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Assessment criteria for determining the suitability of carbonate rock types for calcination in modern vertical (shaft) kilns in Southern Africa

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ABSTRACT

Lime kilns have been used through history, initially to produce a key building material, as demonstrated by construction in the days of the Roman empire. Since the time of the Industrial Revolution, the use of lime has developed widely into applications in chemical and metallurgical industries and environmental control.

The production of good quality lime requires a high purity raw material (limestone) and well–controlled kiln operation. Lime kilns developed as shaft or vertical kilns, with rotary kilns being implemented from the early 20th century to meet the increasing demand for production of high quality lime.

In recent times, new global lime kiln projects have seen the implementation of modern, high thermal efficiency vertical kilns in preference to rotary kilns due to lower heat consumption – which also contributes to a reduction in CO_2 emissions – together with their ability to produce lime of competitive quality. In southern Africa, where lime has been produced mainly in rotary kilns since the mid–1950s, the most recent large–scale kiln projects have seen the installation of modern vertical kilns.

Knowledge on the make-up and decomposition characteristics of the stone used for kiln feed is absolutely vital, considering that the quality of the stone directly impacts the quality of the lime product, while the behaviour of the stone under high–temperature calcination conditions can affect kiln operation.

With new kiln installations, there are indications in some cases that – in spite of the established empirical tests done by kiln suppliers – kiln operating problems attributed to the feed stone characteristics have occurred unexpectedly during the commissioning and early operating stages. This research project sets out

to establish a set of assessment criteria for limestone feedstocks in order to assess their suitability for use in shaft kilns.

A range of analytical, visual and thermal investigative methods was used to characterise limestone, including X–ray fluorescence spectrometry (XRF) to characterise the composition, X–ray diffractometry (XRD) to characterise the major phases, Raman spectroscopy to characterise the minor phases, single particle analysis to characterise impurities/phases, petrography to characterise the geological make-up, decrepitation tests and thermogravimetry to characterise the decomposition behaviour.

These techniques were applied to three limestones and one dolomite, all of high grade (purity), from three different geographic regions in southern Africa. Each carbonate rock had a unique chemical composition and geological origin. The complexity of each sample's unique chemical and physical features necessitated a thorough review of each rock's geological history. The review gave a better understanding of the phases and crystal structure in the stone that was formed during sedimentation.

This investigation found that the assessment criteria of limestone had to include physical *and* chemical characterisation methods with an emphasis on physical characterisation. The thermal methods and petrography were used to assess the physical characteristics such as crystal size and decomposition behaviour; while the chemical methods were used to assess the chemical characteristics such as chemical and phase composition. The two types of method were applied in a complementary approach. Thermal methods together with petrography were found to be the most adequate methods for assessing the suitability of stone for use in shaft kilns. Petrography offered information on how the hot gasses move through the crystal structure during calcination and the thermal methods showed how the decomposition was affected by that movement of hot gasses. However, analytical techniques were complementary

to the thermal techniques, offering explanations for observations in the thermal methods.