Journal of African Earth Sciences 120 (2016) 238–247

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

# Quantitative textural investigation of trachyandesites of Damavand volcano (N Iran): Insights into the magmatic processes

Mohsen Zadsaleh [a], Hamed Pourkhorsandi [b, *]

[a] RS-GIS Section, Tehran Municipality, Tehran, Iran
[b] Aix-Marseille Université/CNRS/IRD, CEREGE UM34, Technopôle de l'Arbois BP80, 13545 Aix-en-Provence, France

ARTICLE INFO

*Article history:*
Received 26 February 2016
Received in revised form
10 May 2016
Accepted 12 May 2016
Available online 13 May 2016

*Keywords:*
Magma mixing
Crystal size distribution (CSD)
Texture
Volcano
Damavand
Iran

ABSTRACT

Damavand volcano is a dormant stratovolcano in northern Iran in the middle of the Alborz Mountains. Investigation of the magmatic processes responsible for the eruption of the volcano and the conditions of the magma chamber is important in order to understand the volcanism of this system. Owing to their higher abundance and younger age, trachyandesitic rocks are the main components of this volcano. To get insights into the crystallization of these rocks, we carried out a quantitative and qualitative petrographic study of three main volcanic units erupted between 63 and 66.5 years ago. Crystal Size Distribution (CSD) studies can reveal details about magmatic processes. Measuring 4732 individual plagioclase crystals and conducting a CSD study, revealed a non-straight and concave-up CSD curve for nearly all of the studied volcanic units which suggests the occurrence of similar physico-chemical processes responsible for their magmatism. Plagioclase crystals occur as microlites and phenocrysts; the phenocrysts show either oscillatory zoning or sieve textures. Each segment of the CSD curves are consistent with a particular plagioclase texture in all the studied volcanic units. The presence of different plagioclase textures and the concave-up shape of the CSD curves suggests the variation of the physico-chemical conditions of the magma chamber during the magmatism of the Damavand in this time period. Mixing of magmas with different crystal populations can be an alternative for this phenomena.



## 1. Introduction

Damavand volcano with an elevation of 5671 m.a.s.l. is the highest peak in the Middle East. It is a large intraplate composite cone representing an accumulation of volcanic rocks and pyroclastic deposits overlying the Alborz [Elborz] Mountains system, an active fold and thrust belt separating southern Caspian Sea basin from central Iran (Fig. 1) (Aghanabati, 2004; Alavi, 1996). Alkaline olivine basalts, trachytes and trachyandesites are the main volcanic rock components of the Damavand (e.g., Allenbach, 1966). Petrological and geochemical studies by Allenbach (1966) and Davidson et al. (2004) on trachyandesites reveal a discontinuous volcanic activity as the occurrences of two major explosive and lava outflows, resulting in the formation of "Old and Young Damavand". The geochemistry and the classification of these volcanic rocks (summarized in Sec. 2) have been described in detail in different studies (Allenbach, 1966; Ashrafi, 2003; Davidson et al., 2004; Emami and Irannejadi, 1993; Liotard et al., 2008; Pandamouz, 1998). Generally, these works show a similar geochemistry and mineralogy for both "Old and Young Damavand" rocks, although no data exists on any textural differences or similarities between their different volcanic units.

Studies on terrestrial igneous rocks have shown that different magmatic processes are responsible for the formation of various volcanic rocks and the wide spectrum of chemical and textural compositions. Among the most important are partial melting, fractional crystallization and mixing of magmas. Variations of chemical and textural compositions within and between different eruptions or lava flows reflect the behavior of the magmatic plumbing systems beneath a volcanic complex (Gioncada et al., 2005; Higgins, 1996a; Tepley et al., 1999). The behavior of magma in the chamber is controlled by different factors such as: temperature, pressure, chemistry, oxygen fugacity, etc., which any variations of them will affect the texture of the resultant rock. Therefore, the texture of an igneous rock is a remarkable recorder of the igneous processes and can be used to investigate the plumbing

* Corresponding author.
*E-mail addresses:* mohsen.zadsaleh@gmail.com (M. Zadsaleh), pourkhorsandi@cerege.fr (H. Pourkhorsandi).

http://dx.doi.org/10.1016/j.jafrearsci.2016.05.011
1464-343X/

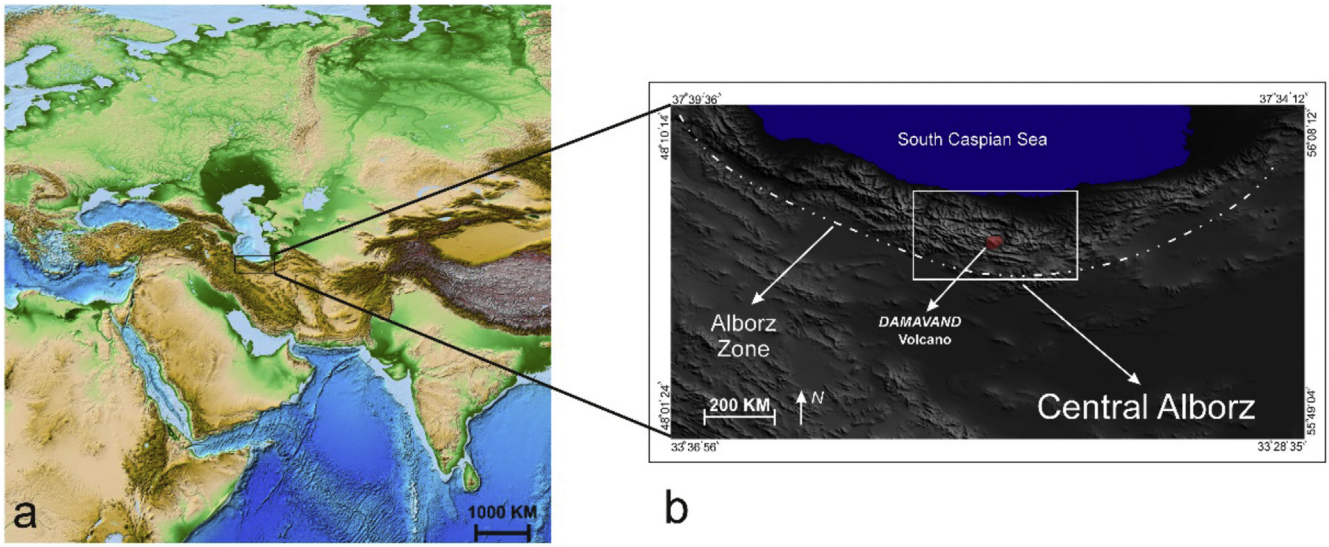


**Fig. 1.** (a) Regional topographical map of Iran. The Alpine-Himalayan belt occupies majority of the country. (b) Damavand volcano is situated in the central parts of Alborz Mountains.

systems of volcanoes (Higgins and Roberge, 2007; van der Zwan et al., 2013; Vernon, 2004; Viccaro et al., 2006).

Textural studies and in particular quantitative CSD analysis have proven to be valuable in many volcanic systems to quantify crystallization and textural equilibration processes (Cashman and Marsh, 1988; Higgins, 1996b; Marsh, 1998). According to these authors, crystal size and number density are intricately linked to the rates of crystal growth and nucleation, which change in response to variations in magma temperature, vapor pressure, and melt composition. CSD studies on volcanic rocks have revealed the relationship between the occurrences of different crystal populations and the different petrologic processes. Magma mixing is among the processes that is suggested to be recorded as multiple crystal size distributions (Higgins and Roberge, 2007; Martin et al., 2006; Salisbury et al., 2008). Effects of magma storage time (Armienti et al., 1994; Mangan, 1990), textural coarsening (Higgins, 2002; Vinet and Higgins, 2011) and depressurization during magmatic ascent (Ngonge et al., 2013) are some of the other processes that have been investigated by using CSD. Thus, temporally-constrained studies of crystal textures provide insight into magma crystallization kinetics under changing thermo-barometric conditions.

During the volcanism of Damavand which has occurred frequently from the Late Pliocene to the Holocene (Davidson et al., 2004; Liotard et al., 2008), the volcano has produced different volcanic rocks. The purpose of this study is to investigate (i) the magma chamber processes and the volcanism in a time period of 63–66.5 ka (which has led to the formation of three major trachyandesitic lava flows) and also (ii) to observe the possible variation in this period. To get insights to the preceding questions, we tried to quantify the textural information recorded in the trachyandesites of Damavand volcano (Young Damavand), by measuring 2D parameters of plagioclase which is the most prevalent mineral in CSD studies.

## 2. Geological background

The Iranian plateau is tectonically an active region within the Alpine-Himalayan orogenic belt. The occurrence of Paleo and Neo-Tethys subduction zones in this region has led to the formation of significant plutonic and volcanic complexes (Azizi and Moinevaziri, 2009; Hassanzadeh et al., 2008; Mirnejad et al., 2013). Damavand volcano located at 35°51′–36°02′N, 52°0.5′–52°13′E with a volume of more than 400 $km^3$ is a young dormant stratovolcano and currently shows a fumarolic activity (Fig. 2). Damavand volcano is made of pyroclastic breccia deposits and lahars interbedded with thick lava flows (Allenbach, 1966; Davidson et al., 2000; Liotard et al., 2008). According to Allenbach (1966) and Davidson et al. (2004), it is constituted of two superimposed edifices. An "Old Damavand", active between 1.8 and 0.8 Ma, and subsequently eroded, is located slightly to the north and east of the present cone. A "Young Damavand", active between 0.4 Ma and 7 ka, corresponds to the migration of activity centers towards the south and west. The activity of the "Old Damavand" was probably preceded and accompanied by regional basaltic emissions south and south/east of the volcano. The results of K/Ar, $^{40}Ar/^{39}Ar$ and (U–Th)/He dating methods suggest that the Damavand volcanism has occurred frequently from the Late Pliocene to the Holocene (Davidson et al., 2004; Liotard et al., 2008). Based on the investigations of the type and the spread of pyroclastic deposits, Mortazavi (2013) suggests a Sub-Pillinian eruption type.

Generally, a spectrum of basic, intermediate and acidic volcanic rocks with an alkaline affinity occurs in the Damavand (Emami and Irannejadi, 1993). Trachyandesite, trachyte and olivine basalt are the main exposed volcanic rocks in the Damavand, respectively. Which among them, olivine basaltic rocks are considered to be erupted first (Allenbach, 1966; Emami and Irannejadi, 1993). Based on this suggestion, Emami and Irannejadi (1993) propose that the trachytes and trachyandesites of Damavand are the magmatic differentiation products of these olivine basalts. However, Davidson et al. (2004) exclude this theory and show that trachyandesites have erupted before the olivine basalts and are not products of the mentioned differentiation. Fig. 3 shows the total-alkali-silica (TAS; Le Bas et al., 1986) classification diagram of the Damavand's whole-rock compositions and the dominance of trachyandesites and trachytes. Based on the modal abundance of ferromagnesian minerals Emami and Irannejadi (1993) have defined seven sub-groups.