

Predicting the Durability of Basic Crystalline Rocks for use as Road Construction Materials

CSIR R&I Conference

Built Environment

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Fellow

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Introduction

- Roads comprise more than most users normally appreciate
- Can cost anything from R300k to R3 or R4 m/km
- We can't afford too many things going wrong
- This project looked at one of the specific problem areas
- Hopefully mechanisms for overcoming this problem have been identified



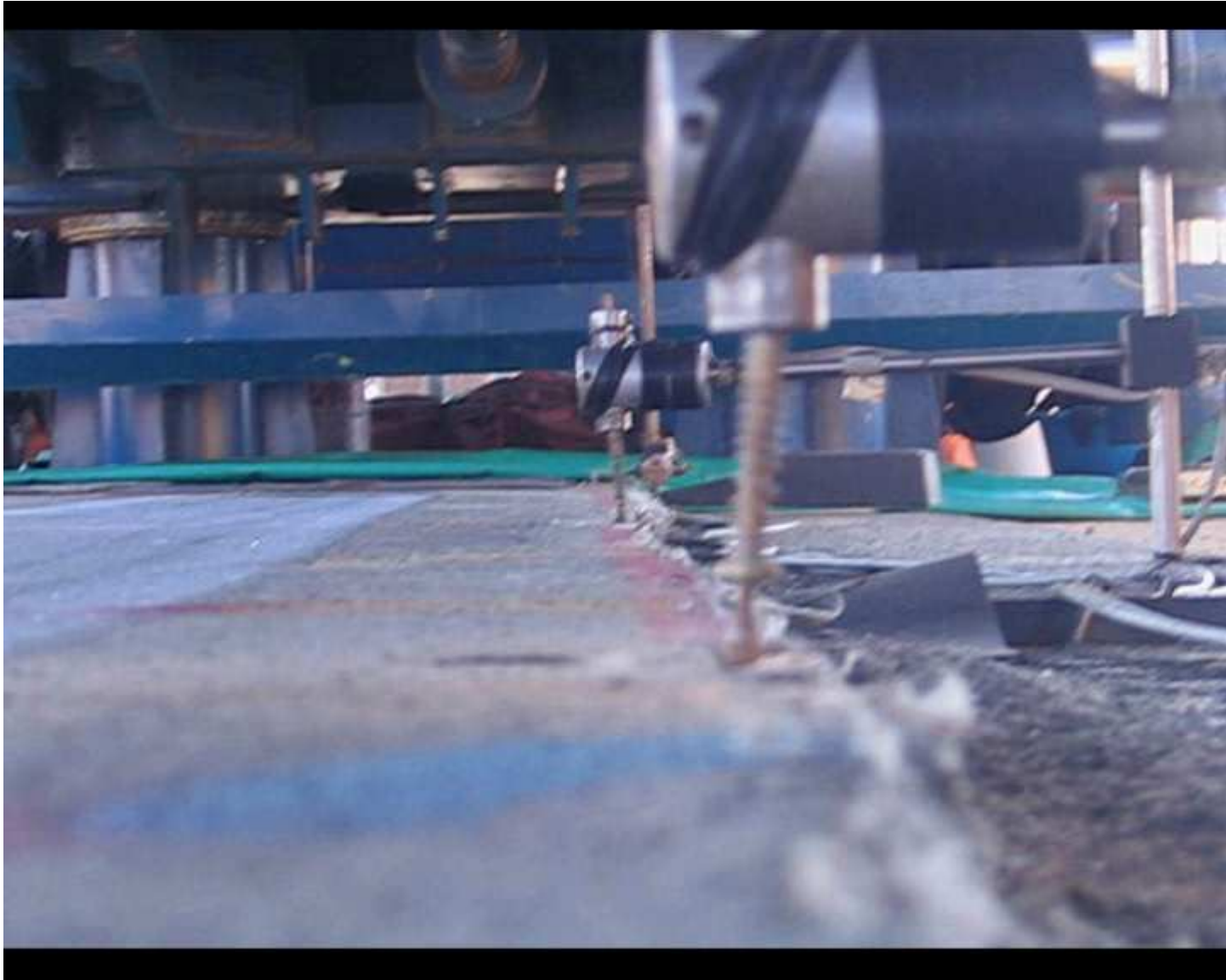




Traffic

- Vehicles apply loads (90 kN/ axle)
- Causes deflection of pavement
- 0.2 to 1.5 mm (or higher)
- Internal movement





Environment

- Environmental effects occur on and within the road
 - Moisture
 - Temperature
- Combination with traffic = problems if the material is not right

Basic crystalline rocks

- One of the most widely used materials for road construction in South Africa



**GEOLOGICAL MAP
OF THE REPUBLIC OF
SOUTH AFRICA
AND THE KINGDOMS OF
LESOTHO AND SWAZILAND
1997**

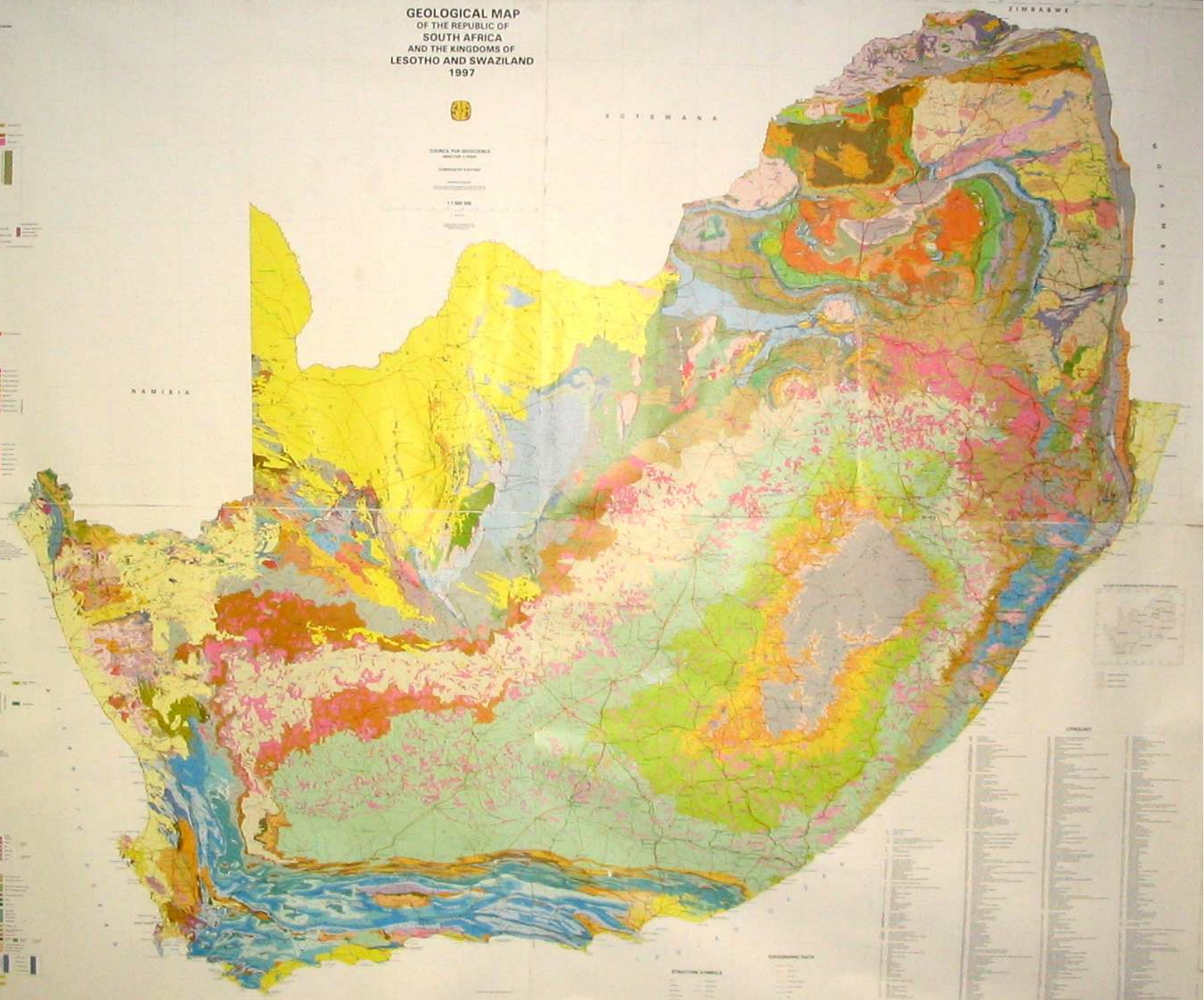


**BUREAU FOR GEOLOGICAL
SURVEY**
DEPARTMENT OF MINES
AND ENERGY

1:1 000 000

STRATIGRAPHICAL LEGEND

Symbol	Formation	Age
[Yellow]
[Orange]
[Red]
[Pink]
[Light Green]
[Green]
[Dark Green]
[Blue-Green]
[Blue]
[Light Blue]
[Purple]
[Grey]
[Brown]
[Tan]
[Light Yellow]
[Dark Yellow]
[Black]

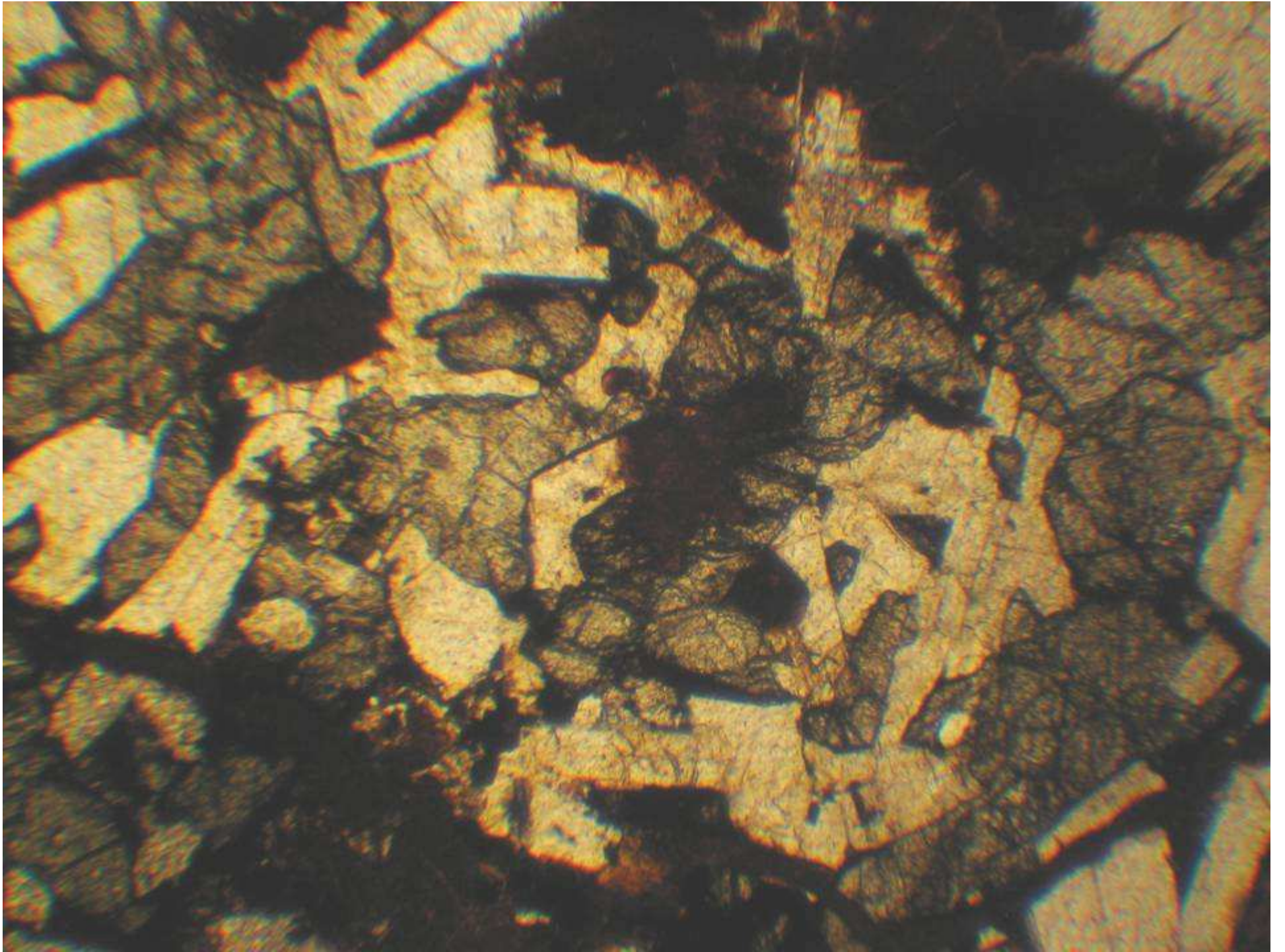


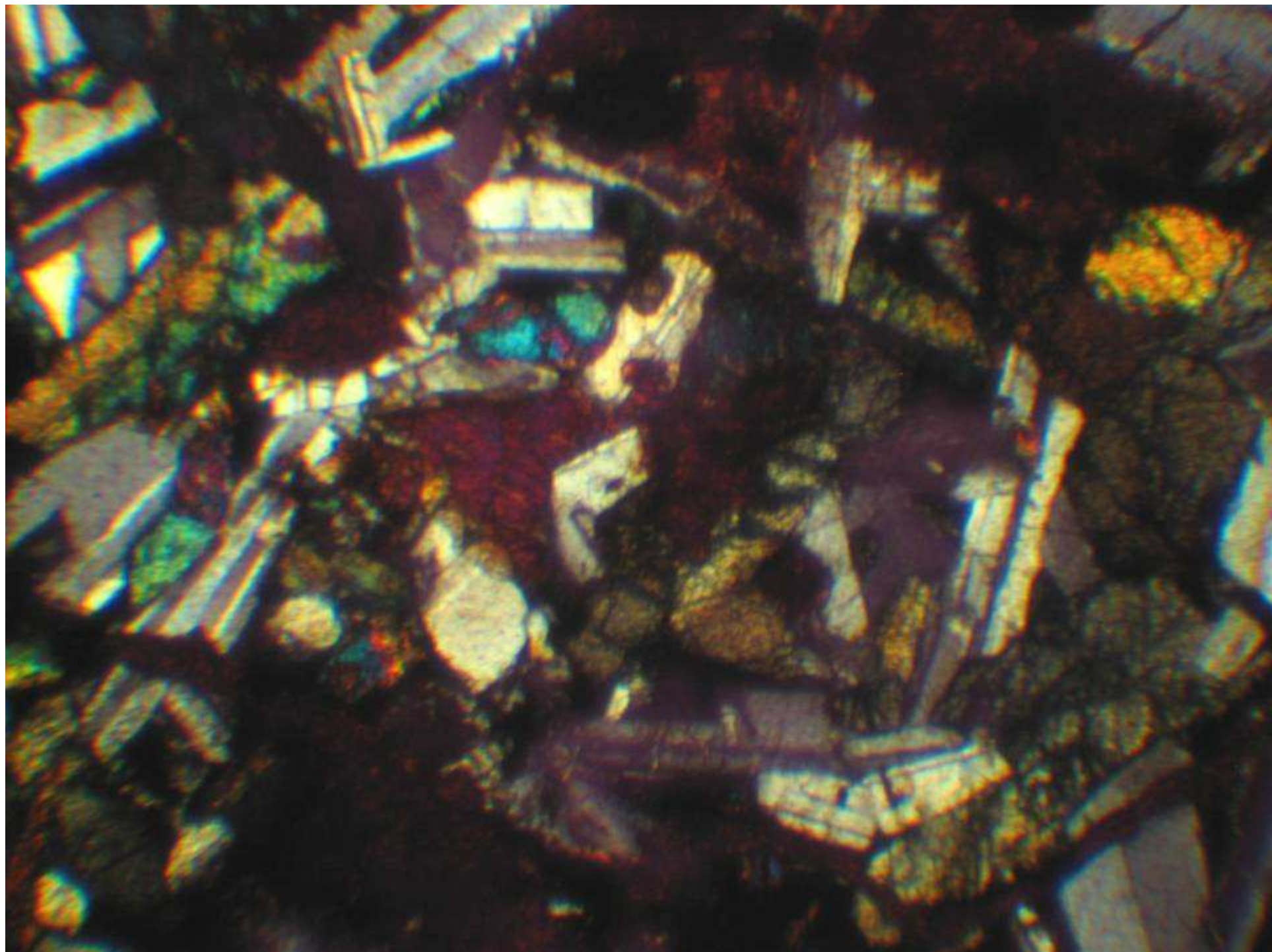
SYMBOLS

Symbol	Description
[Red line]
[Blue line]
[Green line]
[Black line]
[Grey area]
[Yellow area]
[Orange area]
[Red area]
[Pink area]
[Light Green area]
[Green area]
[Dark Green area]
[Blue-Green area]
[Blue area]
[Light Blue area]
[Purple area]
[Grey area]
[Brown area]
[Tan area]
[Light Yellow area]
[Dark Yellow area]
[Black area]

Basic crystalline rocks

- No quartz
- Primarily pyroxene and feldspar
- 12 - 40 % pyroxene & 40 – 50% feldspar
 - Pyroxene $(\text{CaNa})_{1-p}(\text{MgFe})_{1+p}(\text{SiAl})_2\text{O}_6$
 - Feldspar $(\text{CaNa})_x\text{Al}_y\text{Si}_z\text{O}_8$
- Unstable under atmospheric conditions
- Alter to clay (hydrous silicates – Al & Mg)





Durability

- Must be adequate to provide 20 – 30 years service
- Must not change to clay
- Durability is poorly specified currently
- BCR tend to be used with caution
- Increased costs

Experimental program

- Collect samples
- Laboratory test
- Relate to field performance

Sampling

- As wide as possible
- Crushers and old quarries

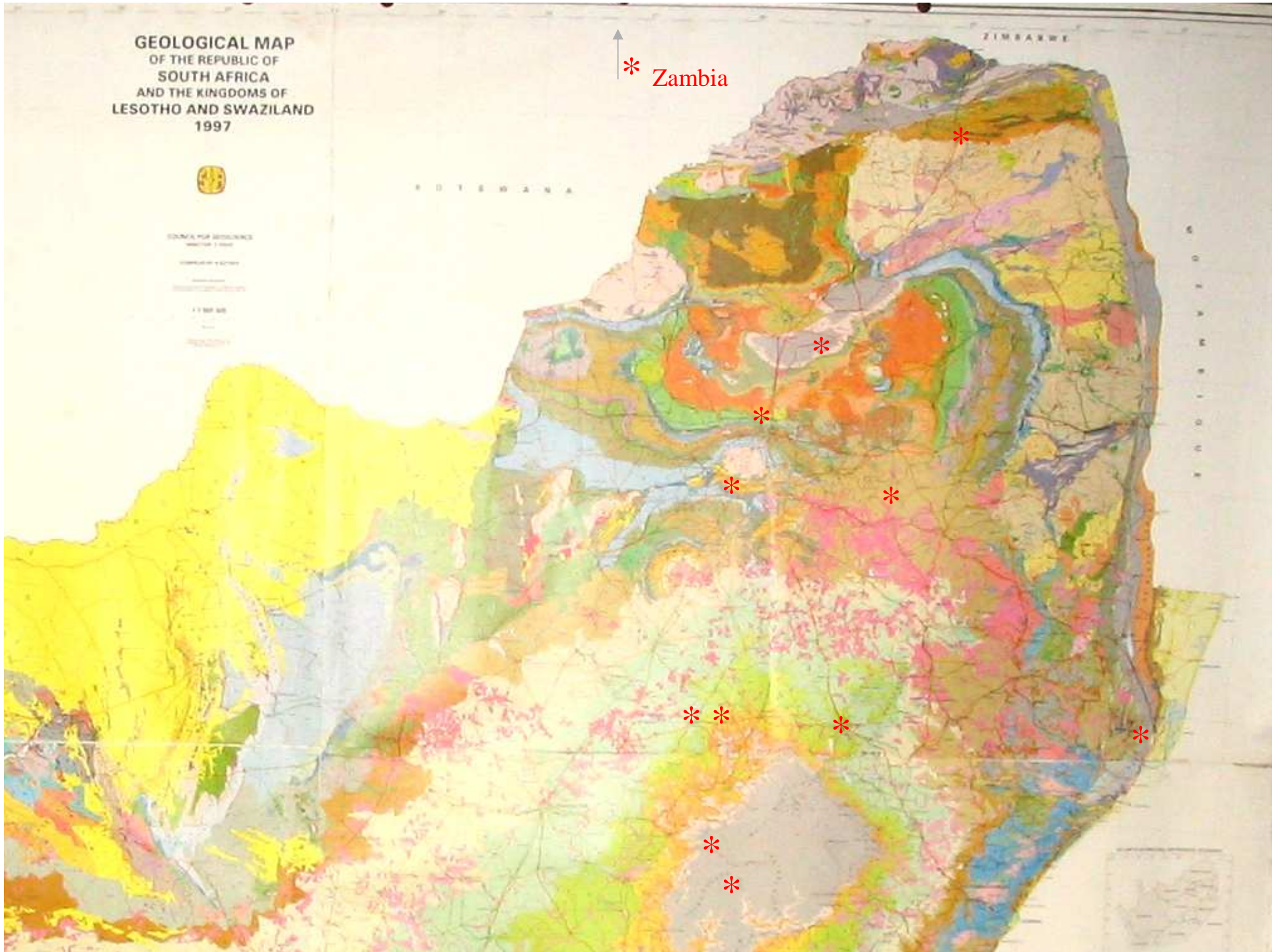


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COUNCIL FOR GEOLOGICAL
SURVEY
1997

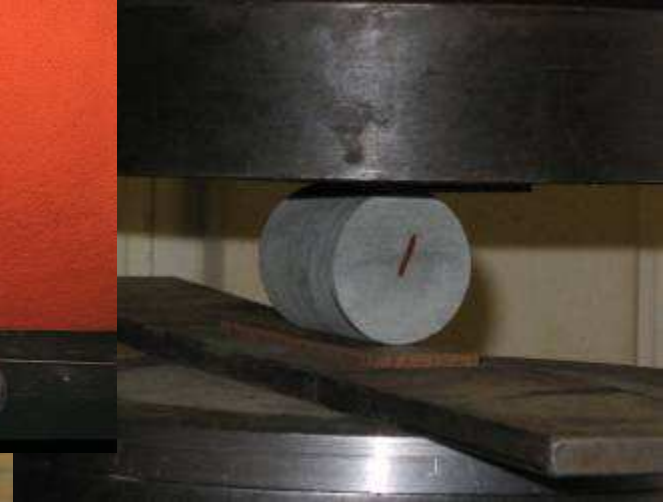
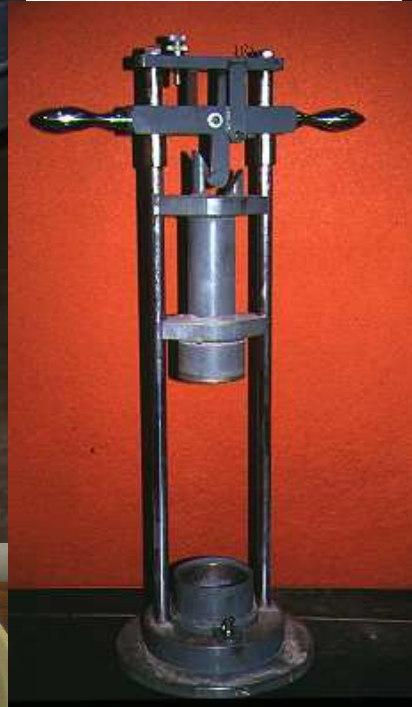
* Zambia



Testing

- Wide range of tests
 - Mineralogy and composition
 - Classification
 - Abrasion
 - Crushing/strength
 - Ethylene glycol soaking - smectites
- 21 methods in all with 3 treatments on some

Testing



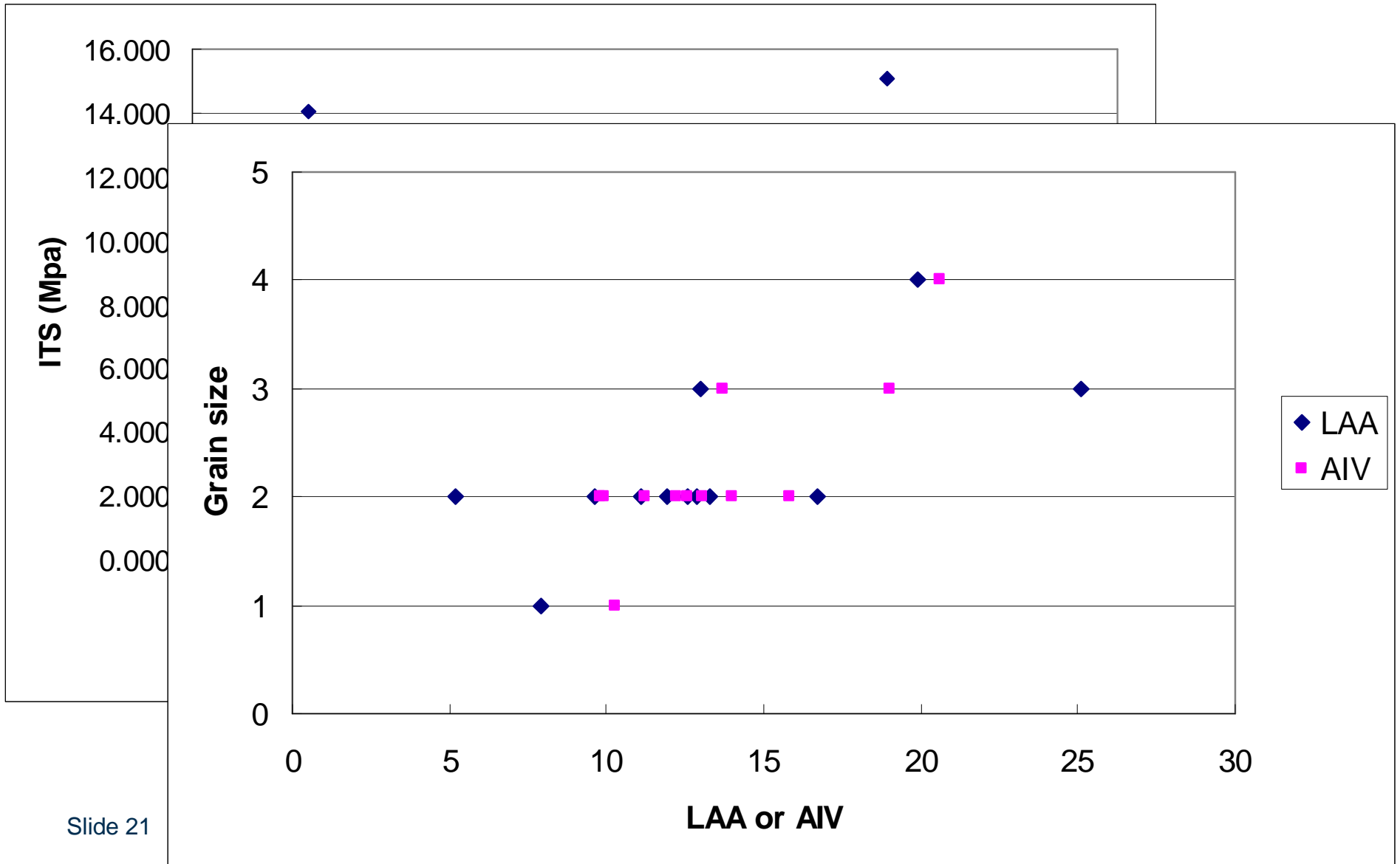
Test Results

- Summarised in paper
- Wide ranges
- Eg
 - Smectite XRD 0 – 21%
 - ITS 5.97 – 27.1 MPa
 - Mod Glycol index 0 – 35%
 - DMI 0 – 173
 - AIV 7d glycol 9.2 – 64.5%

Discussion of results

- Compared with existing specifications and other suggested limits
- Most of the materials complied with all existing specifications and would be accepted for use (even for seals)
- No consistency between test methods

Discussion of results

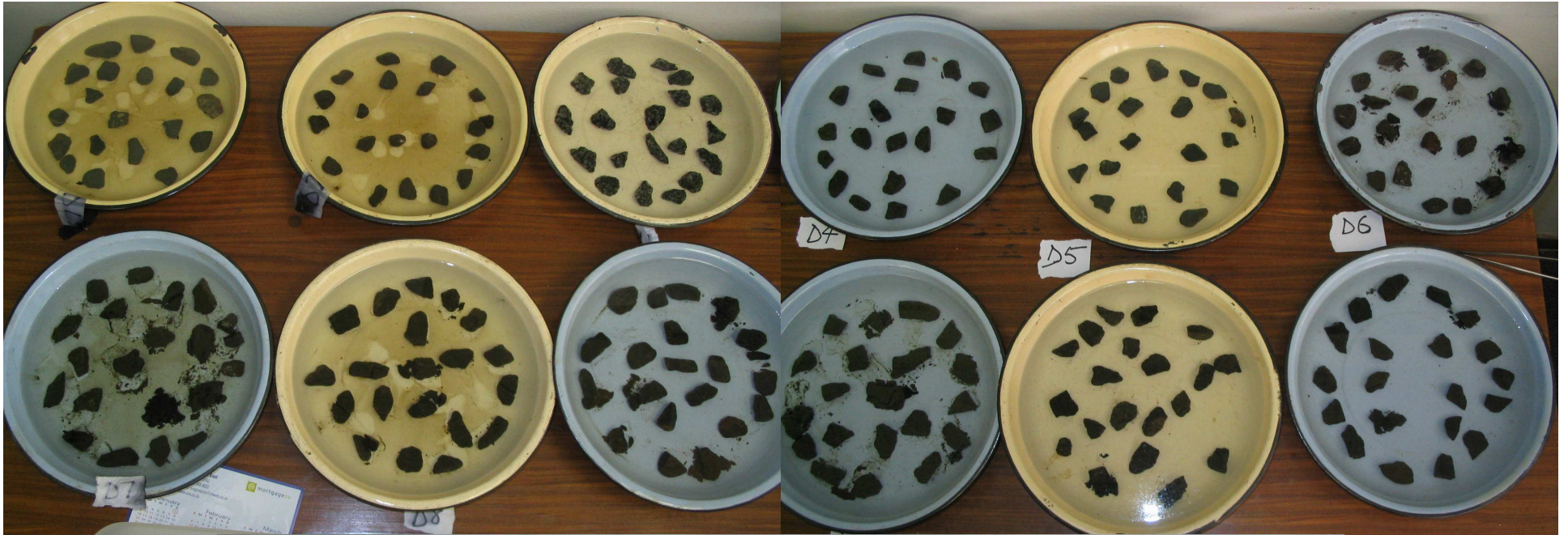


Analysis

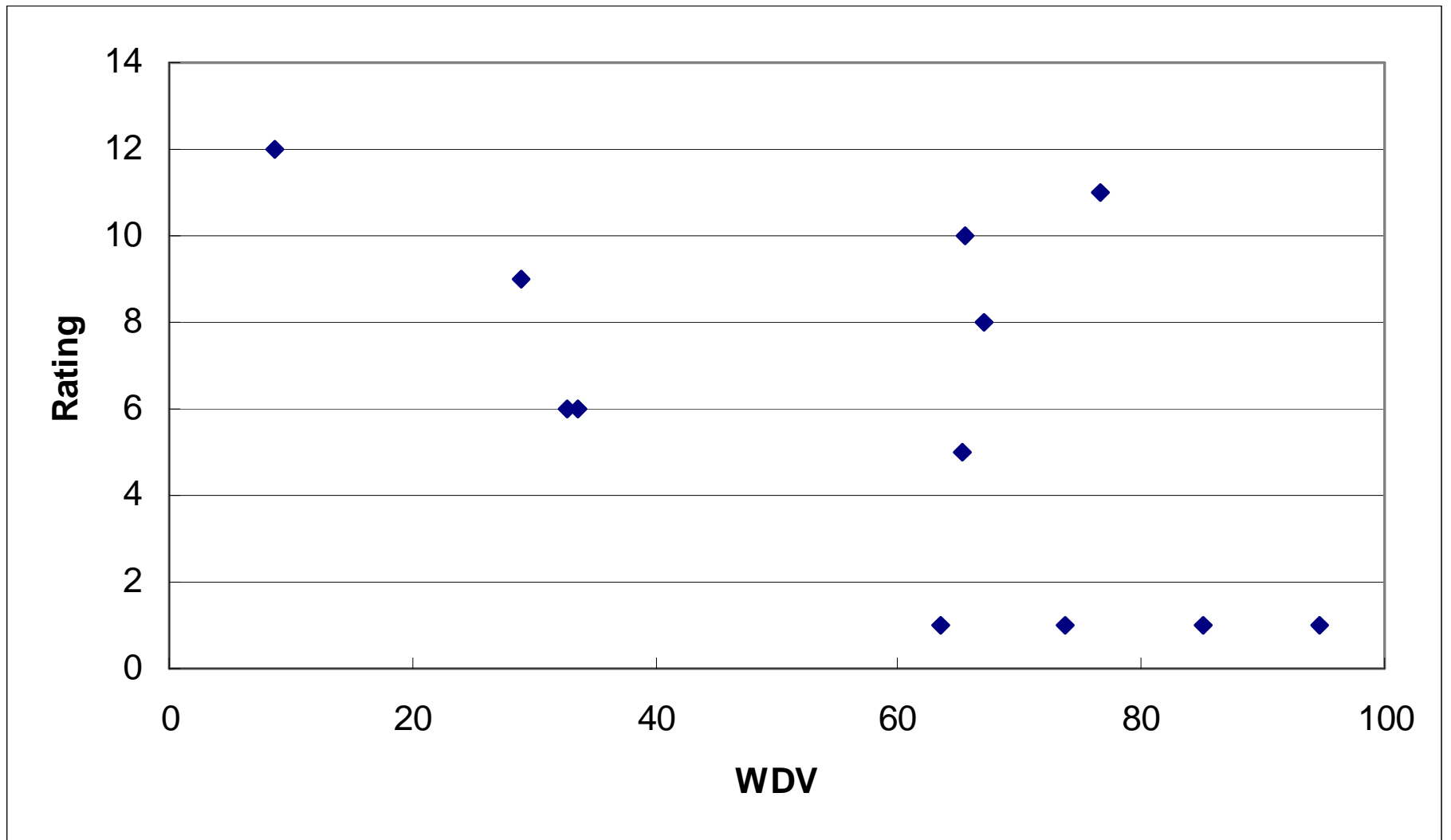
- Needed to relate to performance
- Performance records poor
- Subjectively rated the materials based on discussions, past records and effect of glycol
- No current specs use this although most recent work has concentrated on this

Performance

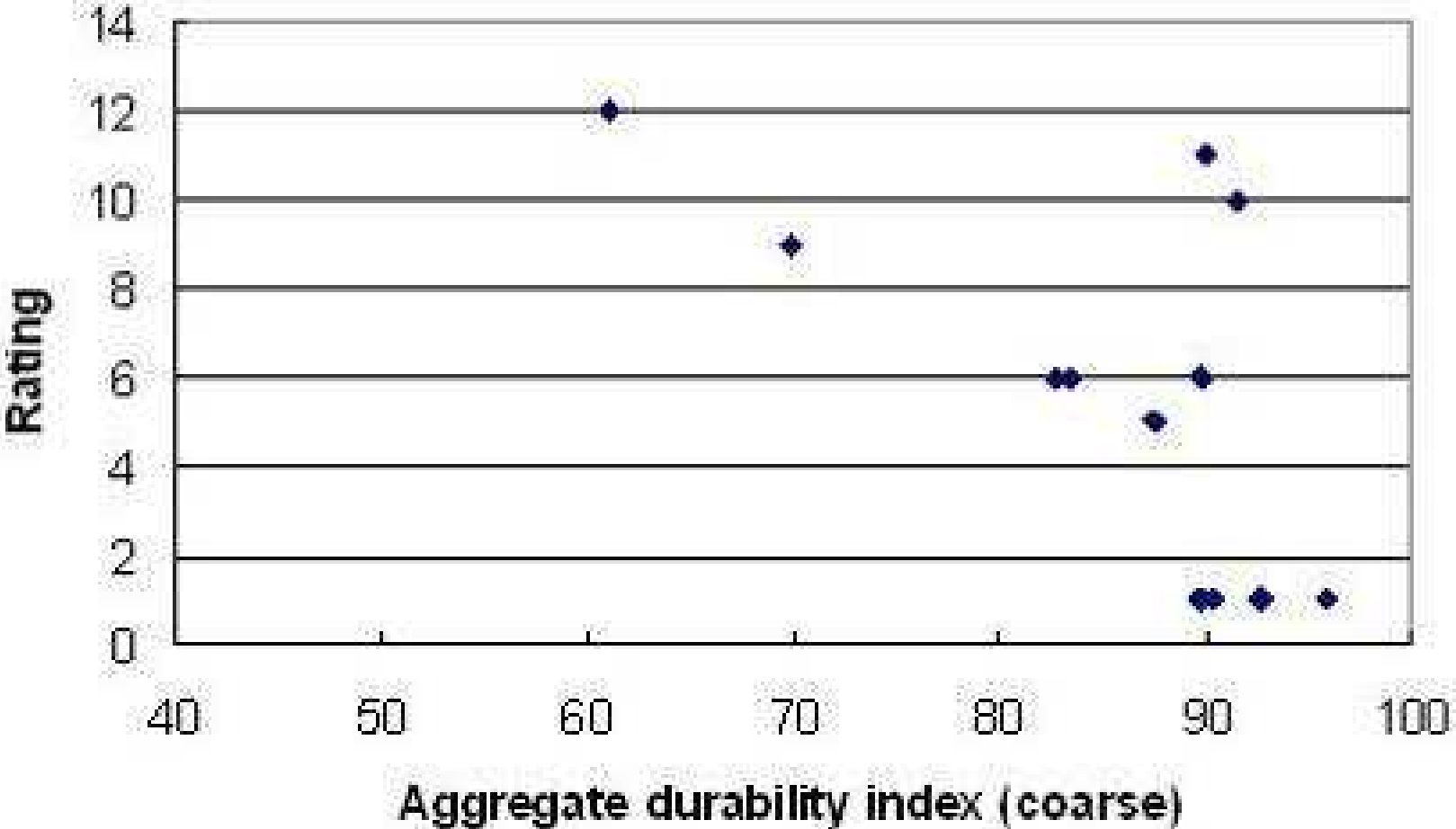
Sample No	Effect of glycol	Rating
D1	None	1
D2	None	1
D3	None	1
D4	Minor spalling	5
D5	None	1
D6	Significant spalling, some fracturing	9
D7	Significant fracturing and disintegration	12
D8	Significant fracturing, some disintegration	11
D9	Significant fracturing	8
D10	Significant fracturing, some disintegration	10
D11	Significant fracturing, minor disintegration	6
D12	Significant fracturing, minor disintegration	6



Analysis



Analysis

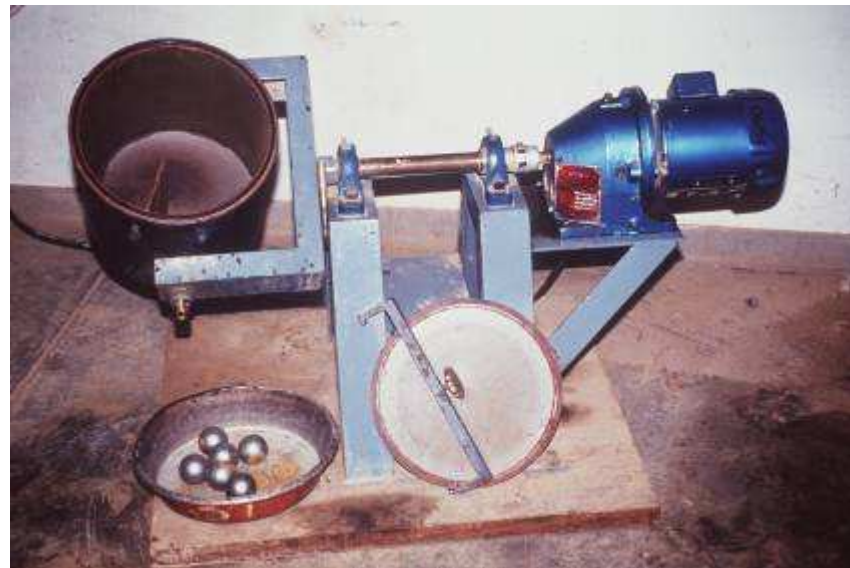


Suggested test methods

- Petrographic & mineralogical analyses
- Durability Mill Index
- 10%FACT or ACV
- AIV or modified AIV
- Glycol soaking test
- **Materials must not fail more than 2 of these**

Suggested limits

Property	Limit
Smectite content	< 10%
DMI	Max 125 If 0 then $P < 0.425 \text{ mm} < 35\%$



Suggested limits

Property	Limit
10%FACT (kN)	
Dry	≥ 210
Wet	≥ 160
4 day glycol	≥ 120
ACV (%)	
Dry	≤ 18.5
Wet	≤ 20.5
4 day glycol	≤ 22.2



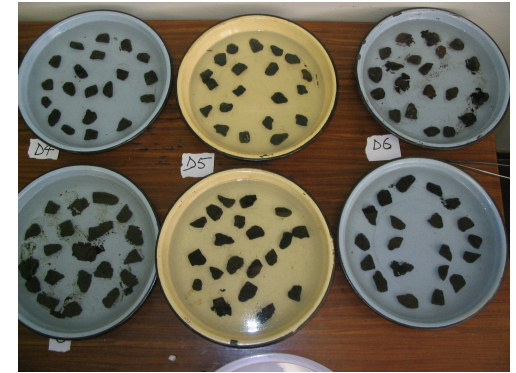
Suggested limits

Property	Limit
Mod AIV (%)	
Dry	≤ 25
Wet	≤ 30
4 day glycol – wet	≤ 3
4 day glycol -24h glycol	≤ 2
AIV (%)	
Dry	≤ 20
Wet	≤ 31
4 day glycol – wet	≤ 3
4 day glycol -24h glycol	≤ 2



Suggested limits

Glycol test – soak random 40 pieces



Application	Deterioration	Time
Base	<p>< 10 pieces disintegrated or < 15 pcs disintegrated & fractured</p>	<p>20 days 20 days</p>
Surfacing	<p>< 2 pieces disintegrated or < 4 pcs disintegrated & fractured</p>	<p>10 days 10 days</p>

Slic

Conclusions

- Current durability specifications are inadequate
- New test methods and limits suggested
- Based on laboratory testing and subjective performance rating
- Requires implementation and testing