

Contents

Acknowledgements	i
Abstract.....	iv
Résumé	vi
List of Figures.....	xi
List of Tables	xvi
Glossary	xviii
CHAPTER 1: Introduction.....	20
1.1. Context.....	20
1.2. Objective of the PhD work.....	21
CHAPTER 2: State of the art	23
2.1. Cement hydration.....	23
2.1.1. Portland cement.....	23
2.1.2. Blended cements	23
2.1.3. Influence of SCM on hydrates	24
2.2. Calcium silicate hydrates	26
2.2.1. Alkali uptake in C-S-H	32
2.2.2. Aluminium uptake in C-S-H: C-A-S-H.....	33
2.2.3. Impact of the aluminium on alkali uptake	34
2.3. Conclusion	35
CHAPTER 3: Materials and methods	36
3.1. Synthesis	36
3.1.1. Materials.....	36
3.1.2. Synthesis	36
3.1.3. Drying	38
3.2. Analytical methods	38
3.2.1. Thermogravimetric analyses (TGA).....	38
3.2.2. X-ray diffractometry (XRD).....	38
3.2.3. Nuclear magnetic resonance (NMR).....	39
3.2.4. Ionic chromatography (IC).....	40
3.2.5. pH measurement	41
3.2.6. Zeta potential.....	41
3.2.7. Thermodynamic modelling.....	42
CHAPTER 4: Aluminium uptake in C-S-H at constant Ca/Si ratio of 1.0	44
4.1. Introduction.....	44
4.2. Results and discussion	45
4.2.1. Kinetics of C-A-S-H formation.....	45
4.2.2. Influence of aluminium on C-S-H	47
4.2.2.1. Solids.....	47
4.2.2.2. Aqueous concentrations	52

4.2.2.3.	Correlation between dissolved aluminium and aluminium uptake in C-S-H	55
4.2.3.	Influence of potassium hydroxide.....	56
4.2.3.1.	Solids.....	56
4.2.3.2.	Aqueous dissolved concentrations.....	62
4.2.3.3.	Influence of high pH values on the aluminium uptake	63
4.2.3.4.	Comparison of synthetic C-S-H with C-S-H in cement.....	65
4.3.	Conclusions.....	66
CHAPTER 5:	Effect of the Ca/Si ratio on aluminium uptake in C-S-H	68
5.1.	Introduction.....	68
5.2.	Results and discussion	69
5.2.1.	Solid phase composition	69
5.2.1.1.	Influence of time	69
5.2.1.2.	Solids present and mean basal spacing in C-(A-)S-H.....	71
5.2.1.3.	Bound water	74
5.2.1.4.	Structure of the C-S-H and C-A-S-H.....	75
5.2.2.	Aqueous concentrations	80
5.2.3.	Aluminium uptake in C-S-H.....	82
5.3.	Conclusions.....	84
CHAPTER 6:	Alkali uptake in C-S-H	86
6.1.	Introduction.....	86
6.2.	Results and discussion	88
6.2.1.	Effect of alkali on the solids	88
6.2.2.	Effect of alkali hydroxides on the aqueous solution.....	91
6.2.3.	Alkali uptake in C-(A-)S-H.....	95
6.2.3.1.	Effect of the measurement methods.....	95
6.2.3.2.	Effect of aluminium on the alkali uptake.....	96
6.2.3.3.	Potassium uptake in C-A-S-H with Al/Si=0.05	97
6.2.3.4.	Comparison of potassium uptake with sodium uptake	101
6.3.	Conclusion	101
CHAPTER 7:	Effect of temperature on C-A-S-H at constant Ca/Si ratio of 1.0.....	103
7.1.	Introduction.....	103
7.2.	Results and discussion	104
7.2.1.	Solids.....	104
7.2.2.	Aqueous phase chemistry and C-A-S-H chemical composition.....	106
7.2.3.	²⁹ Si magic angle spinning nuclear magnetic resonance	110
7.2.4.	C-A-S-H solubility.....	115
7.3.	Conclusions.....	117
CHAPTER 8:	Conclusions and outlook.....	118
8.1.	Conclusions.....	118
8.1.1.	Influence of Ca/Si ratio on C-S-H.....	118
8.1.2.	Aluminium uptake in C-S-H.....	119
8.1.3.	Alkali uptake in C-(A-)S-H.....	120
8.2.	Outlook	120
Appendix.....		122
Appendix A	Mixing proportions used to prepared C-(A-)S-H.....	123
Appendix B	Dissolved concentration.....	124
Appendix C	Saturation indices.....	132

Appendix D	Samples and C-(A-)S-H compositions.....	137
Appendix E	TGA of C-A-S-H at different Al/Si ratio	145
Appendix F	Details of the deconvolution method for the ²⁹ Si MAS NMR spectra.....	149
Appendix G	Tabulated data relevant to the thermodynamic modelling calculations.....	150
Appendix H	Detailed ²⁹ Si MAS NMR spectral deconvolution results.....	151
Appendix I	Relevant thermodynamic data.....	157
References		161
Emilie L'Hôpital		171