The Volcano-Stratigraphy of Jabal Al-Shahba Cinder Cone, South Syria

by

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Abstract

The Tertiary-Quaternary basaltic lavas of southern Syria are divided into three separate volcanic phases, of Miocene, Pliocene and Quaternary age. These basalts are parts of the large intra-continental basaltic terrain of Harrat Al-Shaam, which covers an area of about 45,000 km2. and lies in NW-Arabian plate. Detailed field investigation shows that Jabal Al-Shahba is one of a large number of scoria and basaltic cones that are distributed in the Syrian parts of Harrat Al-Shaam. Jabal Al-Shahba volcano forms a single, relatively small hill of circular shape. It has a height of 50 m and covers an area of bout 3 sq. km. The flanks of the volcano have slopes of about 25-30^o, producing almost a symmetrical geometry.

The stratigraphy of the volcano is mainly composed of bedded scoria, fall lapilli that make up the volcano from the base upwards. The ejecta are dominated by angular to subangular clasts that are generally of less than 2.5 cm in diameter. This classifies Jabal Al-Shahba as a cinder cone.

Petrographically, the rocks of the studied volcano are dominated by scoriaceaous olivine- and plagioclase-phyric basalt. They have modal olivine (3-6 vol.%), plagioclase (4-8 vol.%), volcanic glass (35-40 vol.%) and vesicles (30-35 vol.%). The rocks are mostly fresh; however, slight alteration has been recorded in some samples.

The volcano appears to have resulted from multiple eruptions of one prolonged phase. Its volcanic activity consisted of a series of discrete explosion intervals. The time gap between each explosive interval producing the successions was relatively long as deduced from the existence of separation sections. The ejecta of Jabal Al-Shahaba are of Strombolian type of volcanicity. The small dispersal area and the height of the cone support this interpretation. The cone was originated by a magmatic mode of fragmentation.

1. Introduction

Harrat Al-Shaam plateau basalt covers an area of 45 000 km^2 and lies in the NW part of the Arabian plate. This plateau extends from Syria to Saudi Arabia through Jordan (Mouty et al., 1992). It is considered to be globally one of the largest alkali olivine basalt plateaus. The Syrian part of the plateau is locally known as Jabal Al-Arab basalts and occurs in the southern Syria. It covers an area of about 20,000 sq. km and extends from the southern rim of the Damascus Basin, which is marked by the folded mountain of the Antilebanon southwards to the Jordanian border. The basalt attains a thickness of about 1500 m and is of Neogene-Quaternary age (Mouty et al., 1992 and Otaki, M.198)

Large numbers of volcanic cones (scoriaceous and basaltic) with unlimited number of eruptive centers occur in the area and are distributed through the plateau. Jabal Shihan and Jabal Al-Shahba are the most outstanding volcanoes in this basaltic field. This study aims at a detailed investigation of Jabal Al-Shahba Volcano. The Volcano is located near Al-shahba Village which is lies about 15 km to the north of Al-Suweida (Fig. 1).

A trip around the volcano can be usaoll by newly established small tracks that meander to the summit of the volcano. The volcano has a height of about 65m and covers an area of about 3 km^2. An open pit mine (30m X 40 m) is located in the northern flank of the volcano.

Jabal Al-Shahba is exposed as a single, relatively moderate-lying hill of almost circular overall shape within a vast plain area. The flanks of the volcano have slopes of about 25-30^o in all directions, creating a nearly symmetrical conical geometry (Fig. 2). It is surrounded in the western and southwestern parts by several basaltic volcanoes forming a volcano group.

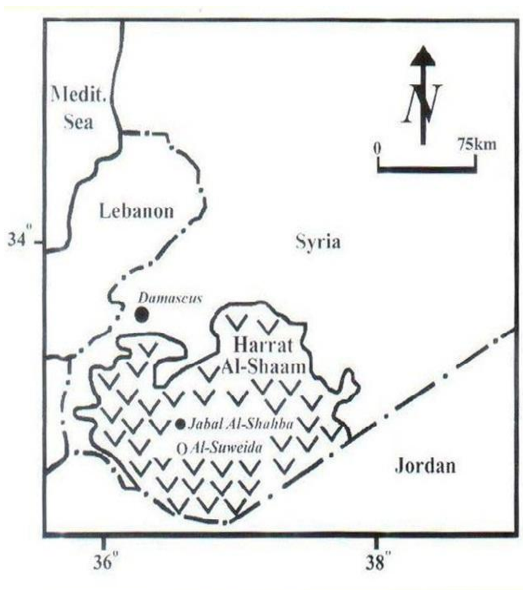


Fig. 1. *Location map of Jabal Al-Shahba Volcano.*

Volcanic succession of Jabal Al-Shahba

Jebal Al-Shahba is a medium-sized edifice. It represents one of the best developed scoria cones in the area. Stratigraphical investigations indicate that the volcano exhibits only limited vertical and horizontal variations. Thus, no subdivision into horizons was possible. The ejecta consists mainly of scoria fall, mostly of lapilli dominated by clast ranging in size between 2 and 4 cm and deposited as well-developed bedding. The layers have, in general, constant thickness with small lateral variation in all directions; they overlie each other gently without any post-eruption tectonics.

About 22 beds are counted within the succession with a total thickness of 18.9 m (Fig. 3). They are thick to very thick beds, the majority of which are well sorted. One badly sorted bed 200 cm occurs at the top of the succession. Grading is generally limited through the section. However, two beds show reverse grading and one exhibits normal grading. The ejecta are mostly black to grayish black in color and moderately vesiculated. The size of the clasts mainly ranges from 0.5 to 3 cm, but less than 2.5 cm is the dominant size.

The pyroclastics are mostly loose and friable with a limited degree of lithification and exhibit no welding or agglutination. They are almost fresh with limited alteration. Limited secondary minerals are recorded in the vesicles. No basaltic flows or dikes are observed. Moreover, xenoliths and accessory lithic fragments are totally absent.

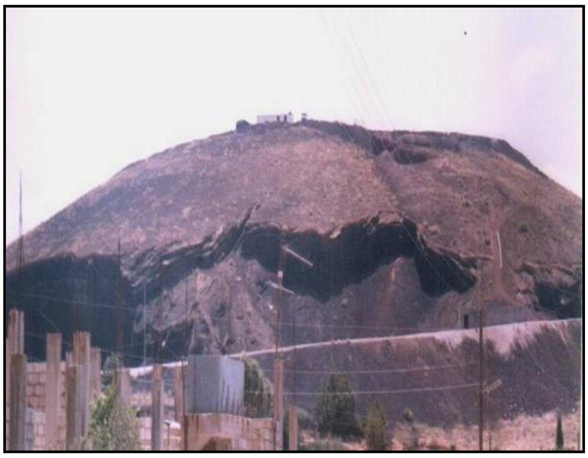


Fig. 2: *General view of Jabal Al-Shahba Volcano, looking south, showing the northern part of the volcano. In front of the photo the open mine is exposed.*

Detailed stratigraphical description

The volcano-stratigraphy of Jabal Al-Shahb was studied by mapping and subdividing of the volcanic succession, determining the vertical and lateral facies changes, interpreting the types of eruptions, and looking at the origin and mode of fragmentation.

The beds drape gently over one another and are separated from one another by intervening soil layers, erosion surfaces and oxidation zones. Moreover, different types of beds were identified from one another by differences in: grain size, thickness, color, type of grading and relative stratigraphic position. From to base top, the succession consists of the following units (Fig. 3):

1-A well-sorted layer of 80 cm composed of lapilli with a grain size ranging between 2 and 5cm (hereafter 2-5 cm).

2- Four well-sorted beds of 20 cm (1-2 cm), 170 cm (2-5 cm), 30 cm (0.5-1cm), 40 cm (1-3 cm), respectively.

3- A multiple reversely graded bed. It has a thickness of 150 cm and a grain size range 2-5 cm.

4- A sequence of 3 well-sorted beds. The sequence starts with 170 cm thick bed of 1-4 cm, followed by 40 and 50cm thick beds with grain size (1-3 cm), (2-4 cm), respectively.

5- A normally graded bed, 80 cm thick. Normal grading is demonstrated by relatively coarse clasts (2-3 cm) finning upwards to fine lapilli 0.5-1 cm. The bombs included are general by about 15 cm in long diameter (Fig. 4).

6- A well-sorted, thick-bedded sequence consisting of four beds. The sequence is arranged in the following order: a well-sorted bed of lapilli (2-5 cm) with a thickness of 30 cm; it is followed by well-sorted, 80 cm thick bed, with clasts size ranging from 2-4 cm. The overlying bed is 110 cm thick, with well-sorted lapilli-sized clasts (2-5 cm). It is overlain by a well-sorted, lapilli-sized (2-4 cm) bed with 90 cm thickness (Fig. 5).

7- A reversely graded bed 80 cm thick, and a grain size ranging 0.7-1 cm coarsening upward to 2-4 cm.

8- A sequence of five well sorted beds as follows: 50 cm (2-4 cm), 30 cm (0.5-1cm), 130 cm (2-4 cm), 140 cm (2-6), 70 cm (2-3 cm), 50 cm (1-5 cm), respectively.

9- The topmost layer is markedly different and constits of a thickly bed of 2 m. The bed is of brown color and consists of 50% blocks and 50% of fine lapilli.

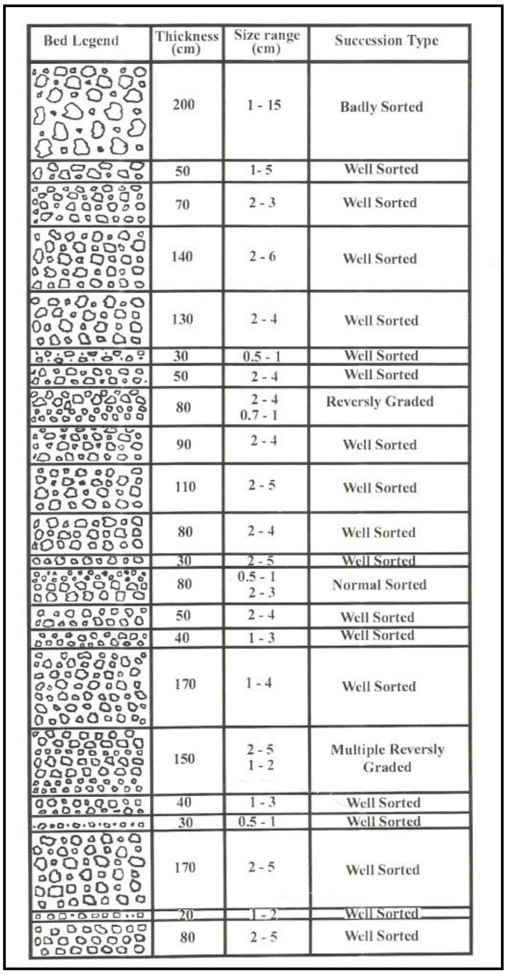
Petrography and Mineralogy

Petrographic and mineralogical analyses of the rocks of Jabal Al-Shahba has indicated that they consist of scoriaceous glassy olivine-plagioclase basalt. The constituents are olivine (3-6 vol.%) and plagioclase (4-8 vol.%), set in glassy groundmass (35-40 vol.%) and vesicles (30-35 vol.%).

The sideromelane (original glass) is fresh and has not undergone post-depositional alteration. They are light gray to black. However, the upper most bed is dark brown in color due to oxidation. The glass is vesiculated to different degrees, and serves as groundmass for the associated mineral phases. Palagonitization and other secondary minerals are not recorded.

The large number of vesicles indicated a huge volume of volatiles. Formation of the vesicles is the result of trapping of steam. This would require a gas phase trapped in a viscous, coating medium (Lorenz, 1970, Houghton; and Wilson,1989) The essential conditions governing this process are the dissolved gases and the relation of gas pressure in the bubbles to the strength of the liquid. When the total force exerted by entrapped gases exceeds the strength of the liquid fraction over the same cross-sectional area, the liquid will be torn apart as pyroclastic ejecta (Williams and McBirney, 1979).

Olivine is present both as phenocrysts and as groundmass ingredients forming seriate texture. The phenocrysts are up to 1.5 mm in length and have eu hedral to subhedral shape. They are mostly occurring in isolated crystals that are randomly oriented. The crystals are mostly fractured and resorption embayment is



Bed Legend	Thickness (cm)	Size range (cm)	Succession Type
	200	1 - 15	Badly Sorted
	50	1- 5	Well Sorted
	70	2 - 3	Well Sorted
	140	2 - 6	Well Sorted
	130	2 - 4	Well Sorted
	30	0.5 - 1	Well Sorted
	50	2 - 4	Well Sorted
	80	2 - 4 0.7 - 1	Reversly Graded
	90	2 - 4	Well Sorted
	110	2 - 5	Well Sorted
	80	2 - 4	Well Sorted
	30	2 - 5	Well Sorted
	80	0.5 - 1 2 - 3	Normal Sorted
	50	2 - 4	Well Sorted
	40	1 - 3	Well Sorted
	170	1 - 4	Well Sorted
	150	2 - 5 1 - 2	Multiple Reversly Graded
	40	1 - 3	Well Sorted
	30	0.5 - 1	Well Sorted
	170	2 - 5	Well Sorted
	20	1 - 2	Well Sorted
	80	2 - 5	Well Sorted

Fig. 3: *Columnar section through Jabal Al-Shahba Volcano, south Syria.*

very common. Iddingsite is restricted along the rims of crystals. Olivine groundmass occurs as small crystals and as needle-like forms.

Plagioclase also occurs in two generations as phenocrysts and in the groundmass. The phenocrysts are quite fresh and well developed, showing albite and Carlsbad twining. The extinction angle measured on several plagioclase phenocrysts, is between 30^o - 34^o, indicating a labradorite range in composition. The elongated, lath-shaped crystals of plagioclase measure up to 3 mm in length. They occasionally occur in glomeroporphyritic aggregates. Plagioclase groundmass is composed of microlites that exhibit pilotaxitic texture. They are partly altered to epidot.

Discussion and conclusions

The present study reveals that the Jabal Al-Shahba volcano was formed by consecutive eruptions, separated in time from each other and from a terminal pulse of volcanic activity that partially mantle them. The overall symmetrical geometry of the studied volcano indicates a magmatic source discharging through a simple conduit or “point source”. The tephra–successions of the investigated cone consists of pyroclastic rocks, and scoriaceous ejecta. They posses features similar to those published on this type of ejecta

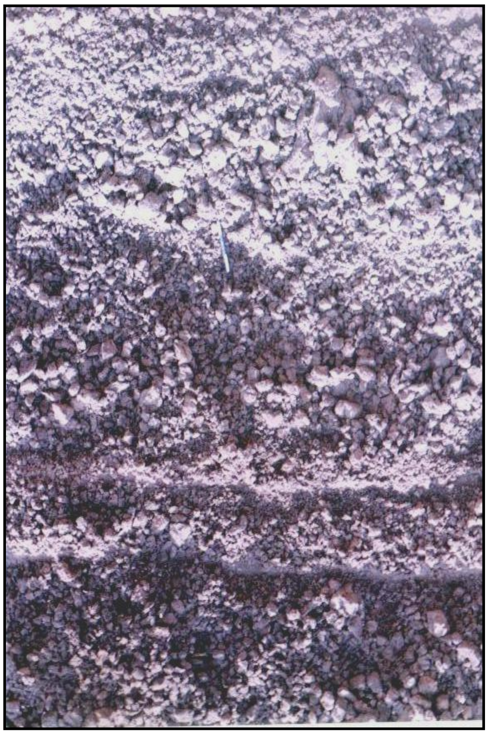


Fig. 4: *Field photograph, showing a sequence of well-sorted beds in the middle parts of Jabal Al-Shahba Volcano, south Syria*

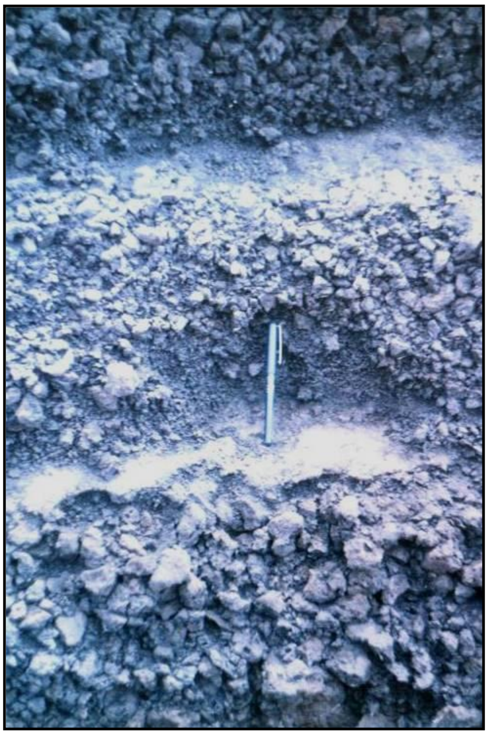


Fig. 5: *Field photograph, showing a well-sorted bed at the bottom topped by reversibly graded bed. Separation zone of mm thick is seen between the two beds*

(Walker, 1973, Blackburn, 1976, Heiken, 1978, Cas and Wright, 1987). About 95% of the rocks are made up of lapilli. The rest are blocks, dominantly around 10 cm in diameter; therefore the cone can be reasonably classified as a scoria cinder cone.

The rocks of the volcano drape gently over one another. They consist mainly of well-bedded successions arranged in shower bedding and planar stratification. The parallel horizontal bedding shows that the volcano formed uniform blanket topography. The beds posses a uniform thickness; thus they may be described as “mantle bedding”.

This study also shows that the volcano resulted from multiple eruptions and one prolonged eruptive phase, giving rise to dissimilar stratigraphic successions from the base upwards that nevertheless retain a comparable overall character.
The volcanicitiy occurred in pulses, that varied in pattern from eruption to eruption and that was not
uniform within the individual eruptions. The time gap between each event was relatively long as deduced from the existence of a weathering surface, oxidation zones and other separations. However, the period of quiescence in volcanoes may repeat over time intervals as small as several days, or several weeks extending to several months or to two or more years (Fisher and Schmincke, 1984). The duration of each explosive interval was not identical, as is seen by the variation in the thickness of beds of the volcano. The occurrence of some ballistic clasts suggests more powerful explosions particularly in the last phase of history.

Concerning the genetic classification of Jabal Al-Shahba, the pyroclastics consist mainly of well-bedded successions arranged in planar stratification called “shower bedding”. The bedding maintains a uniform thickness; thus it may described as “mantle bedding” (Cas and Wright, 1987). The pyroclasts are mainly scoria fall deposits and mostly angular to subangular and lapilli-sized. This would classify Jabal Al-Shahba as a “cinder cone” (Best, 1982) having a low content of “fines” (Walker, 1981). This was determined quantitatively, and reflects a low degree of fragmentation. The petrography showed that the ejecta mostly have a low crystal content (<10%), in keeping with a low degree of fragmentation. The latter “characterises sustained eruptions of fluids and Newtonian magma taking place from an open vent“, having “free access to the surface” (Walker, 1981). Thus a magmatic type of eruption is proposed for Jabal Al-Shahba based on its lapilli-sized, vesiculated basic ejecta (Cas and Wright, 1987). The involvement of water in the explosive activity is unlikely here as phreatomagmatic eruptions are characterized by a high degree of fragmentation (Walker, 1981). The limited occurrence of ash is consistent with this result. The Strombolian style of eruption and the low degree of fragmentation as well as the low crystal content of the ejecta make an argument for this mode of formation (Zimanowski et al., 1997 and Buettner et al., 1999).
An elementary objective of this study is to classify the eruptive type of the investigated cone. The ejecta of Jabal Al-Shahaba are similar in most respects, to those of active volcanoes with Strombolian activity such as Stromboli in Italy and Heimaey in Iceland (Self et al., 1974 and Houghtoz and Hackett 1984). The suggested type of volcanicity is supported by several criteria; such as the low dispersal area (the actual area over which a pyroclastic deposits is dispersed) which is approximately 3km2. This low dispersal area hints at low height of the eruption column. The Strombolian eruption column is lower than 10 km (Wright, 1980, Wood,1980, Houghton and Schmincke, 1989). Additional features that support this type of eruption are the low degree of fragmentation, dominated by lapilli (average 2.5 cm).
The black color of the ejecta may indicate that they did not suffer from extensive oxidation. However, the brown color of the upper most bed may reflect that it suffered from oxidation. However, strombolian pyroclastics are peculiar by the oxidation of steam which produces a bright red coloration (Walker and Croasdale, 1972).

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