# AGGREGATES – TESTING FOR HARMFUL ALTERATION

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## INTRODUCTION

It is well documented that the use of altered and weathered basaltic aggregates in constructions may cause premature *in-service* failures. Case studies and previous research relate this failure to the presence of smectite minerals in the aggregates used (Scott 1955; Van Atta & Ludowise 1976; Wylde 1976; Van Rooy 1991; Lagerblad & Jacobsson 1997). The reported failure mechanisms include the release of plastic fines and the potential of these minerals to expand and contract upon moisture fluctuations.

Over 90% of the bedrock in Iceland is basalt, consequently aggregates are predominantly basaltic. Smectite is a fairly common secondary product in the basalt, resulting from low-grade alteration and weathering. Aggregates that comply to specifications are usually either unaltered or have suffered low-grade alteration and weathering, indicating that smectite may be present in the material, even though conventional testing fails to detect it. Further, a recent Icelandic research has shown that the presence of smectite increases drying shrinkage of mortar samples when present in aggregates that were used in concrete (Sveinsdóttir et al 1999).

Tests with methylene blue have become popular to test the soundness of aggregates, i.e. existence of smectite minerals. The titratation method described in EN 933-9 is the method most used. However, only the fines fraction, i.e. material < 63 µm, is tested but material composition may vary with particle size. Also, it has been criticised as the end-point of titration and thereby the test result is somewhat subjective (Kühnel 1997; Ingimarsson 1997).

Cole & Sandy (1980) suggested a combination of thin section and XRD analyses. Shayan & van Atta (1986) proposed analysis of thin sections treated with methylene blue. The advantage of this method is that the particle size fraction used is tested and textural distribution of the harmful minerals may be assessed as well in addition to an evaluation of the amount of these minerals.

## THIS STUDY

The focus of previous work has mainly been on highly weathered and or altered aggregates. It was the aim of the work presented here to assess the suitability of the MB thin section method for classification of basalt and basalt glass that is either unaltered or has suffered low-grade alteration. The alteration state was assessed according to the IBRI petrographic classification method (Helgason & Guðfinnsson 1989). Secondly, the results of the thin section study are related to frost resistance of the material.

Samples from nine Icelandic quarries were collected. Aggregates from all quarries are or have been used for road construction or concrete production. Aggregates from five quarries are crushed rock and the remaining four are from natural sand and gravel deposits. The alteration state of the aggregates varies from unaltered basalt and basalt glass through altered basalt to highly altered basalt, see Table 1 for a brief description. For all tests, 8–16 mm aggregates were used. The samples were analysed in thin section, their loss on ignition was measured and they were tested for frost resistance.

The 8–16 mm fraction was crushed and the 2–4 mm fraction separated and analysed in thin sections that had been treated with methylene blue. The assumption made is that mainly clay minerals like smectite are affected by the dye and, therefore, point count of bluepoints was taken as an indicator of the relative quantity of smectite in the aggregate samples (Shayan & van Atta 1986). No fewer than three thin sections were point counted for each sample with a minimum of 500 points as a general requirement.

For loss on ignition, the fraction 8–16 mm was pulverized and subsamples then heated stepwise from 110 to 1000 °C. Mass loss from 110 °C was calculated. The frost resistance of the fraction 8–16 mm was tested according to the Nordtest method (NT BUILD 485, 1998).

## RESULTS

Results of thin section analyses (bluepoints with their standard deviation) and frost resistance are listed in Table 1 and the measurements of loss on ignition are plotted in Figure 1.

**Table 1**: Results. Bluepoints with their standard deviation and frost resistance value. A brief description is given of the rock type and main alteration state according to the IBRI petrographic classification method (Helgason & Gudfinnsson 1989).

| Sample no. and description | Blue-points % | Standard deviation | Frost resistance % |
|---|---|---|---|
| 1. Crushed basalt, highly altered | 20,8 | 0,75 | 64,8 |
| 2. Crushed basalt, highly altered | 17,8 | 1,51 | 7,0 |
| 3. Sand & gravel (basalt), altered | 16,1 | 0,81 | 13,5 |
| 4. Sand & gravel (basalt), altered | 14,7 | 2,95 | 11,0 |
| 5. Sand & gravel (basalt), altered | 15,5 | 3,62 | 7,0 |
| 6. Crushed basalt, altered | 6,5 | 0,19 | 1,4 |
| 7. Sea-dredged sand & gravel (basalt & basalt glass), unaltered | 3,2 | 0,93 | 2,9 |
| 8. Crushed basalt, unaltered | 0,4 | 0,10 | 0,6 |
| 9. Crushed pillow lava (basalt & basalt glass), unaltered | 0,3 | 0,13 | 1,7 |

## CONCLUSIONS

- The results imply that a relationship exists between bluepoints and loss on ignition, indicating that the two methods measure a similar property, i.e. the proportion of hydrated minerals in the aggregates. This is probably also a measure of the amount of minerals with a swelling potential.
- The results show a correlation between frost resistance and bluepoints.

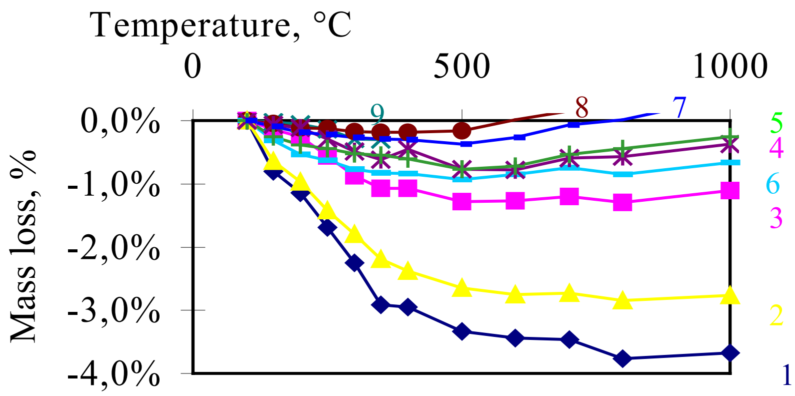


**Figure 1:** Results of loss on ignition. Sample numbers are the same as in Table 1.

- The data imply that loss on ignition correlates with frost resistance. The interpretation of this is that it is probable that the proportion of hydrated minerals (which probably also have a swelling potential) influence the freezing susceptibility of the aggregates.
- Thin sections treated with methylene blue are considered suitable to identify deleterious secondary minerals in aggregate samples ranging in alteration state from unaltered through altered to highly altered basalt and basalt glass.

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