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Experimental Investigation on the Reactivity of Mg-orthopyroxene and Ca-plagioclase under Direct Aqueous Mineral Carbonation – Eastern Bushveld Igneous Complex Case Study.

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Direct aqueous mineral carbonation, a process in which CO₂ (g) is converted into a stable Mg and/or Ca-carbonate, was investigated under varying experimental setups. The study was conducted on minerals from tailings produced by mining of platinum-group metals and pyroxenite rocks from the eastern limb of the Bushveld Igneous Complex (BIC), South Africa. The aim of this work is twofold: To store CO₂ permanently in an effort to mitigate global warming and to reduce the millions of tons of waste produced by mining activity in South Africa. Eventually, it is hoped to use mineral carbonation and tailings waste to fabricate a useful product for the local markets, e.g. the construction industry. The carbonation process has been widely considered by the National Energy Technology Laboratory (formally known as the Albany Research Centre) based in the USA. However, their material of choice was Mg, Fe, and Ca containing olivine, serpentine and wollastonite – in no particular order, and found valuable for CO₂ sequestration [1].

Preliminary investigations conducted by Vogeli et al. [2] on the BIC tailings, highlighted the extent at which it is possible to theoretically use the tailings dump left behind by decades of platinum mining. They demonstrated that the tailings contained the essential Mg and Ca bearing minerals, namely pyroxene and plagioclase in large volumes.

Our sample tailings were obtained from the Two Rivers mining operation located south of Steelpoort, in Limpopo. Direct aqueous (in the presence of NaCl and NaHCO₃) mineral carbonation experiments were conducted in a Parr Reactor™ under supercritical CO₂ conditions, where the temperature and pressure was maintained at 200°C and 160 bars, respectively. In order to observe the kinetics of carbonation, the reaction period was varied from 2, 3, 6 and 24 hrs. The resultant reaction materials were analysed for total carbon and sulphur.

In addition to the tailings material, pristine pegmatitic – phaneritic orthopyroxenite samples were obtained from two locations along the eastern limb. These are rocks of the Rustenburg Layered Suite critical zone, where the major economic reefs (Merensky and UG2) are situated. In order to evaluate the reactivity of the two major Mg and Ca-rich minerals (orthopyroxene and cumulus plagioclase), the samples were crushed/milled and the two minerals individually concentrated (i.e., via density separation). The reactions were also conducted under supercritical CO₂, saline and carbonic aqueous conditions, in 36 cm³ capacity autoclaves. The reaction time was 13 days, and the resultant content was sent for various analyses, including ICP-OES of the filtered liquid content, X-ray fluorescence, X-ray diffraction, and carbon and sulphur, in order to determine the degree of reactivity of the two minerals, in their concentrated states.

The results of this study will assist in advancing the discourse of Carbon Capture and Storage (CCS), with a specific focus on the viability of mineral carbonation processes. This forms part of the portfolio of studies currently conducted by the University of Pretoria CCS working group and its various partners, local and international.

References:

[1] O'Connor, W.K. et al. (2005). In: *DOE/ARC-TR-04-002*. United States of America: Department of Energy.

[2] Vogeli, J. et al. (2011). In: *Minerals Engineering*, 24, pp.1348-56.