

Laboratory Studies of Clathrate Hydrates with Relevance to Icy Solar System Bodies

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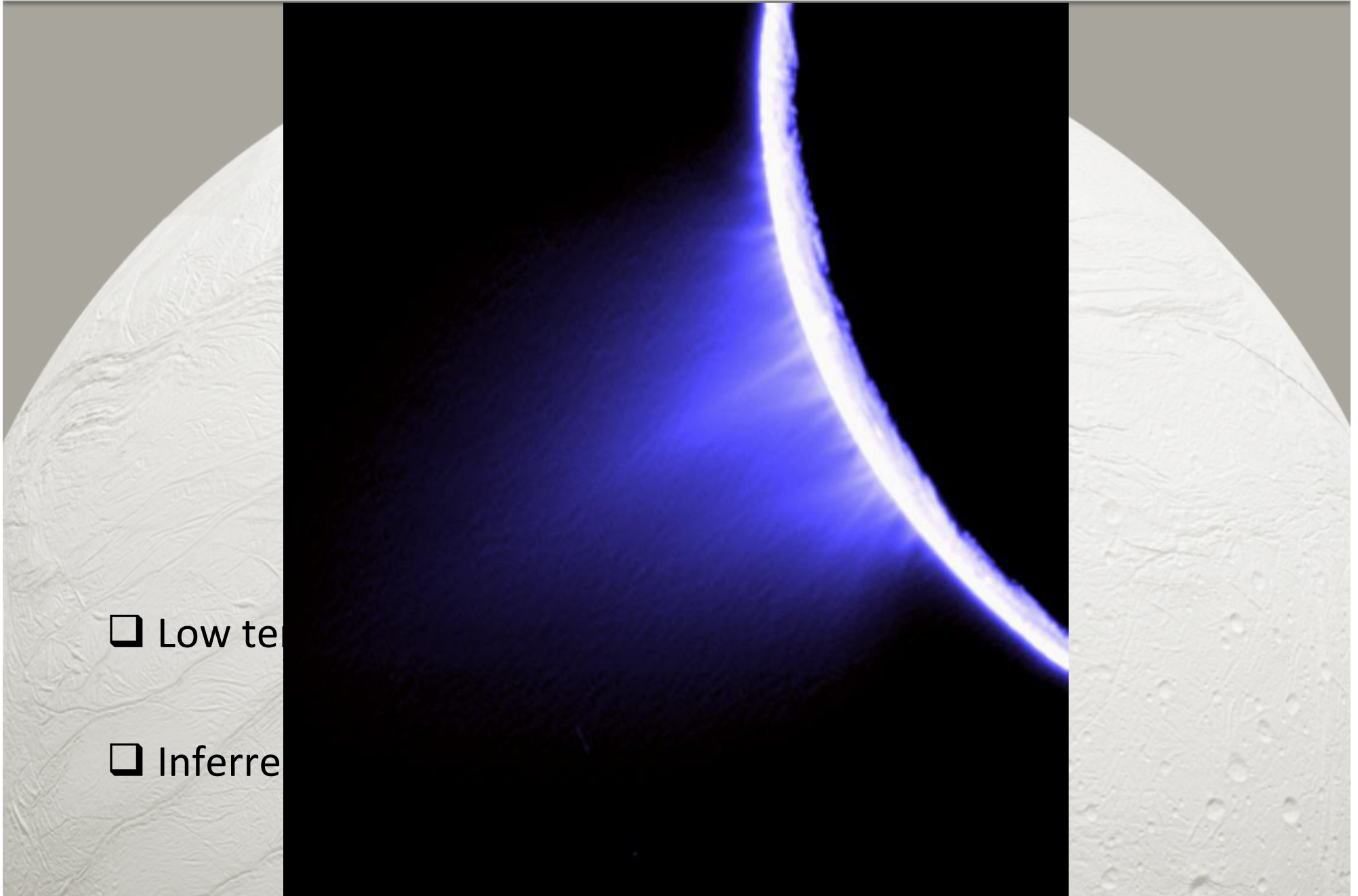
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Presentation Outline

- Clathrate hydrates in the Solar System
- Laboratory work on Clathrates
- Results
- Summary
- Conclusion

Clathrate Hydrates in the Solar System



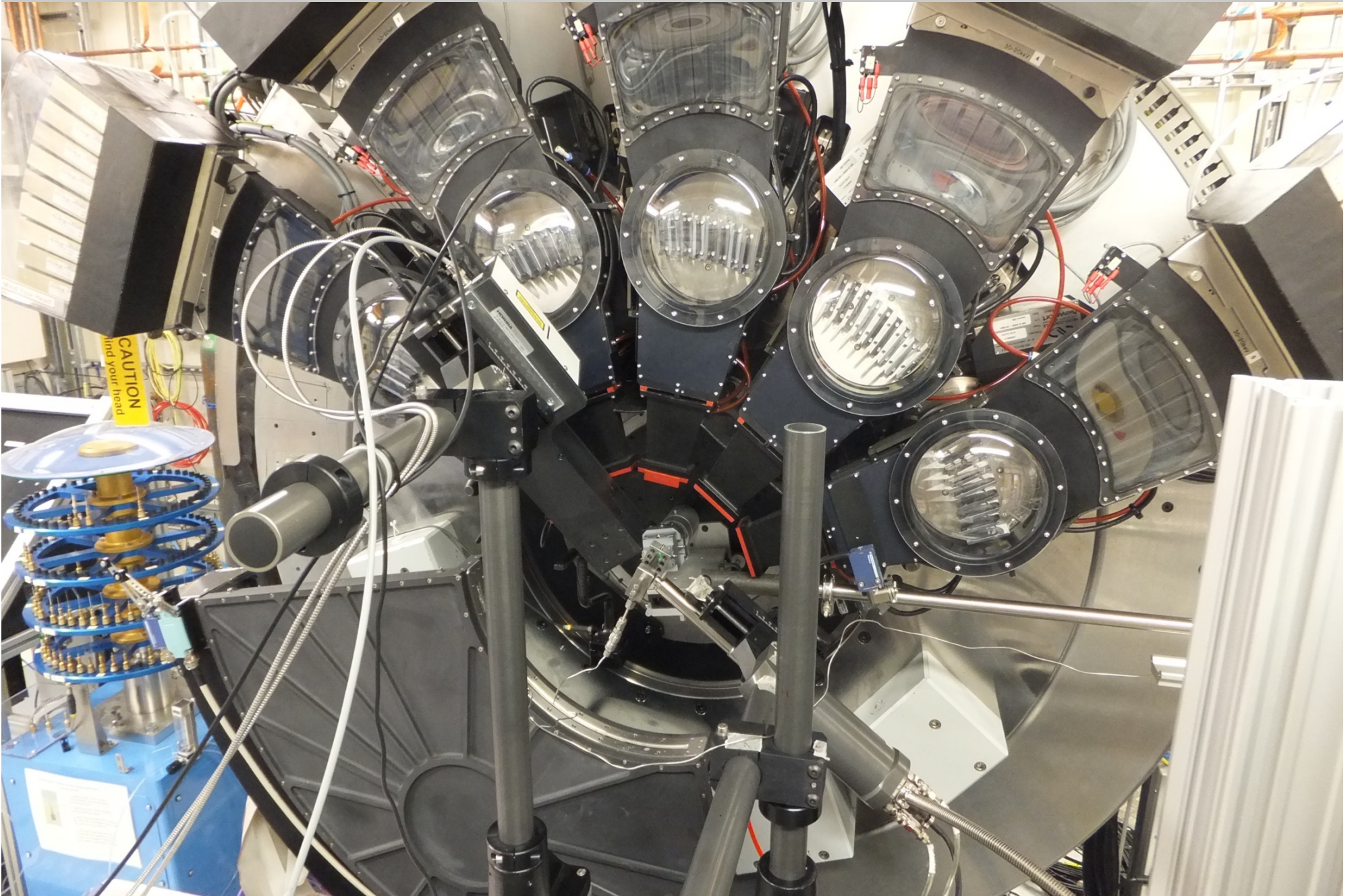
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Inferred

Laboratory work on Clathrates



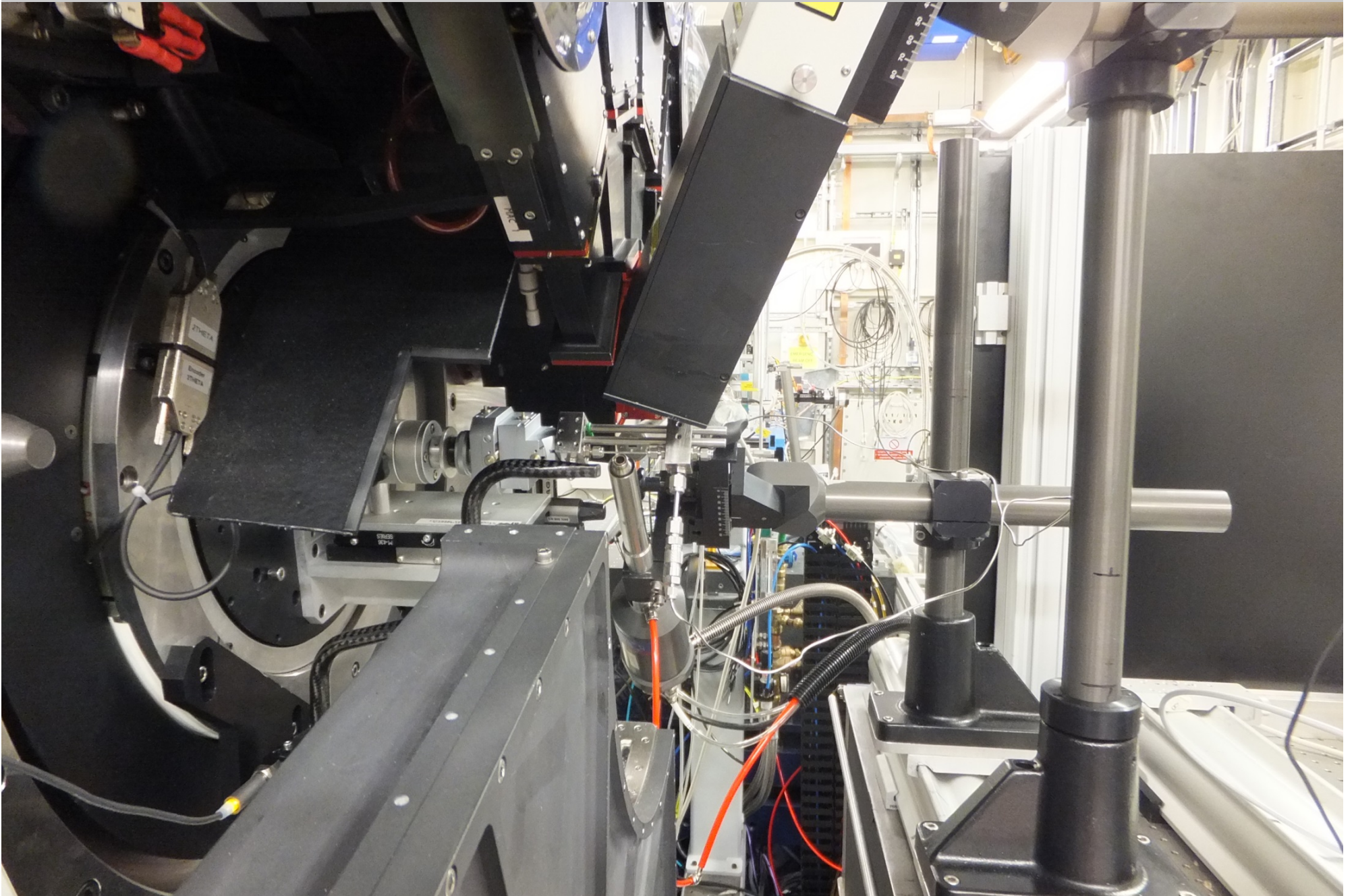
Laboratory work on Clathrates



Laboratory work on Clathrates



Laboratory work on Clathrates



Results

- Thermal expansion
- Density
- Composition
- Comparison to Arrhenius curve

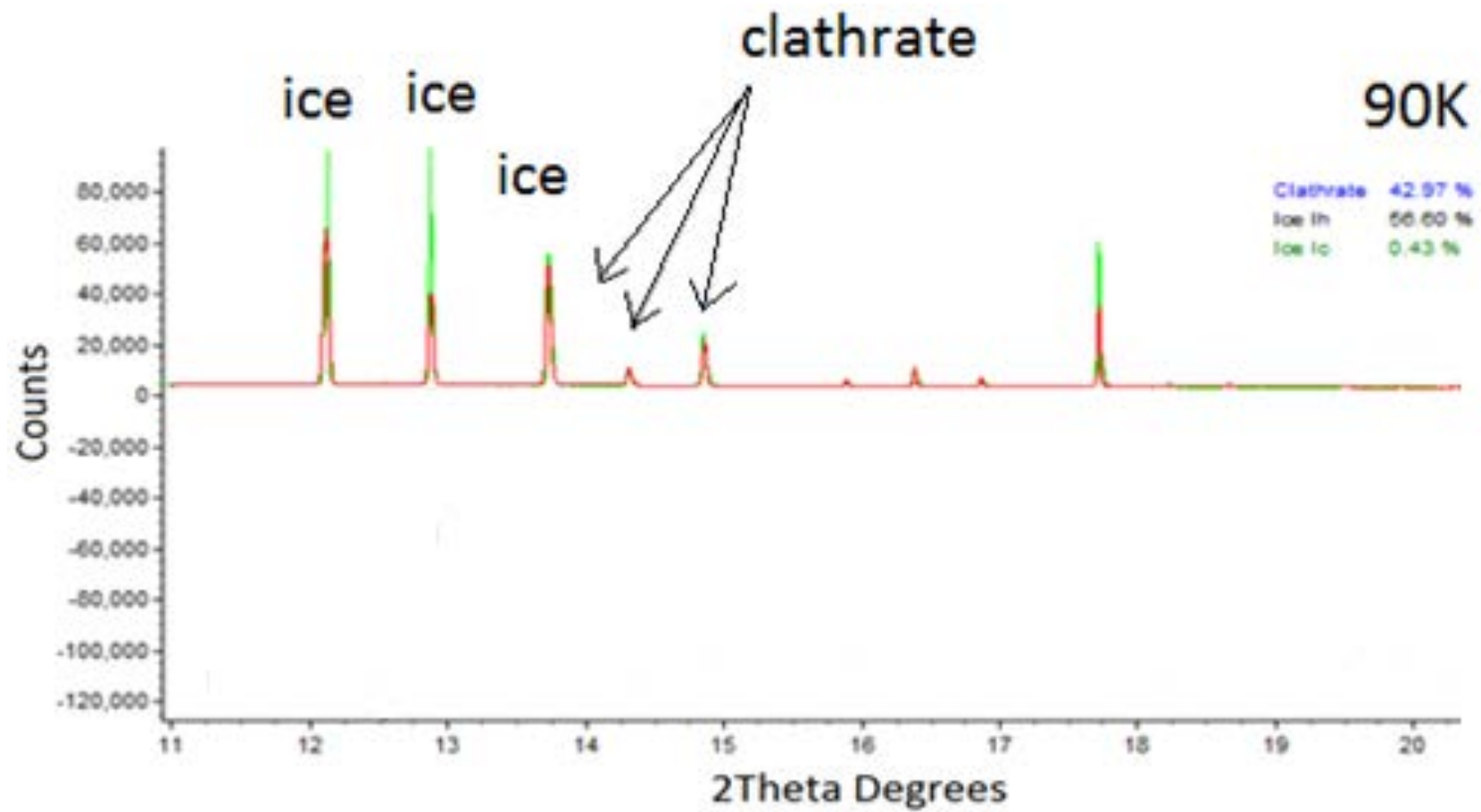


Fig 1. Diffraction pattern of sample at 90K

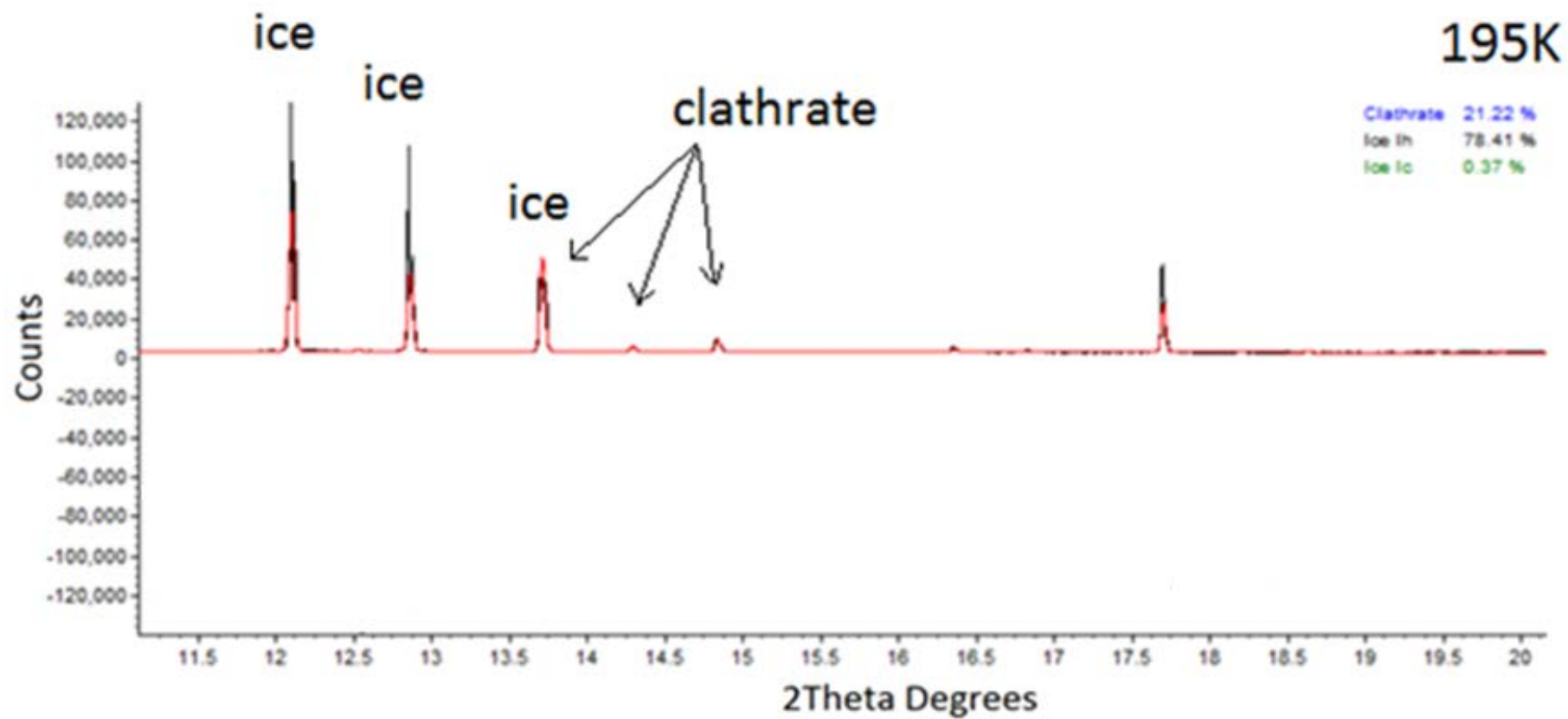


Fig 2. Diffraction pattern of sample at 195K

240K

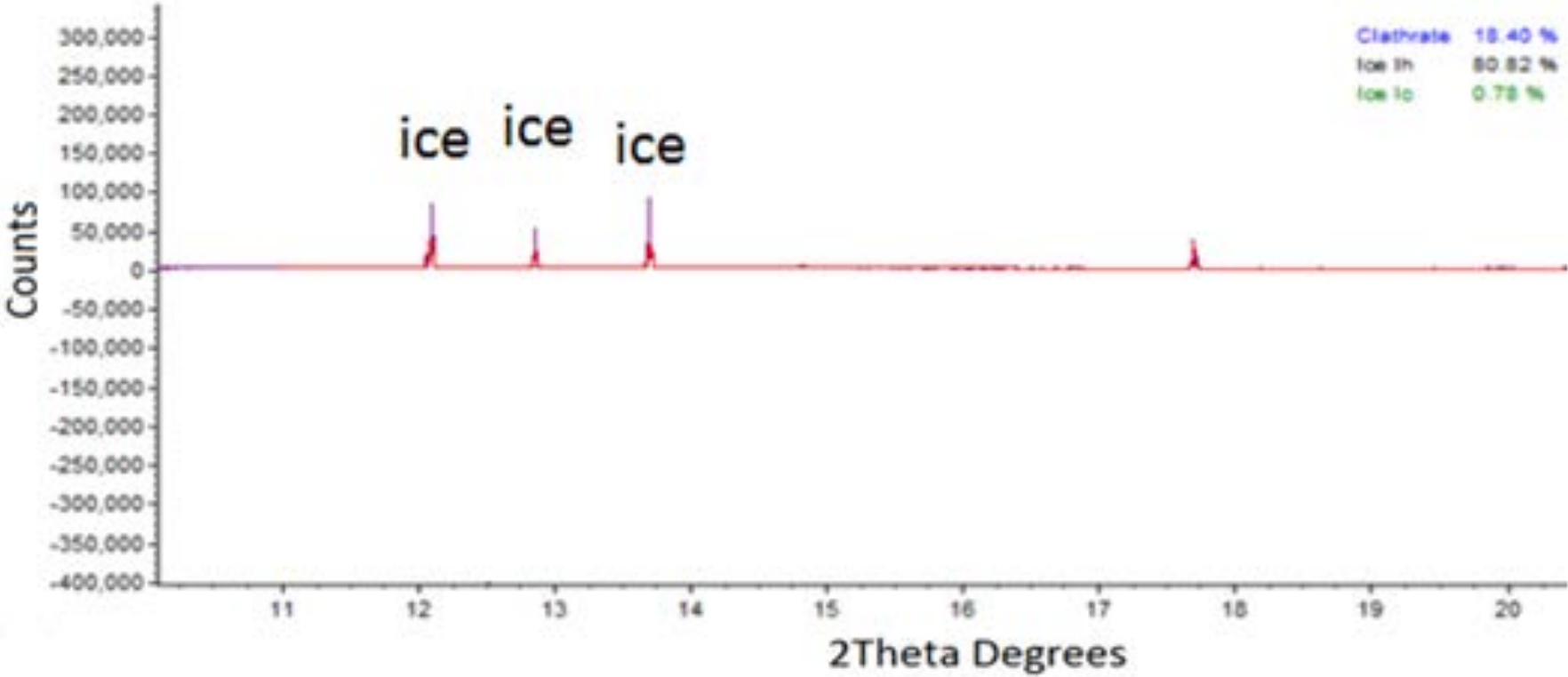


Fig 3. Diffraction pattern of sample at 240K

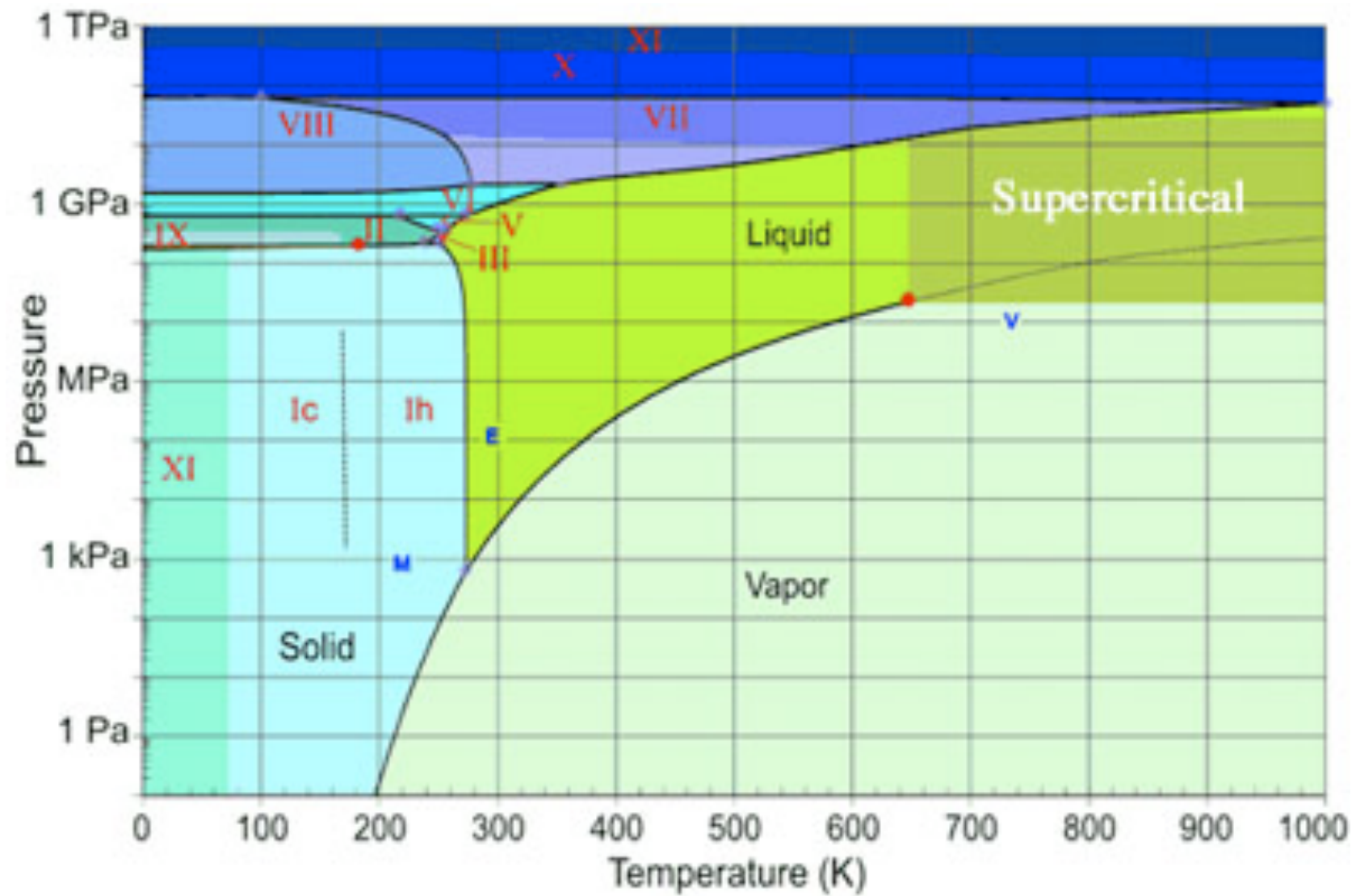


Fig 4. Phase diagram of ice, (Greenside, 2011)

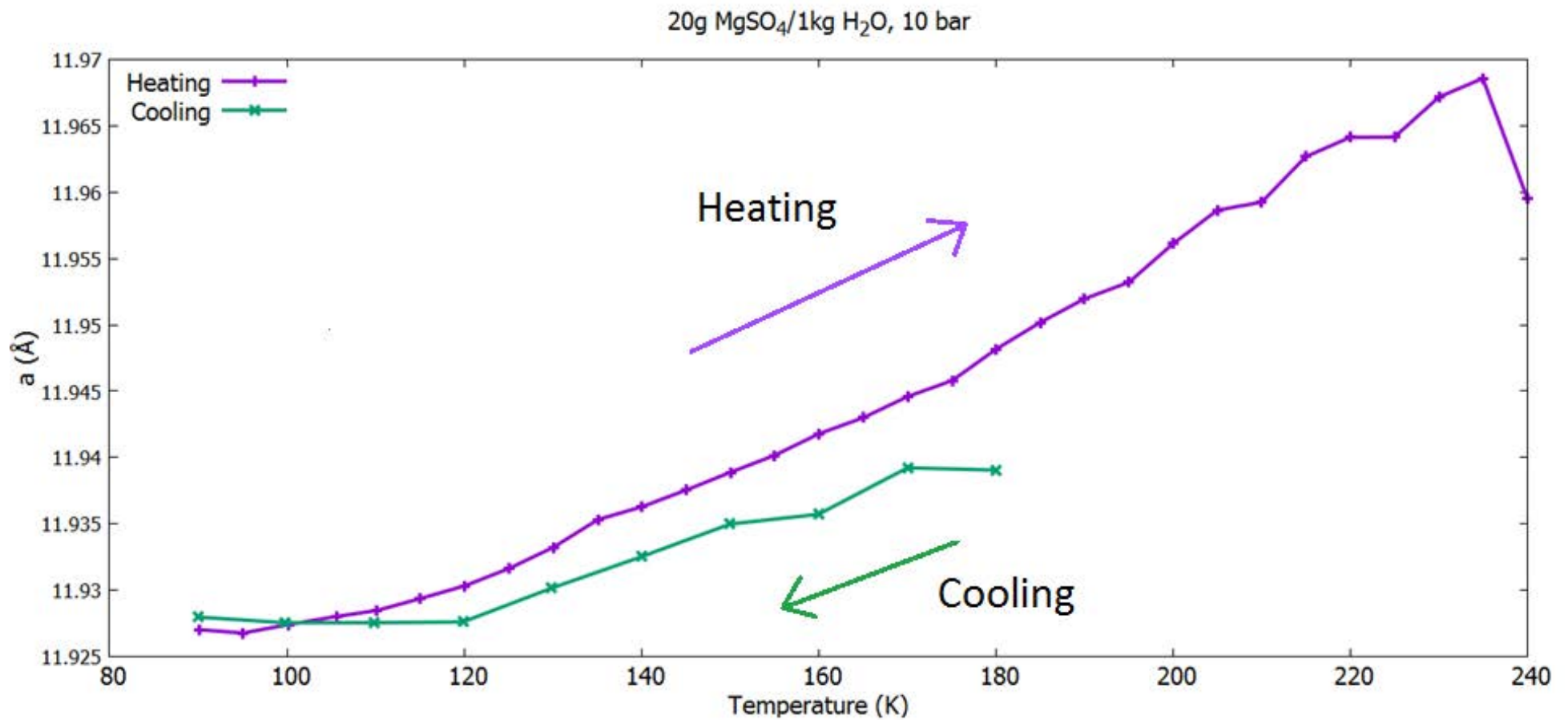


Fig 5. Thermal expansion curve for the sample at 10 bar

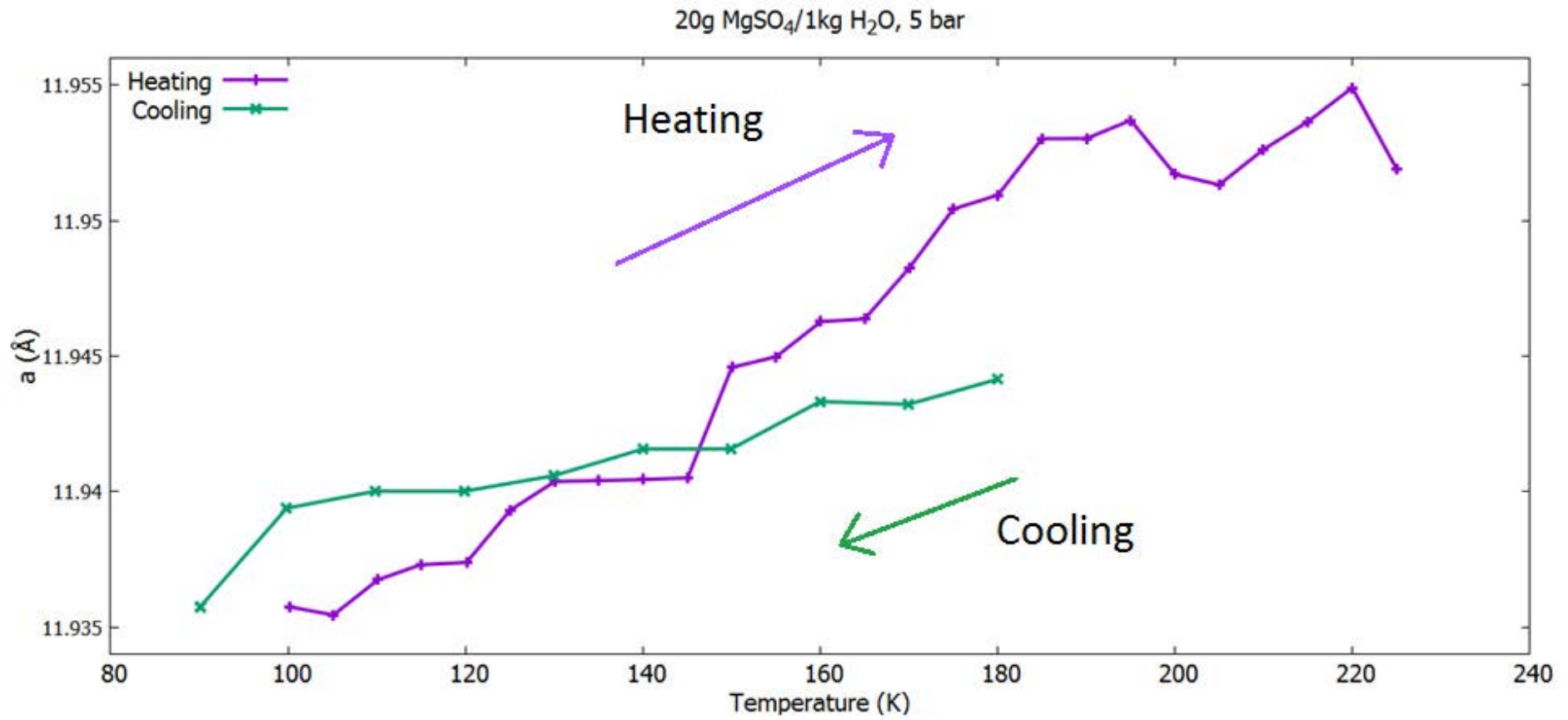


Fig 6. Thermal expansion curve for the sample at 5 bar

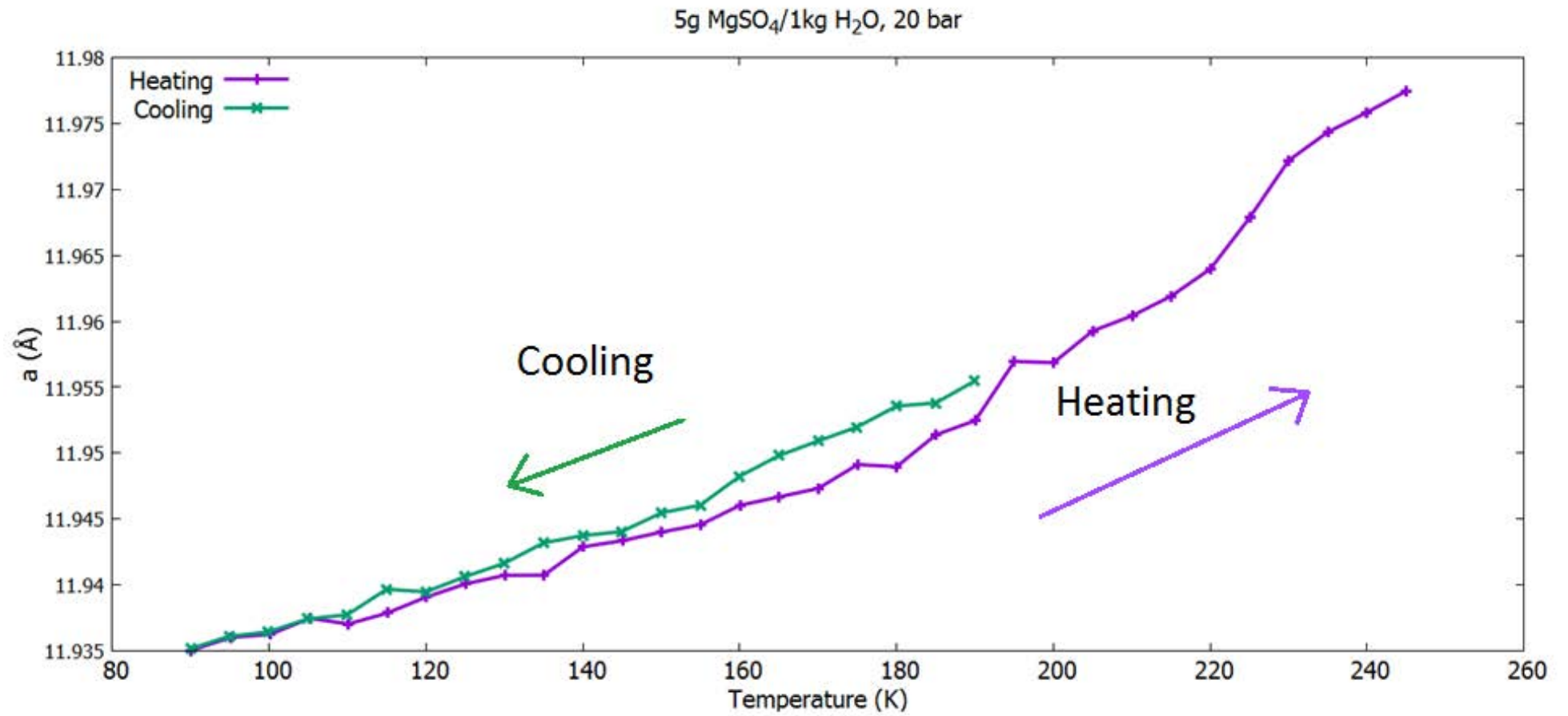


Fig 7. Thermal expansion curve for the sample at 20 bar

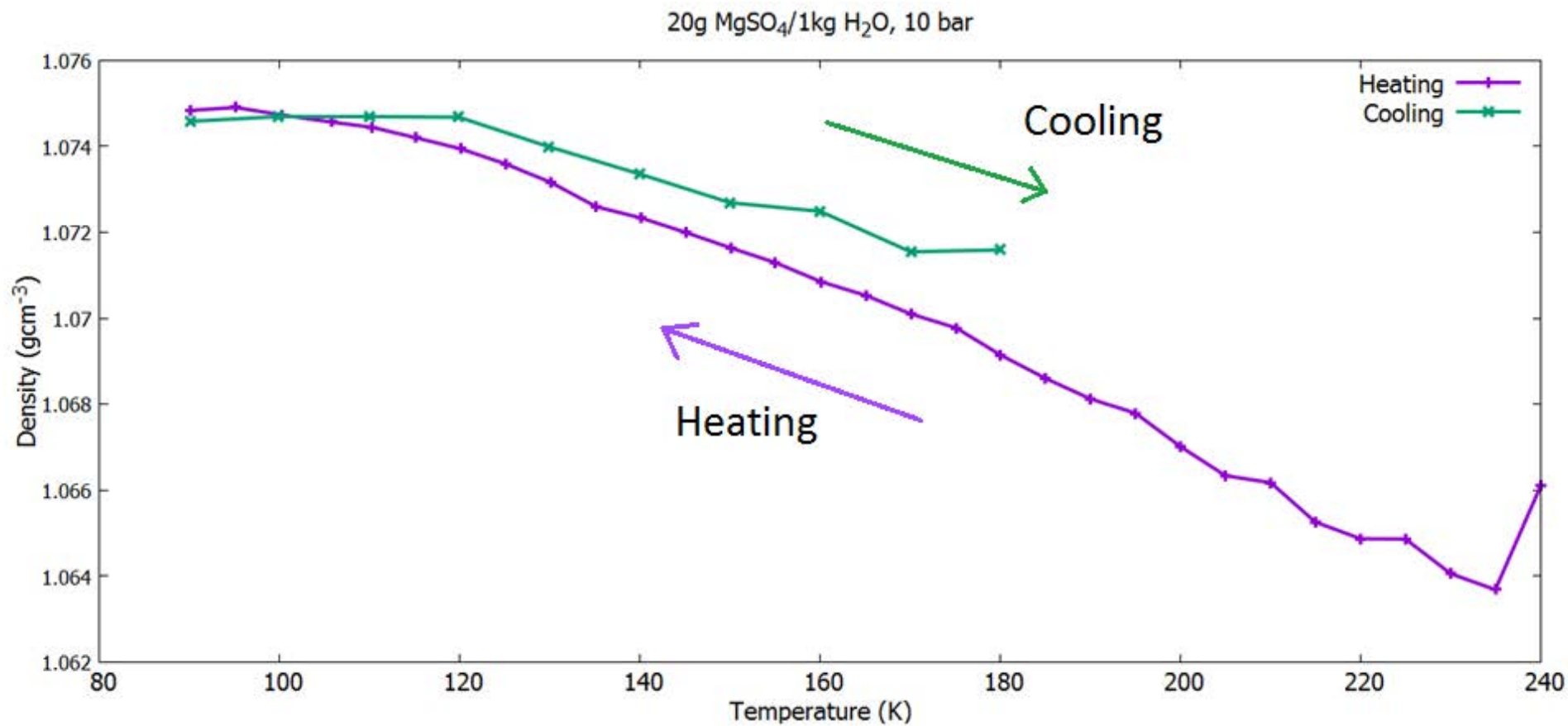


Fig 8. Density curve for the sample at 10 bar

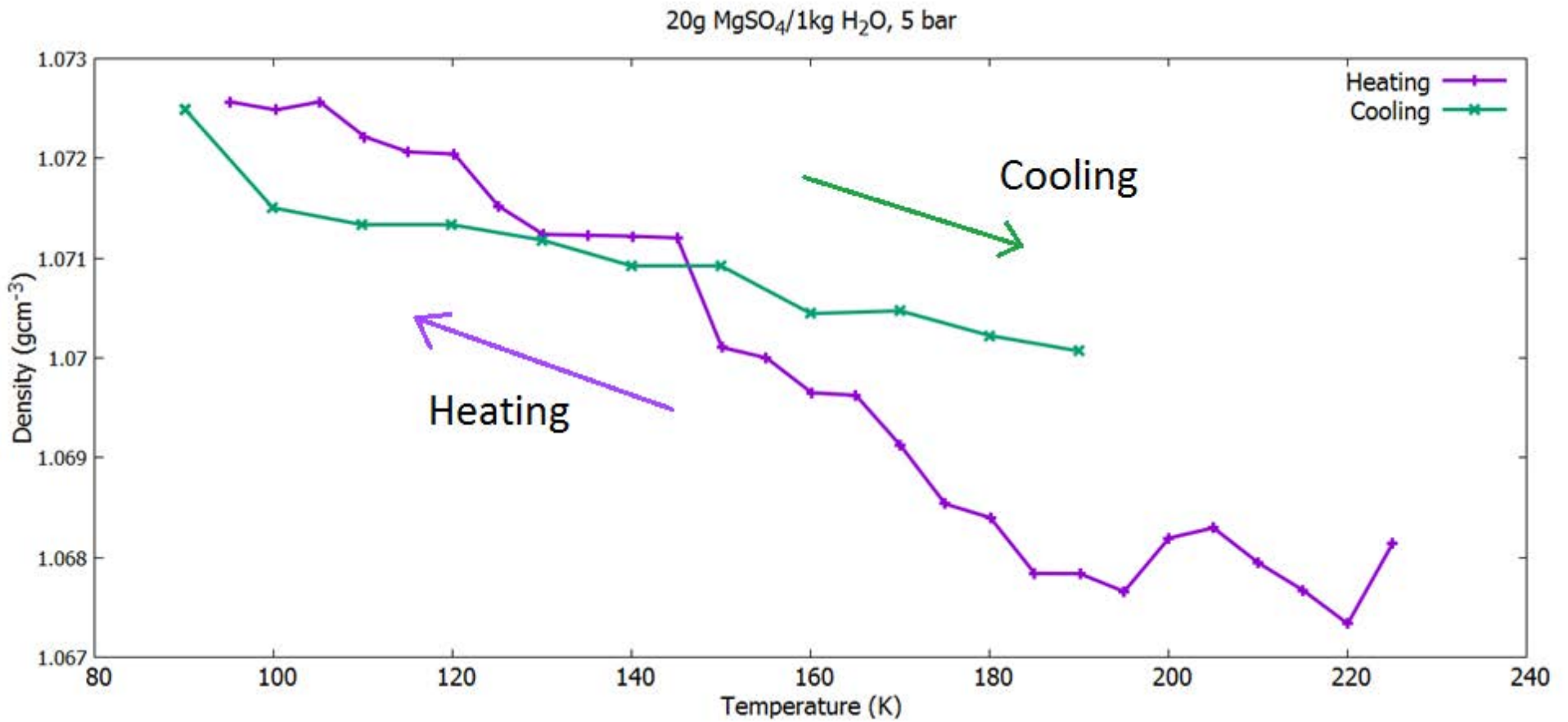


Fig 9. Density curve for the sample at 5 bar

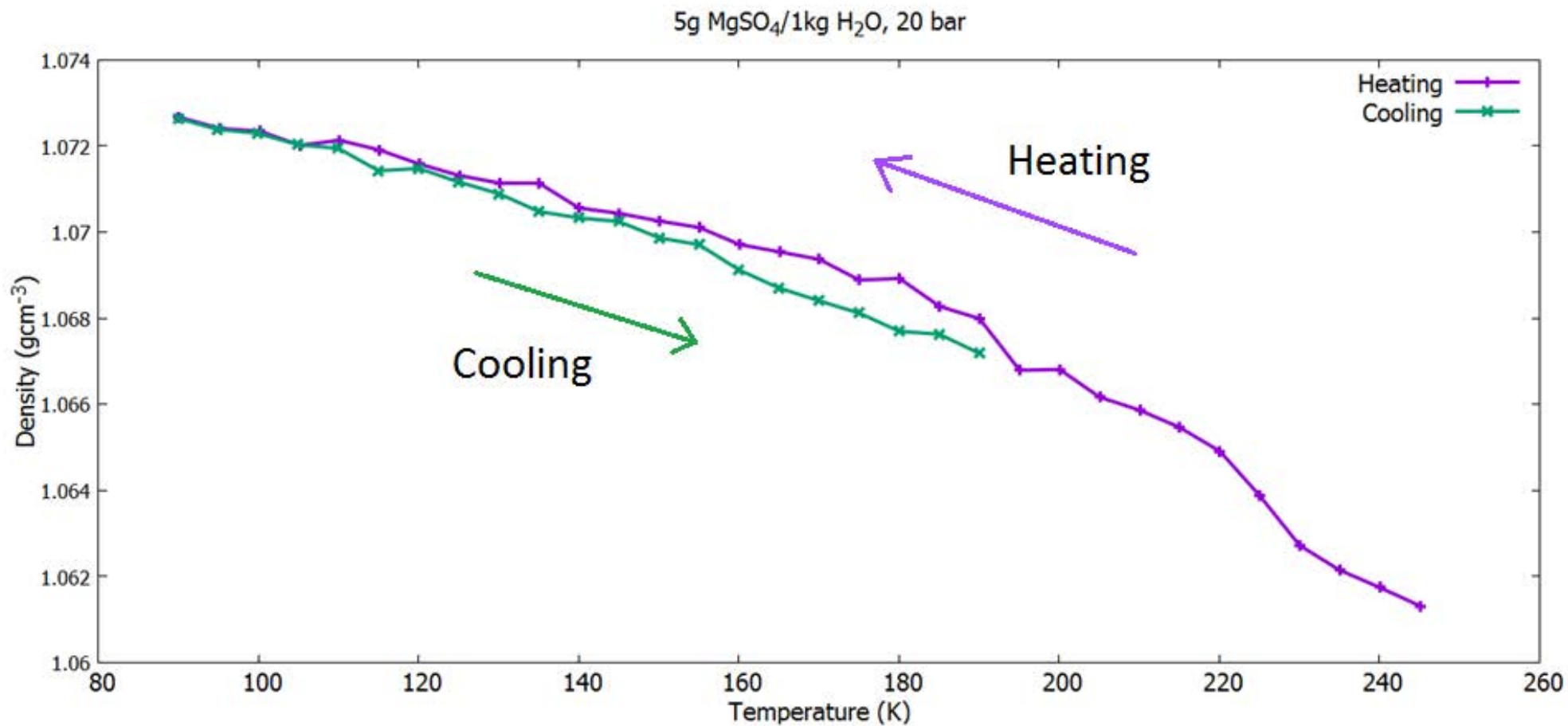


Fig 10. Density curve for the sample at 20 bar

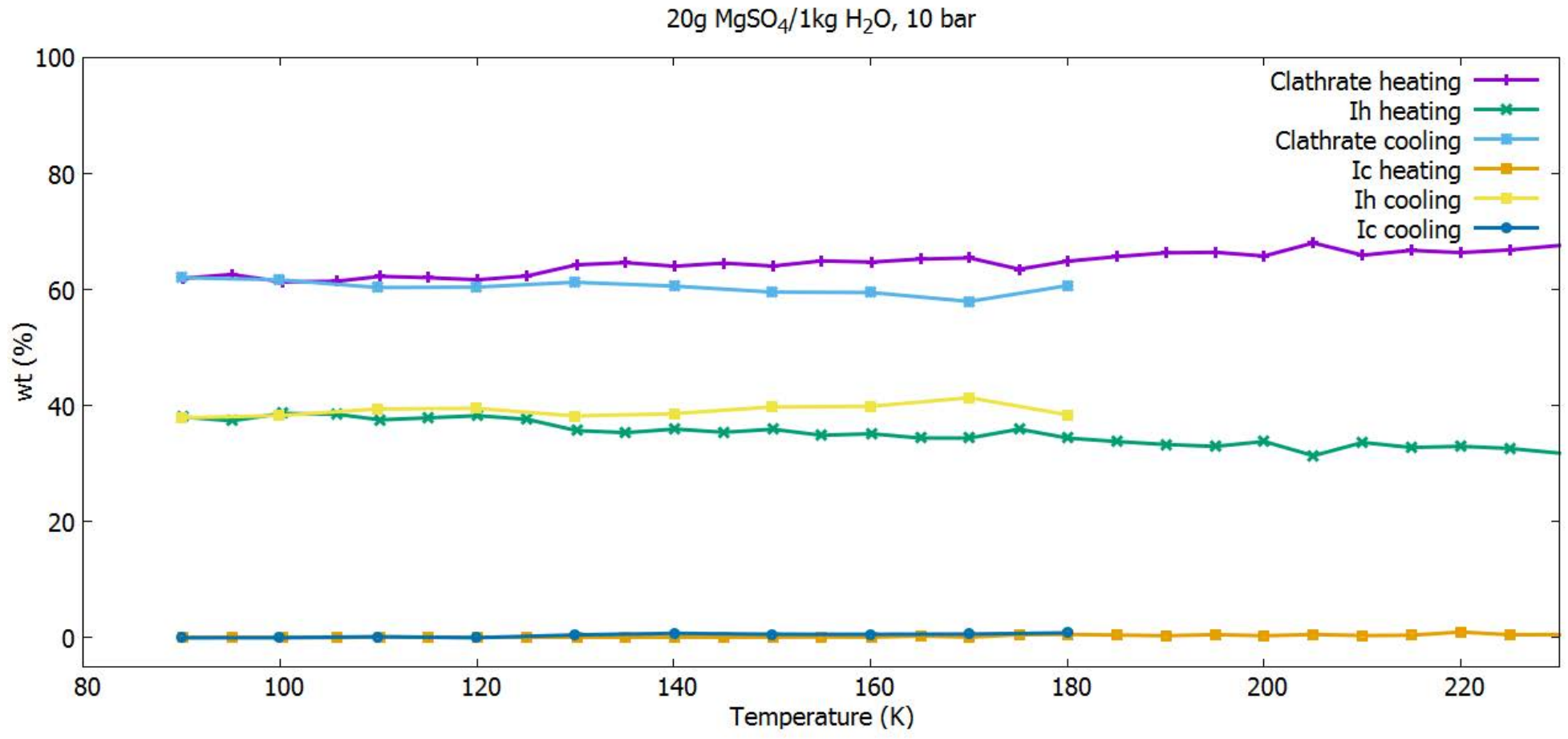


Fig 11. Composition of the sample at 10 bar

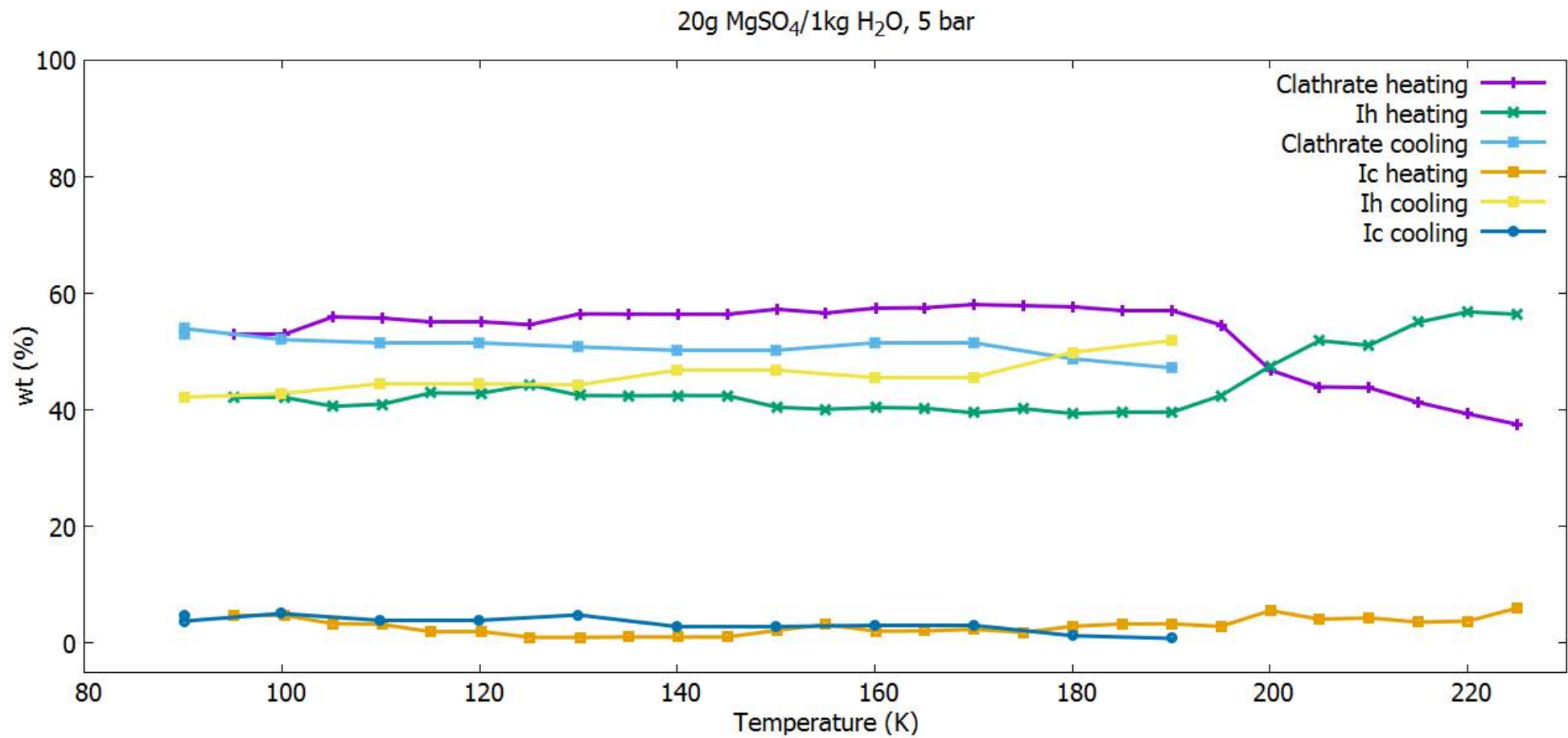


Fig 12. Composition of the sample at 5 bar

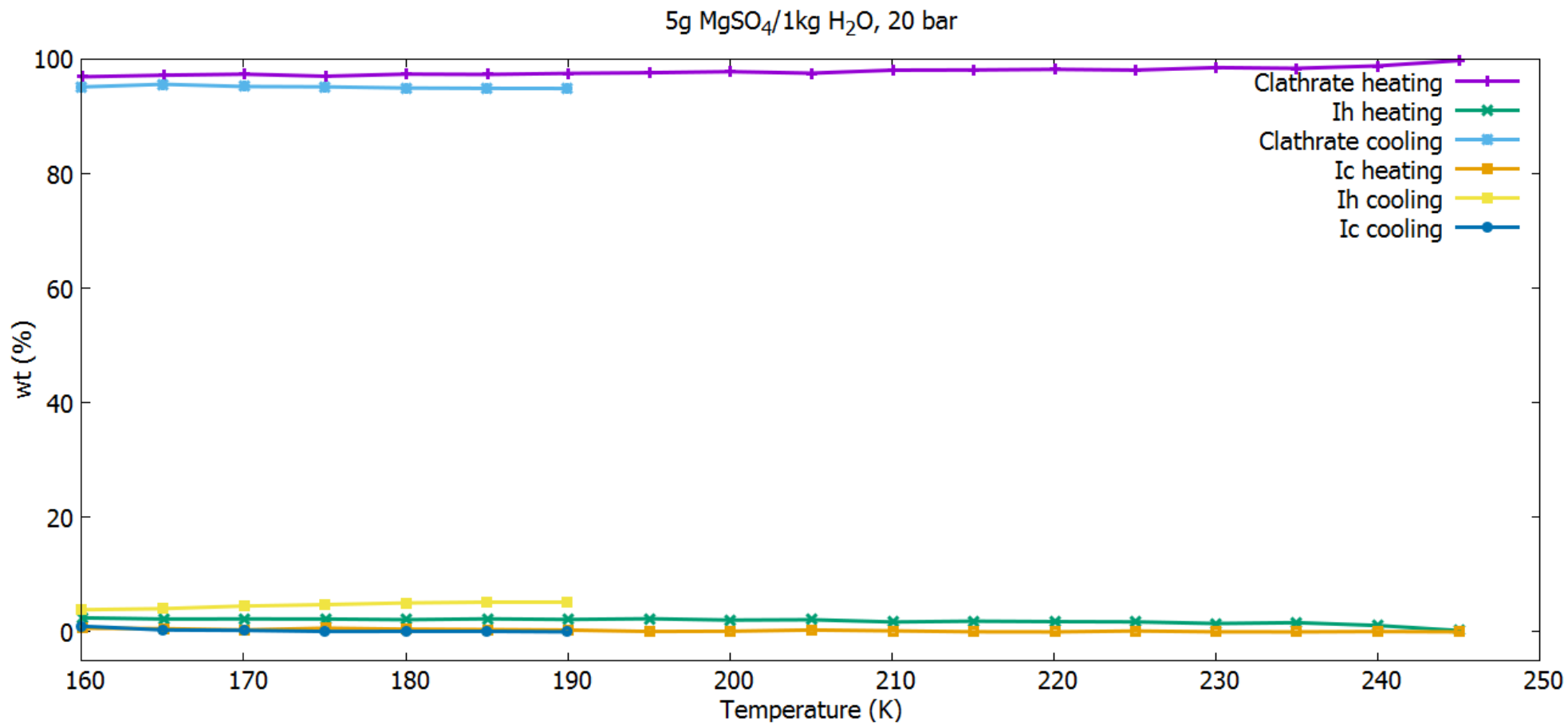


Fig 13. Composition of the sample at 20 bar

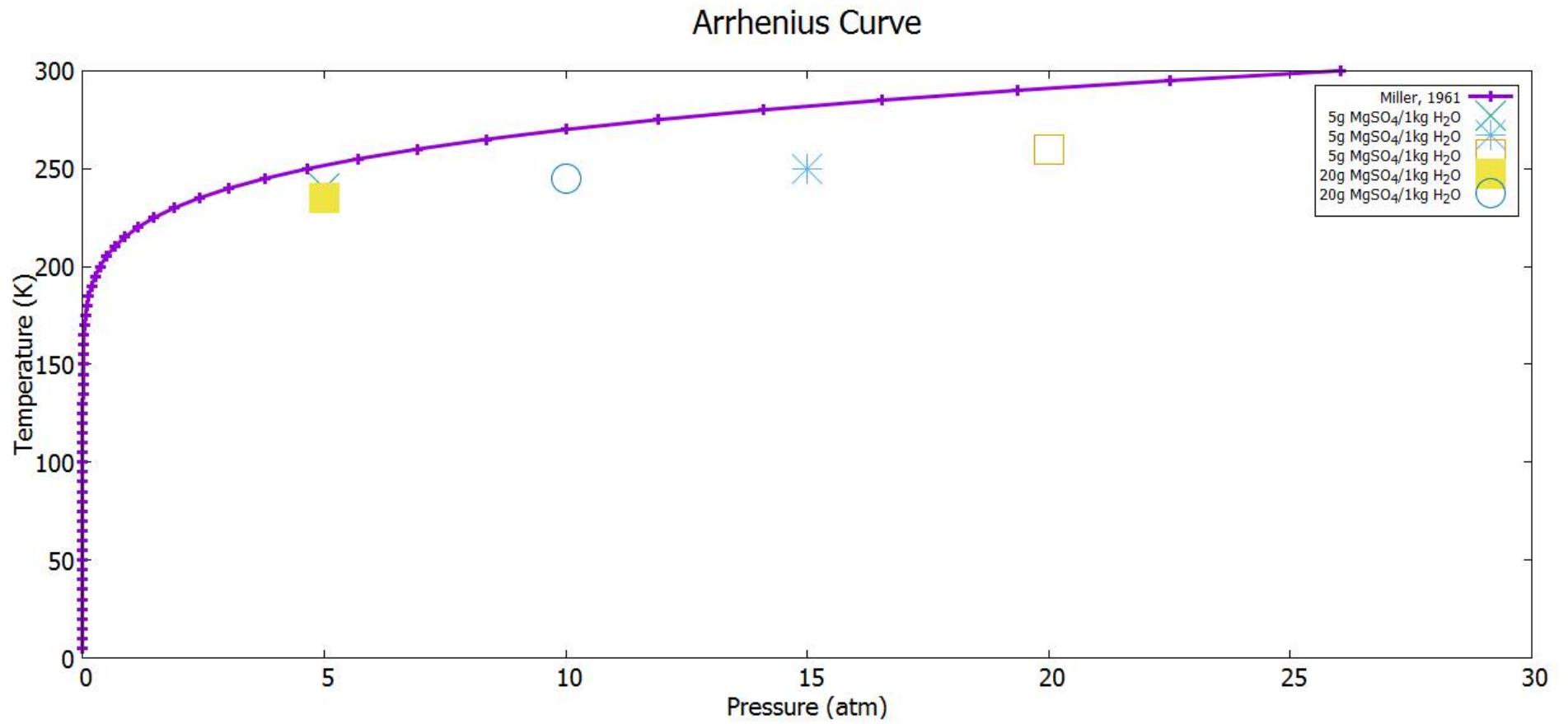


Fig 14. Arrhenius curve for CO₂ clathrate hydrate, (Miller, 1961)

Summary

☐ Hysteresis

- Is seen in thermal expansion and density curves
- Could be due to pressure conditions.
- In MS7 solutions hydrogen bonding could be contributing to the hysteresis.

☐ Polymorphs of ice

- Cubic ice is the most common polymorph of ice at low temperatures.
- Little cubic ice observed even at 90K.

Conclusion

❑ Contribution

- Experimental data on clathrate hydrates in astrophysical conditions.
- Salinity does have an effect on clathrate dissociation.

❑ Future work

- Investigate the behaviour of other clathrates under similar conditions.
- Further investigation of cubic ice.

Acknowledgments

- Nye Evans, Stephen Thompson
- Sarah Day, Claire Murray, Annabelle Baker,
Jacco van Loon, Joana Oliveira

