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Behaviour of Multicomponent Geomaterials: Pilot Experimental Study in Rock Mechanics

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Abstract

Rock massifs traditionally used for the construction of foundations, tunnels or as a source of crushed stone, frequently contain compositionally (texturally, mineralogically, geochemically) contrasting inclusions – xenoliths. The presence of xenoliths is a commonly overlooked fact which may, however, significantly affect the total strength of the massifs. The most frequent xenoliths in igneous massifs are mafic microgranular enclaves occurring as ellipsoidal inclusions with the size varying from centimetre to metre scales in the host rocks. Our pilot experimental study brings a complex assessment of strength properties (e.g., rebound hardness, uniaxial compressive strength, rock tensile strength) of multicomponent geomaterials, i.e., host-rocks and their enclaves, sampled both from quartz-rich (granitoid) and quartz-poor (syenitoid) massifs.

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1. Introduction

Rock mechanics is a dynamically developing scientific discipline integrating a range of modern geological and geotechnical approaches [1, 2]. This discipline is absolutely irreplaceable in the study of the behaviour of geomaterials and rock massifs affected by civil engineering works.

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Rock massifs frequently contain compositionally (texturally, mineralogically, geochemically) different parts generally described under the term **xenoliths** (from ancient Greek: “foreign rock”) [3]. The presence of xenoliths is a commonly overlooked fact in rock mechanics that, nevertheless, can significantly affect the total strength of the massifs [4].

2. Mafic microgranular enclaves

The most frequent xenoliths in igneous rocks are mafic microgranular enclaves occurring both in quartz-rich (granitoid) and quartz-poor (syenitoid) massifs [4–7]. The shape of mafic microgranular enclaves is mostly ellipsoidal with the size varying from centimetre to metre scales. The name “mafic microgranular enclaves” reflects their high contents of dark (mafic) minerals (dark micas, amphiboles) and fine- to medium-grained, equigranular texture (Fig. 1A).

Genetically, the mafic microgranular enclaves represent relatively rapidly chilled “drops” of more basic (mafic) melt which was variably mingled with the surrounding felsic melt characterized by higher content of SiO_2 [8–11]. Thus, mafic microgranular enclaves are usually preferentially oriented (stretched) in the flow direction of the host magma.

3. Multicomponent geomaterials

From the perspective of rock mechanics, we can consider the host rocks enclosing mafic microgranular enclaves as multicomponent geomaterials. These materials are multicomponent on several scales:

- on elemental scale – mafic enclaves geochemically differ from their host rocks;
- on mineral scale – mafic enclaves contain different minerals than their host rocks;
- on textural scale – mafic enclaves are usually more fine-grained than their host rocks.

4. Multicomponent geomaterials in civil engineering

The correct understanding of strength properties of multicomponent geomaterials is very important for several reasons:

- Rock massifs containing mafic microgranular enclaves are frequently used for both foundation engineering and tunneling.
- Rock massifs containing mafic microgranular enclaves are mined for the production of crushed stone. Depending on the abundance of mafic microgranular enclaves, individual fractions of crushed stone can contain a substantial proportion of multicomponent geomaterials.
- Rock massifs containing mafic microgranular enclaves are preferably exploited for fine stone production (Fig. 1B).

5. Samples and methods

Samples of mafic microgranular enclaves and their host rocks were collected both from the Brno Massif (enclave-granitoid system) and from the Třebíč Massif (enclave-syenitoid system). For detailed petrographical characterisation of studied samples and for principles of estimation of the proportions of enclaves via geochemical modelling as briefly suggested in the chapter 7 see the work by Krmíček (2015) [12].

The Brno Massif located on the eastern margin of the Bohemian Massif is a Cadomian batholith approximately 600 km^2 in area, divided by the Central Basic Belt into the Western Granitoid Complex and Eastern Granitoid Complex [13]. Mafic microgranular enclaves concentrate in the Eastern Granitoid Complex [14].

The Třebíč Massif is the largest (~500 km^2) syenitic body in the Bohemian Massif. Rocks of the Třebíč Massif were formed by intensive mixing of basic (mantle-related) and acidic (crust-related) types of melts, and are characterised by abundant occurrences of mafic microgranular enclaves [15].

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