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Investigation of the relationship between the condensed structure and the chemically bonded water content in the network of geopolymer cements

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PLAN

INTRODUCTION

OBJECTIVE OF WORK

MATERIALS AND EXPERIMENTAL METHODS

RESULTS AND DISCUSSION

CONCLUSION

GENERAL INTRODUCTION

Geopolymer cements

- Semi-crystalline inorganic materials
- Mixing an amorphous aluminosilicate material with a hardener
- Empirical formula: $M_n[-(SiO_2)_z-AlO_2]_n\ {}_wH_2O$

According to Davidovits (2011), Water plays a crucial role during geopolymerization because a part of water generated during polycondensation remains within the tridimensional geopolymeric frameworks.

GENERAL INTRODUCTION

Types of water in geopolymer (Davidovits, 2011)

- Physically bounded water that escapes at the temperature less than 100 °C

- Chemically bounded water that escapes between 100 and 300 °C

- Hydroxyl groups at the temperature beyond 300 °C

GENERAL OBJECTIVES

Objective of Work

Investigate the relationship between the condensed structure and the chemically bonded water content in the geopolymer network.

MATERIALS AND EXPERIMENTAL METHODS

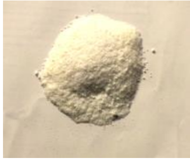
❑ Materials

- Metakaolin (MK)

Characterized by XDR and IR

- Waste glass (WG)

- Silica fume (SF)



Characterized by XDR, IR and the determination of their specific surface area

- NaOH pellets

- Distilled water

MATERIALS AND EXPERIMENTAL METHODS

❑ Preparation of Hardeners

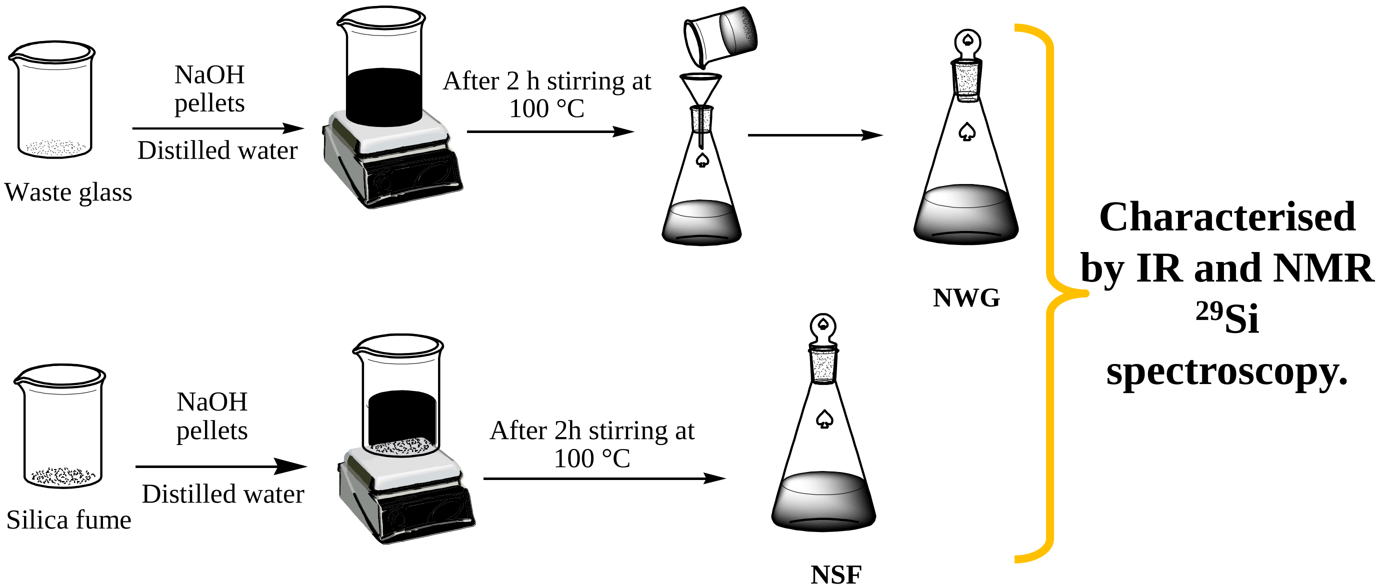


Figure : Diagram of preparation of hardeners (NSF and NWG).

MATERIALS AND EXPERIMENTAL METHOD

❑ Preparation of geopolymer cements

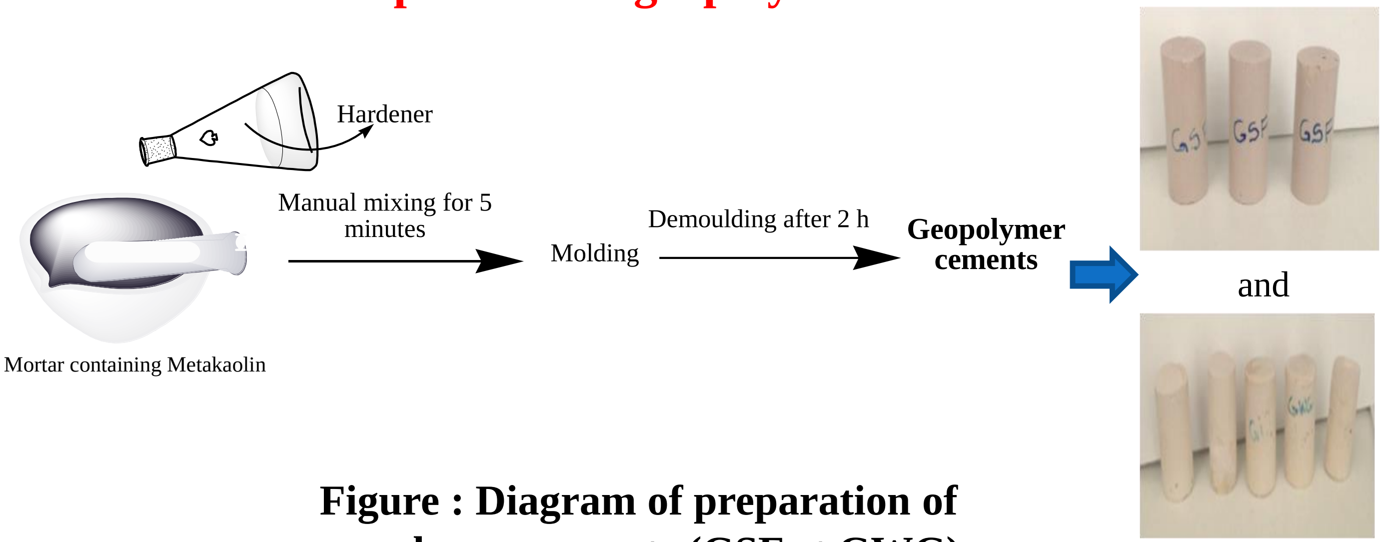


Figure : Diagram of preparation of geopolymer cements (GSF et GWG).

GSF and GWG were characterized by XRD, IR, SEM, MIP, thermal analysis (TGA/DSC), ^{29}Si and ^{27}Al MAS-NMR and the determination of the compressive strengths.

RESULTS AND DISCUSSION

❑ Specific surface area and XRD spectra of SF and WG

Materials	Specific surface area (m^2/g)
Silica fume	170.0
Waste glass	0.9

Table I: Specific surface area of SF and WG

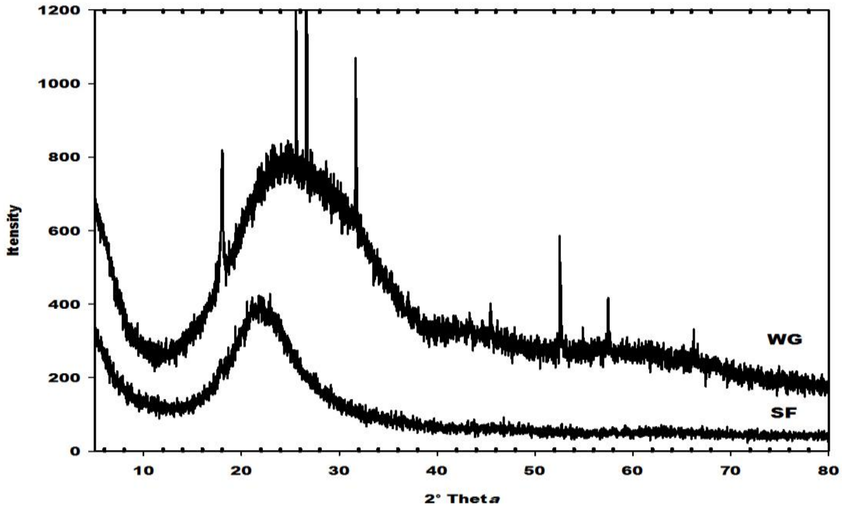


Figure : X-ray pattern of silica fume (SF) and waste glass (WG).

RESULTS AND DISCUSSION

❑ IR spectra of hardeners

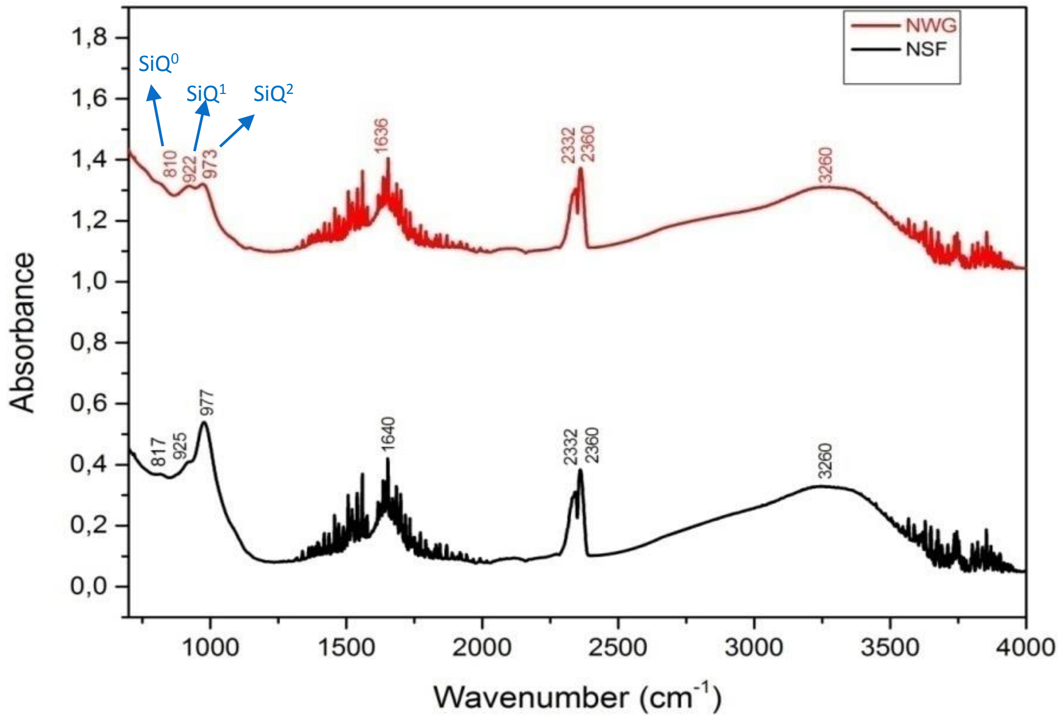


Figure : IR Spectroscopy of NSF and NWG.

RESULTS AND DISCUSSION

❑ ^{29}Si MAS-NMR spectra of hardeners

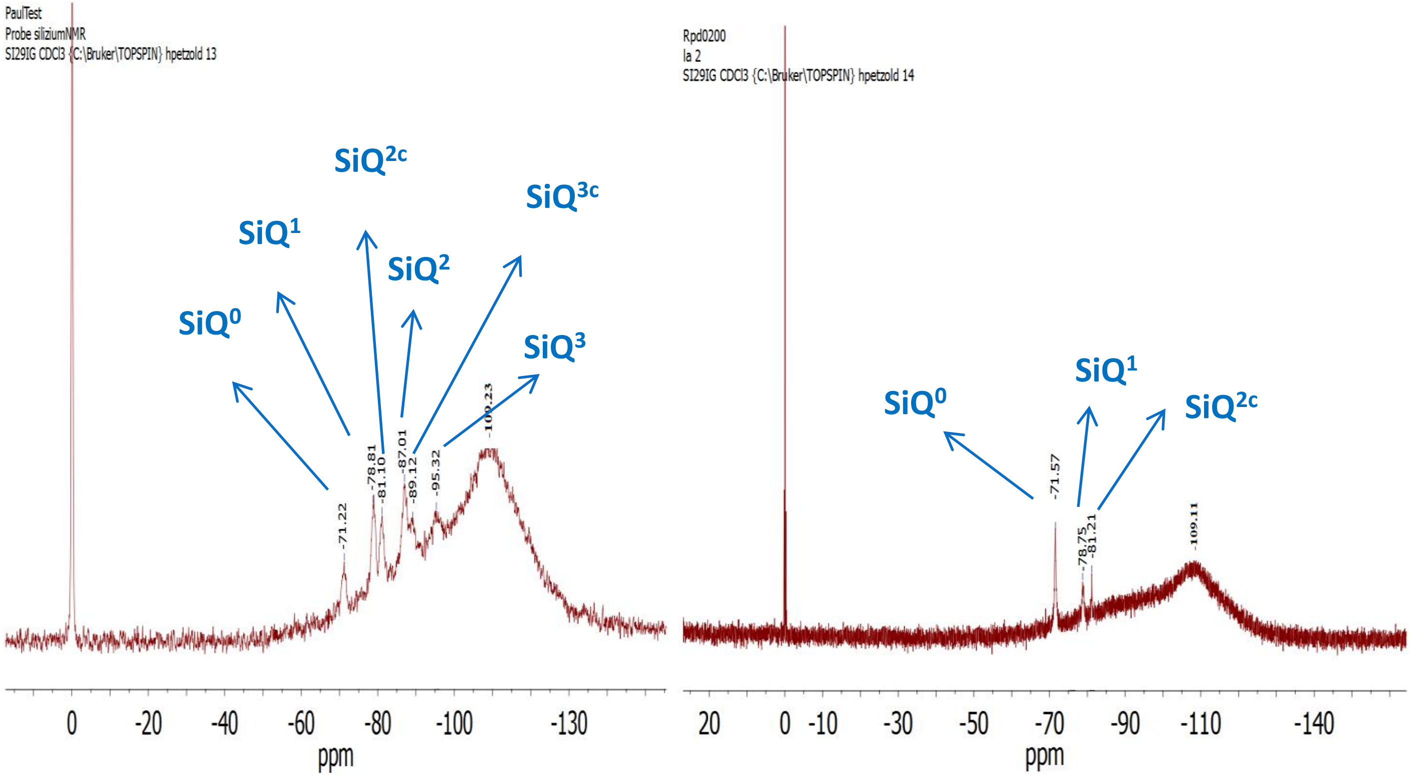


Figure : ^{29}Si MAS-NMR Spectra of hardeners NSF and NWG.

RESULTATS ET DISCUSSION

❑ X-ray patterns of geopolymers and metakaolin

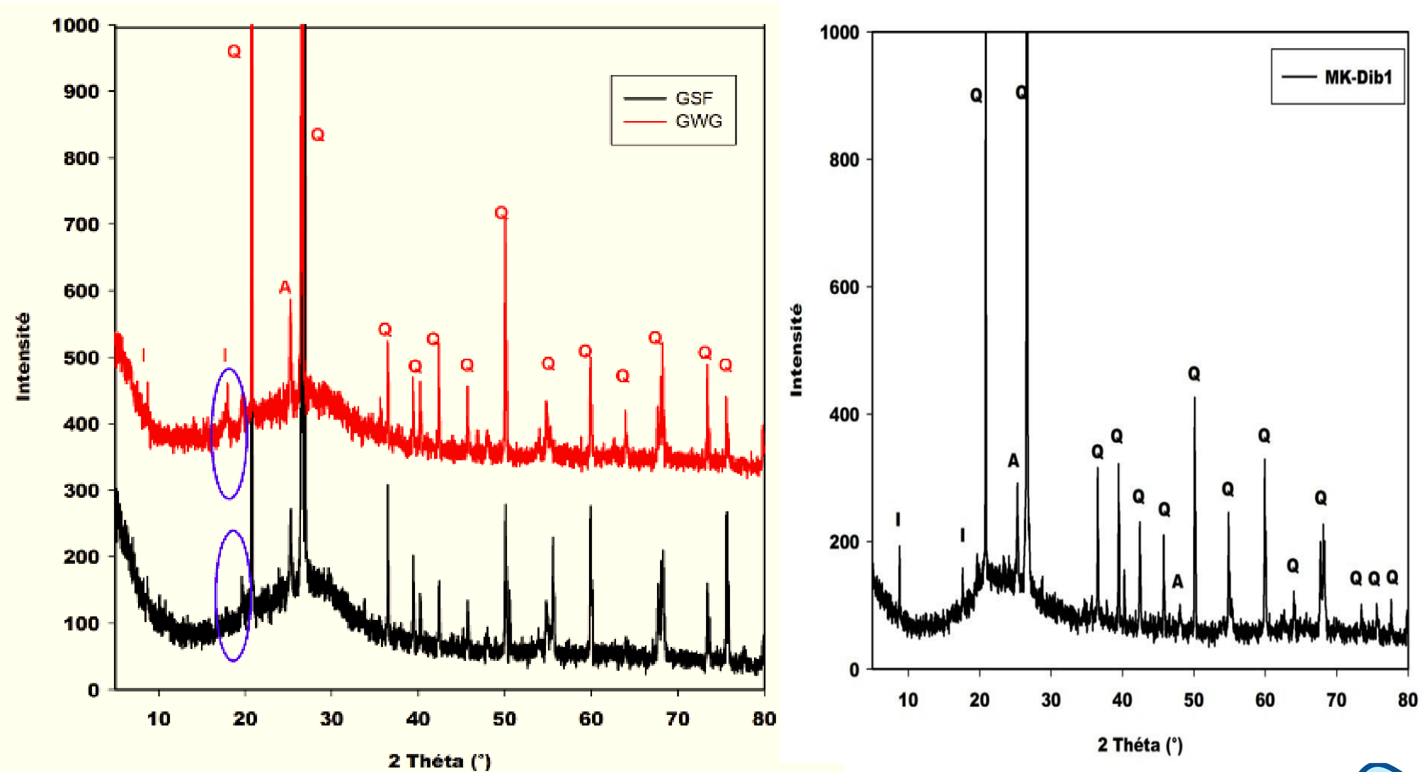


Figure : X-ray patterns of GSF, GWG and MK-Dib1.

RESULTS AND DISCUSSION

❑ ^{29}Si MAS-NMR spectra of geopolymer cements

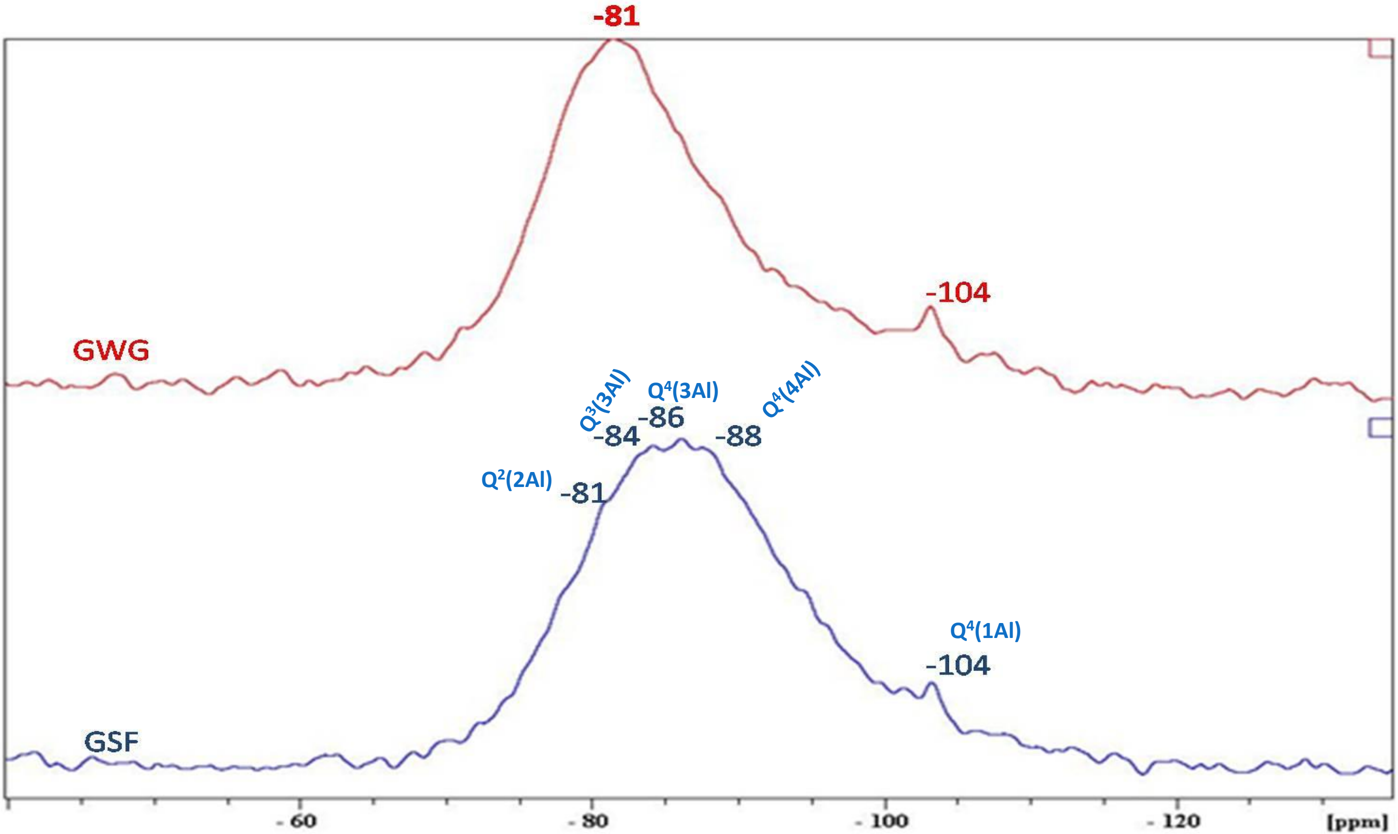


Figure : ^{29}Si MAS NMR spectra of GWG and GSF.

RESULTS AND DISCUSSION

❑ Scanning Electron Microcopy of geopolymer cements

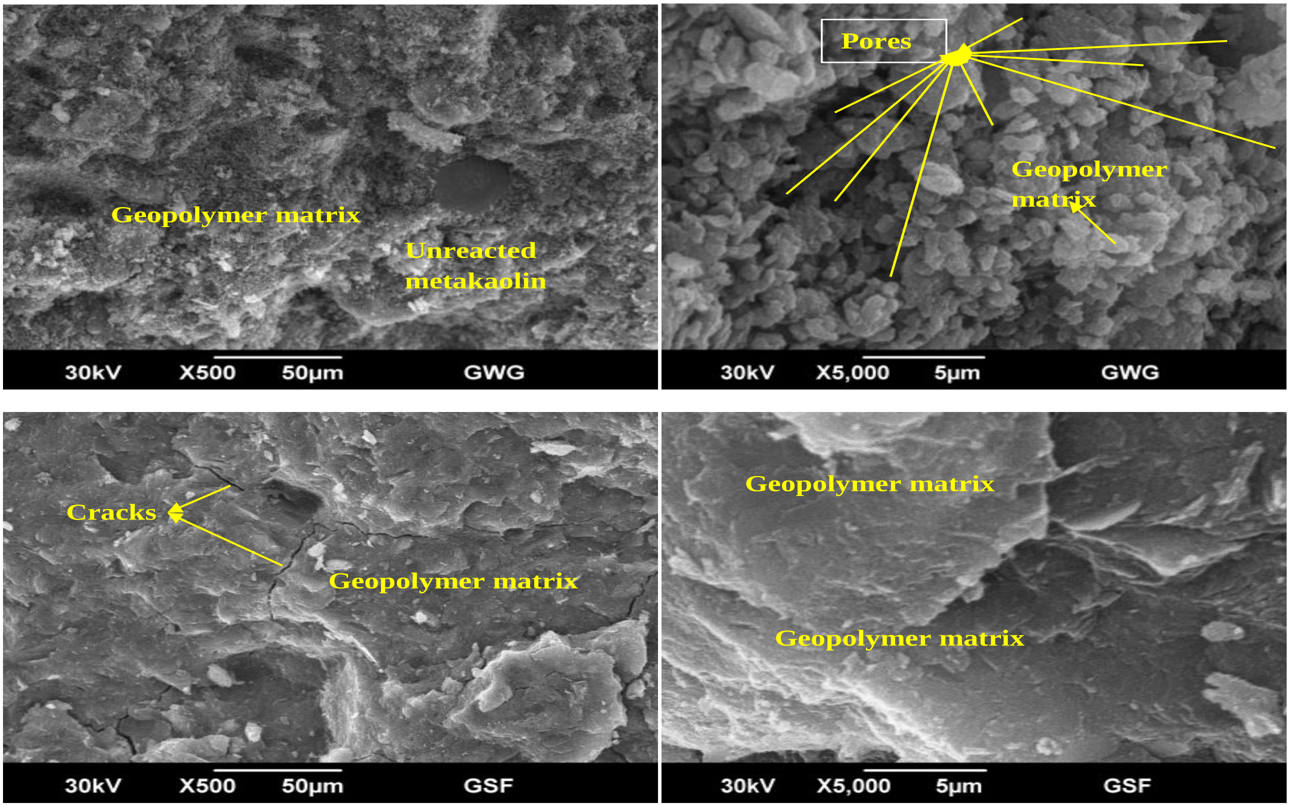
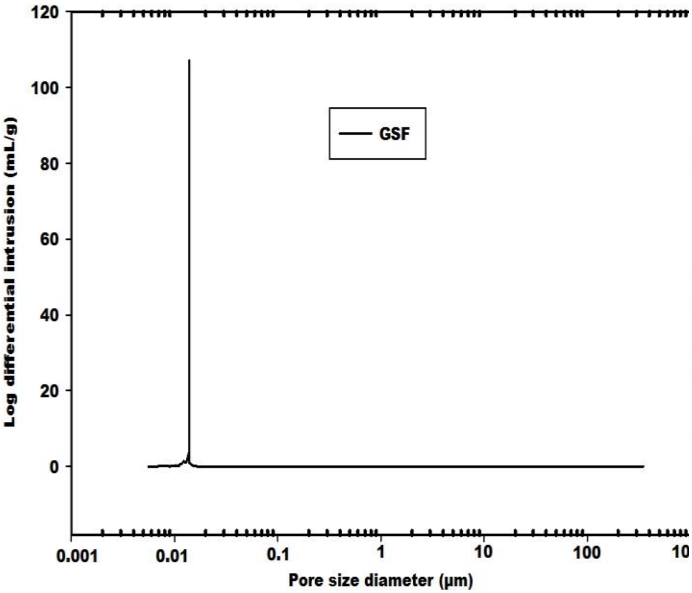


Figure : Micrograph images of GWG and GSF.

RESULTS AND DISCUSSION

❑ Mercury Intrusion Porosimetry of geopolymer cements



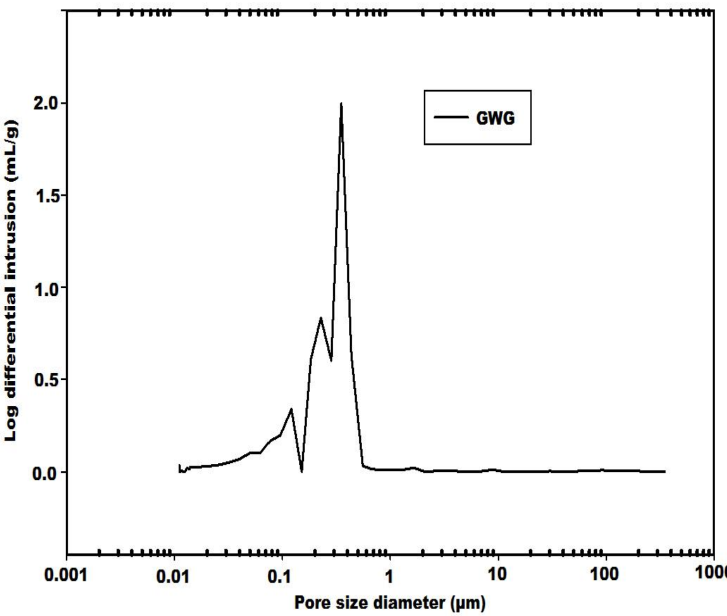


Figure : Pore size distribution of GSF and GWG.

RESULTS AND DISCUSSION

❑ Compressive strengths and Thermal Gravimetry analysis of geopolymer cements

Samples	Compressive strength (MPa)
GSF	62
GWG	26

Table III: Compressive strength of GSF and GWG.

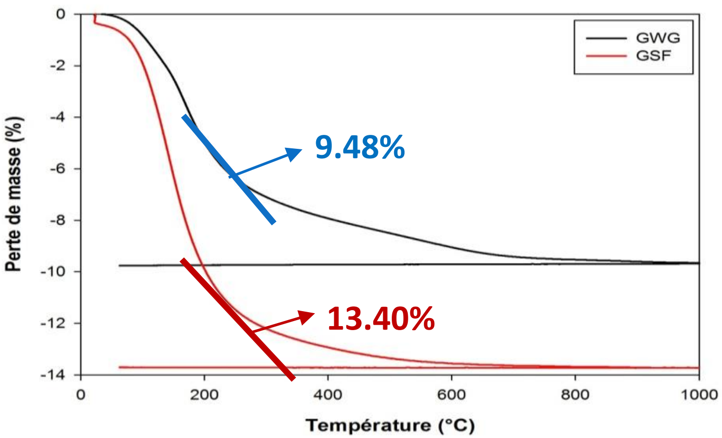


Figure 14: Thermal analysis of GSF and GWG.

Physically bound water	0.68% (GSF)	0.33% (GWG)
Chemically bound water	11.23% (GSF)	6.82% (GWG)
Hydroxyl groups	1.51% (GSF)	2.52% (GWG)

Table IV: Summary of the different mass losses.

CONCLUSION AND PERSPECTIVES

- The specific surface area of silica fume (170 m^2/g) is higher than the one of waste glass (0.9 m^2/g) and the hardener from the silica fume is more reactive than the one from waste glass.
- The compressive strength of the geopolymer cement from silica fume (62 MPa) is greater than the one from waste glass (26 MPa);
- The results of NMR-MAS ^{29}Si show that the geopolymer obtained using hardener from silica fume contains the significant amount of aluminum in its structure;
- The results of mercury intrusion porosimetry show that the average pore diameter of the geopolymer cement obtained using hardener from silica fume is lowest than the one from waste glass. This shows that the specimen from silica fume is a highly cross-linking geopolymer network;

CONCLUSION AND PERSPECTIVES

- The chemically bonded water content in the geopolymer obtained using hardener from silica fume (11.23%) is higher than the one from waste glass (6.83%). This is due to the more Al include in the geopolymer networks during the polycondensation reaction. These Al uptake chemically water in the structure of GSF owing to its hydrophilic character. This water is necessary to maintain the strength of the specimen.

Based on these results, we can conclude that the chemically bonded water content in the geopolymer network is beneficial to maintain the strength.

It was typically found that the higher the chemically bonded water content implies a more condensed geopolymer network.

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