X-ray computed tomography visualisation and quantification of microwave induced cracks in particles

Edson Charikinya, Steven Bradshaw*, Anton du Plessis
Department of Process Engineering, University of Stellenbosch, Private Bag X1, Matieland, 7602, South Africa

Background

Microwave treatment of mineral ores results in micro cracks in the ore matrix due to the difference in microwave absorption and thermal expansion rates(1). In some cases these micro cracks form around the grain boundaries resulting in reduced fracture strength of the ores and greater liberation of value minerals (2). Since heap leaching processes depend on the accessibility of grains to lixiviants, accessibility can potentially be improved through microwave induced particle fracture .

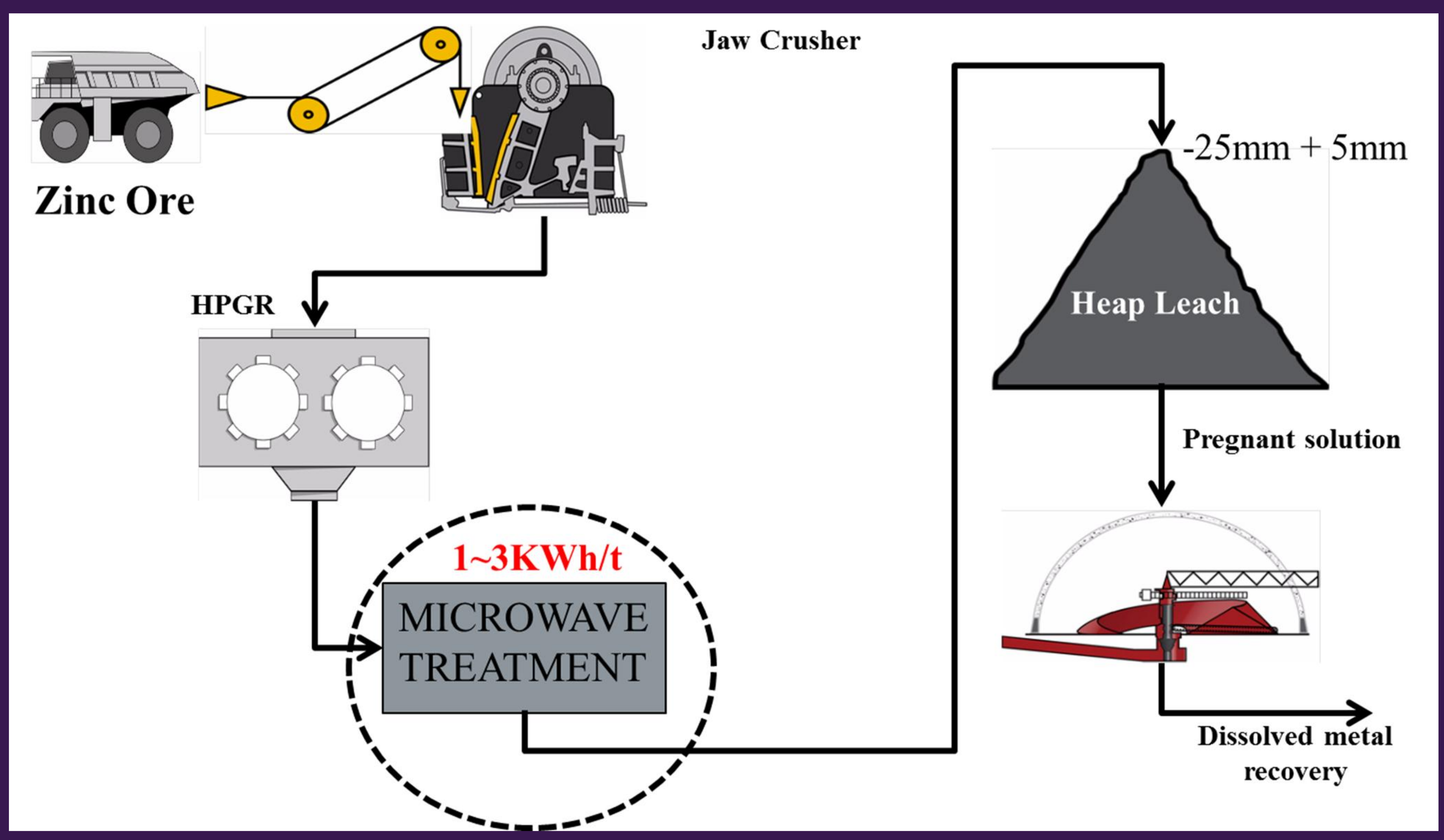

Figure 1. Process flow diagram of a typical BMR process

Problem statement

Before microwave technology can be applied to ore preparation for heap leaching, key issues surrounding the application of the technology need to be addressed. One of these issues involves understanding the micro crack pattern of microwave treated particles and quantifying particle damage due to microwave treatment.

Objectives

The objective of this study is to characterise and quantify microwave induced particle crack damage through the use of X-ray computed tomography (CT) analysis. Further the effects of particle size and mode of comminution on observed microwave induced crack fracture needs to assessed.

Experimental set up

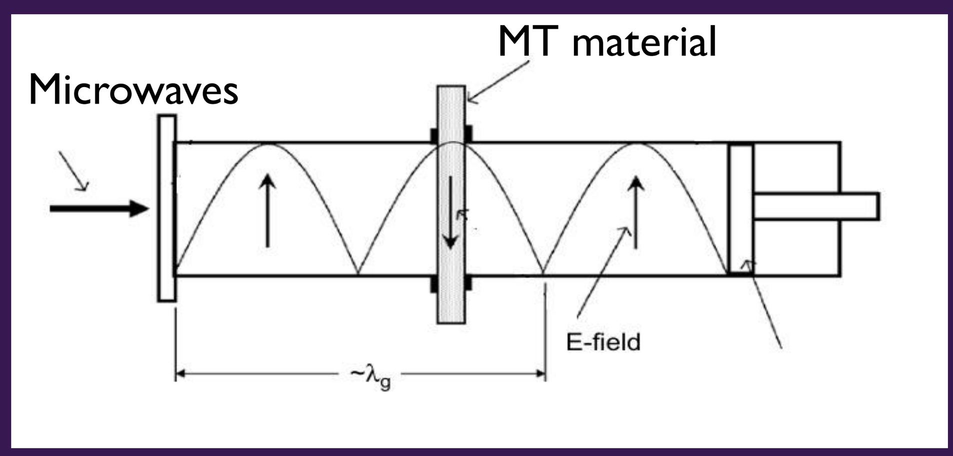

FIG 2: Microwave treatment applicator laboratory set up

Table 1: Microwave treatment conditions

Size (mm)	Forward applied power (kW)	Reflected power (kW)	Time (sec)	Actual energy input into ore sample (kWh/t)
(-25+19)	5.92	0.93	1	2.11
(-16+9.5)	5.50	0.53	1	2.65
(-5+4.75)	5.56	0.71	1	2.37

Results

FIG 3: X-ray CT scan of particle before and after microwave treatment

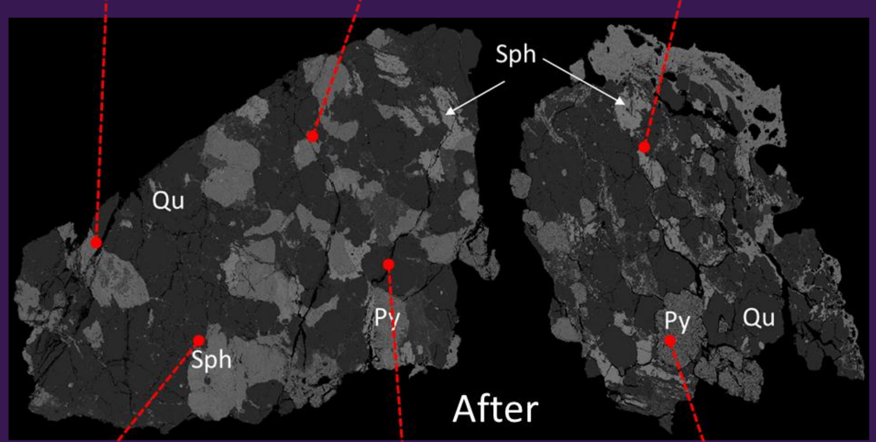

FIG 4: X-ray CT images showing microwave crack pattern

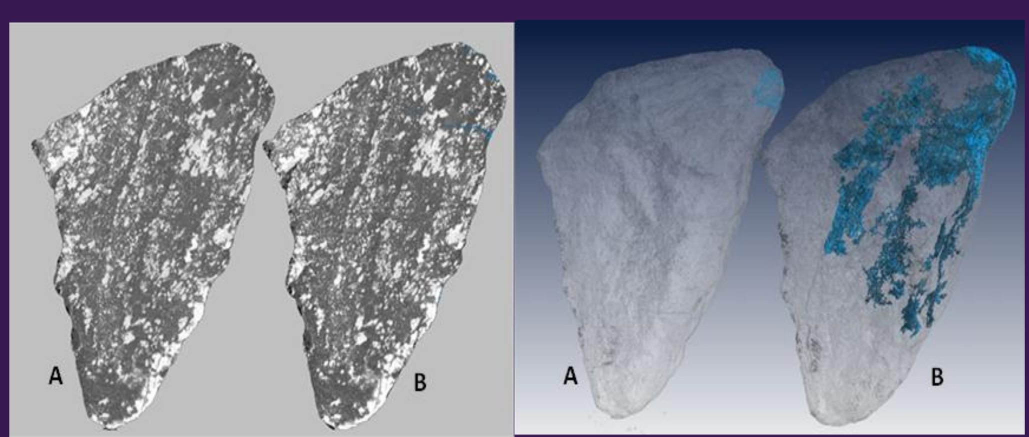

FIG 5: 3D crack view A-Before, B-After microwave treatment

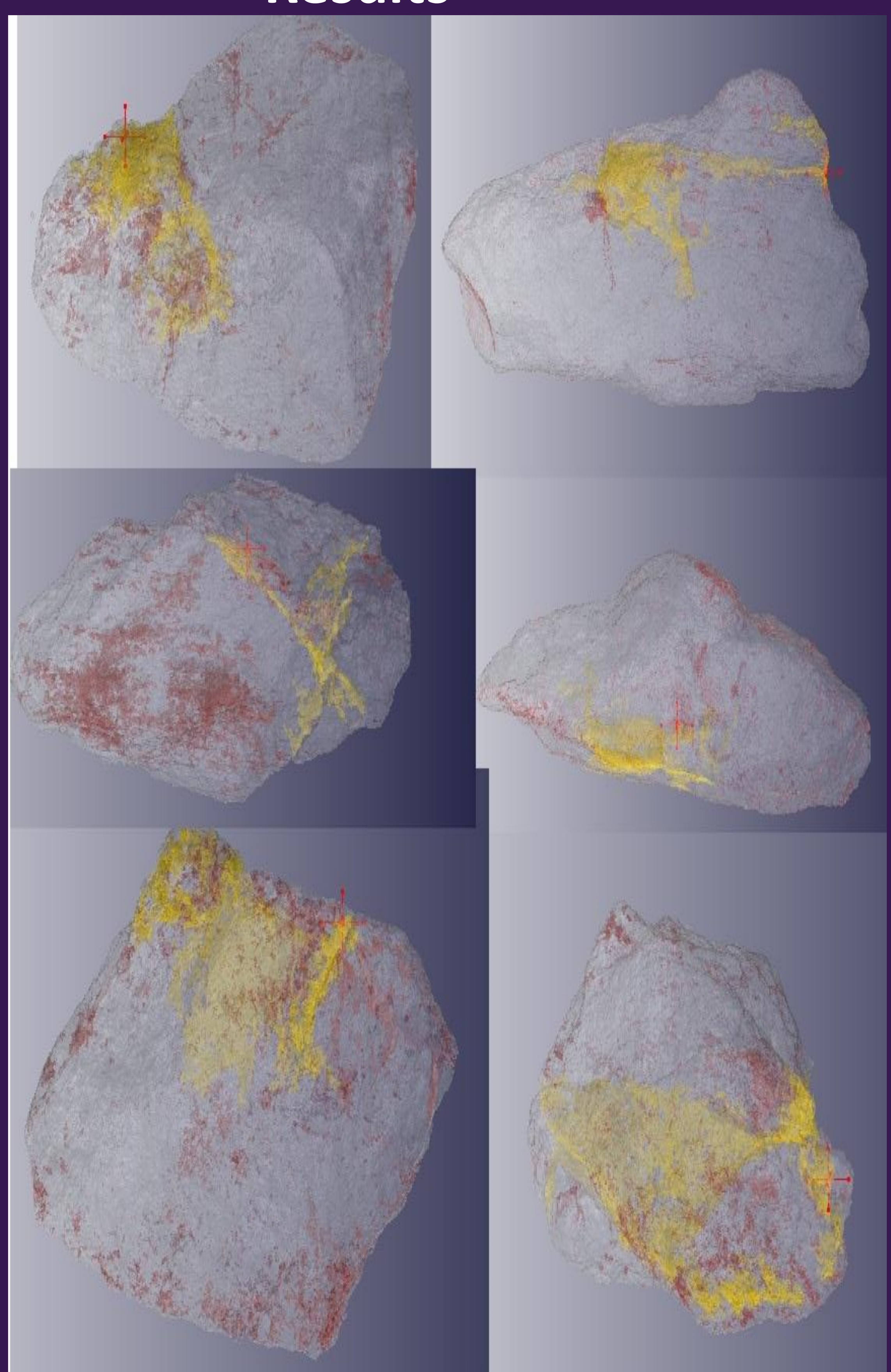

FIG 6: X-ray computed tomography 3D images showing cracks in red and yellow

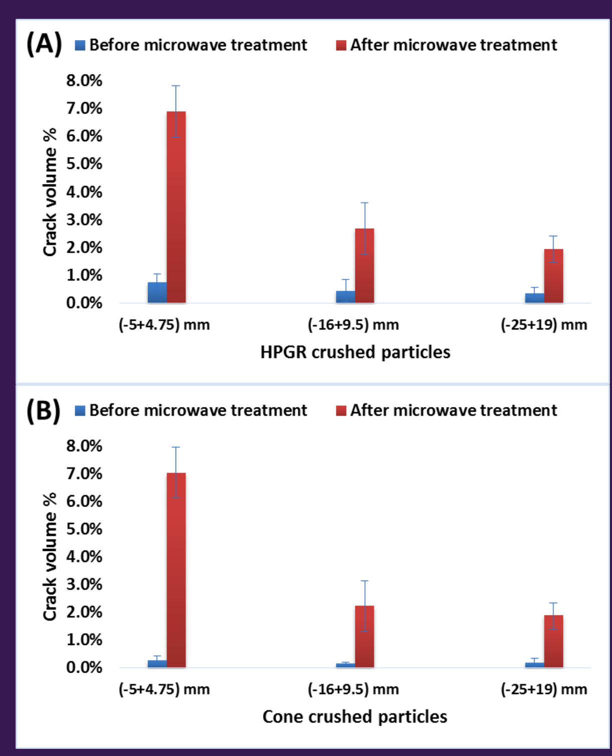

FIG 7: Crack volume of HPGR (A) and cone crushed (B) particles

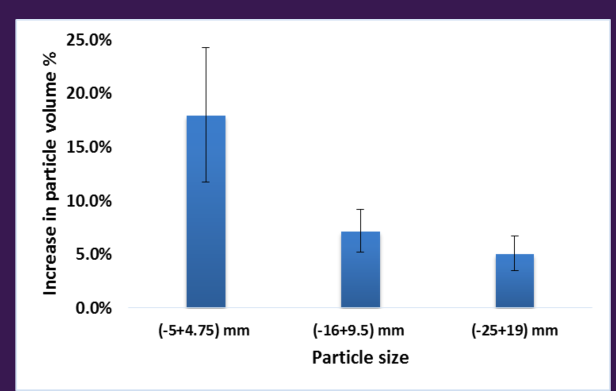

FIG 8: Percentage increase in particle crack volume after microwave treatment

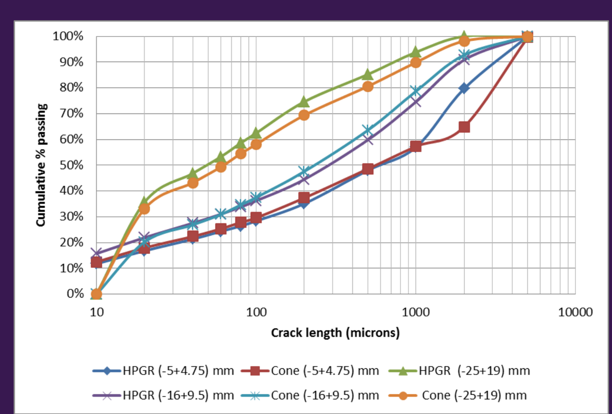

FIG 9: Crack size distributions of microwave treated particles

Discussion

Analysis of the X-ray CT images after microwave treatment shows considerable micro cracks within the cone and HPGR crushed particles of microwave treated ores, FIG 3 and 4.

The crack pattern showed interphase cracks propagating across all phases, with no evidence of preferential cracking, FIG 4 , 5 and 6.

A greater density of microwave induced cracks was observed on fine (-5+4.75) mm particles compared to the medium (-16+9.5) mm and (-25+19) mm large particles, FIG 7 and 8.

No significant difference in particle porosity was observed between the cone and HPGR crushed particles, FIG 9.

Significance of the research

X-ray CT has successfully been applied to investigate microwave induced cracks giving quantitative as well as qualitative information on the crack; pattern, distribution and volume for the first time.

Acknowledgement

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2. Ali, A.Y. and Bradshaw, S.M., (2009) 'Quantifying damage around grain boundaries in microwave treated ores', Chemical Engineering and Processing: Process Intensification, vol. 48, no.(11-12), pp. 1566-1573.