

# The influence of chloride and sulphate ions on the slaking rate of lime derived from different limestone deposits in South Africa

O Gheeverhese<sup>1</sup>, CA Strydom<sup>1\*</sup>, JH Potgieter<sup>2</sup> and SS Potgieter<sup>3</sup>

<sup>1</sup> Department of Chemistry, University of Pretoria, Pretoria, 0002

<sup>2</sup> Department of Chemical & Metallurgical Engineering, Technikon Pretoria, Private Bag X680, Pretoria, 0001

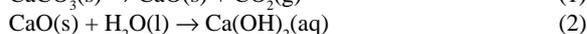
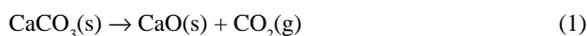
<sup>3</sup> Department of Chemistry and Physics, Technikon Pretoria, Private Bag X680, Pretoria, 0001

## Abstract

This paper describes an investigation into the influence of chloride and sulphate ions on the slaking of lime prepared from limestones of different geological origin in South Africa. It was endeavoured to assess the effects of the presence of chloride and sulphate ions on the hydration rate of lime, compared to its slaking in pure water. It was found that the rate of hydration is slightly retarded in the presence of a high concentration of chloride ions, while sulphate ions retard the slaking of lime significantly. This investigation indicated that impurities present in the original limestone, as well as those commonly found in water used for slaking purposes, may exert an influence on the hydration behaviour of lime.

## Introduction

Limestone (mainly  $\text{CaCO}_3$ ) is one of the most widely occurring industrial minerals worldwide. It is not surprising that lime, obtained by calcining limestone, is a frequently used industrial base and features on the list of the top 50 industrial chemicals (National Lime Association, 1990). When applied as an alkali, unslaked lime,  $\text{CaO}$ , is commonly converted to slaked lime,  $\text{Ca(OH)}_2$ , by reacting it with water. The conversion of limestone to lime and its slaking with water, can be represented by the following reactions:



Although it is the  $\text{Ca(OH)}_2$  species that is desired in the application, its production is closely linked to a number of physical and chemical influences. These include, among others, the origin of the limestone from which it is derived, calcining conditions in the kiln and constituents in the water used for slaking. Different geological origins of limestones can result in lime of different chemical compositions which can possibly influence its rate of hydration during the slaking process. Furthermore, calcining conditions inside the kiln can give hard burnt, medium burnt or soft burnt limes with different reactivities, i.e. different rates and extent of reaction with water (Gaylard, 1994). Chloride and sulphate ions are common constituents of many waters and are often found in high concentrations in water used for the slaking of lime.

Furthermore, conditions after production can also influence the reactivity and, consequently, the slaking rate of lime. Due to its hygroscopic nature, lime can be changed into  $\text{Ca(OH)}_2$  by any humidity present in the atmosphere, or revert back to  $\text{CaCO}_3$  due to the laws of thermodynamics which favour the more stable naturally occurring form (Strydom and Potgieter, 1997). Both back

conversions to either the slaked lime or limestone form can influence the rate of slaking of the lime. It is also known that this back conversion to limestone after atmospheric contact is influenced by the prevailing relative humidity (Meyer, 1998). This latter phenomenon can cause considerable operational problems at plant level to ensure the production of lime that complies with customer demands and expectations in terms of its reactivity.

The purpose of this investigation was to assess quantitatively the effect of various chemical influences (e.g.  $\text{SO}_4^{2-}$  and  $\text{Cl}^-$  concentrations), whether it be from a geological origin or presence in the slaking water on the slaking rate of lime. Ultimately, the aim is to assist consumers in the correct choice of product and in using it optimally.

## Experimental procedure

### Samples

Samples from naturally occurring limestone deposits of different geological origin were collected from three sites in South Africa. Pienaars River limestone, just to the north of Pretoria, is a secondary limestone deposit occurring as calcrete nodules embedded in a silt/clay matrix, while Beestekraal limestone, between the towns of Brits and Thabazimbi, is a primary deposit with a significant level of magnesium contamination. Lime Acres limestone is chemically the most pure limestone deposit in South Africa and the source of the bulk of unslaked lime sold in the country. The chemical composition of these three samples, as obtained by XRF analysis, is given in Table I. Using the values for the percentage of  $\text{CaO}$  in each sample, it was calculated that the maximum amount of  $\text{CaCO}_3$  in the Pienaars River sample is 75.6% limestone, in the Beestekraal specimen 88.2% and in the Lime Acres material 98.7%. These values were used to normalise the degrees of slaking obtained for each sample during the investigation. For purposes of comparison, a pure sample of  $\text{CaCO}_3$ , obtained from Fluka, was also included in the investigation.

\* To whom all correspondence should be addressed.

☎ (012) 420-2511; fax: (012) 362-5297; e-mail: cstrydom@postino.up.ac.za

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