

# Microwave-assisted rock breaking modelling and application

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## INTRODUCTION

The fracturing and emolliating of rocks has traditionally been used in the process of liberating minerals from the ore. These methods however utilise a lot of energy. As a novel solution, new methods to fracture and weaken the strength of rocks are currently being investigated at the Centre for Mining Innovation. One of these methods is the application of microwave energy to weaken the strength of rocks and thereby fracture it. Microwave heating was successfully applied in the laboratories to test its efficiency in the process of liberating minerals from the ore. However, the method has not been applied underground on real ore. This work aims to investigate the effect of the application of microwave energy on real ore to fracture or emolliate rocks.

## AIM

In this work, the influence of electric field strength on the microwave treatment of ore was explored. Simulations undertaken using finite difference modelling techniques for rock samples are explained. Simulations model the microwave heating, expansion, induced fracturing and strain softening and, finally, uniaxial compressive strength to predict the effect of microwave heating on the strength of the ore material. Predictions made are validated by investigating the influence of microwave pre-treatment on the real mineral ore breakage utilising a single mode cavity.

## NUMERICAL MODELLING

Numerical modelling is undertaken using the geo-mechanical 2D finite difference modelling software application, FLAC V6.0. The software is based on the finite difference method of solving the partial differential equations which governs the overall behaviour of the material being modelled. In the default mechanical mode, the calculation process involves solving the equation of motion by stepping in time to resolve the applied forces into velocities and then strain rates at distinct nodes within the model, until a steady static state is obtained. The mechanical module allows the simulation of the transient forces in materials and the subsequent development of the induced displacements and stresses.

## ORE CHARACTERISATION

- The specimen is a rectangular slab approximately 95 mm long X 65 mm wide X 20 mm thick. It is composed of pyrite, cement and sand particles.
- The specimen is approximately 85 mm long X 65 mm wide X 35 mm thick, and is sawn off a large diameter borehole core. It is a clast-supported, medium pebble conglomerate from the Witwatersrand Supergroup.

## MICROWAVE TREATMENT

Microwaves are generated using a 1.9 kW generator operating at 2.45 GHz. This is connected by a rectangular WR 340 single mode microwave applicator shown in **Figure 1**. The applicator is used with a fixed or sliding short circuit at the back to place the maximum field on the sample. A 3-stub tuner may be fitted between the applicator and the generator to provide maximum energy transfer to the rock sample. The applicator can tolerate temperatures of 800–1200 °C because of the stainless steel construction.

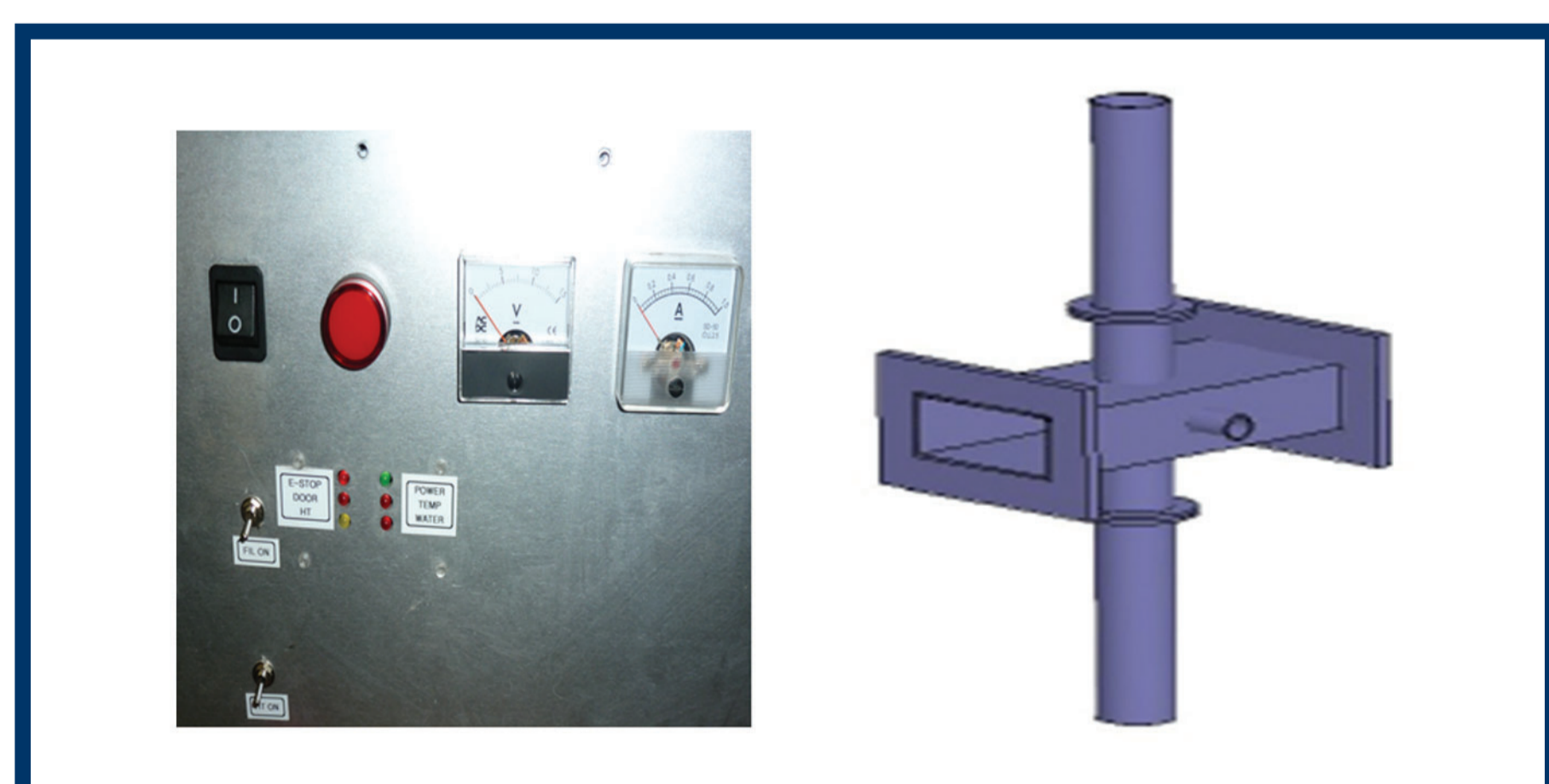


Figure 1: Microwave generator and applicator

## EXPERIMENTS

Ore a) was modelled with pyrite and sandstone in FLAC, as shown in **Figure 2a**. In simulations, pressure was applied, and induced displacements and stresses predicted (**Figure 2b**).

Tests were undertaken to determine the effects of changes in power density and exposure time on the stress fields and weakening of the samples during microwave heating. For modelling purposes, four different power levels were applied to the simulations ranging from 0.14 to 1.9 kW. Three different heating times were adopted, namely 1 s, 10 s and 20 s heating.

*As part of the ongoing development of novel mining methods, the CSIR has developed alternative methods to break rocks. In this case, we show the application of microwave energy to break narrow tabular ore bodies.*

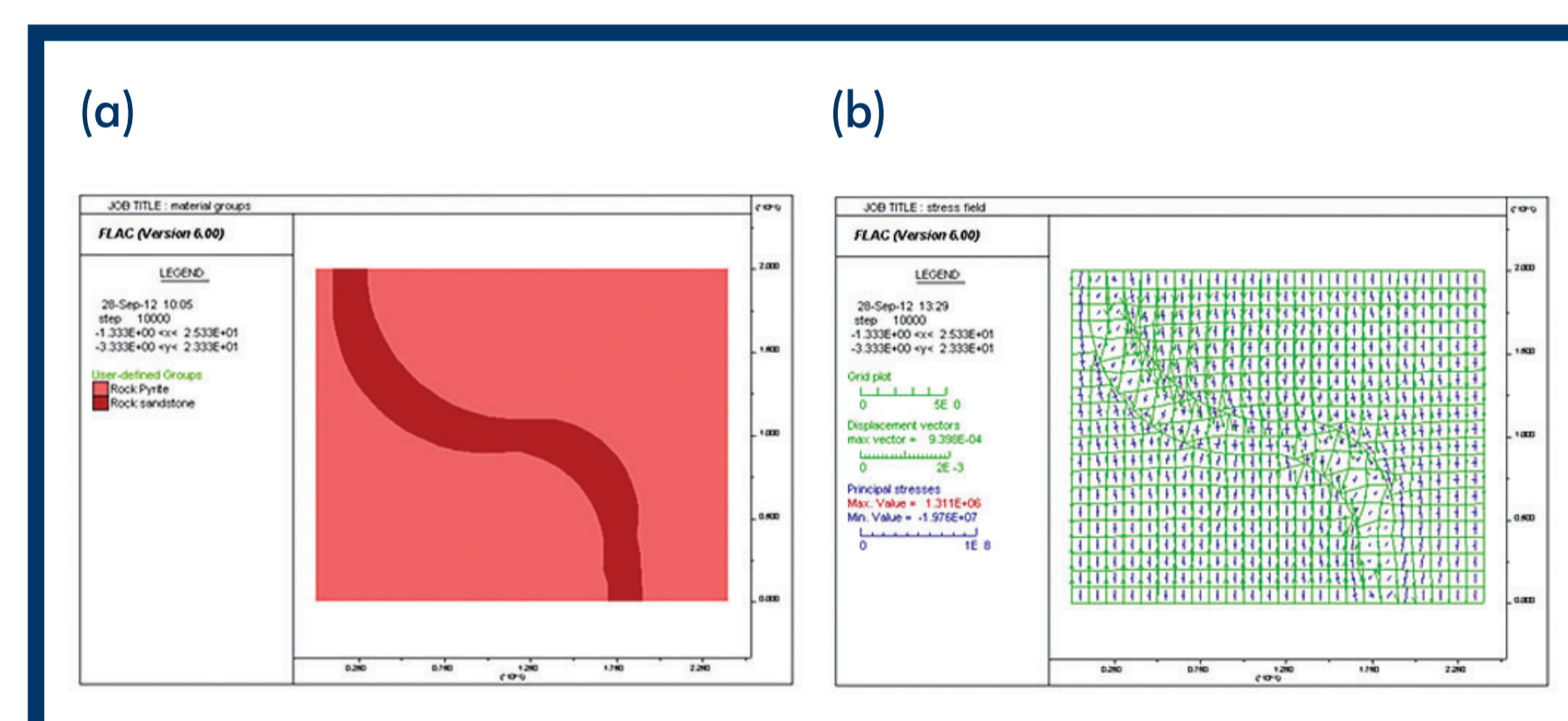


Figure 2: a) Plot showing material groups and b) Plot showing stress fields

## RESULTS AND CONCLUSION

The two ore samples both developed fractures at 10 s. The power applied on ore a) was 0.54 kW and the measured temperature was 72.3 °C. Ore b) developed fractures at a temperature of 115.9 °C and the applied power was 1.63 kW. The simulated brittle failure in **Figure 2b** for ore a) follows a pattern more or less like the fracture developed when the ore was heated with microwave energy (**Figure 3**). The FLAC numerical method proved to be effective in simulating brittle failure in rocks.

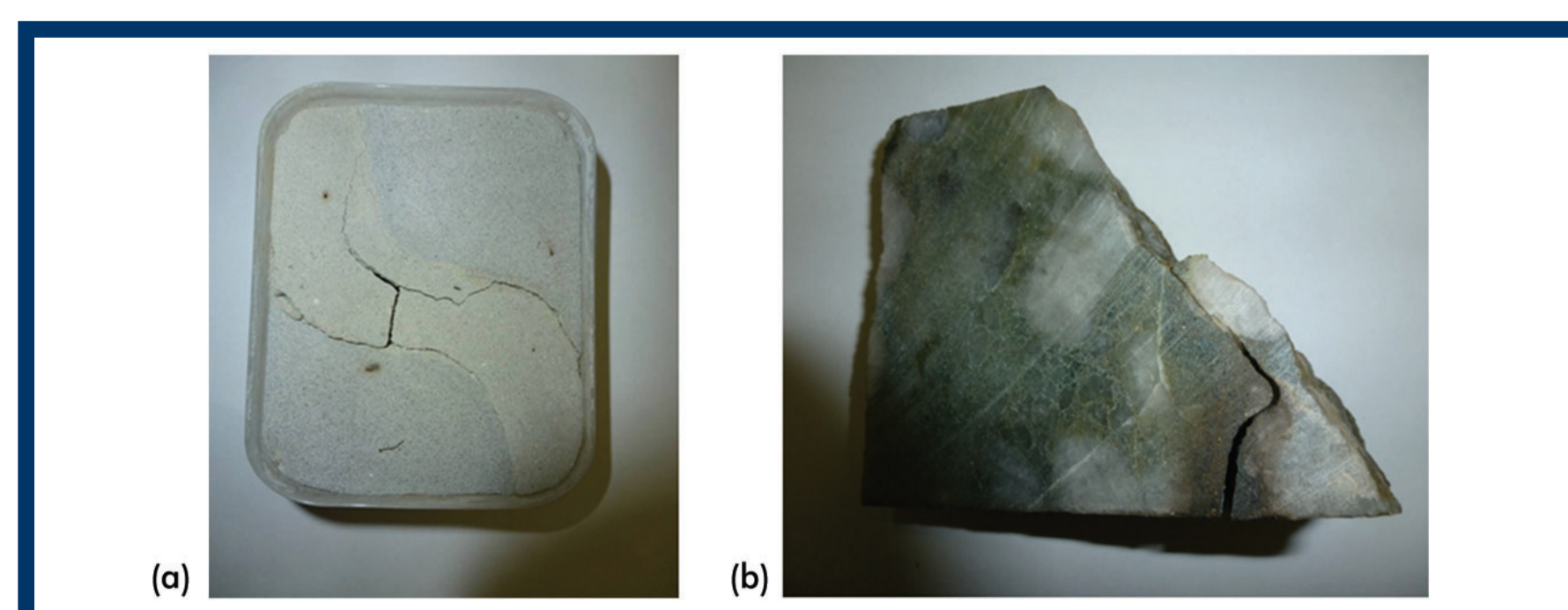


Figure 3: Rocks fractured with microwave energy

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