British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Aggregate Carbon Demand

The hunt for low-carbon aggregate

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Aggregate Carbon Demand

- What is Aggregate Carbon Demand?
- How to determine it?
- Laboratory testing
- What to do with the data?
- Conclusions

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Aggregate Carbon Demand?

- Carbon (or energy) consumed to produce aggregate
- Carbon : kilograms of CO_2 per tonne ($kg/CO_2/t$)
- Energy : kilowatt hours per tonne (kWh/t)

Mineral product	**Carbon *** $kg/CO_2/t$	**Energy #** kWh/t
Ready Mixed Concrete	0.95	1.76
Sand & Gravel	4.28	8.3
Crushed rock	4.32	9.7
Asphalt	34.4	98.11

***** Carbon data from Mineral Products Association (MPA) 2009 Sustainable Development Report.

Energy data from Tarmac 2009 Sustainable Development Report.

All data for 2008 calendar year.

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Drivers for carbon reporting

International

- UN Framework Convention on Climate Change (1994), incl. the Kyoto Protocols (2005)
- Green House Gas Protocol Initiative (1998)
- UN Global Compact (2000)
- Sustainability Reporting Guidelines (G3) (2006)

UK

- Climate Change Levy; Climate Change Agreement (2001)
- Carbon Reduction Commitment (CRC) Energy Efficiency Scheme (Climate Change Act 2008)
- The Strategy for Sustainable Construction (DECC/ Industry)
- Framework Standard for Responsible Sourcing of Construction Materials (BRE, 2009)

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How is it currently calculated?

- Energy audits, survey and modelling of production including blasting, processing and other operations
- Plant analysis software includes JKSimBlast & JKSimMet; AggFlow; and Bruno
- Carbon conversion factors (kg/CO_2 per kilowatt hour)*:
  - National Grid electricity: 0.54303
  - Industrial coal: 0.30794
  - Fuel oil: 0.26530
  - Gas oil: 0.25215
  - Natural gas: 0.18358

***** Carbon data from Defra / DEC GHG Conversion factors: www.defra.gov.uk/environment

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Energy efficiency

- Production optimisation to reduce energy/ carbon consumption
- Mine-to-mill optimization: http://www.jkmrc.uq.edu.au

  Luck Stone quarries (Bealeton, Virginia & Pittsboro, N Carolina, USA) achieved energy reduction up to 5% (mainly through blast redesign)

Process stage	**Luck Stone**	**Mine-to-mill**
Primary (Jaw crushers), kWh/t	0.35	0.29
Secondary (Cone crushers), kWh/t	0.26	0.24
Tertiary (Cone crushers), kWh/t	1.17	1.05
Total, kWh/t	1.77	1.57

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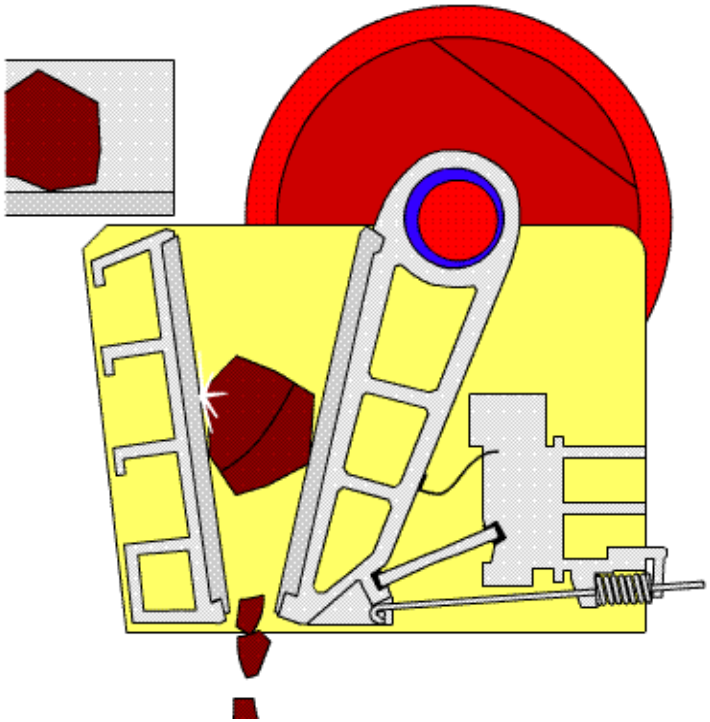

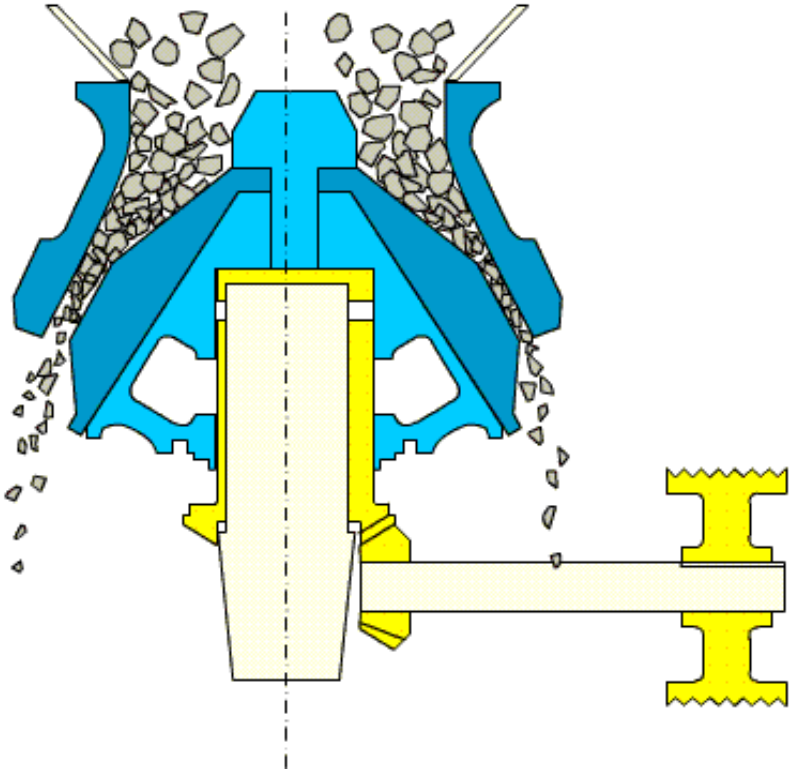

Jaw Crusher

www.aggdesigns.com/Jaw-Crusher-info.htm

Cone Crusher

www.aggdesigns.com/Cone-Crusher-info.htm

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Aggregate Carbon Research

- Carbon & energy data is from existing operations
- Efficiency plays a part in optimising production and reducing energy & carbon consumption
- How about looking for ‘low-energy’ resources, the same way we look for ‘high-quality’?
- Classification of resources based on the likely ‘energy’ or ‘carbon’ demand is a possibility
- BGS research in its early days

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Testing

- Aggregate Crushing Value (ACV)
- Aggregate Impact Value (AIV)
- Unconfined/ Uniaxial Compressive Strength (UCS), point load test, Brazilian test, triaxial test, ring shear test and Schmidt Hammer
- Bond Crushing Work Index (“Crushability”)
- Bond Rod Mill / Ball Mill Work Index (“Grindability”)
- Ultrasonic testing

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Crushability testing

- Modified Bond Work Index (Wi) test
- Twin pendulums / swing hammers,10kg each
- Drop height, 0.5m
- Specimen size, 60mm x 60mm x 60mm
- Potential energy up 95.7 Joules
- Impact pressure up to 0.5MPa
- Compared to 2MPa for a jaw crusher and up to 40MPa for a cone crusher

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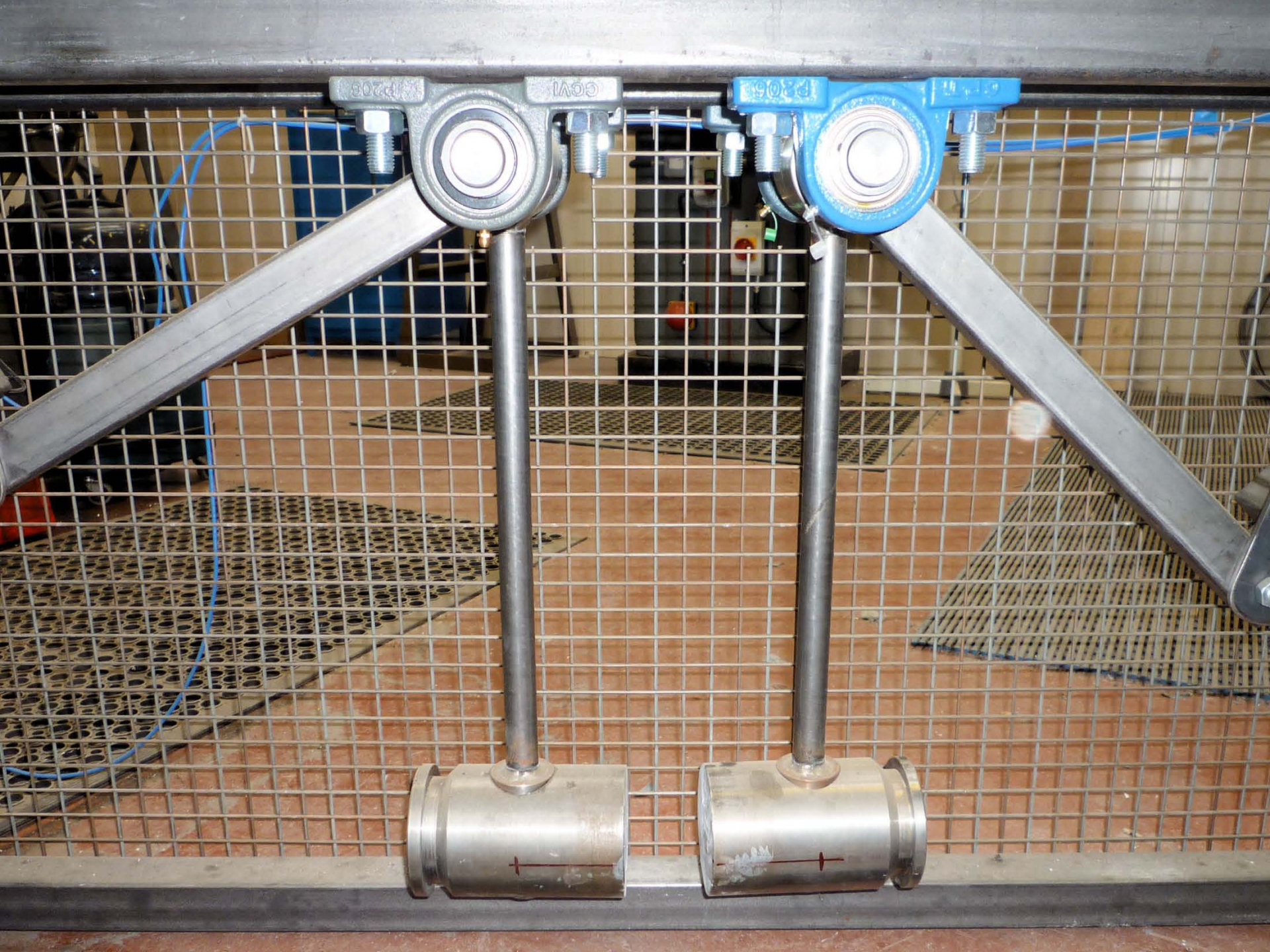

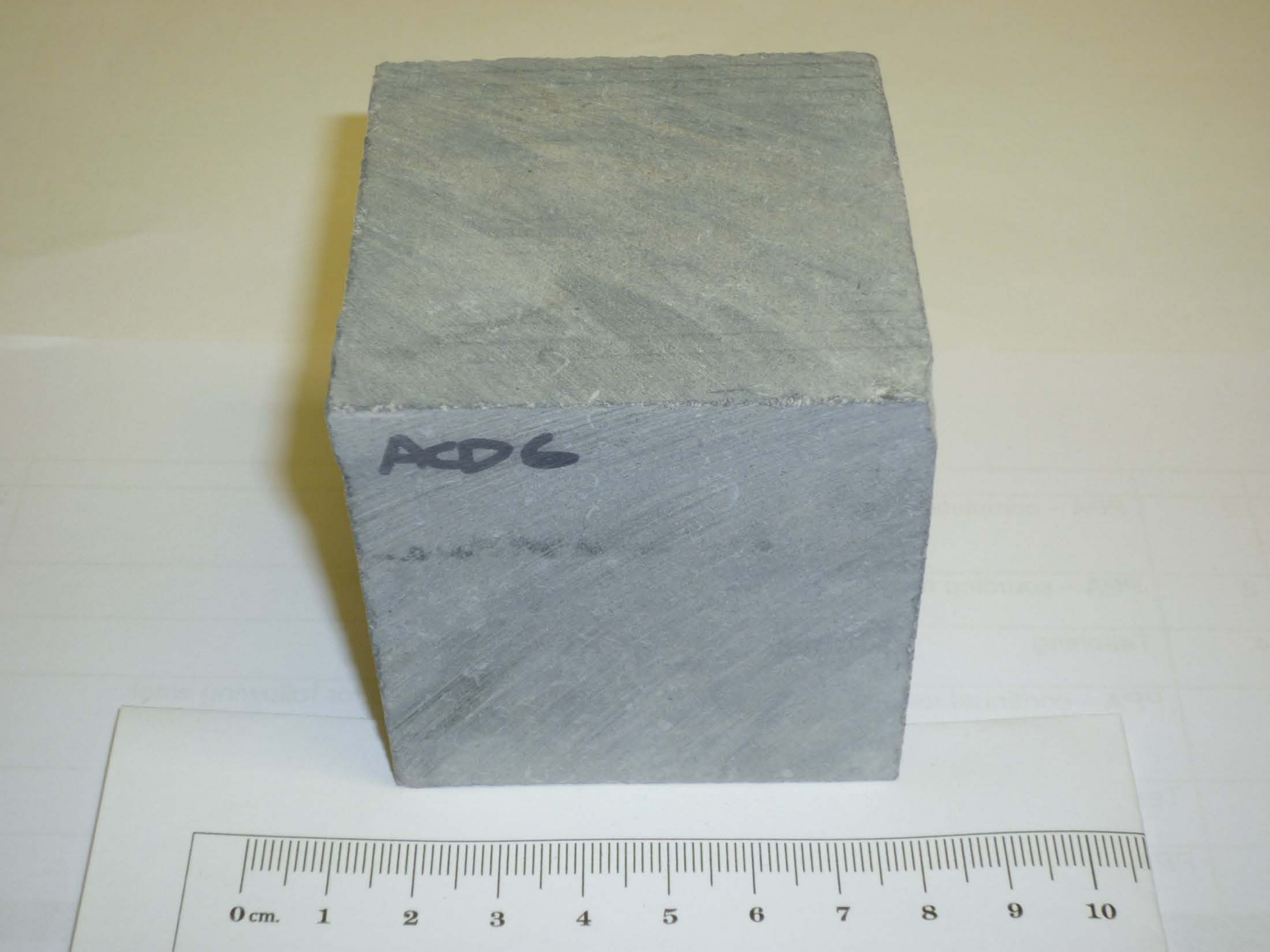
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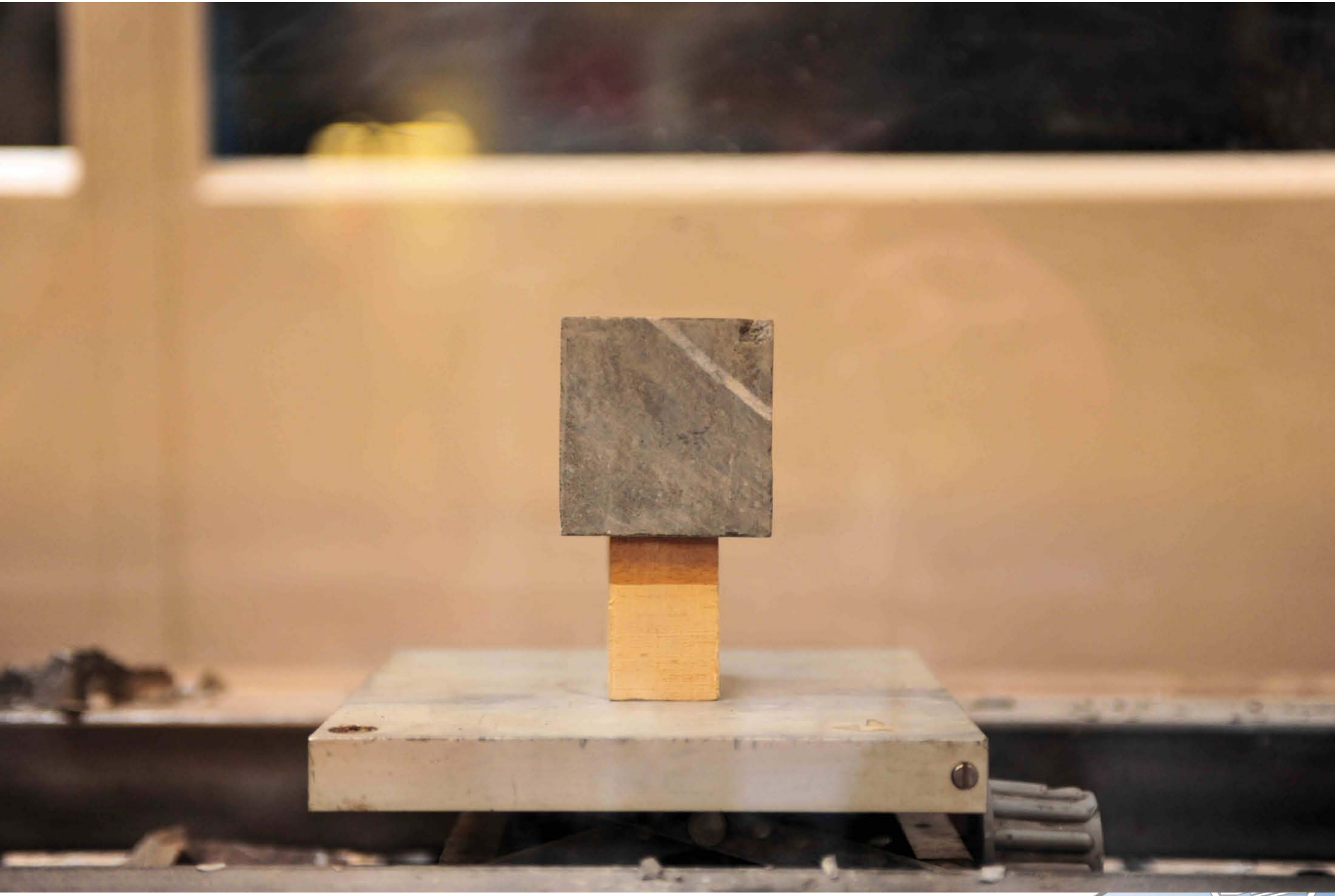

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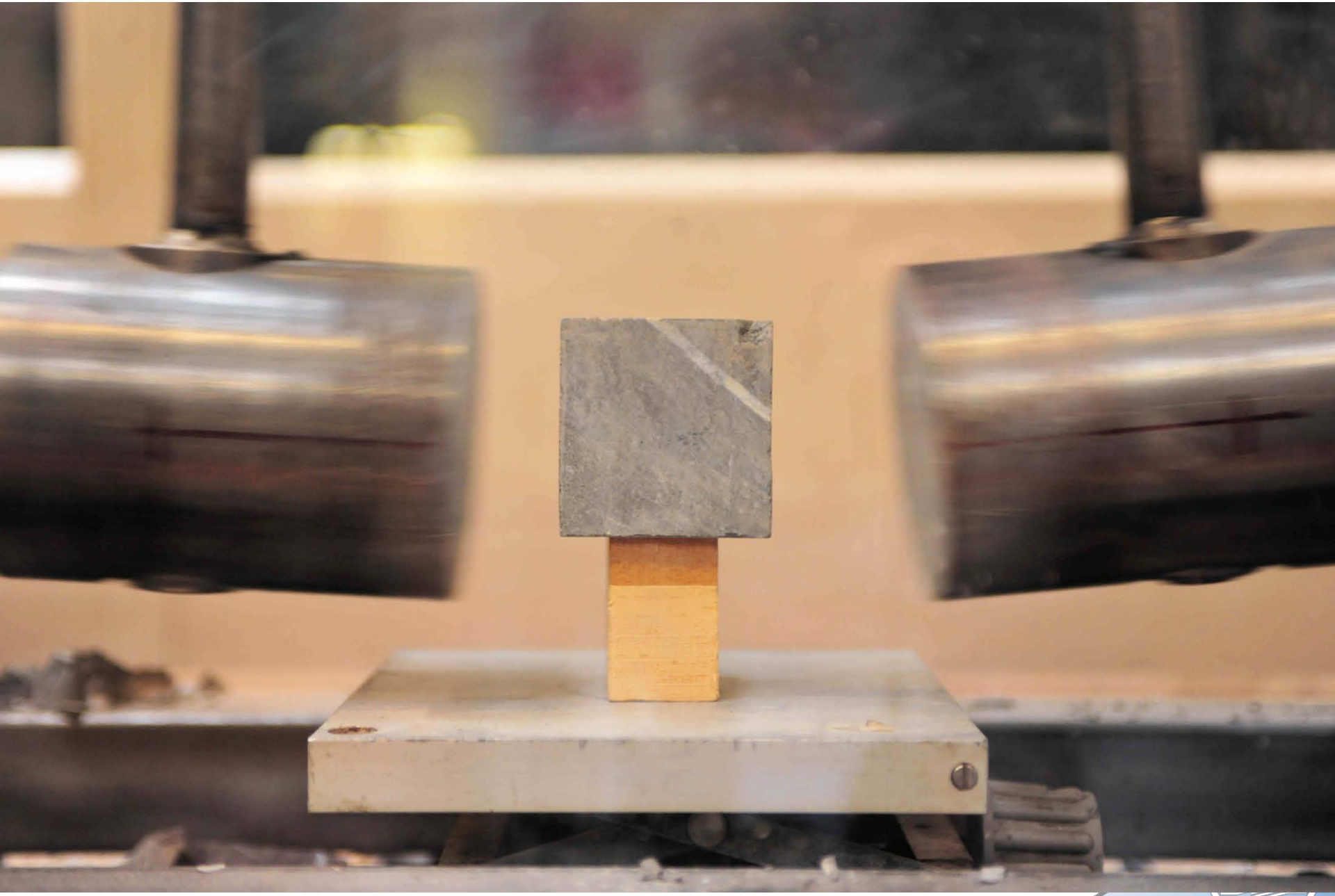

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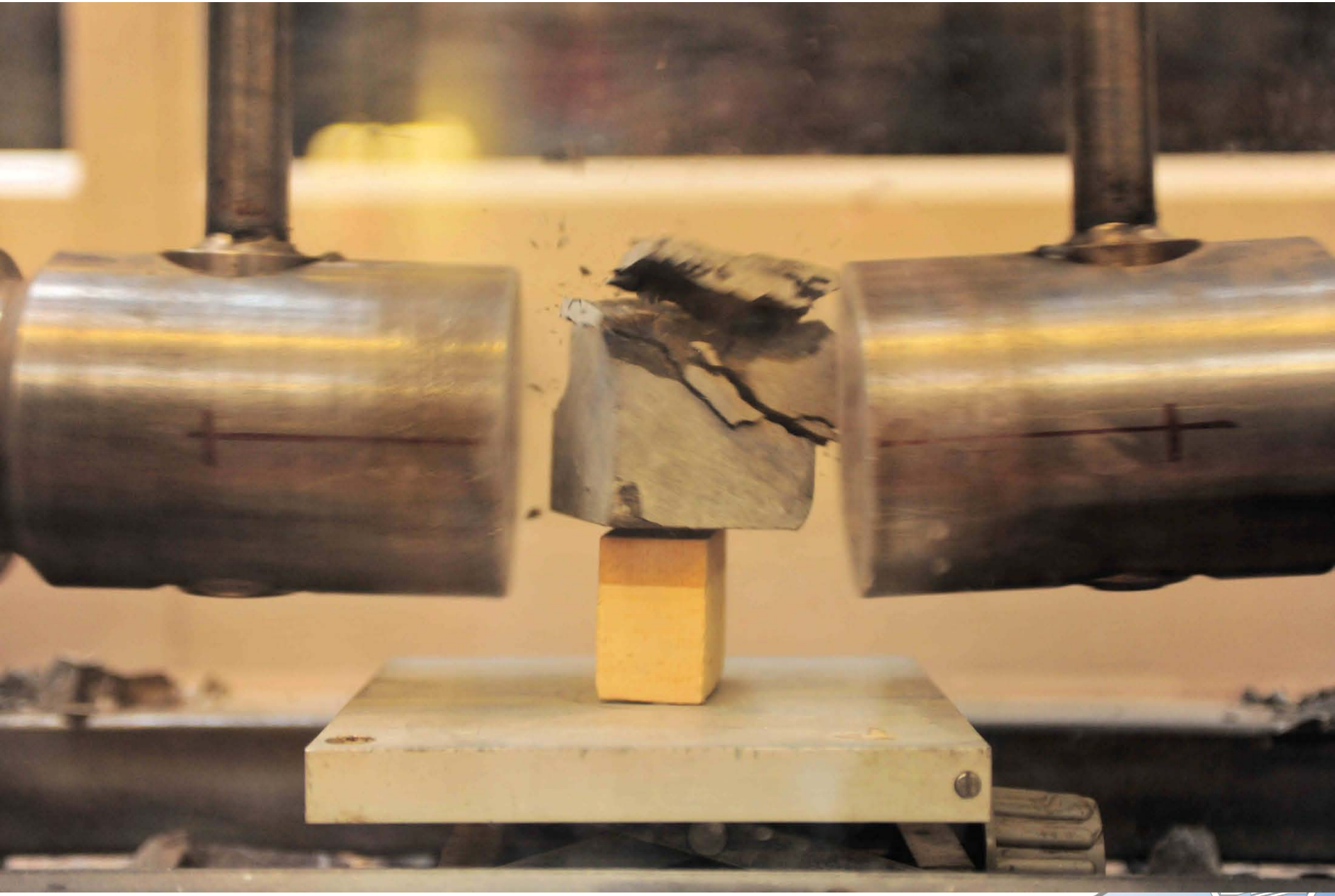

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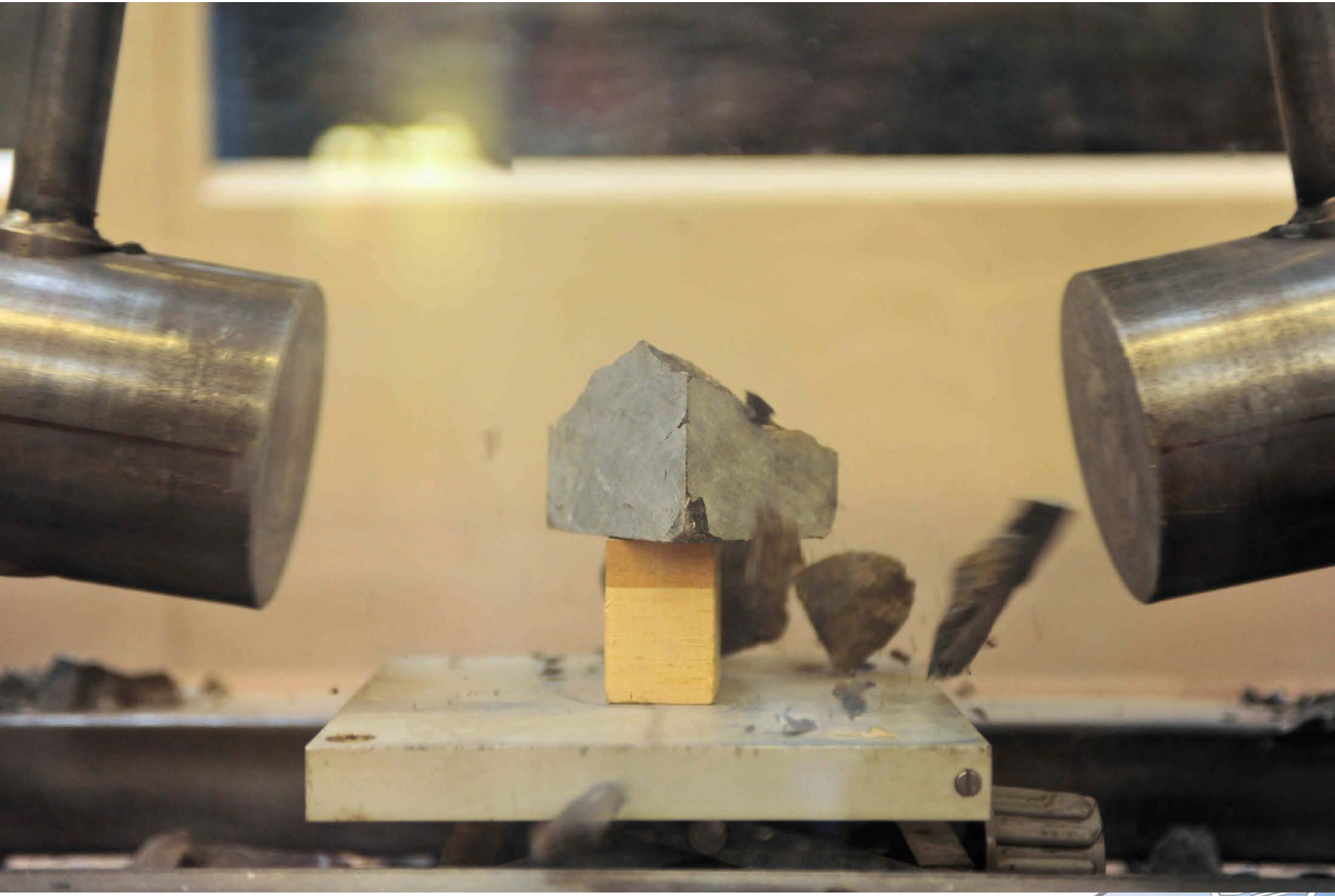

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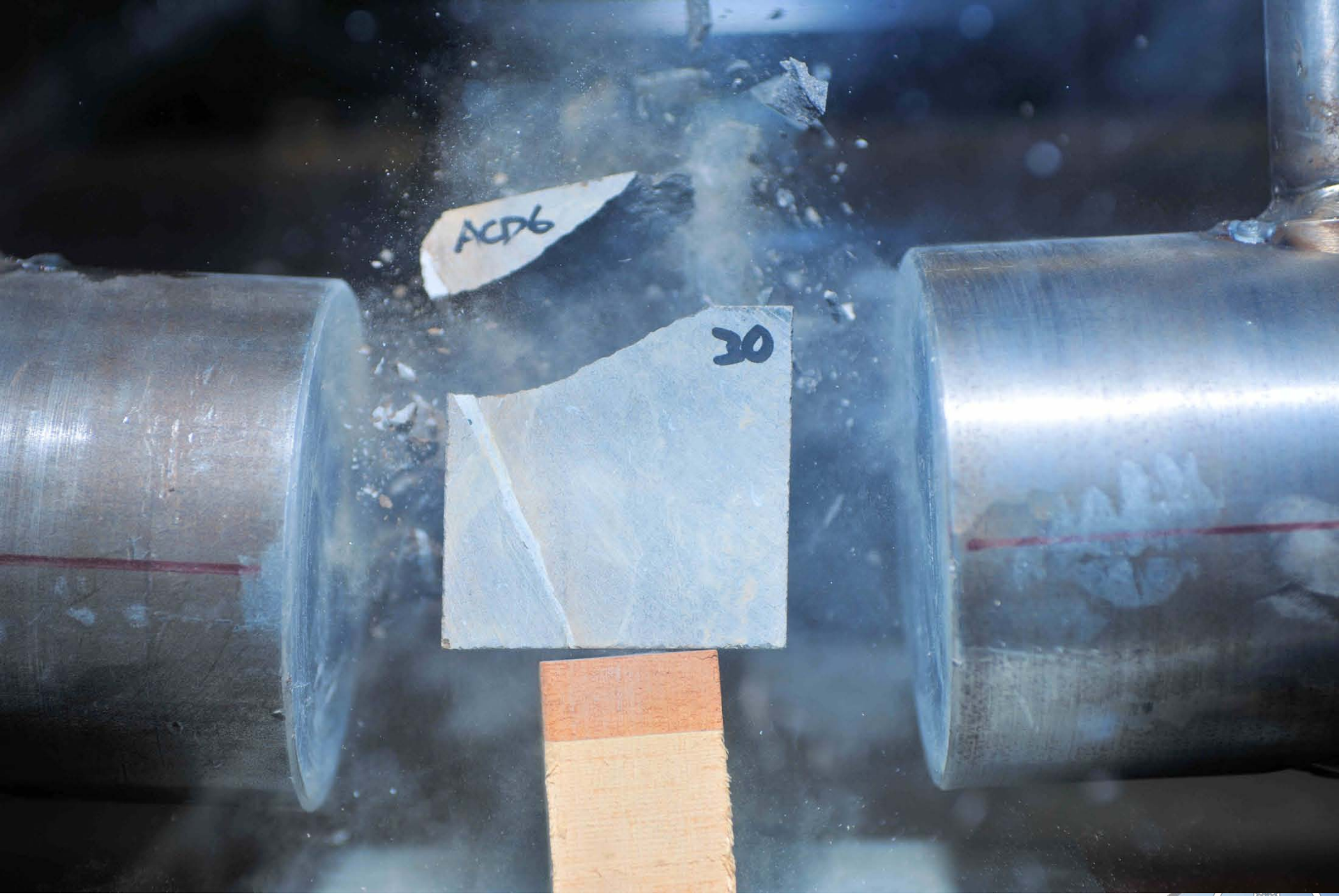

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Crushability testing of limestone

Calculation of Impact Crushability Energy:

$$E_p = m.g.h$$

E_p = Potential energy (Joules)

m = Mass of the hammers (Kilograms)

g = Gravitational constant (metres per second squared)

h = Height of the hammers (meters)

1 kilowatt hour (kWh) is 3.6 Megajoules (MJ)

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Test data

Quarry	**No of tests**	**Average** (kWh/t)	**Max** (kWh/t)
1	n/a	n/a	n/a
2	1	0.044	0.044
3	2	0.013	0.017
4	8	0.036	0.061
5	10	0.045	0.060
6	9	0.028	0.053
7	14	0.033	0.079

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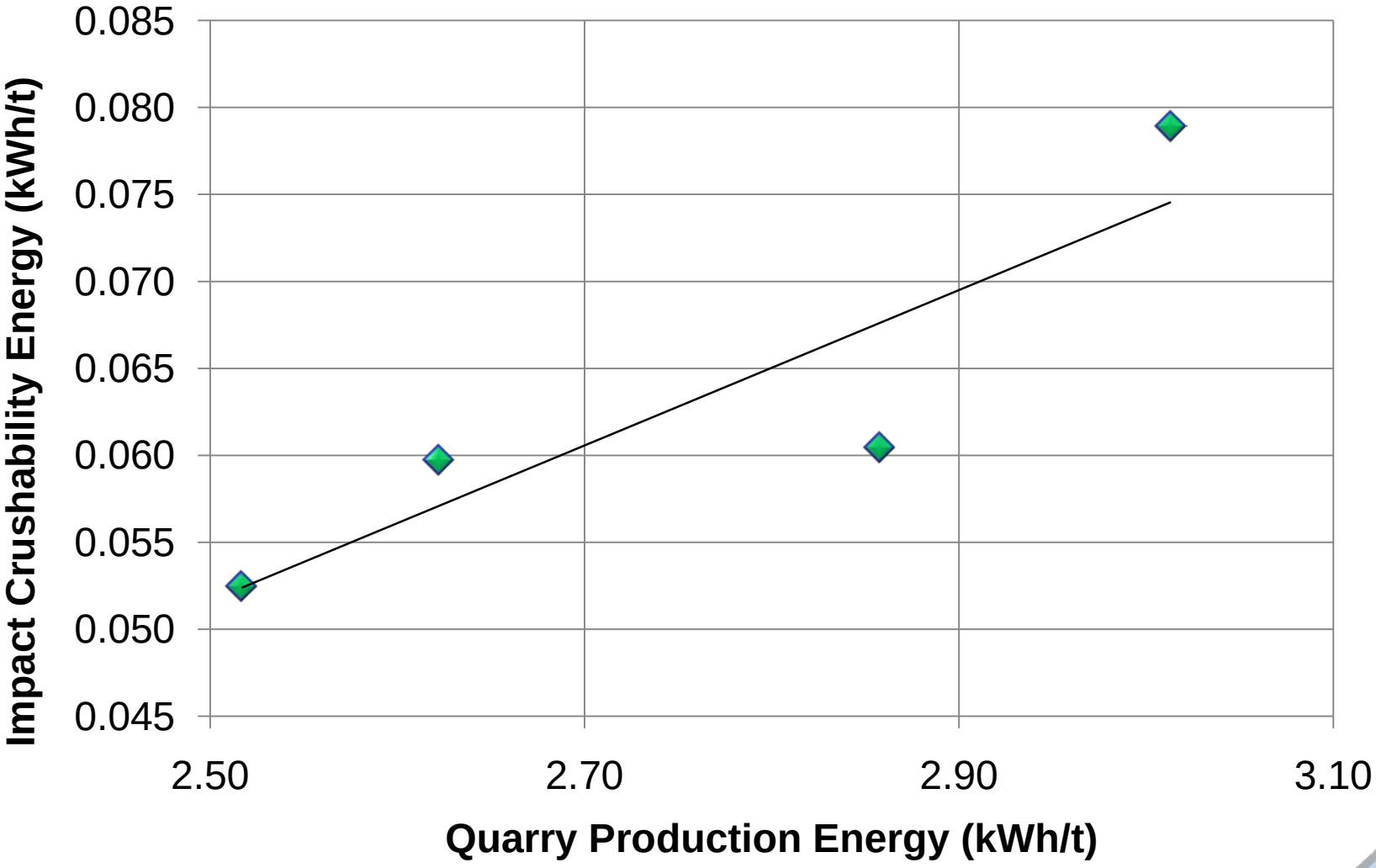
Aggregate Carbon Demand test data



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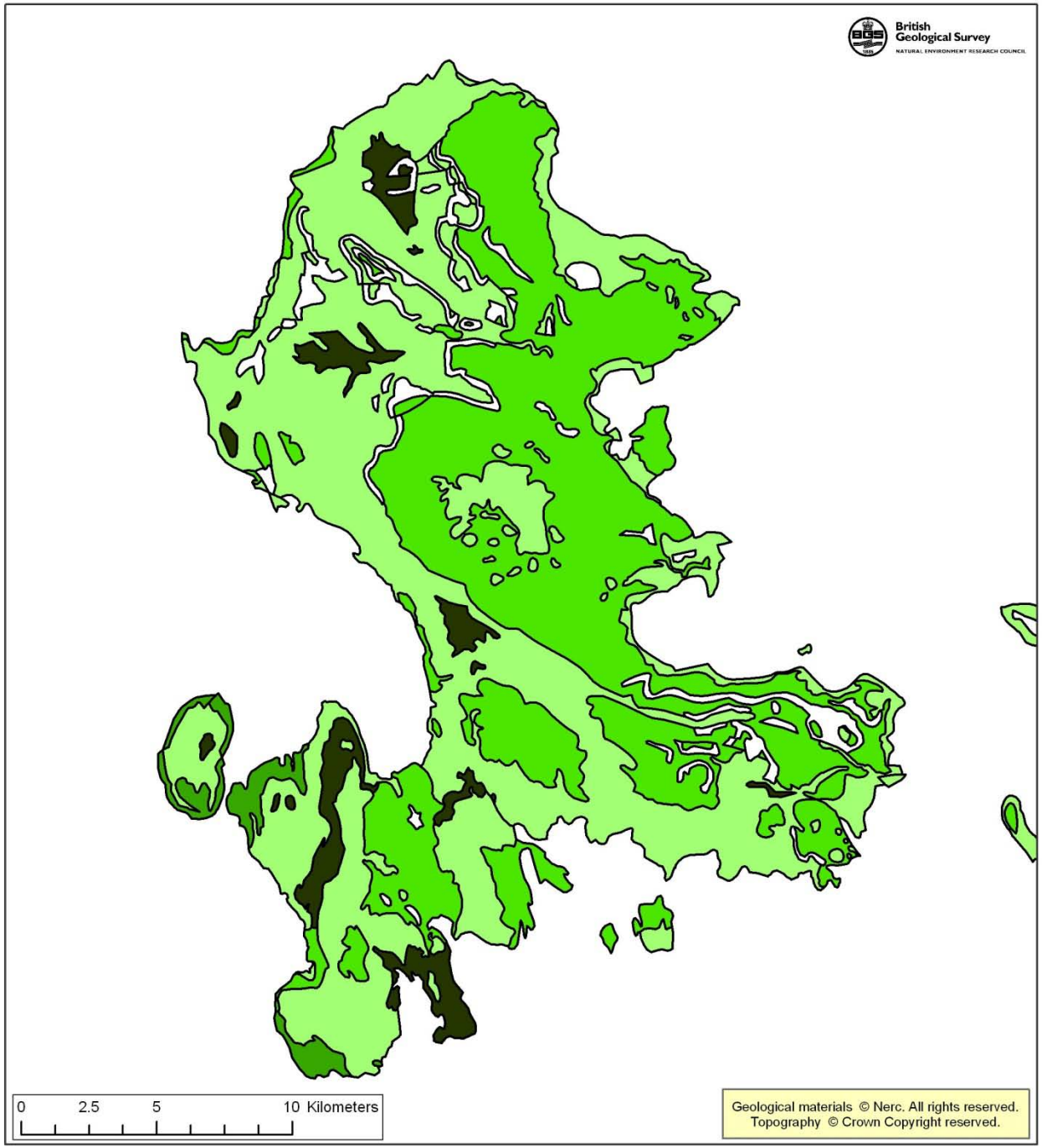
Aggregate Energy Resource Map

(Mock-up)



Rock unit	Energy (kWh/t)
	High (> 0.08)
	Medium (0.06 – 0.08)
	Low (0.04 – 0.06)
	Very low (< 0.04)

Conclusions

- Energy is likely to become more significant in resource use
- Efficient extraction & processing is only part of the equation
- Low-energy resources will be more favoured
- Future research on Aggregate Carbon Demand will include:
  - Greater number of samples
  - Different rock types
  - Improved measurement of potential energy
- If you are interested in this research please contact me…

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Thank you for your attention

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