



# Cenozoic Basaltic Lava Flow of Wadi Al-Masan (Southwest of Tarhuna Region, Libya): Morphology and Petrography Study

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## Abstract:

One of the most dominant types of igneous volcanic rocks on the earth's surface is basalt. Wadi Al-Masan area southwest of the Libyan city of Tarhuna is one of the places where the basaltic lava flow is presented. This study aims to identify the morphological structures and petrographic description that indicate mineral composition. Four different morphological forms of basaltic lava structures have been identified as a result of this study, which are lava blisters, lava toes, lava vesicles, and olivine phenocrystals. The work is limited to making thin sections for two rock samples and XRD analysis. The value of this study lies in assisting to employ these morphological forms and petrographic description to understand the geological conditions that formed them in that period of time. Furthermore, to compare these findings with the results found in other areas in Libya with basaltic lava that contain similar geological events.

**Keywords:** Basalt, Lava Flow, Morphological Structure, Petrography, Tarhuna, Libya.

# تدفقات الحمم البازلتية في حقب الحياة الحديثة في وادي المسن (جنوب غرب منطقة ترهونة، ليبيا): دراسة تشكيلية وصخرية

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## الملخص:

ان أحد أكثر أنواع الصخور البركانية المهيمنة على سطح الأرض هو البازلت. تعتبر منطقة وادي المسن جنوب غرب مدينة ترهونة الليبية من الأماكن التي يظهر فيها تدفق الحمم البازلتية. تهدف هذه الدراسة إلى التعرف على التراكيب المورفولوجية والوصف الصخري الذي يدل على التركيب المعدني. تم تحديد أربعة أشكال مورفولوجية مختلفة لهياكل الحمم البازلتية كنتيجة لهذه الدراسة، وهذه هي بثور الحمم البركانية، وأصابع الحمم البركانية، وحوصلات الحمم البركانية، وبلورات الزبرجد الزيتوني. تقتصر الدراسة على عمل مقاطع رقيقة لعينتين صخريتين وتحليل حيود الأشعة السينية (XRD). تكمن قيمة هذه الدراسة في المساعدة على توظيف هذه الأشكال المورفولوجية والوصف الصخري لفهم الظروف الجيولوجية التي شكلتها في تلك الفترة الزمنية. علاوة على ذلك، يمكن مقارنة هذه النتائج مع النتائج الموجودة في مناطق أخرى في ليبيا والتي بها حمم بازلتية تحتوي على أحداث جيولوجية مماثلة.

**الكلمات المفتاحية:** البازلت، تدفق الحمم البركانية، التراكيب المورفولوجية، الوصف الصخري، ترهونة، ليبيا.

## 1. Introduction

Lava flows or basalt lava, which is the most common name to describe lava flows to the surface through cracks and fractures that occur in the rocks on the surface at the time of the lava exit. The reason for the common name of basalt flows is that they have a lower viscosity than rhyolitic lavas because they contain less silica and are therefore less viscous, which helps them flow [1]. These molten rocks of silicate

materials have a great influence on the formation of the topography of the earth and the formation of different morphological forms [2] that reflect the nature of these lavas in terms of viscosity, temperature, and flow strength [3]. Understanding their geomorphological characteristics, surface features and chemical composition is essential for understanding geological events at the time of their formation.

## **2. Basaltic Lavas in Libya**

It has been suggested that the magma that formed the Tertiary basaltic lava flow may have been easily brought to the surface with the help of pre-existing fractures in southern Libya and northern Chad. The existence of these old fractures is due to the flexure of crustal blocks [4]. On the other side, estimating the absolute age of the basalt rocks in the Gharyan region, which considered to include the basalts of Wadi Al-Masan, it has estimated from 53 to 3.5 million years, which corresponds to the Eocene-Pliocene time within the Tertiary period [5]. In contrast, the volcanic flows in Wadi Ghan area in the Gharyan region have been estimated to be recent flows dating back to the Quaternary age [6].

## **3. Study Area**

The study area is the basaltic lava flow in Wadi Al-Masan area, southwest of the city of Tarhuna. Specifically, the study area is located southeast of the capital, Tripoli, at a distance of approximately 120 kilometers, and is located between longitudes  $13^{\circ},28',81''$  and  $13^{\circ},38',10''$  east and latitudes  $32^{\circ},02',61''$  and  $32^{\circ},09',65''$  north.

These flows are essential part of the basalt lava of Gharyan basaltic lava flow in the Tertiary - Quaternary period, and they are considered one of the four main basalt flows in Libya in the Cenozoic period [4], [7]. These are Gharyan lava flows, which also includes Wadi al-Masan lava flow of

this study, in addition to the Jabel al Haruj al Aswad, Jabal as Sawdah, and Jabal Eghie lava flow [5] (Figure 1).

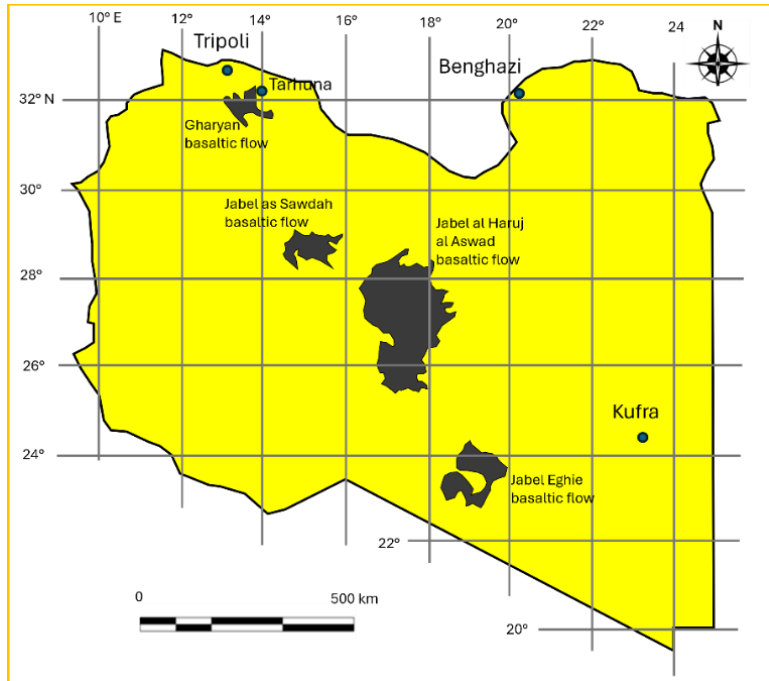


Fig. 1. Map of Libya shows the four major Cenozoic basaltic lava flow including study area (Modified after (Ramos, et al., 2006)) [8]

#### 4. Geomorphological Features

The morphological structures which are formed by the flow of basaltic lava flow on the surface take several shapes. Basalt is in the form of flows and domes, which may reach a thickness of a kilometer, and its area is hundreds of thousands of square kilometers [9]. This diversity of forms and shapes is due to several factors such as the chemical composition of the lava and the proportion of volatile materials originally in the magma, in addition to the viscosity and temperature of the lavas as well as the rate of eruption, and the terrain present on the surface at the time of the eruption. The following are the distinctive types of morphological

structures of basaltic lava flow that are observed in the Wadi Al-Masan area.

#### **4.1. Lava Toes**

One of the morphological observations found in the Wadi Al-Masan basaltic lava flows is what is known as the curled-over edges or convoluted flow edges which is about 2 - 3 cm in diameter and up to 100 cm long (Figure 2). Although they are not commonly found in the valley, they are present at least in two places. These distinctive morphological structures occur from solidifying lava as it flows from top to bottom or when it advances forward as the molten interior steadily advances forward, creating toe-like formations.



**Fig. 2. Vertical and horizontal lava toes within Wadi Al-Masan basaltic lava flow.**

#### **4.2. Ropey Features**

Ropey or Pahoehoe lava features are a form of basaltic lava flow means smooth or rope like. The liquid lava flowing beneath a thin, still-plastic crust drags and wrinkles it into tapestry-like folds and rolls resembling twisted rope (Figure 3).



**Fig. 3. Vertical and horizontal lava toes within Wadi Al-Masan basaltic lava flow.**

#### **4.3. Lava Blisters:**

One of the distinctive basaltic lava flow forms in Wadi Al-Masan are those formations called lava blisters or tumulus. They are basaltic lava forms that occur when molten lava increases the pressure under the crust of the solid lava flow. This pressure causes the crust to swell and crack, forming crusts of rock layer upon layer, allowing the molten rock balls to escape and solidify at the top, creating a small (40 – 50 cm in diameter) dome-like structure (Figure 4). This structure may be accompanied by bubble protrusions that appear on the surface of the flow due to the presence of gas trapped inside the molten material.



**Fig. 4. Lava blisters in Wadi Al-Masan basaltic lava flow.**

#### **4.4. Basaltic Vesicles**

Basalt vesicles are one of the types of basaltic lava flow forms found in the basaltic lava flow in the study area. They are cavities or holes formed in basalt rock formed when the molten rock reaches the surface, so the pressure decreases, making the gases trapped in the magma, such as water vapor and carbon dioxide, are released into the atmosphere, leaving behind a group of pores or vesicles that vary in size and shape, but are generally round or elliptical in shape (Figure 5). These vesicles may be filled with minerals in what are called amygdaloid structures (Figure 5).



**Fig. 5. Basaltic vesicles within Wadi Al-Masan lava flow.**

#### **4.5. Olivine Phenocryst**

One of the observations worth noting when studying the basalt rocks in Wadi Al-Masan are the large or phenocrystals (about 2 cm in diameter) of olivine. The olivine crystals are found within the aphanitic groundmass texture of basalt rock. These crystals form in the initial stages of mineral crystallization in magma due to their high melting point. Once the basalt magma cools, olivine is often the first mineral to crystallize because it can no longer remain melted in the magma. These crystals continue to grow as the temperature of the magma decreases, eventually becoming large enough to be seen with the naked eye (Figure 6) and what is called porphyritic texture is formed.



Fig. 6. Clear Olivine phenocryst within Wadi Al-Masan basaltic lava flow.

## 5. Petrographic Study

The petrography and geochemistry of number of rocks of Gharyan lava have been studied and discussed by Piccolo and Spadea [10]. In terms of the mineral composition of the lava flows that make up the basalt rocks in the study area, some of them consist of olivine basalt, and some of them consist of nepheline basalt [5]. Olivine basalt is dark gray in color and petrographically contains crystals of olivine, plagioclase, and opaque minerals with traces of zircon and apatite. Nepheline basalt is dark gray to black and contains large titanite and olivine crystals. Olivine crystals are mostly colorless, un-zoned, and anhedral to subhedral. As for titanite phenocrysts, they are often in small clusters and contain hourglass zoning and sometimes narrow pleochroic rims [5].

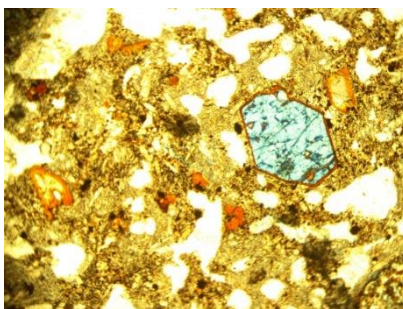
### 5.1 Thin sections presentation

The microscopic study of the samples collected from the basaltic lava flow in Wadi Al-Masan area revealed that a porphyry texture appears in both samples (Figure 7) and may indicate the early crystallization stage of some minerals of the magma underneath. The crystals were formed from the magma before it reached the surface, especially those minerals with a high melting point such as Olivine and pyroxene. As the magma reaches the

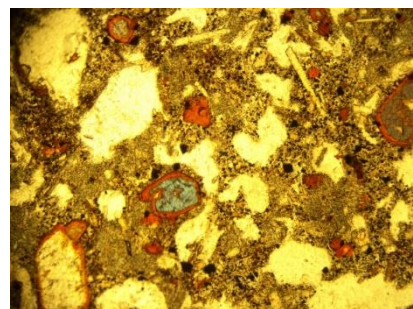
surface, the materials in the magma crystallize rapidly, which prevents them from growing in size. However, these pre-existing crystals remained in the melt as they rise up to the surface.

The components of this basaltic lava under study are composed of fine prismatic or elongated crystals of calcium plagioclase with other crystals that are predominantly equant or tabular such as olivine, pyroxene, and amphibole crystals. Amphibole crystals may appear in the form of euhedral crystals (Figure 7.a, 7.f).

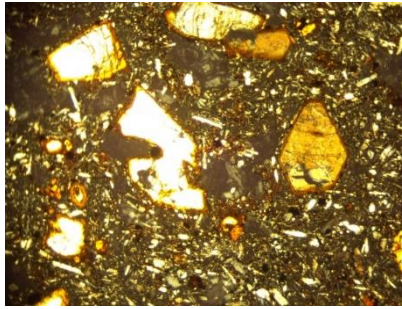
On the other hand, it is observed that the olivine crystals had mostly undergone a change process, forming what is known as addingsite (Figure 7.b), which is a common change for olivine during oxidation and hydrothermal processes in a highly oxidizing environment under low pressure and at medium temperatures. This addingsite is a pseudomorph of olivine crystals when exposed to alteration processes making change in the chemical composition with the preservation of the outer shape of the olivine crystals and make a rim of reddish brown colour (Figure 7.b, 7.d, 7.e).



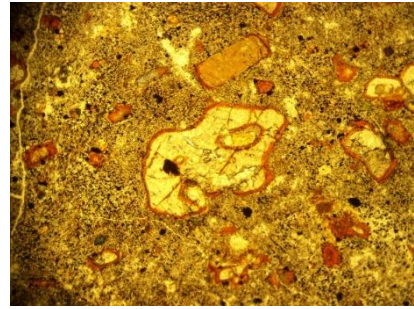
(a)



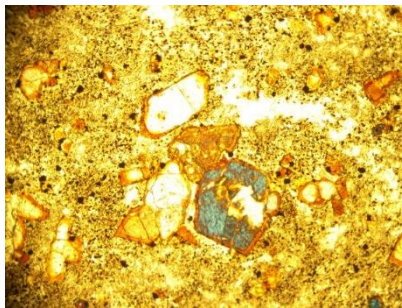
(b)



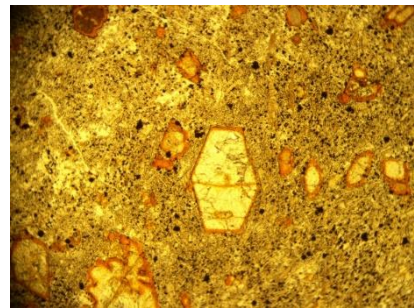
(c)



(d)



(e)

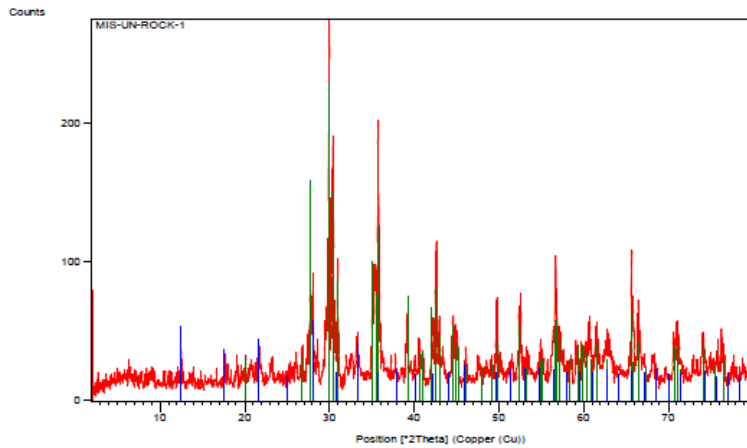


(f)

**Fig. 7.** Petrographic thin sections for selected samples of Wadi Al-Masan basaltic lava flow. (a): Porphyritic texture of basaltic lava flow with euhedral phenocryst of amphibole with anhedral crystals of pyroxene and olivine in aphanitic plagioclase groundmass. (b): Altered olivine crystals. (c): Amphibole and pyroxene phenocrysts within aphanitic groundmass of plagioclase, olivine, and opaque minerals. (d): Highly altered olivine crystals. (e): Altered olivine and pyroxene phenocrysts. (f): Porphyritic texture with euhedral amphibole crystal and altered olivine in plagioclase, pyroxene, and opaque minerals groundmass.

## 5.2 Graphics and Analyze View of Samples

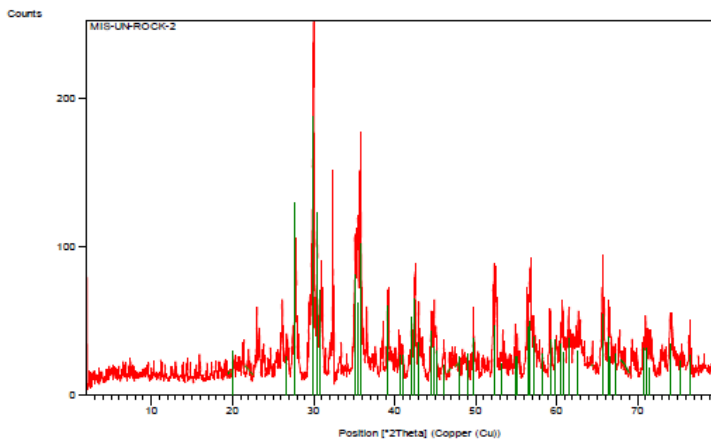
The X-ray diffraction (XRD) analysis of the rock samples collected from the basaltic lava flow in the study area is performed by Libya Petroleum Institute in Tripoli, and the results as following (Figure 8 and 9):



**Fig. 8. Graphical presentation of XRD analysis of sample 1 of Wadi Al-Masan basaltic lava flow.**

**TABLE I. PATTERN LIST AND SEMI QUANTITATIVE OF SAMPLE 1**

No.	Ref. code	Mineral name	Chemical formula	Semi quantitative %
	00-041-1483	Augite, aluminian	$Ca ( Mg , Fe , Al ) ( Si , Al )_2 O_6$	92
	01-071-0962	Zeolite P1	$Na_6 Al_6 Si_{10} O_{32} ( H_2 O )_{12}$	8



**Fig. 9. Graphical presentation of XRD analysis of sample 2 of Wadi Al-Masan basaltic lava flow.**

TABLE II. PATTERN LIST AND SEMI QUANTITATIVE OF SAMPLE 2

No.	Ref. code	Mineral name	Chemical formula	Semi quantitative %
	00-041-1483	Augite, aluminian	Ca ( Mg , Fe , Al ) ( Si , Al ) <sub>2</sub> O <sub>6</sub>	100

## 6. Conclusion

Four distinct morphological variations of basaltic lava formations have been discerned: lava blisters, lava toes, lava vesicles, and olivine crystals or xenolith texture. Through X-ray diffraction analysis (XRD), several minerals constituting the basaltic rocks under examination were recognized, specifically Augite and zeolite. By examining thin sections, it has been clear to find out a range of minerals that comprise basalt, namely Olivine, pyroxene, amphibole, in addition to calcium plagioclase.

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