

Carbonation of low clinker binders

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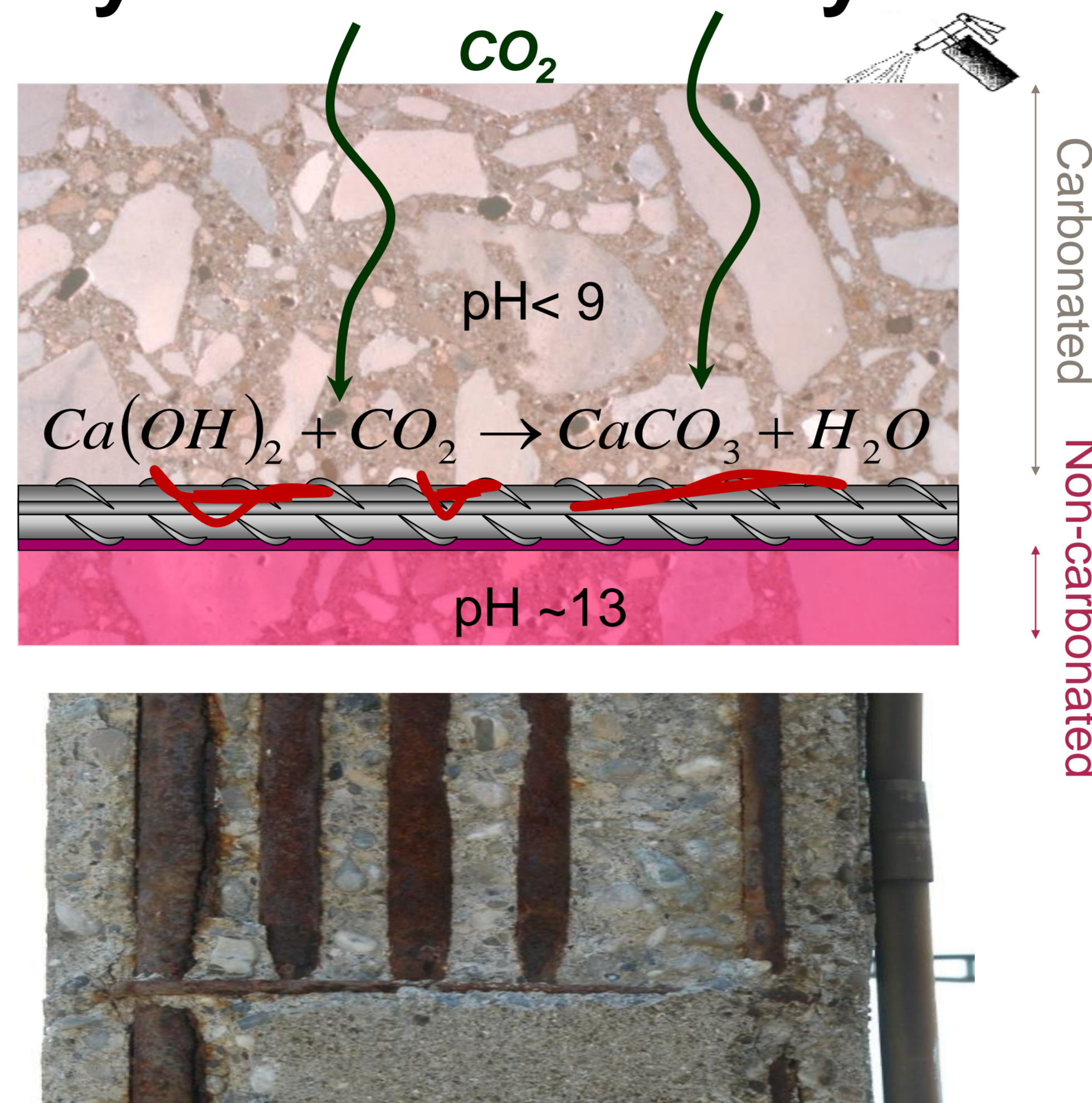
Energy Turnaround
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Wioletta Soja, Karen Scrivener

Laboratory of Construction Materials, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

What is carbonation and why should we worry about it?

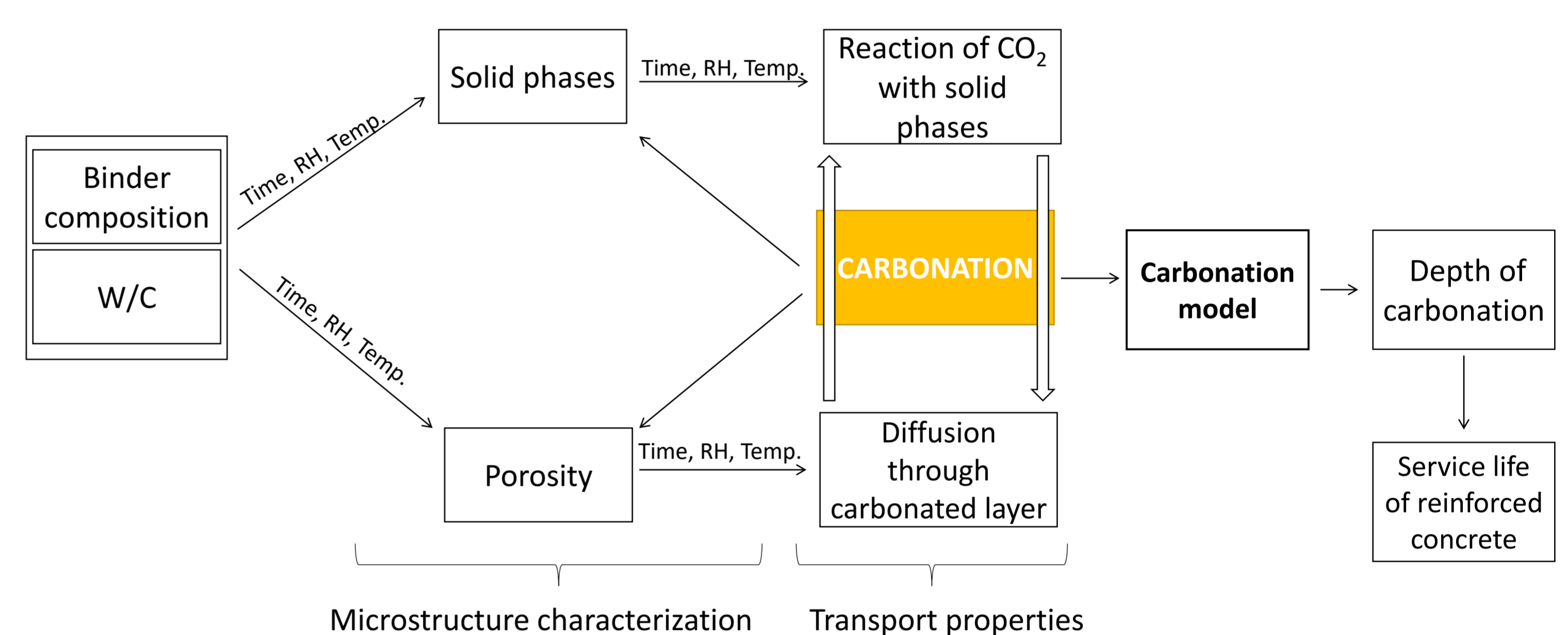
Concrete makes up around half of all materials produced annually and accounts for 5-8% of man-made CO₂ emission worldwide. The use of supplementary cementitious materials (SCMs) is an efficient way to reduce CO₂ emission during cement production. However, the practical use of such cements is limited. Two of the major reasons blocking this uptake are the limited strength at early ages and uncertainties about long term performance, especially carbonation which causes deterioration in reinforced concrete.



Atmospheric CO₂ can penetrate into concrete through the pores, dissolve in the pore solution, and react with hydrated phases to form carbonates. This process leads to the lowering of pore solution pH from about 12.6 - 13.5 to around 9. This is responsible for the dissolution of the protective surface oxide layer of the steel reinforcements and their depassivation, leading to corrosion. To increase the protection of the steel in the concrete full understanding of the microstructure changes is necessary. Diverse exposure conditions will have different impact on that microstructure.

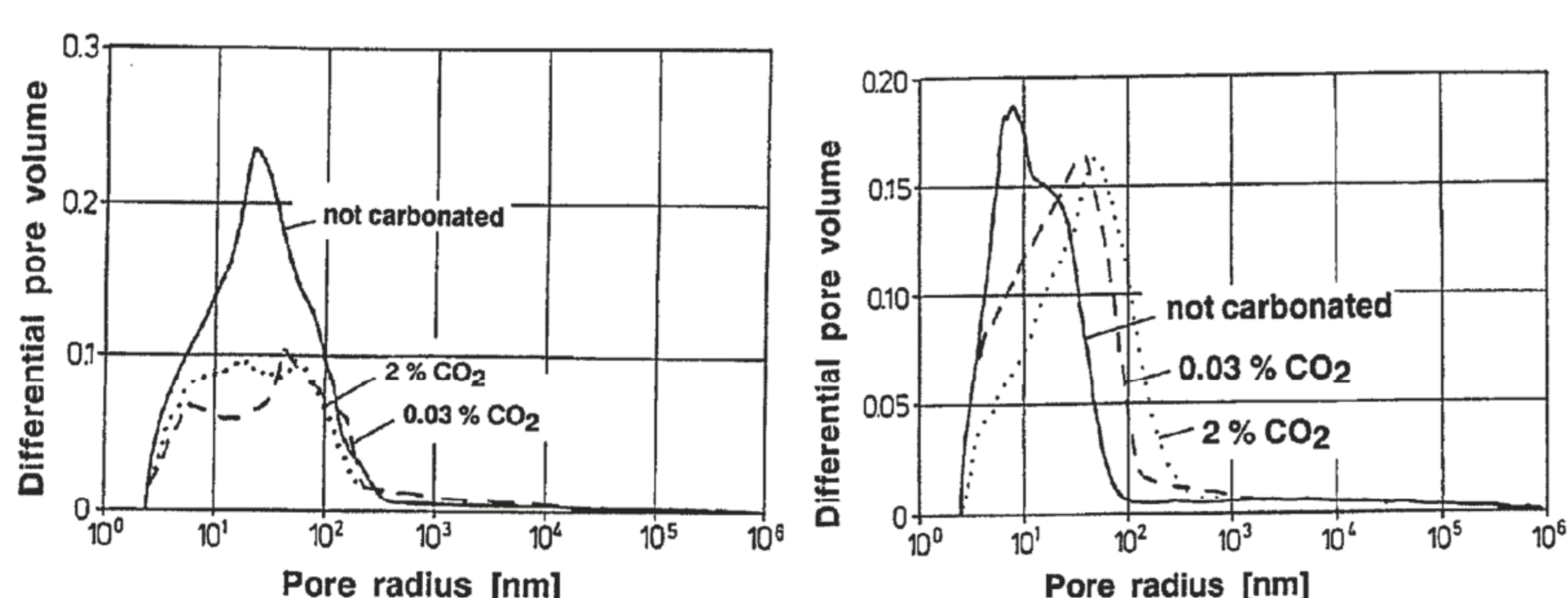
Factors affecting carbonation rate

Carbonation rate is affected by many aspects. The design of the concrete and curing conditions have an influence on formed solid phases and porosity. Transport properties in concrete, which depend not only on diffusion through carbonated layer but also on the reaction of CO₂ with solid phases, affect this microstructure. Understanding and quantifying the correlation between reactive transport properties and microstructure changes on carbonated samples help to model the carbonation rate and to predict the service life of reinforced concrete.



Natural carbonation and characterization techniques

The formation of different calcium carbonate polymorphs in the blends for accelerated carbonation is not representative of the reality in natural carbonation conditions. The main difference is the formation of more aragonite in accelerated conditions. Compared to calcite and vaterite, aragonite is a calcium carbonate polymorph with a lower molar volume which causes changes in the microstructure and results in higher porosity. Therefore the pore structure will be coarser than in natural carbonation conditions causing an easier CO₂ ingress in the case of blended cements. That is why the focus of the study is on paste as this is where the principle changes occur in different materials. The use of thin paste samples allows fully carbonated materials to be obtained in a relatively short time for natural carbonation



Pore size distribution by Mercury Intrusion Porosimetry as a function of CO₂ content during carbonation for Portland cement (left) and Slag cement (50% slags) (right).

Reactive transport model:

- Capacity of calcium bearing hydrates to react with CO₂
- Transport of CO₂ through the carbonated layer

