Some geological and geophysical aspects in electric rock breaking

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* Now with SSI

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Introduction

CMI Carlow Road Campus

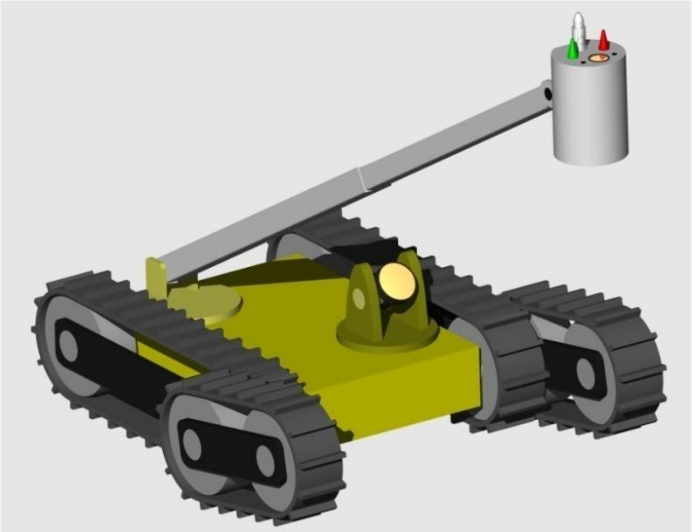
CMI focus areas

Real time risk management

Human factors in mining

Novel mining methods
autonomous narrow reef miner (<50 cm high)

Rock breaker (non-explosive; ore processor)
3D scanner – mapping
Roof sounding device
Underground navigation



How rock breaks

Elsburg reef samples

From: Ilgner (2006)

Under tension

tensile strength – force needed to pull the rock until it fails and fractures develop

Under compression

compressive force applied to a rock until failure is induced and the rock fractures

Important : rocks are much weaker under tension (10 times) than under compression

Rock-breaking methods

Great Noligwa Mine – air drill

Photo: courtersy AngloGoldAshanti

(1) Localised force inclined to a rock face
e.g. chisel bit

(1) Compressive stress applied parallel to a free face

High stresses behind free face
Thermal expansion

(2) Forces inside a cavity
drill and blast method

(3) Compression across a rock fragment
secondary rock-breaking - comminution

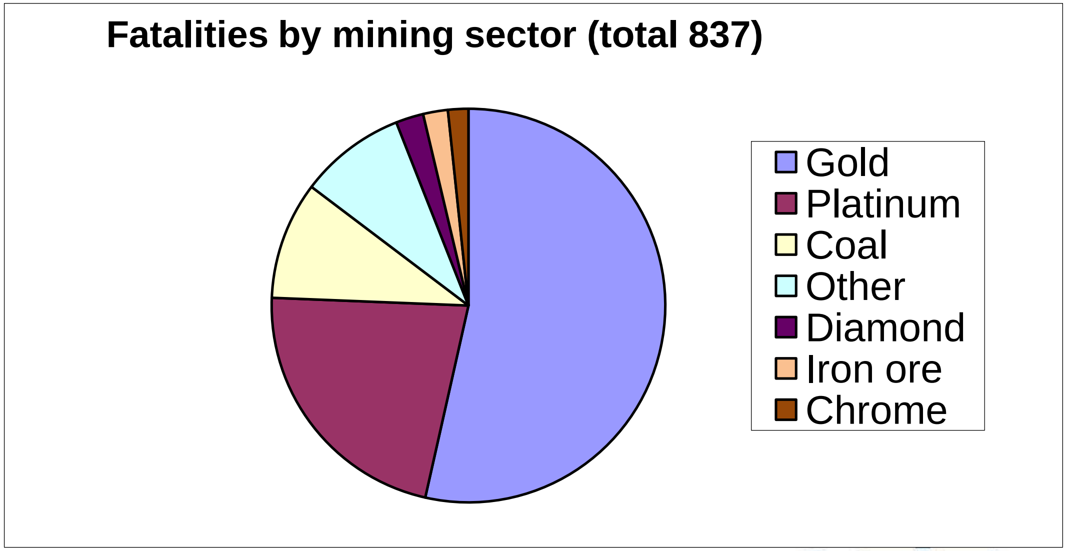
Cook and Joughin, 1970

Why non-explosive rock breaking?

Health and Safety – underground environment is noisy and dusty; away from high risk areas

Labour intensive and time consuming – long mining cycle

Integrate with autonomous narrow-reef miner



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Research work in non-explosive rock breaking

Impact ripper (Willis et al., 2001)
Water pulse rock breaker

Cheapest – drill and blast

Other technologies

- Impact ripper
- Drilling out the reef
- Mini-disc cutting
- Water pulse rock breaking
- Controlled foam injection
- Diamond wire cutting
- **Electrical methods**

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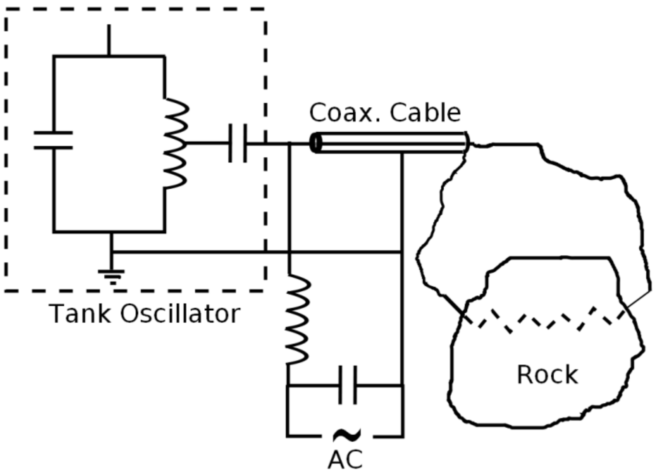
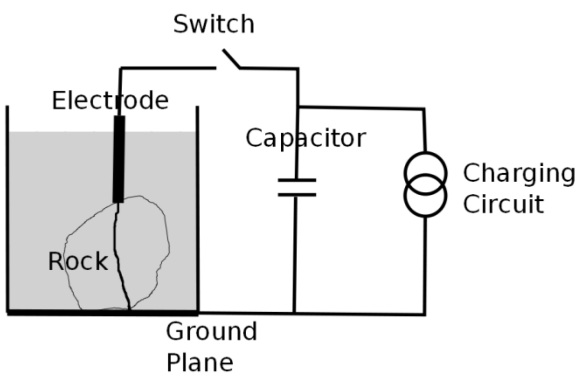
Electrical methods in rock breaking





Types

(a) Alternating Current
low voltage (700-1200 V), high frequency (250 kHz)

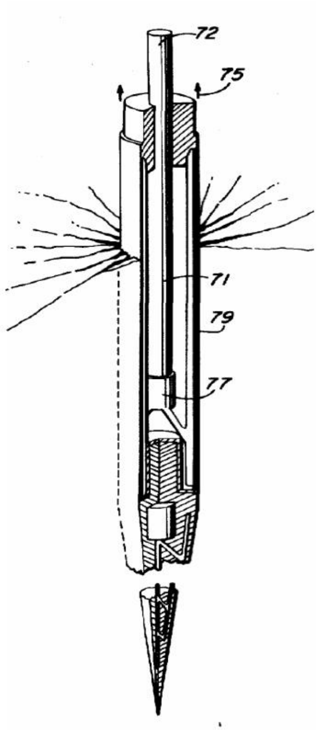
(a) Direct Current
very high voltage (100-400 kV)

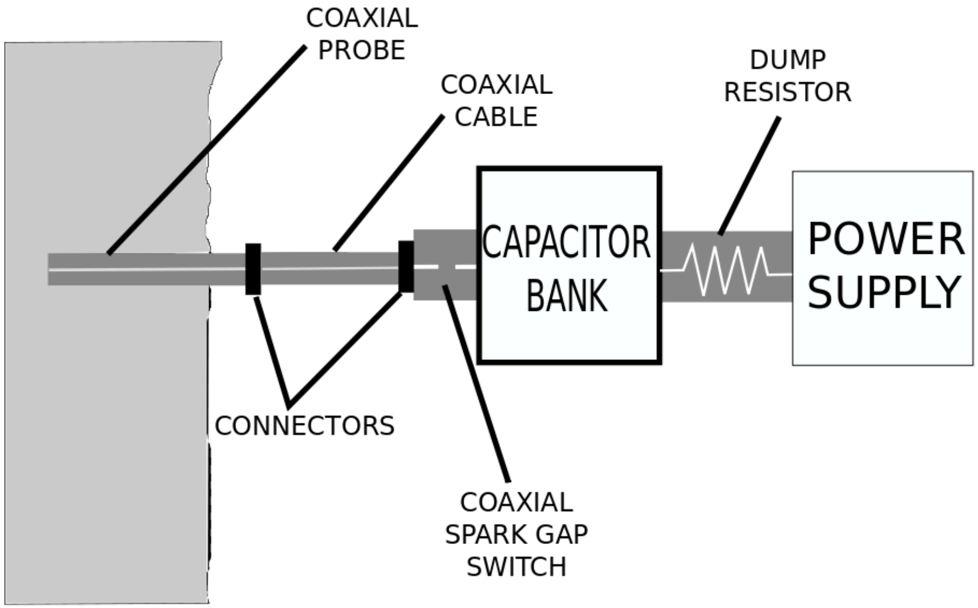
(a) Submerged discharge (under water)
electrode combustion
plasma blasting
pulsed discharge streams

(d) Thermal methods
rock melting

Other methods – submerged discharge, rock melting (plasma)

Rock melting drill





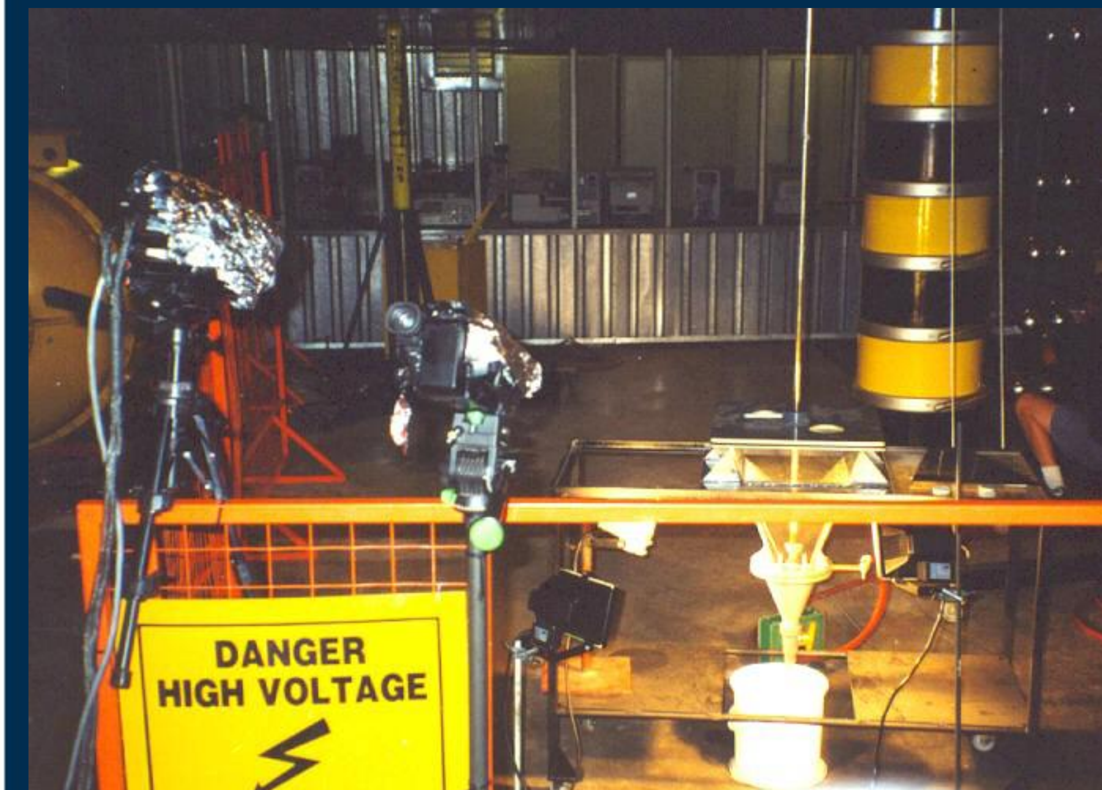
Plasma blasting system

Previous research work in electric rock breaking by CSIR

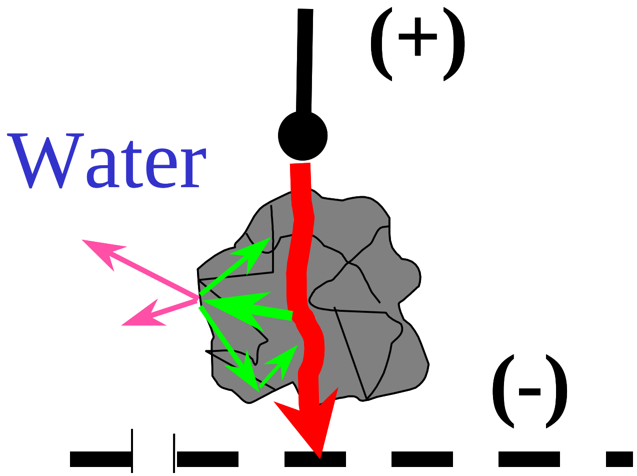
Marx generator transformer

From: Ilgner (2006)

High voltage



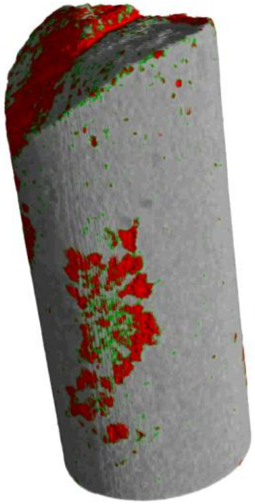
Single –shot high voltage electric rock breaking (2003)



230 kV fast ramp up,
(about 1 MV / µs)

48 mm diameter round core sample:
split right through the middle by plasma

Present research



Neutron tomography image core

AIM : to understand the science behind electric rock breaking

Experiments

AC test rig - low voltage – high frequency

range of different rock types

Numerical modelling

no robust models exist at present

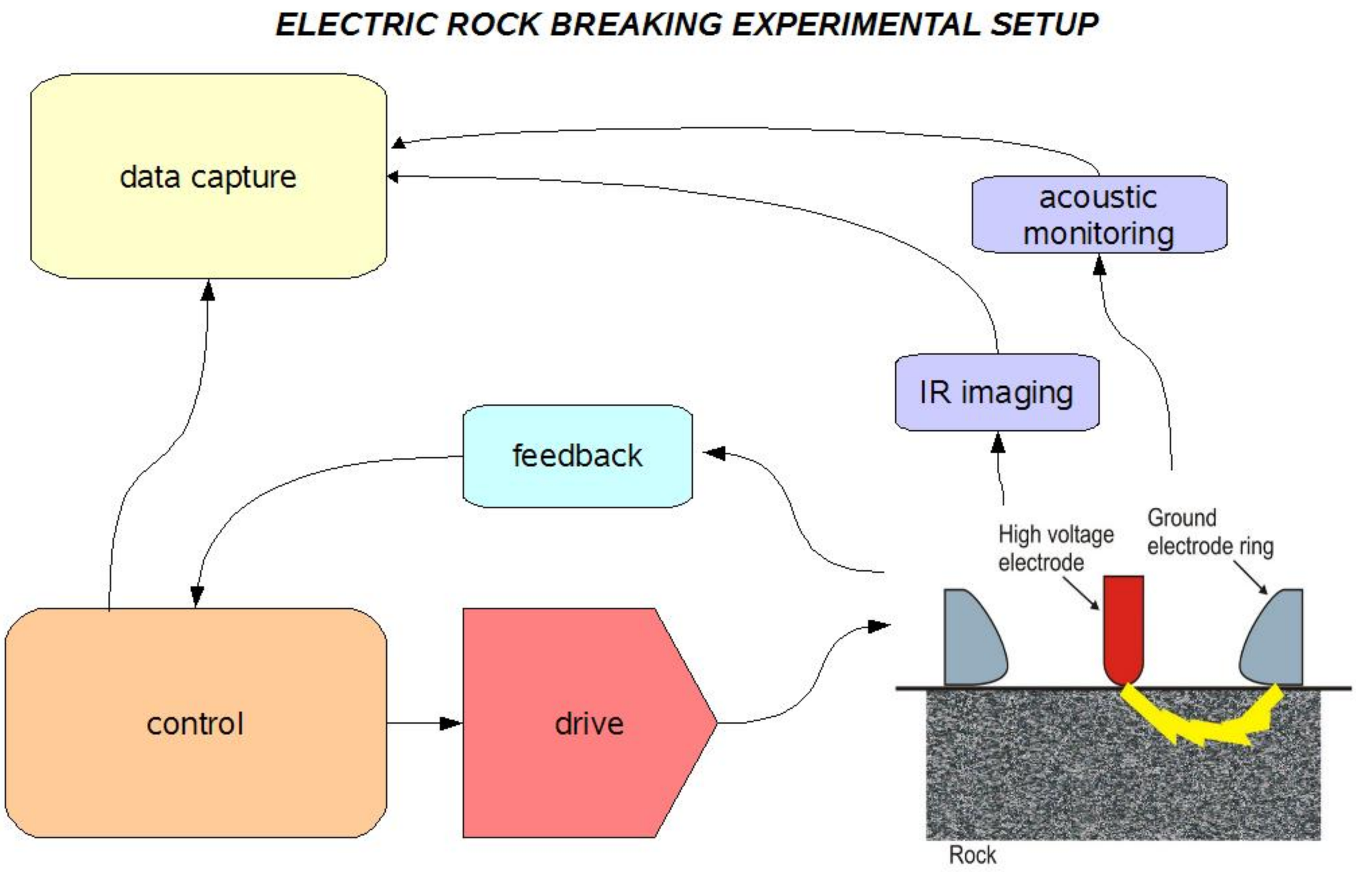
Will be novel if successful

Test Rig

Johannesburg

Pretoria

Experimental setup



Rock types tested

Main Reef Leader conglomerate

Witwatersrand conglomerate reef
quartz, pyrite

Bushveld Complex pyroxenite and chromitite
pyroxene, feldspar, chromite, sulphide

Rooiberg tin ore
carbonate, feldspar, cassiterite, sulphide

Kimberlite
olivine, pyroxene, serpentine

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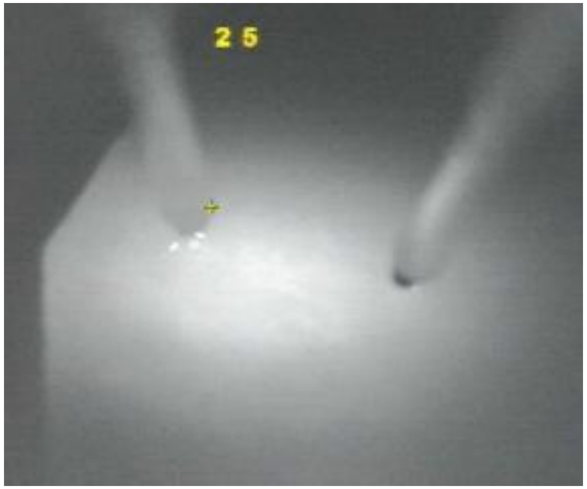
Some results

Ventersdorp Contact Reef

Infrared thermal photography - Sample 114

Witwatersrand conglomerate



Even heating

Rock fracture

Theories of why and how rocks break using electricity

Photo: National Geographic (2002)

Ongoing research

Very high voltage (DC)

analogous to lightning strikes

Lower voltage (AC)

Idea –

Rock need to be "suitably resistive" to absorb electrical power to create "hot spots"

rapid thermal expansion leads to cracking

Geological factor – rock type (mechanical properties)

From: iRocks.com (9 cm high)

Common rock-forming minerals

- quartz
- feldspar
- carbonate
- pyroxene
- amphibole
- olivine

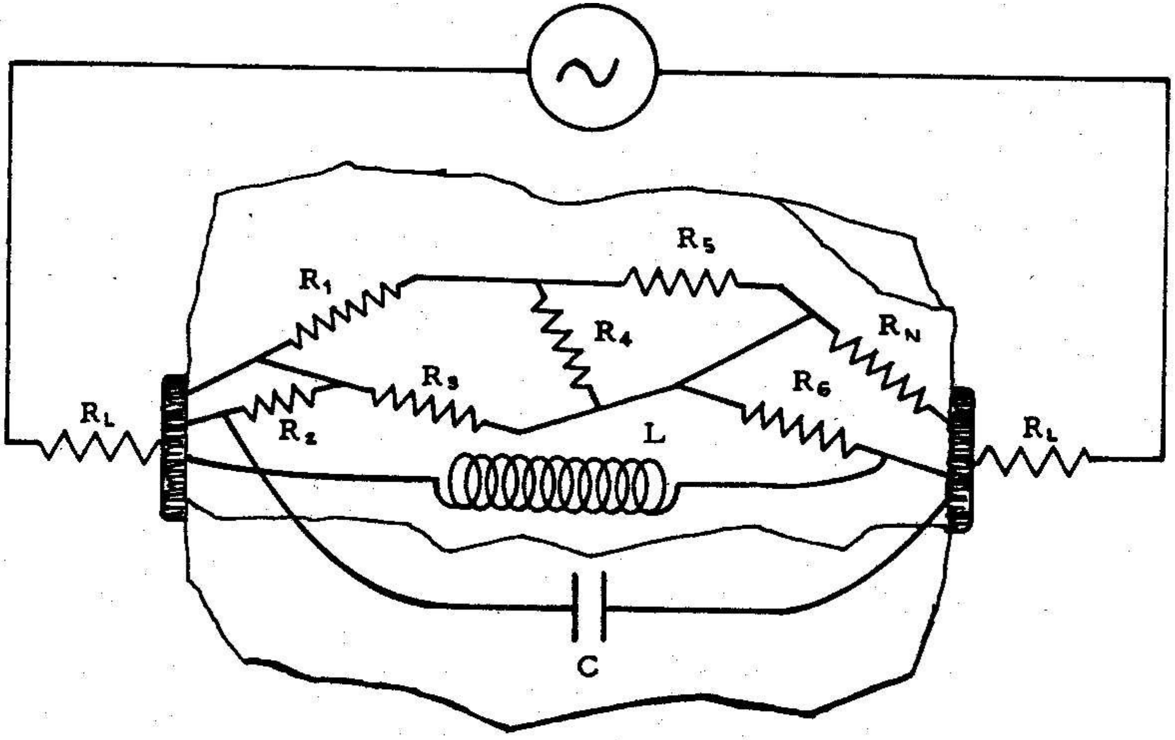
Ore mineral (minor components)

- sulphides (pyrite, chalcopyrite, galena)
- oxides (cassiterite, haematite)

Bulk compressive strength

- tensile strength

Geophysical factors



R_L Electrode contact resistance
R_1 - - R_N Ohmic resistance in the rock

L Inductance
C Capacitance

Electrical conductivity/ resistivity

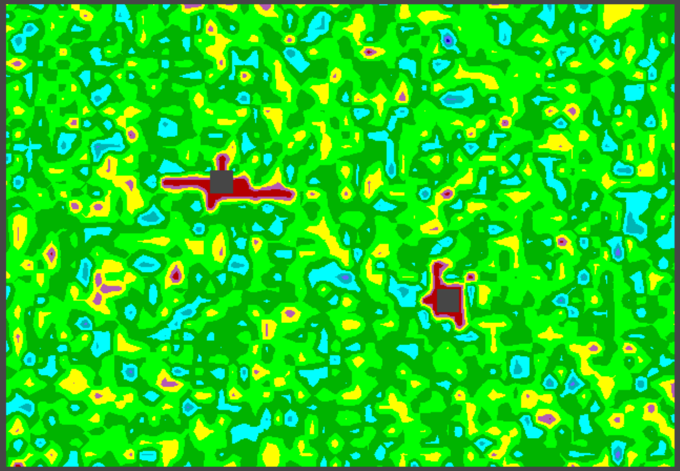
individual minerals

bulk rock

high variability

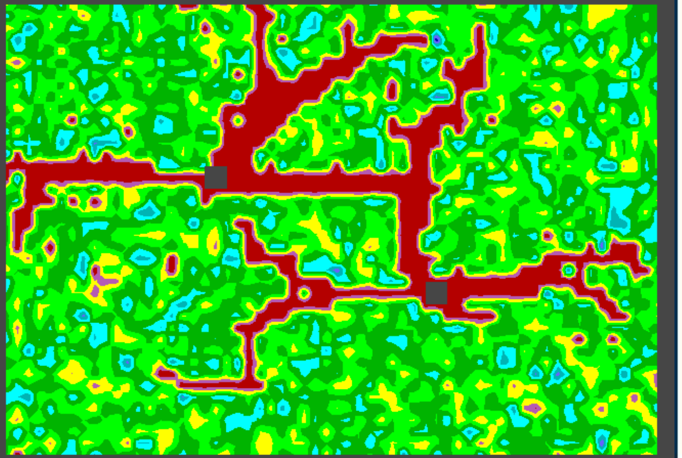
Dielectric constant

Numerical modelling

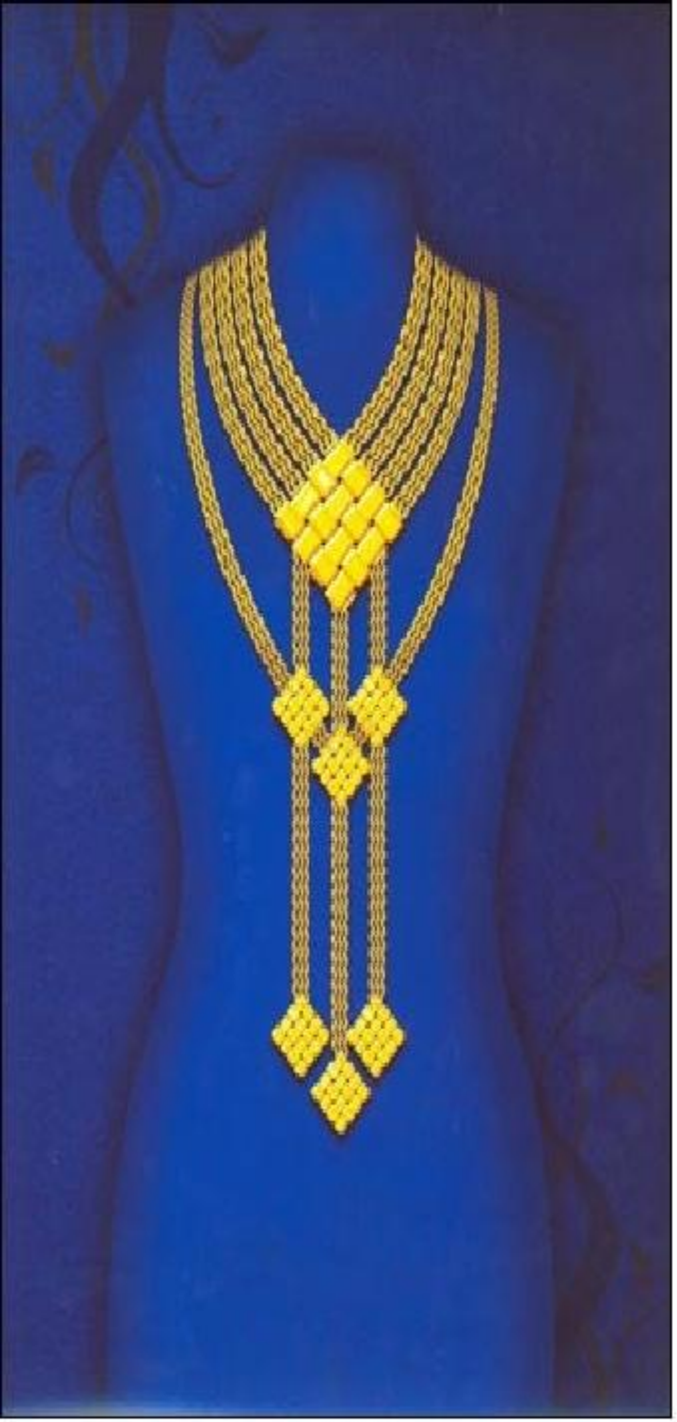


Using *FLAC* – early stage (top)

Late stage (below)



Purpose – quantify at least one mechanism that would lead to electric rock breaking



Conclusion

Geological and geophysical factors play an important role in any rock-breaking techniques using electrical power. Our research is towards understanding the science behind electric rock breaking.

This understanding would lead to a practical method to break rocks using electricity that is comparable in energy usage as drilling and blasting.

Thank you.

Questions?

