



Mineralogy, geochemistry and expansion testing of an alkali-reactive basalt from western Anatolia, Turkey

Oğuzhan Çopuroğlu^{a,*}, Özge Andiç-Çakır^b, Maarten A.T.M. Broekmans^c, Radko Kühnel^d

^aDelft University of Technology, Faculty of CiTG, Materials and Environment, Stevinweg 1, 2628CN, Delft, The Netherlands

^bEge University, Civil Engineering Dept., 35100 Bornova, Izmir, Turkey

^cGeological Survey of Norway, Dept. of Mineral Characterization, N-7491 Trondheim, Norway

^dBurgemeester Merkusstraat 5, 2645 NJ, Delfgauw, The Netherlands

ARTICLE DATA

Article history:

Received 10 March 2008

Received in revised form

7 August 2008

Accepted 18 September 2008

Keywords:

ASR

Basalt

Microscopy

Microbar test

Durability

ABSTRACT

In this paper, the alkali–silica reaction performance of a basalt rock from western Anatolia, Turkey is reported. It is observed that the rock causes severe gel formation in the concrete microbar test. It appears that the main source of expansion is the reactive glassy phase of the basalt matrix having approximately 70% of SiO₂. The study presents the microstructural characteristics of unreacted and reacted basalt aggregate by optical and electron microscopy and discusses the possible reaction mechanism. Microstructural analysis revealed that the dissolution of silica is overwhelming in the matrix of the basalt and it eventually generates four consequences: (1) Formation of alkali–silica reaction gel at the aggregate perimeter, (2) increased porosity and permeability of the basalt matrix, (3) reduction of mechanical properties of the aggregate and (4) additional gel formation within the aggregate. It is concluded that the basalt rock is highly prone to alkali–silica reaction. As an aggregate, this rock is not suitable for concrete production.

© 2008 Elsevier Inc. All rights reserved.

1. Introduction

Since its discovery in 1940 by Stanton [1], the alkali–aggregate reaction (AAR) in concrete has become an infamous deterioration mechanism, for a number of reasons. These include the difficulty of durable repair and a very long cubation time, typically several decades. Two major deleterious AARs are known, of which the alkali–silica reaction (ASR) seems to be most widespread. A chemical reaction between reactive silica, alkali species and hydroxyl ions in the pore solution leads to formation of a hydrous alkali–silica gel. This gel absorbs water and expands, generating mechanical distress in the material, eventually leading to disintegration of the host.

The origin and nature of the aggregate material plays a crucial role in the damage process. The generally accepted RILEM AAR-1 guideline [2] classifies sand-/siltstone, greywacke, shale, chert, rhyolite, fine-grained meta-quartzite, and

low-grade metamorphic sandstone all as potentially alkali-reactive, while for instance basalt, gabbro, marble are considered innocuous. However, there is considerable variation in the alkali-reactivity potential of deleterious rocks, reflecting differences in (geochemical, mineral-modal) composition and presumably also in geological history. The variation in reactivity pertains to both different rock types (eg. greywacke vs. meta-quartzite), as well as to one and the same rock type from different locations (eg. Norwegian vs. Dutch sandstone), and even within one and the same quarry location (eg. [3]). Thus, applying rock nomenclature and subsequent classification following standard tables does not offer absolute safety in determining the alkali–silica reactivity potential of a rock type. Many examples of such contradictions are reported worldwide [4].

Basalts are volcanic rocks deposited at the earth surface from the solidification of low-viscosity lava. The term basalt

* Corresponding author.

E-mail address: O.Copuroglu@CiTG.TUdelft.NL (O. Çopuroğlu).

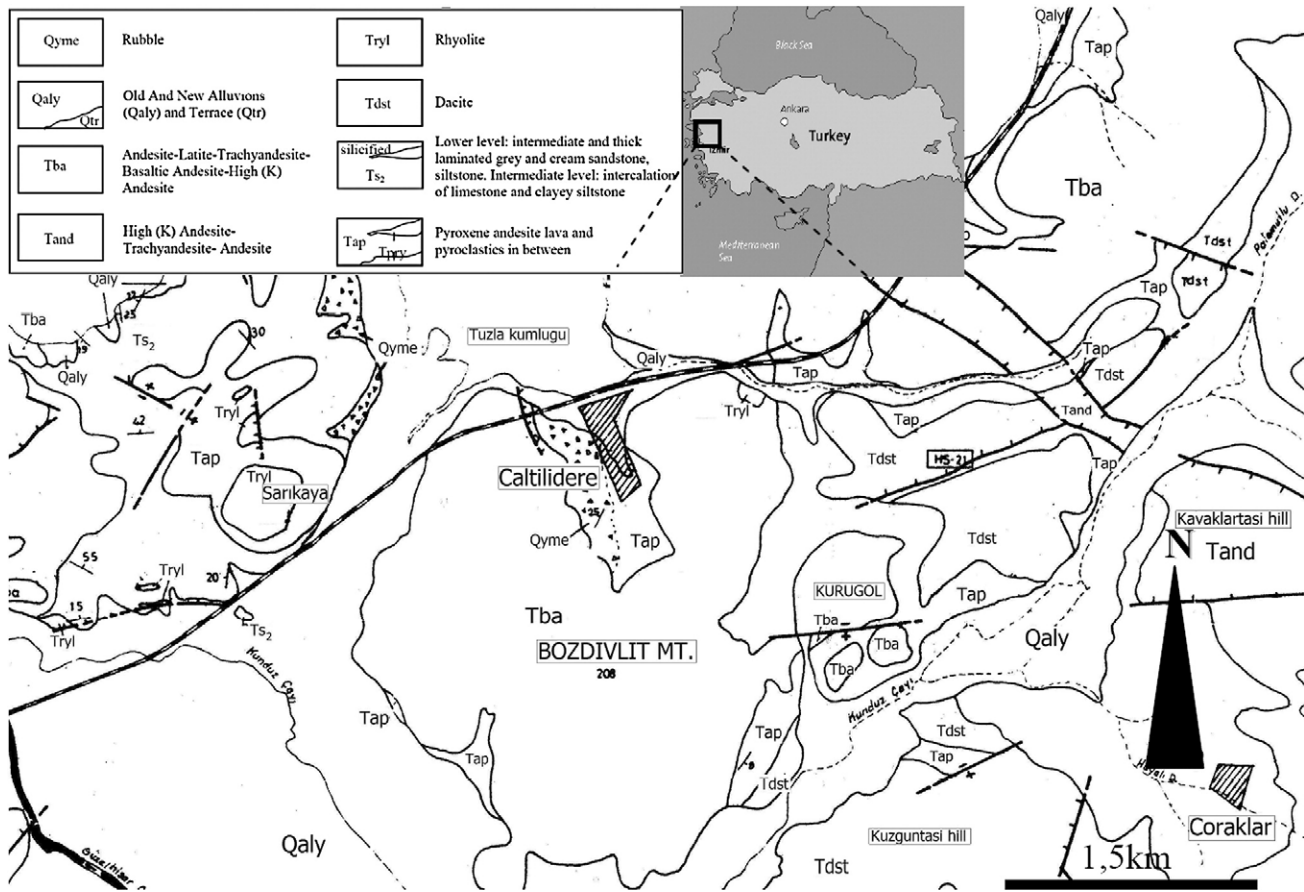


Fig. 1 – Geographical map of Mt. Bozdivlit and surroundings.

covers fine grained extrusive rocks containing either 20–0 vol.% quartz or 0–10 vol.% olivine, up to 35 vol.% K-feldspar, and anorthite-rich plagioclase [5].

The oceanic crust (covering ~65% of the Earth's surface) consists mainly of basalt, thus making it the most common rock type of the entire crust. Owing to its extrusive igneous nature and rapid cooling history (as opposed to plutonic igneous rocks), basalt usually has a porphyritic texture with a very fine-grained matrix, often glassy. The geochemical SiO_2 content of basalt is per definition <52 wt.% [5] and the rock is comparatively rich in magnesium and iron, making it dark in appearance as well as relatively heavy. Massive basalt has a density around 3200 kg/m^3 , vesicular basalt somewhat lower.

Basalt typically contains intermediate plagioclase (An_{35-60}), augitic pyroxene, and either olivine (<10 vol.%) or quartz (<20 vol.%), but not both at the same time. The amorphous glassy matrix, whenever present, is thermodynamically unstable and tends to crystallize upon aging. This process is called devitrification and results in *in situ* precipitation of cristobalite SiO_2 with a net volume decrease [6]. This shrinkage creates nano-channels in the glass, enhancing fluid access. The instability of some basalt and basaltic glass is further illustrated by the formation of clay minerals after only a few seconds (!) of wet grinding [7].

Generally, basalt is considered innocuous to ASR, which is partly attributed to its low content in free silica (ie. quartz).

The glass matrix may even be undersaturated in silica [8]. Its superior strength properties together with high density make basalt suitable as a high-performance aggregate for Portland cement and bituminous concrete, in addition to more specialized applications where refractoriness, high hardness and wear resistance are desired.

The resistance of basalt against alkali-reactivity has been demonstrated by its many successful applications all over the world. Nevertheless, deleterious alkali-reactivity of certain basalt rocks has been reported on more than one occasion [8–11]. Shayan [8] found that a basalt from Queensland, Australia with a glass matrix containing 67 wt.% silica was violently alkali-reactive. Katayama [12] suggested that basalt with over 50 wt.% of total silica ought to be considered as potentially alkali-reactive.

Korkanç and Tugrul [11] studied the Middle Anatolian basalts in terms of alkali-aggregate reactivity. The authors concluded that the reactivity of the basalts was controlled by the presence of volcanic glass, alteration minerals and SiO_2 content of the rock. The basalts having intermediate felsic character or volcanic glass in their matrix showed expansion generally more than 0.10% at 14-days using the CSA A23.2-25A method, which is similar to the RILEM AAR-2 test.

This paper characterizes basalt from Western Anatolia, Turkey and assesses its expansive and gel-forming behavior under ASR-favorable conditions.

Download English Version:

<https://daneshyari.com/en/article/1572162>

Download Persian Version:

<https://daneshyari.com/article/1572162>

[Daneshyari.com](https://daneshyari.com)