

Climate-Friendly Cement for Oil and Gas Wellbore Integrity: Formulation and Performance Test of Geopolymer Binder with Carbon Dioxide-Assisted Curing

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Introduction

The most commonly used binder for wellbore cementation

Ordinary Portland Cement (Class G and H)

Shrinkage, Strength retrogression, CO₂ emission, High energy demand

Partial replacement of OPC with aluminosilicates materials (SCM)

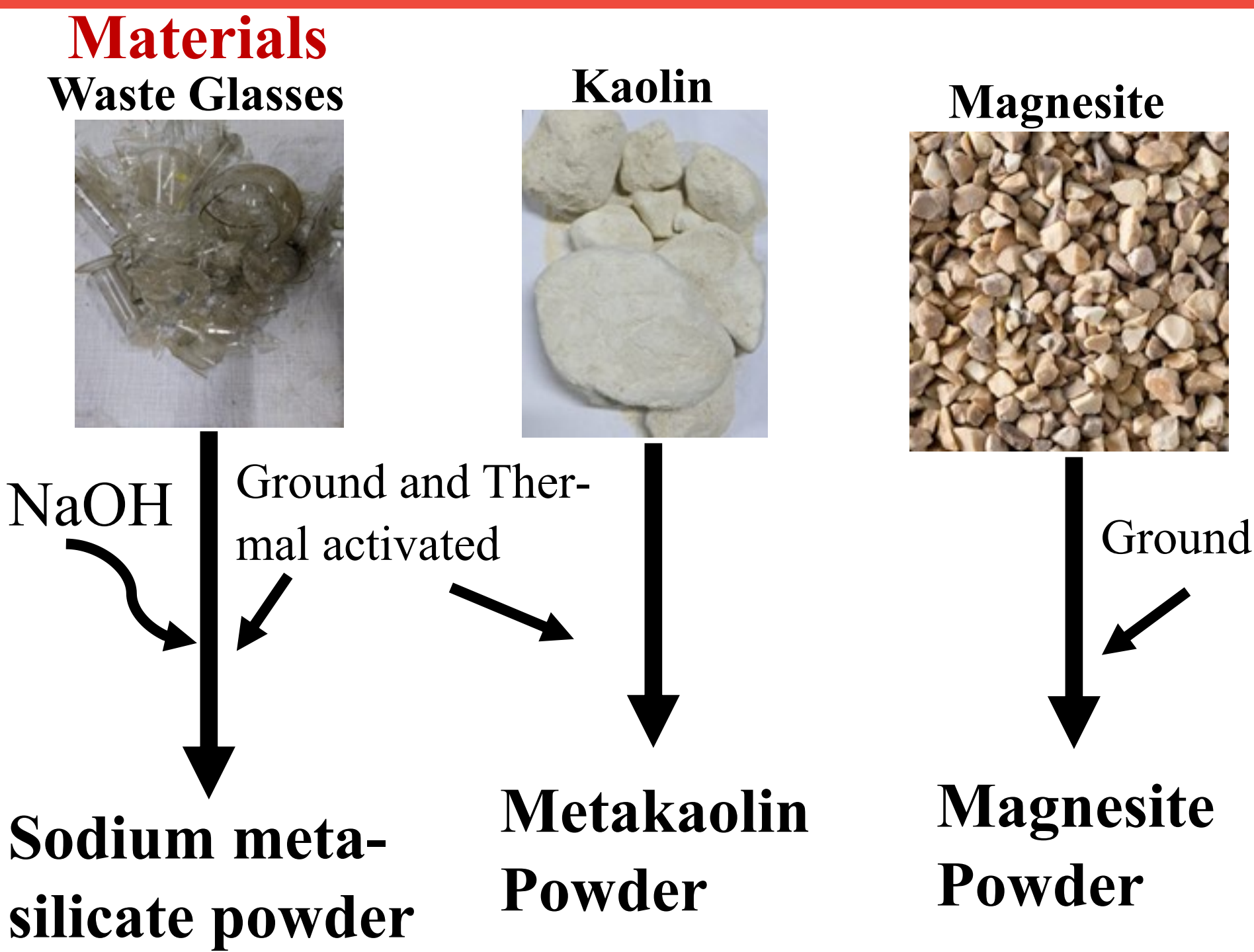
Loss of mechanical strength at early days

Full-scale implementation in oil and gas wellbore cementing is less reported

Geopolymer binders

Environmental friendly, lower energy requirement and higher durability

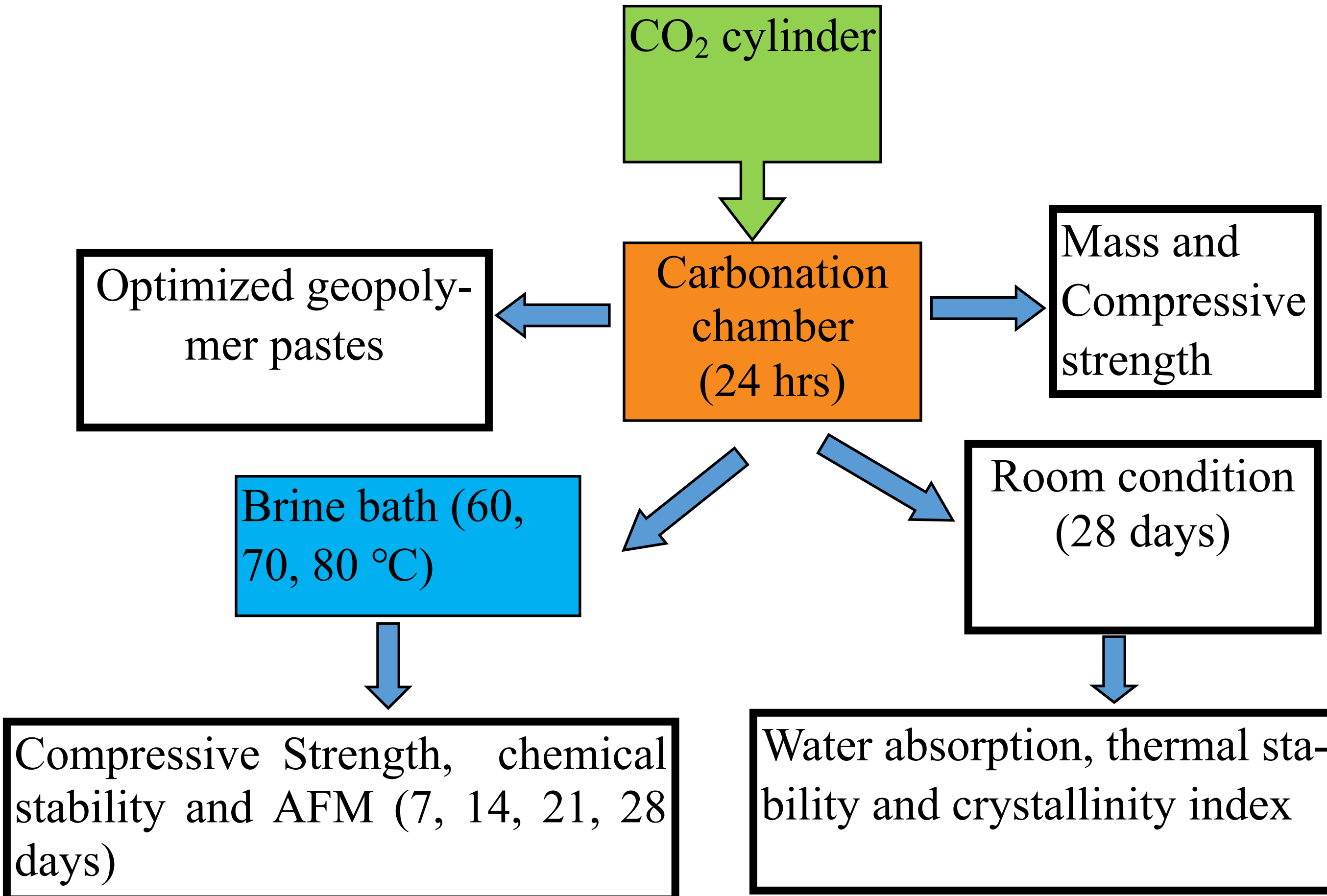
Methodology



Formulation of Geopolymer Binder

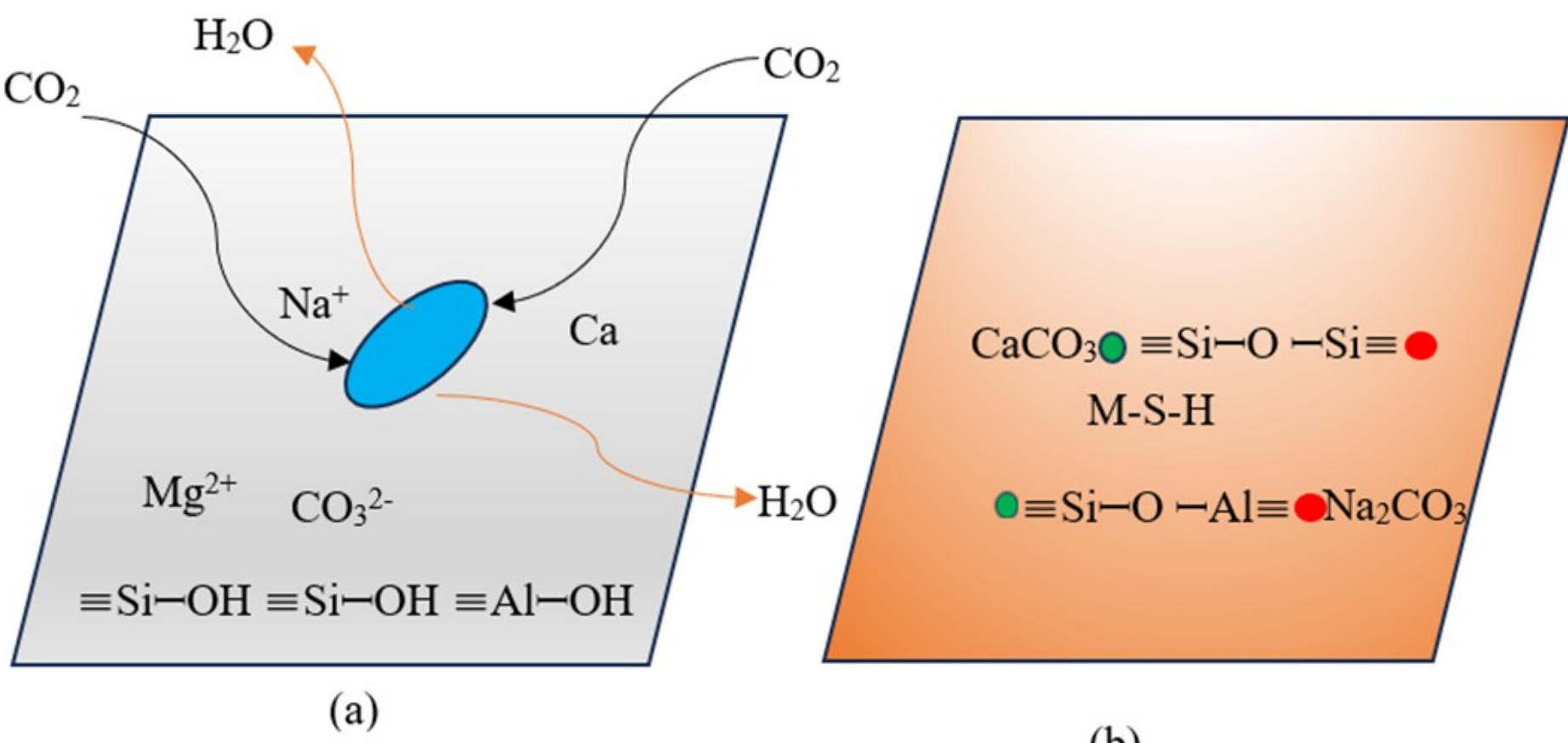
1. Optimization of Sodium Metasilicate
2. Optimization of Magnesite and metakaolin

Performance of Geopolymer Binder



Results

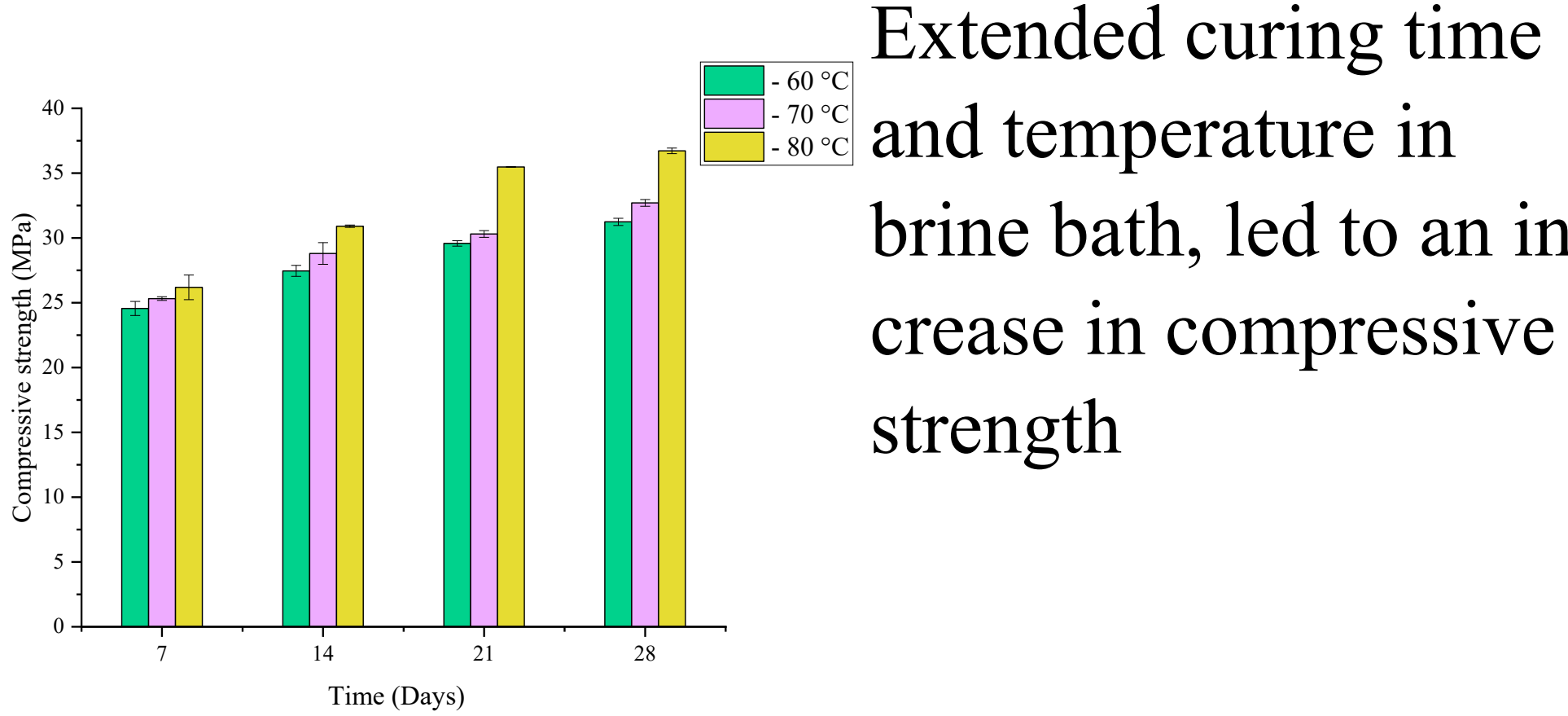
Effects of carbonation of the pastes



a. Before carbonation b. After carbonation

Compressive strength of non-carbonated pastes	Compressive strength of carbonated pastes
9.30 ± 0.44 MPa	11.12 ± 0.23 MPa

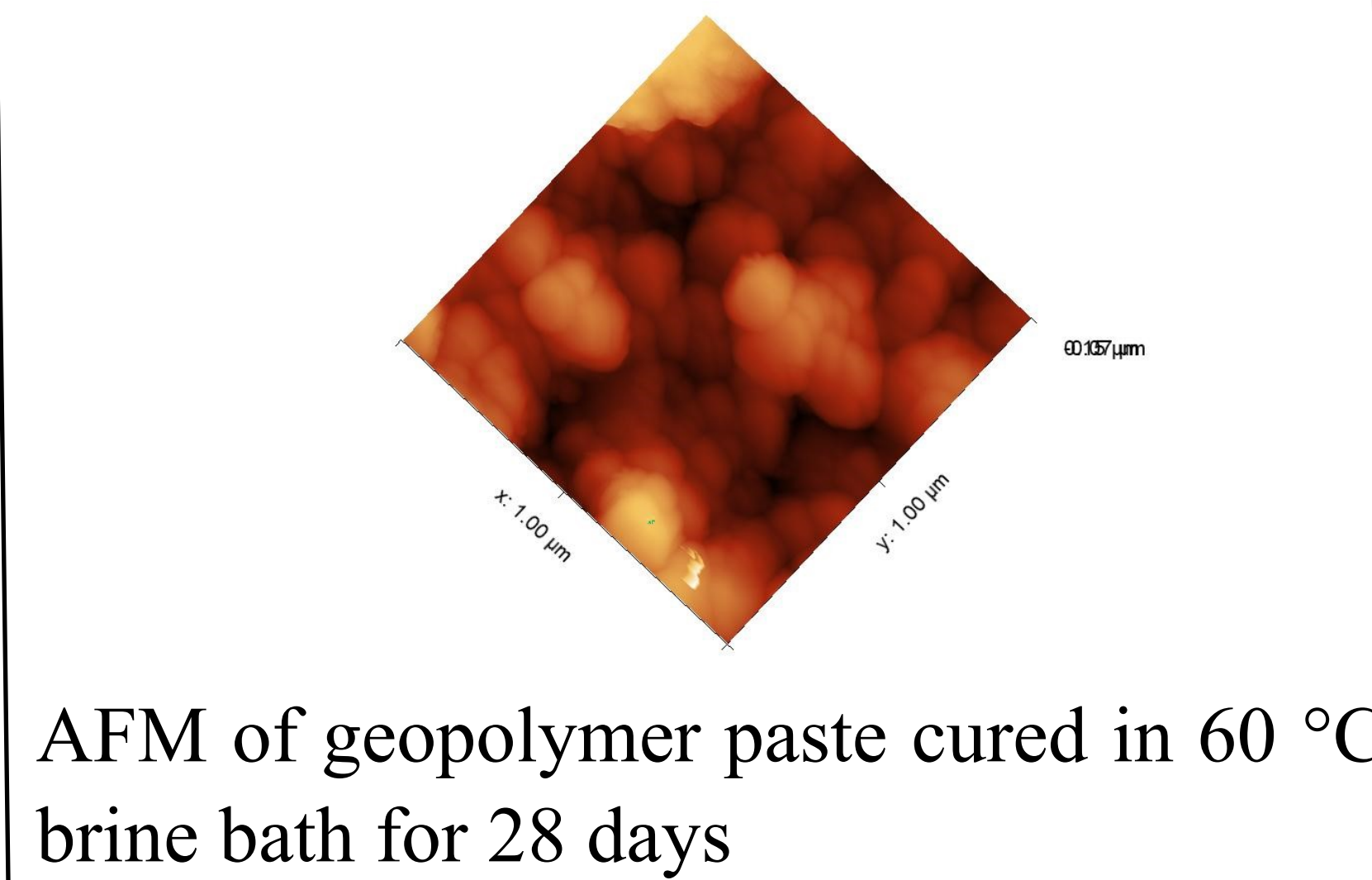
Compressive strength



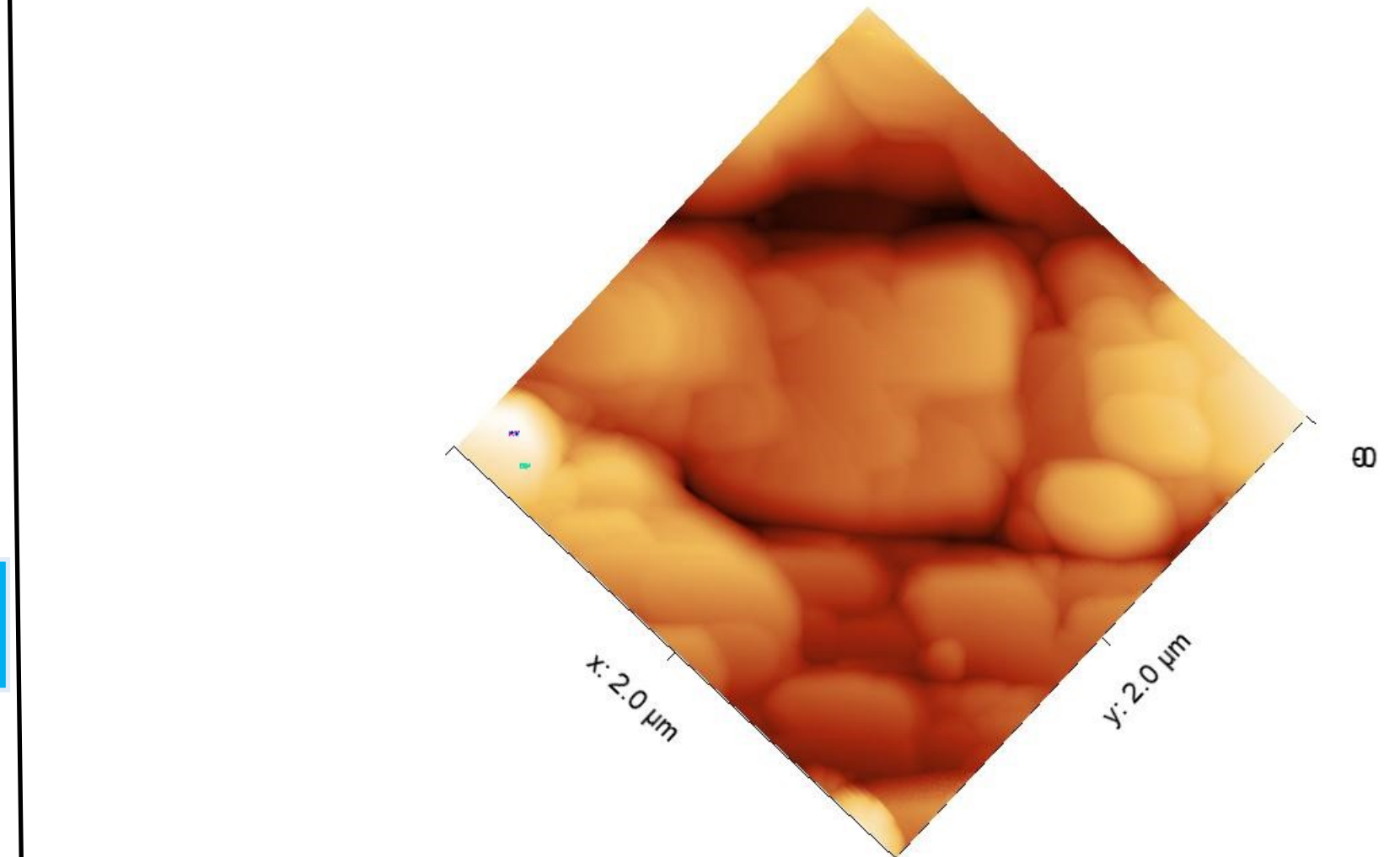
Chemical Stability

Lower concentration of dissolved metal ions at 80 °C indicated that, the pastes were chemically stable

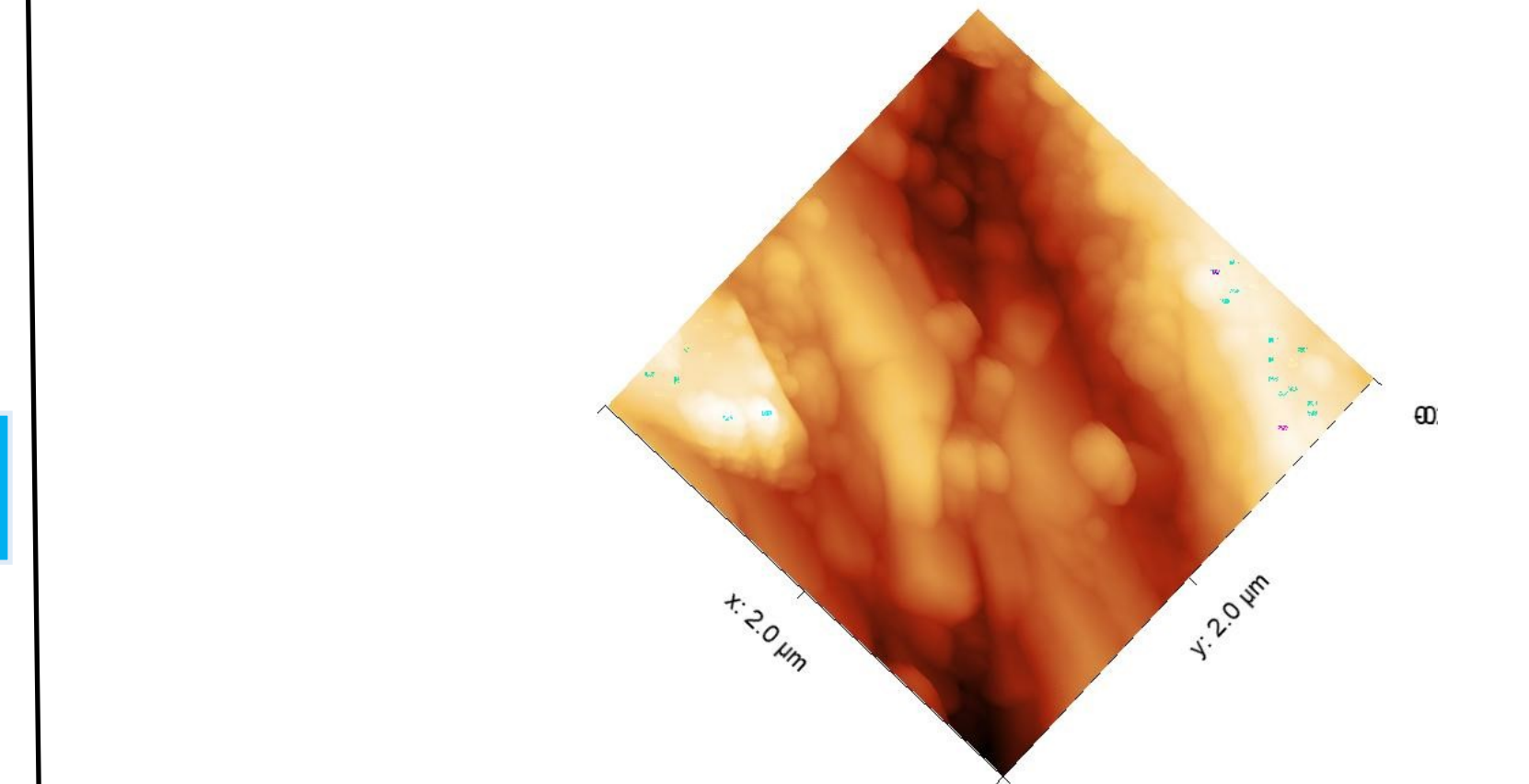
Morphological Structure



AFM of geopolymer paste cured in 60 °C brine bath for 28 days

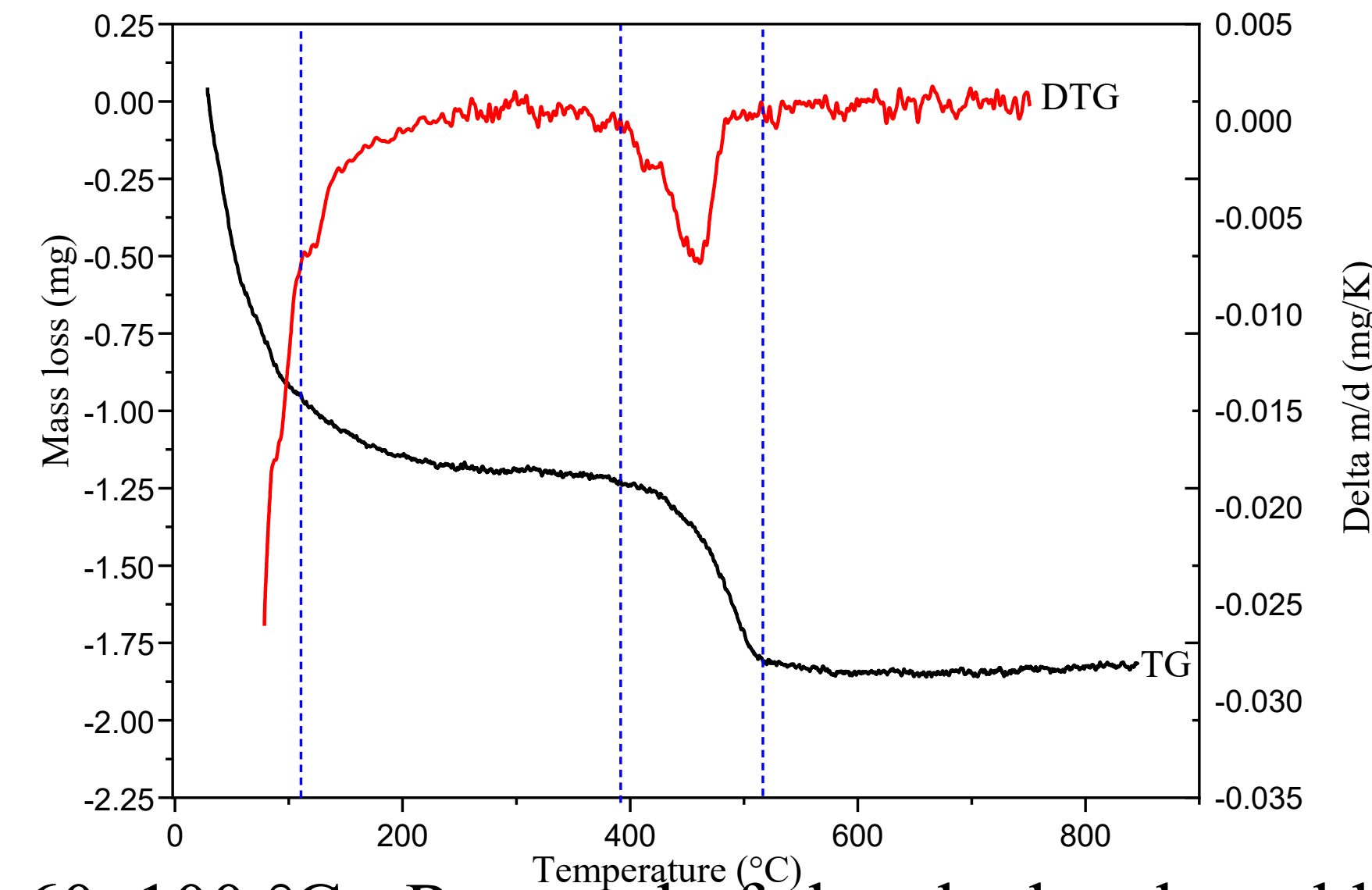


AFM of geopolymer paste cured in 70 °C brine bath for 28 days



AFM of Geopolymer paste cured in 80 °C brine bath for 28 days

Thermal stability of the pastes



- 60–100 °C - Removal of absorbed and weakly adsorbed water
- 100- 400 °C - Removal of chemically bound water
- 400-510 °C - Decomposition of carbonates groups

Conclusion

- The formulated geopolymer binder had acceptable results for oil and gas wellbore construction
- Implementing the findings from this study is expected to contribute significantly to addressing Sustainable Development Goals 9, 11, 12, and 13.

Recommendations

- Further research on the application of this binder in the real oil and gas wellbore environment