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A nanoscale view of natural and engineered cements

Calcium silicate hydrates (C-S-H) are the main binding phase of Portland cement. In spite of more than one century of intensive use, mechanistic details about the nucleation and growth of these hydrates remain elusive. Indeed, the study of nucleation from solution is a difficult experimental task given the nanoscopic sizes of the first nuclei and their short lifetimes. The classical view of the nucleation process is that depicted by the classical nucleation theory, by which the first nuclei formed already have the atomic structure of the final crystals. It has been only in recent years that deviations from this theory have been reported for many mineral phases, which has resulted in what is known as 'non-classical' nucleation pathways in which nanoparticulated or amorphous intermediates are important players during the nucleation process. A study of non-classical nucleation pathways of C-S-H performed using in situ X-ray PDF methods will be reported during the first part of this presentation. Similarities to structural characteristics of natural cements (biominerals) will be highlighted.

In the second part, recent advances in our understanding of the structure of C-S-H and of adsorbed water films will be presented. C-S-H is a disordered, nanocrystalline phase which exhibits variable stoichiometry. This has prevented accurate crystallographic descriptions of its structure, which has also resulted in animated debates in the literature. Recent work seems to converge towards a picture where a defective-tobermorite model could serve to explain most of the structural and mechanical properties of this nanoscopic phase.

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