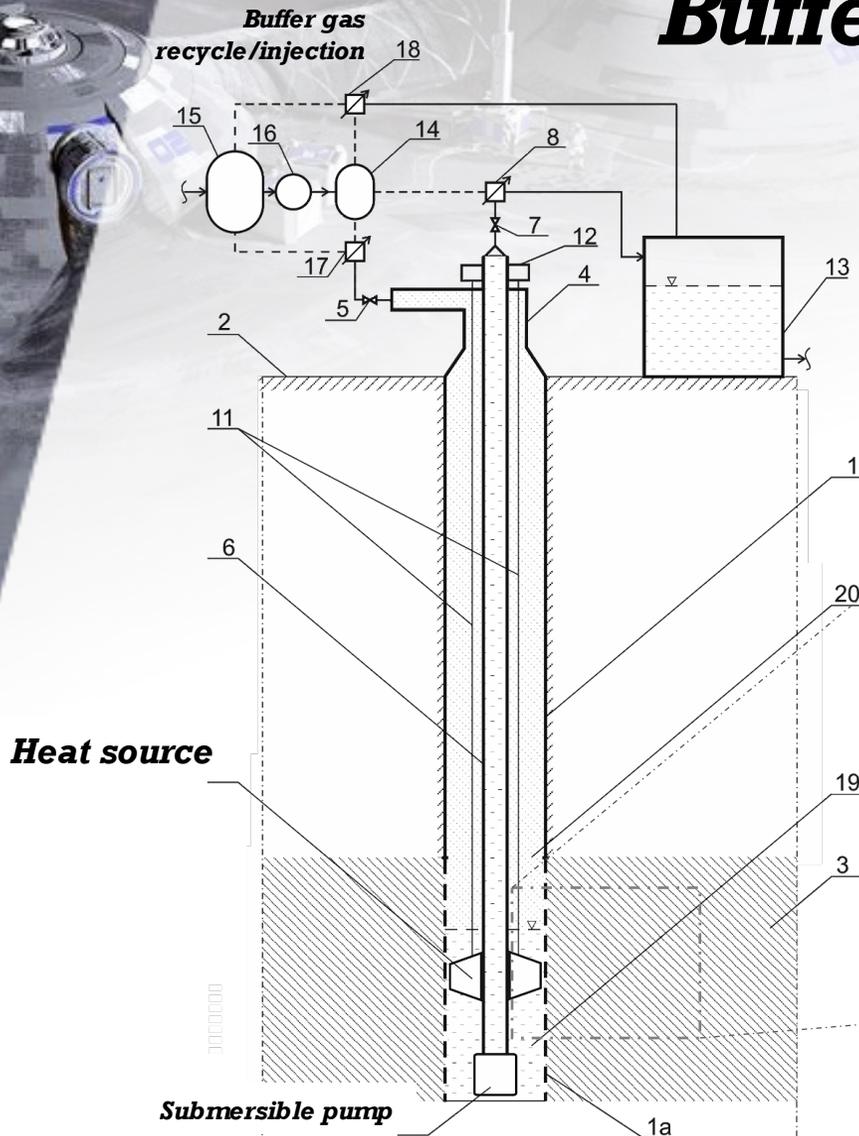
# ***Buffer gas injection and ice melting***



***We patented a method that tries to merge best advantages of low ice content sublimation and high ice content melting***

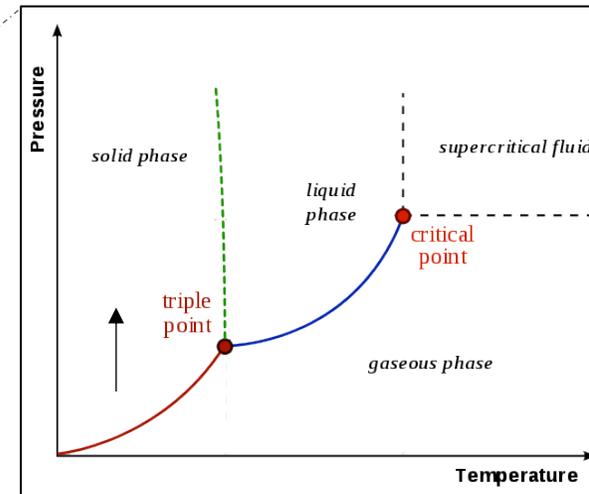


# Buffer gas injection and ice melting

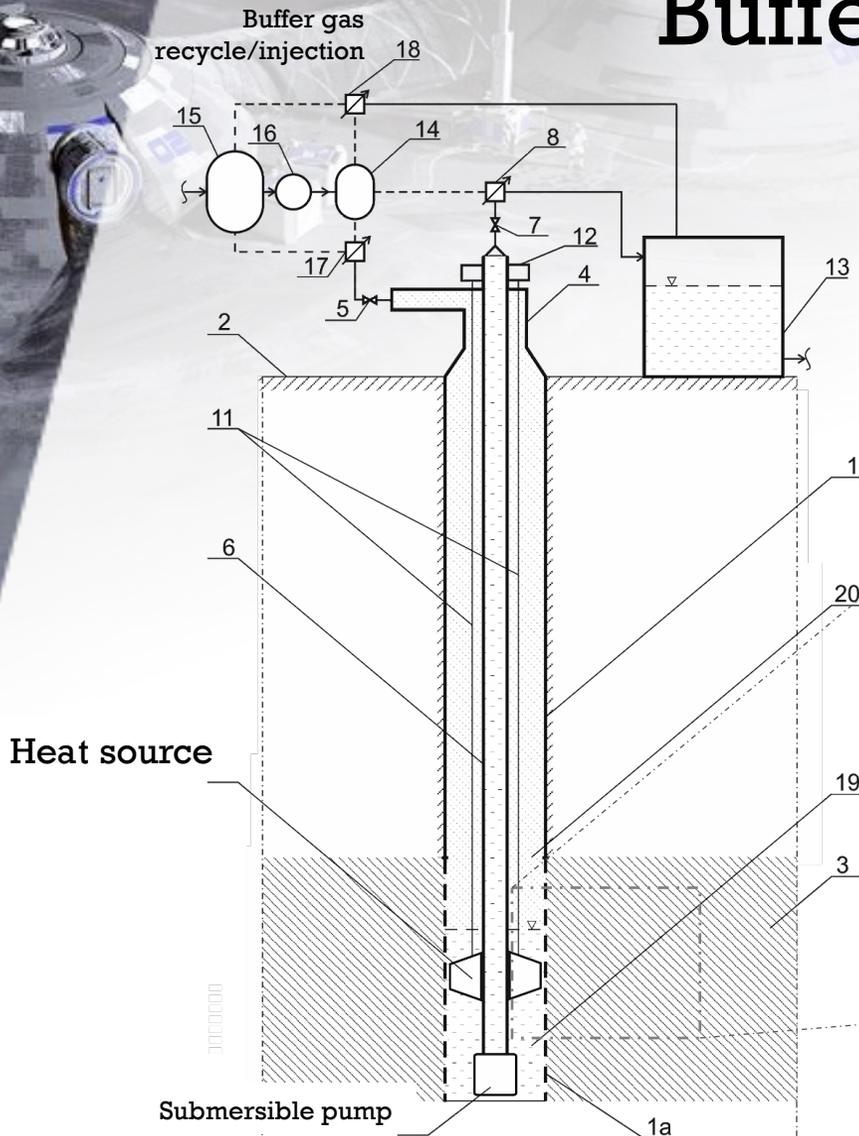


We patented a method that tries to merge best advantages of low ice content sublimation and high ice content melting:

- Pressure increase through a buffer gas ( $\text{CO}_2$ ,  $\text{O}_2$ ,  $\text{H}_2$ , water vapour etc.)

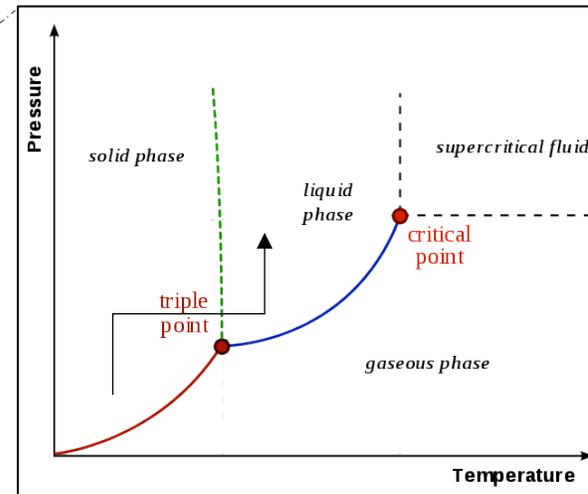


# Buffer gas injection and ice melting



We patented a method that tries to merge best advantages of low ice content sublimation and high ice content melting:

- Ice melting instead of sublimation (8.5 times lower latent heat of phase change)



$$L_f = 333.7 \frac{\text{kJ}}{\text{kg}}$$

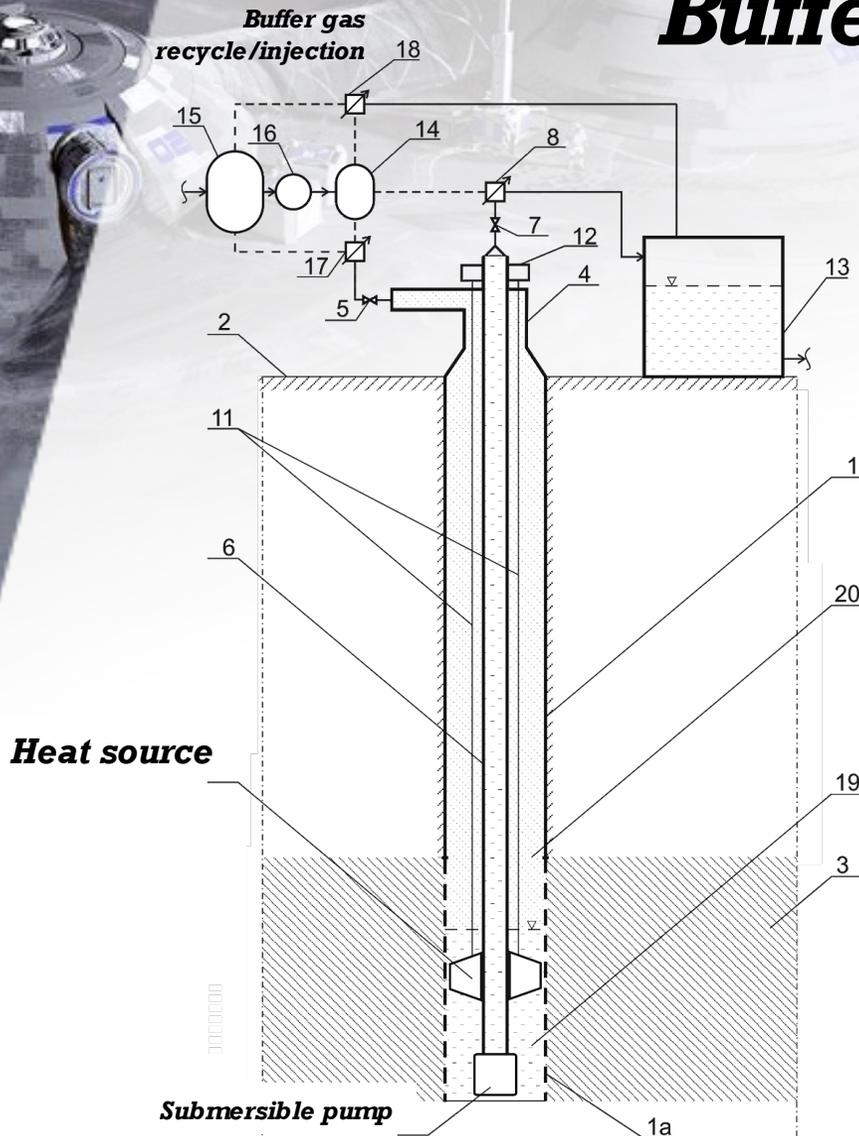
Latent heat of fusion

$$L_s = 2834 \frac{\text{kJ}}{\text{kg}}$$

Latent heat of sublimation

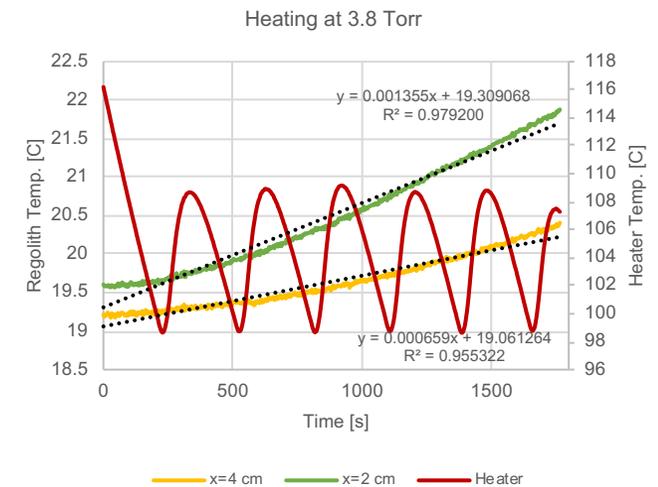
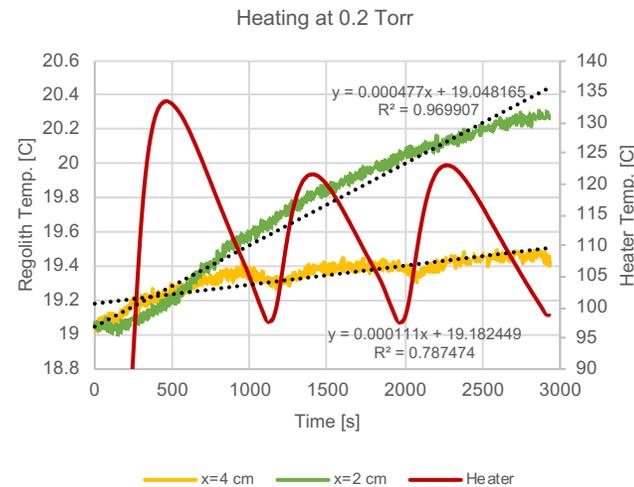


# Buffer gas injection and ice melting

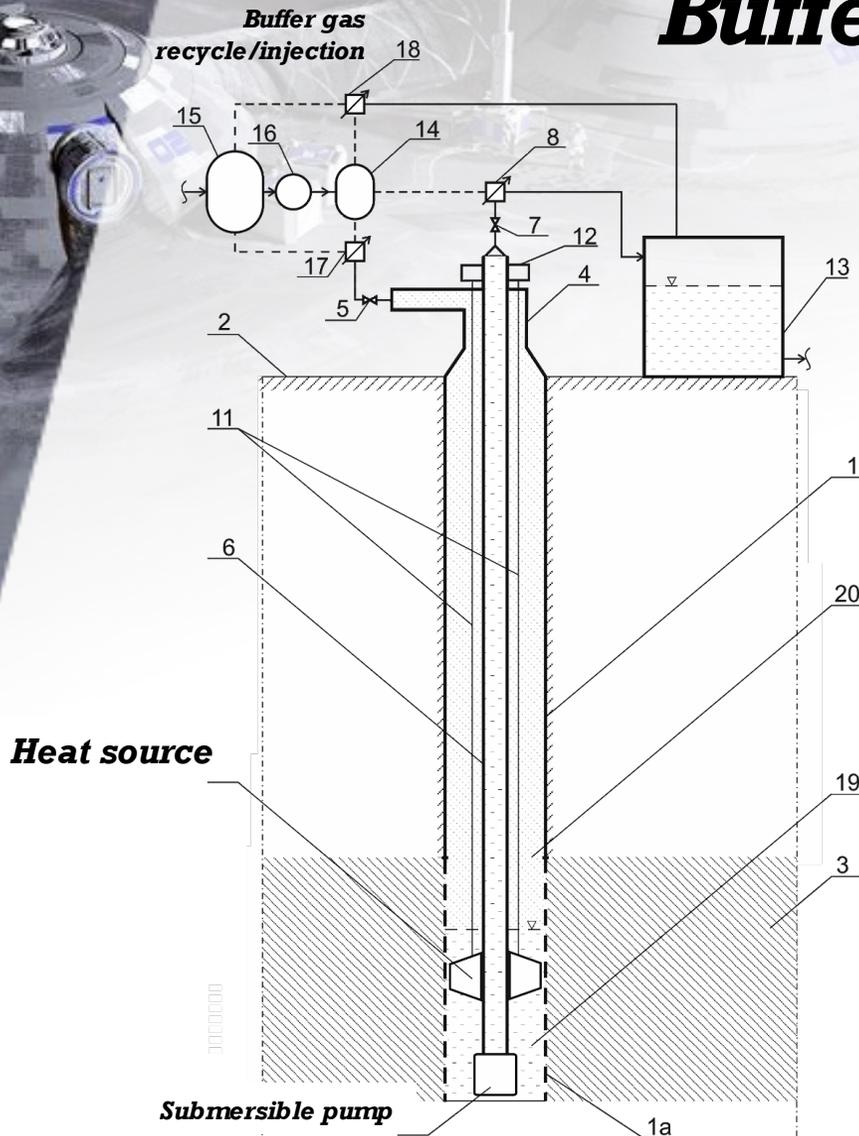


We patented a method that tries to merge best advantages of low ice content sublimation and high ice content melting:

- Heat transfer is faster due to more efficient energy transport (convection plays bigger role)



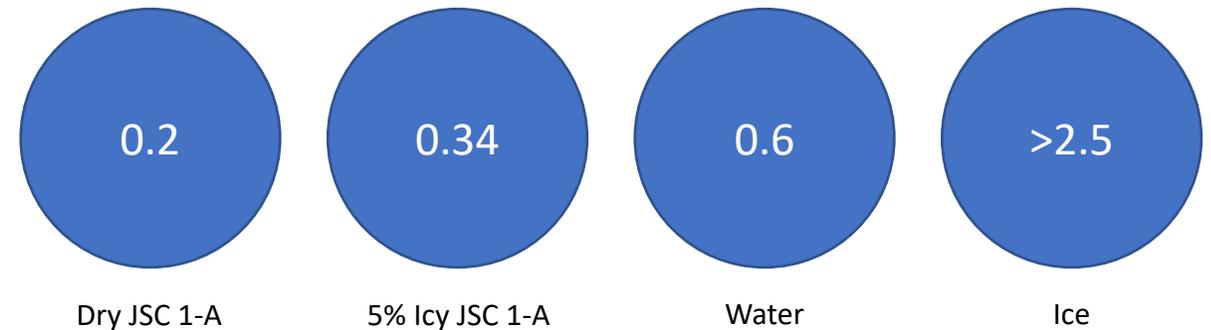
# Buffer gas injection and ice melting



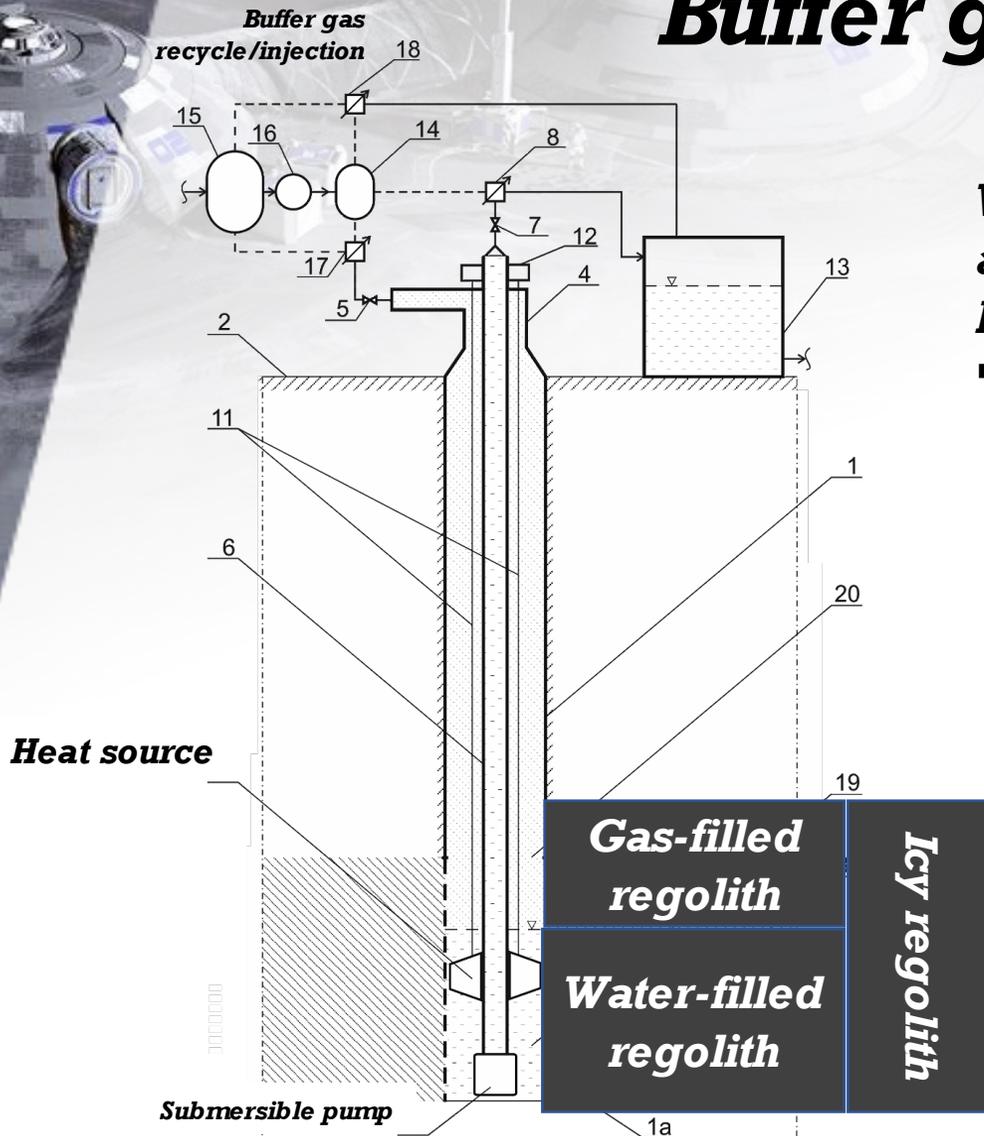
**We patented a method that tries to merge best advantages of low ice content sublimation and high ice content melting:**

- **Melted water in pores conducts heat, empty pores are bad thermal conductors**

**Thermal conductivity [k, W/(mK)]:**

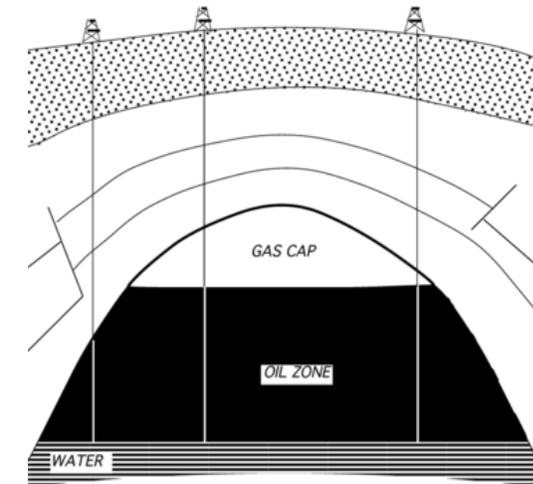


# Buffer gas injection and ice melting



**We patented a method that tries to merge best advantages of low ice content sublimation and high ice content melting:**

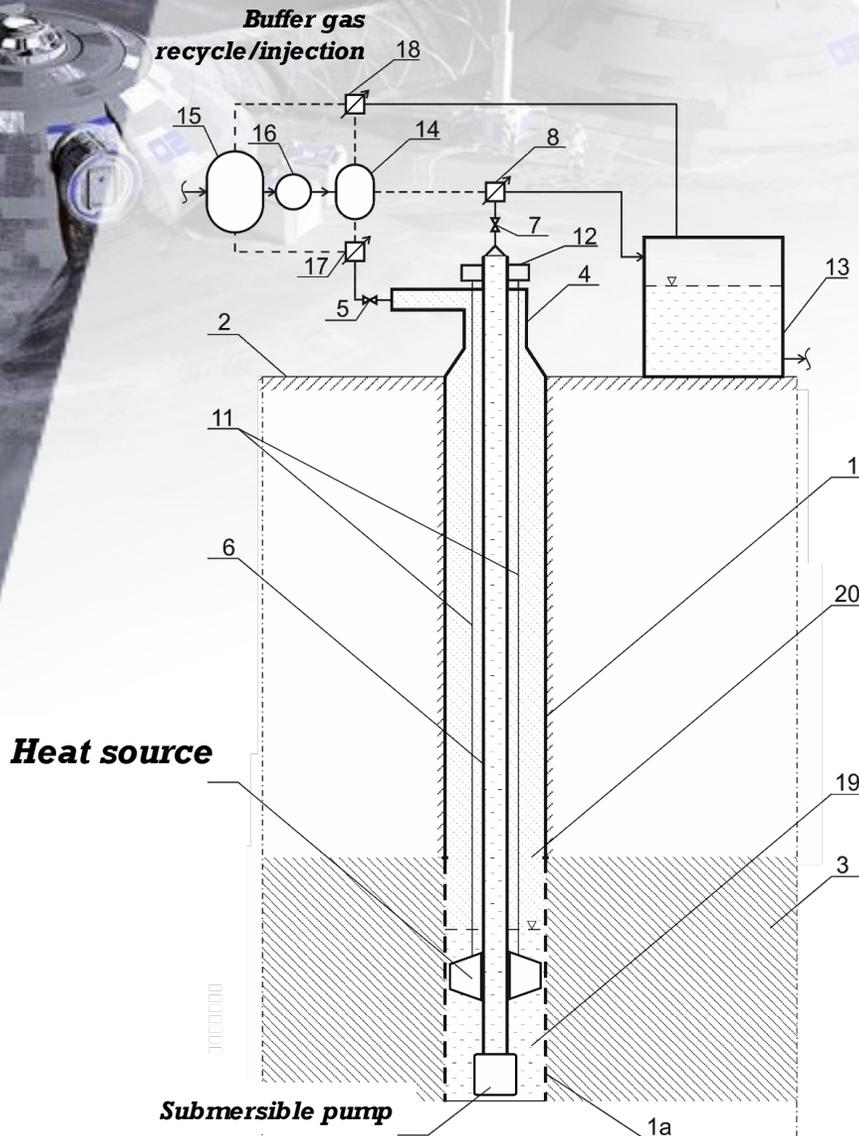
- **Buffer gas-liquid water may act like a gas cap in oil reservoir**



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# Primary Requirements



## 1. Impermeable layer

- **Low permeability regolith/rock, or**
- **Ice saturated deposit, or**
- **Ex situ heating**

## 2. Access to a buffer gas

- **Martian atmospheric CO<sub>2</sub>**
- **Excess oxygen from reduction/electrolysis**
- **Excess mission consumable gas**



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**NAVA**