

PHYSICAL SEPARATION OF HIGH GRADE AND LOW GRADE AFRICAN PHOSPHATES

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Africa is a source of many phosphate deposits of various resource grades and a significant global contributor of phosphate for fertilizer or phosphoric acid applications. Many of these deposits in Africa exist as sedimentary and alluvial deposits. The main phosphate bearing mineral is usually carbonate fluorapatite with quartz occurring as the main gangue mineral. It is common for phosphate deposits to have clay constituents (varying amounts in each deposit) and Mintek has found through various studies that African phosphates can easily be upgraded by removal of barren fines/clays after some initial upfront wet scrubbing. The scrubbed material is then screened wet to remove the barren fines, which normally occur in the <600µm fractions. Coarser fractions, usually >13mm are also scalped off as they also tend to contain barren coarse waste consisting mainly of quartz, calcite and dolomite. In some cases, energy input is required to remove the contaminants from the phosphate mineral surface, hence attritioning would be carried out in these instances. Much of the testwork conducted at Mintek was to determine if the resource can be upgraded to >30% P₂O₅ target specification.

Mintek has undertaken many projects dealing with the physical beneficiation of African phosphates over the past years and had recently conducted testwork on high grade and low grade Angolan phosphate with the results appearing in Table 1 below. The sample had undergone scrubbing followed by screening at 0.5mm. Additionally, the +12mm material was scalped.

Table 1: Performance of a high grade and low grade Angolan phosphate

	High Grade									Low Grade								
	Grade					Recovery				Grade					Recovery			
	Mass	P ₂ O ₅	SiO ₂	Al ₂ O ₃ +Fe ₂ O ₃ MgO	Cd	P ₂ O ₅	SiO ₂	Al ₂ O ₃ +Fe ₂ O ₃ MgO	Cd	Mass	P ₂ O ₅	SiO ₂	Al ₂ O ₃ +Fe ₂ O ₃ MgO	Cd	P ₂ O ₅	SiO ₂	Al ₂ O ₃ +Fe ₂ O ₃ MgO	Cd
[%]	[%]	[%]	[%]	[ppm]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[ppm]	[%]	[%]	[%]	[%]	[%]
+12mm	2.0	10.5	67.5	3.6	69.7	1.1	3.5	1.1	1.4	0.5	8.7	65.6	26.4	56.1	1.1	0.6	0.8	1.2
-12.5+0.5mm	52.8	30.1	10.1	4.4	153.5	85.5	13.9	36.8	80.8	9.04	13.3	53.6	6.7	78.2	29.3	8.2	3.5	27.7
-0.5mm	45.2	5.5	70.3	8.6	39.6	13.4	82.6	62.1	17.8	90.43	3.15	59.8	18.2	20.1	69.5	91.2	95.7	71.2
Total Calc.	100.0	18.6	38.5	6.3	100.3	100.0	100.0	100.0	100.0	100.0	4.1	59.3	17.2	25.5	100.0	100.0	100.0	100.0

The high grade and low grade samples reported head grades of ~19% P₂O₅ and ~4% P₂O₅ respectively. The high grade sample was upgraded to product specification of 30% P₂O₅ at a yield and recovery of 53% and 86% respectively; whereas the low grade sample only upgraded to 13%P₂O₅ at a yield and recovery of 9% and 29% respectively. More stages of processing is recommended for the low grade sample to achieve the target specification. The marked difference between the samples is the significantly high clay content in the low grade sample as compared to the high grade sample, as well as the higher silica content. The high clay content also caused processing difficulties. Deleterious heavy elements such as cadmium (Cd) need to be minimal in the upgraded phosphate rock in order to be used as fertilizer that grow crops for human consumption. The Cd content in the high grade sample was much higher (153ppm) than that of the low grade sample (78ppm). Calcination tests may be conducted to attempt to reduce the Cd content keeping in mind the detrimental effect of calcination on the phosphate fertilizer applications. African phosphate ores generally concentrate to the coarser size fractions, but in some cases the actual phosphate minerals are not 'clean phosphate' and have inclusions containing Fe, Al and Mg which are unfavorable as it renders phosphoric acid production uneconomical. In cases such as these, magnetic separation would be employed to attempt to remove the magnetic minerals containing Fe, Al and Mg. A specific case investigated on a Mali phosphate sample with a high Fe and Al content did not improve its situation via magnetic separation as mineralogical analysis indicated that the elements were present as tiny inclusions (<10µm in diameter) in the phosphate minerals which then indicated that further liberation of these minerals would not be economically viable. Methods other than physical beneficiation (for example selective leaching) is recommended for these cases. This paper will however primarily focus on testwork on Angolan ore bodies in particular the challenges with the high and low grade material treated.