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Evaluation of selected basalts from the point of alkali–silica reactivity

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Abstract

Basaltic rocks are potential rocks for alkali–silica reaction (ASR). The objective of this study is to determine reactivity of the basalts of different compositions and textures. The study was carried out on basalts that are widespread in the Middle Anatolian Region of Turkey. They form the major source of local crushed rock aggregates. Early Quaternary Melendiz volcanites, Quaternary Karataş volcanites and İğredağ basalts were selected around the Niğde Region, and the experimental studies were conducted on these rocks. The samples were collected as being representative of 11 different basalt types. The basalts were firstly classified according to their petrographical and chemical composition. Petrographic techniques and accelerated mortar bar test were then used to evaluate the potential alkali reactivity of the basalt aggregates. The basalts having acidic-intermediate character and matrix that is mainly composed of volcanic glass are potentially suitable for alkali–aggregate reaction (AAR) according to the standard values.

Keywords: Basalt; Alkali–aggregate reaction; SEM; Volcanic glass

1. Introduction

Alkali–silica reaction (ASR) is the most common form of alkali–aggregate reaction (AAR). ASR is a chemical reaction between the alkalis in Portland cement and certain siliceous aggregates and form a silica gel. It is well known that alkaline components of Portland cement chemically react with silica in certain forms found in certain aggregates [1]. There are many studies concerning the effect of the reactive aggregates on the ASR gel formation and the subsequent expansion of concrete [2–10].

The use of alkali-reactive siliceous aggregates in concrete can cause severe damage to concrete structures due to the development of the expansive ASR [5,6]. In the presence of free moisture, the gel will expand and cause cracking and differential movements in structures, as well as other deleterious effects, such as reductions in freeze–thaw durability and in strength properties of concrete [7]. As the concrete deteriorates, more water enters to fuel the reaction. This cycle continues until the concrete deteriorates past the point of serviceability [8]. The expansion behavior of mortars due to ASR varies significantly depending on a combination of both the mineralogical composition of cement and the reactive component of aggregate because for a given reactive aggregate, the degree of ASR is influenced by hydration characteristics of cement used [9,10].

Fookes [11] gave examples of aggregates that cause AAR. They are cherty limestone and mudstone, and some volcanic rocks having acidic or acidic-intermediate character. Grattan-Bellew et al. [12] studied mortar bars made with basalt, dolostone, granite, limestone, and pure crystalline quartz. They indicated that aggregate composition and particle size affect the expansion of mortar bars. Wakizaka [13] and Marfil and Maiza [14] implied that volcanic rocks, including volcanic glass, are dangerous from the point of alkali–silica reactivity. St. John [15] also indicated that volcanic glass in the groundmass of rhyolite, dacite, and andesite is the principal reactive component of rocks. In addition, Katayama et al. [16] indicated that where the silica content of the bulk composition exceeds 50%, basalt may be potentially reactive and should be treated as if it is an andesite in terms of reactivity.

Basaltic rocks have variable composition and texture depending on character of volcanism. Basalts of different compositions and textures were not correlated before, from the point of ASR. The aim of this study is to evaluate aggregate constituents, especially the presence of deleteri-

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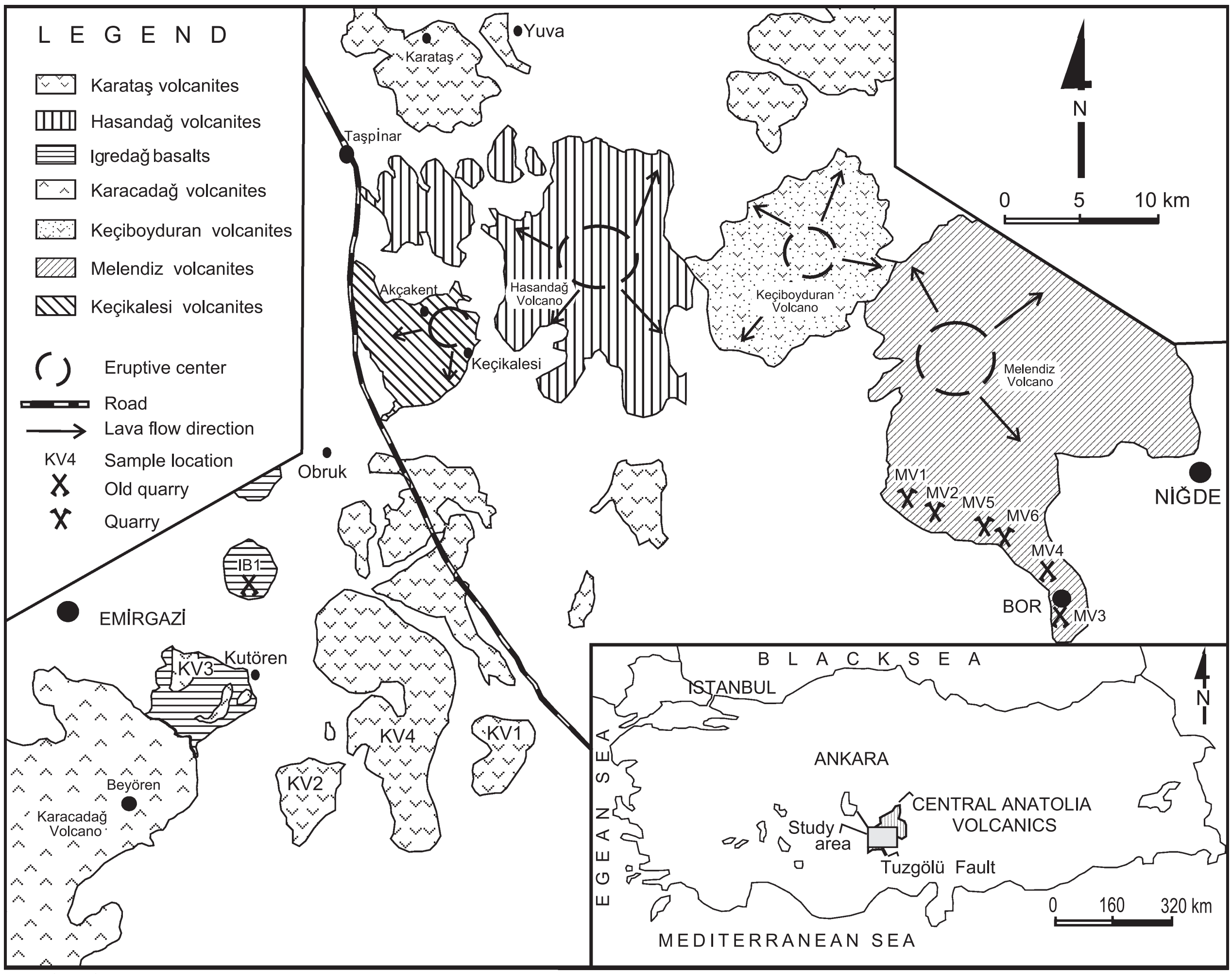

Modified from [19,20]

Fig. 1. Map showing location of the samples.

ous components and find main causes of the AAR based on the petrographic studies on the basalt aggregates and also to determine the reactivity of the basalts by means of accelerated mortar bar tests. Minerals of the basalt aggregates and their percentages were determined by using point counter under optical microscope. The effect of aggregate composition on the expansion of mortar bars, due to ASR, was evaluated by mortar bars made with basalts having different composition and texture. Scanning electron microscope (SEM) studies were conducted to evaluate microcracking,

Table 1
Geological and petrographical characteristics of the basalts

Sample code	Formation	Sample location	Rock name[a]	Age	Minerals and relative abundance
MV1	Melendiz volcanites	North of Bor	Basalt	Early Pliocene–Pleistocene	plg>ol>op>sm>px
MV2	Melendiz volcanites	North of Bor	Basalt	Early Pliocene–Pleistocene	plg>px>sm>op
MV3	Melendiz volcanites	Bor (Kayabaşı)	Olivine Basalt	Early Pliocene–Pleistocene	plg>ol>op>sm
MV4	Melendiz volcanites	Bor (Mezarlık)	Olivine Basalt	Early Pliocene–Pleistocene	plg>px>ol>op>sm
MV5	Melendiz volcanites	Northeastern Bor	Basalt	Early Pliocene–Pleistocene	plg>ol>sm>op
MV6	Melendiz volcanites	Northeast of Bor	Basalt	Early Pliocene–Pleistocene	plg>px>sm>op
KV1	Karataş volcanites	East of Kutören	Olivine basalt	Late Quaternary	plg>ol>op>px
KV2	Karataş volcanites	South of Kutören	Olivine basalt	Late Quaternary	plg>ol>op>px>sm
KV3	Karataş volcanites	West of Kutören	Basaltic andesite	Late Quaternary	plg>g>ol>op
KV4	Karataş volcanites	East of Kutören	Olivine basalt	Late Quaternary	plg>ol>op>sm
IB1	İğredağ Basalts	İğredağ quarry	Olivine basalt	Early Quaternary	plg>ol >px>op

plg.: Plagioclase, px: pyroxene, ol: olivine, g: volcanic glass, sm: secondary minerals, op: opaque minerals.
[a] According to Ref. [27] classification.