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Strength of Damavand Volcanic Cone Quaternary Rocks against Destruction and Erosion based on Mineralogy Composition by Using TAS & KUNO Diagrams

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ABSTRACT: This paper intends to study strength of external igneous rocks by using Kuno diagram and reclassification of TAS diagram with respect to mineralogy composition regarding amount of Sio2 effect on rate of rocks toughness and looseness against destruction and erosion in geomorphological point of view. TAS diagram has been used in recommended classification by International Union Ground Sciences (IUGS) for chemical classification of small stone particles. Two factors are significant in said diagram to classify rocks: sum total of Na2o + K2O weight percent has been used in comparison with Sio2 weight percent. For this purpose, rocks have been classified by Sio2 changes rate to six groups with different percent of weight, by which diagram was divided to five limits which are ranged from one to five as values equal to very sensitive state until very resistant state. Results show that Damavand rocks are ranged between sensitive to resistant and they are among alkaline limit until intermediate limit. Kuno diagram was used for better understanding of chemical range classification of Damavand rocks and the result is all the Damavand rocks are ranged in alkaline series.
Keywords: Damavand, Mineralogy Composition, TAS Diagram, Kuno Diagram

INTRODUCTION

Every stone has a different reaction toward climate concerning minerals size, form, kind and structure. In other words, rocks strength level against climate is origin of various shapes that form different views of natural environment. (Mahmoudi, 1996:3) Generally, it could be said that rocks strength is related with two groups of factors: one group is essential properties of a rock such as tissue, crystallization rate, aggregate and crystals form (Sarabi, 1999: 19) internal fractures of the rock, compaction, size, levels and direction of holes, kind of cement (if any) (Hafezi Moghadas, 2011:229) and the second is climate, environmental conditions such as topography, vegetation, moisture percent, amount of rain and time. (Mahmoudi, 1998:23) Many types of ground formations are resulted from chemical processes that is important for geomorphologists to know them due to their role in formation. Parameters such as quartz, feldspat type, foidites and type and amount of iron and magnesium minerals are main criteria for chemical classification of alkaline external igneous rocks. (Churli et al, translated by Motamed, 1998:11) Quartz is the most significant minerals in stable minerals which is crystallized form of silica acidic rocks and those acidic rocks which have plenty silica are more resistant than basic rocks against erosion. (Mahmoudi, 1996:11) It should be noted that rocks contain quartz mineral has more resistance because quartz minerals are decomposed less than others and they are solved very slowly. (Drive, 1991:89) Various methods are used to classify igneous rocks such as classifications of quantitative, qualitative and chemical mineralogy and chemical mineralogy. (Moin Vaziri & Ali Ahmadi, 2009: 85 & 86) It seems that rock tissue is one important way to recognize and classify rocks and knowing the way of their formation. (Sarabi, 1999:45) TAS diagram presented by IUGS to classify external igneous rocks has been used in order to study strength of Damavand rocks and their classification

based on mineralogy composition. Therefore, at first, silica changes in diagram were studied to classify rocks toughness rate in five groups from one to five (very sensitive to very resistant) by which rate of Damavand rocks resistant have been examined as second step. Next, Kuno diagram was used for better assessment of chemical limit for Damavand rocks which is applied by summing weight percent of Na2o+ K2o toward the Sio2.

RESEARCH METHOD

In order to determine strength of Damavand rocks based on mineralogy against destruction and erosion, in the first place, reference books were studied in relation to rocks roughness and looseness in morphological point of view and then using Damavand geology map 1:100000 and spot satellite images and aerial photos, range of rocks dispersion was studied and they were controlled as cases with field study and sampling. Next step to determine rocks strength, TAS diagram that is related to external igneous rocks, was selected from IUGS offered classification, and strength of rocks against destruction was determined by diagram reclassification based on Sio2 changes and numeral value specification for each range, after that, Damavand rocks were accommodated and their strength rate have been specified. Finally, for better understanding of Damavand volcanic rocks, Alkali-Silica diagram (Kuno) was used that is based on weight percent of N2o + K2o toward Sio2.

Area Study

Damavand volcanic cone is the most prominent quaternary stratovolcano of Iran that is approximately located in geographical coordinate of "51^{o}59'31"E to 52^{o} '4516"E and 35^{o}51'N17 and 36^{o} 5'45"N. (Figure 1) Damavand summit has been located in high Alborz zone according to geological-structural point of view and it has been driven by Masha-Fasham fault on southern parts. (Darvisgzadeh & Mohammadi, 2005:66) Damavand has erupted several times since 1.8 million years ago which the last one has occurred about 7500 years ago. (Davidson et al, 2004:27) During that, pyroclastic materials arisen from eruption activities have covered area about 450 square kilometers. (Zarei Nejad, 2007) It has ejected alkaline basaltic basic lavas and/or Olivine Trachyandesite lavas during its formation over years and it seems that the volcano has ejected the magma which form intermediate limit lava until acidic-inclined with Trachyte composition. (Emami, 1989:48)

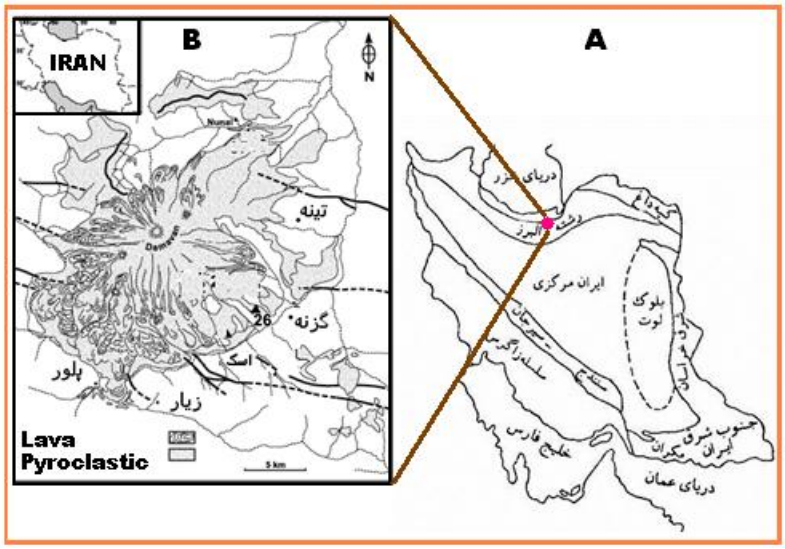

Figure1. A: Damavand Summit in Alborz Zone B: Volcanic Materials in Damavand Quaternary

MATERIALS AND METHODS

Geology of Area Study

Damavand mountain formation is a result of a volcanism happened in a quartz in central Alborz. There is another crater in northeast side that indicates activities by the volcano are not only restricted to central crater but also its side craters had roles to form cane. The craters are more in southwest and northeast sides in a way that, due to high rate of expelling sulphur, a hill has been created that called sulphur hill. (Field Inspection, 2012) The oldest Damavand quaternary lava is from alkaline basalt type that has been arisen from a rich magmatic

differentiation from Silica. (Irannejadi, 1991:85) But main activity of this volcano has occurred in central crater and its activity begun probably before Cretaceous and Eocene periods. (Khosrow Tehrani, 2003:255) The most important Damavand volcanic activity is related to Holocene periods that formed Damavand summit. (Alenbakh, 1966) and the last volcanic eruption has happened 7500 years ago. (Davidson et al, 2004:27) generally, Damavand rocks are in three types: basic, medium and acidic. There are only two kinds of basic: basalt and Trachyte basaltic lava. But in addition to lavas, there are pyroclastic and epiclastic rocks in types of intermediate range and acidic rocks. Most of Damavand mass has been formed by rocks which are in intermediate range regarding Silica, and amount of basic rocks are less than other rocks significantly in a way that the most abundant Damavand lava is from Trachyte type. (Aghanabati, 2004:459)

Damavand Lithology

Damavand volcanic rocks have been formed by various lavas in a way that its chemical composition includes a domain from Olivine-Trachybasalt to Trachyte from lithological point of view. (Emami, 1989:33) Gill classification (1981) is one of the classification criteria of Damavand lavas that has been executed through dry analysis[1] on Damavand rocks ((Bazalt (Sio2<53%), Andesite (Sio2=53-63%), Dacite (Sio2=63-68%), Rhyodacite (Sio2=68-72%)) and it shows that most of Damavand rocks are in intermediate range. Sodium feldspar (figure 2a), Biotite (figure 2b) and Pyroxene (figure 2c) may be mentioned as important minerals in Damavand rocks that each one are consists of different elements.

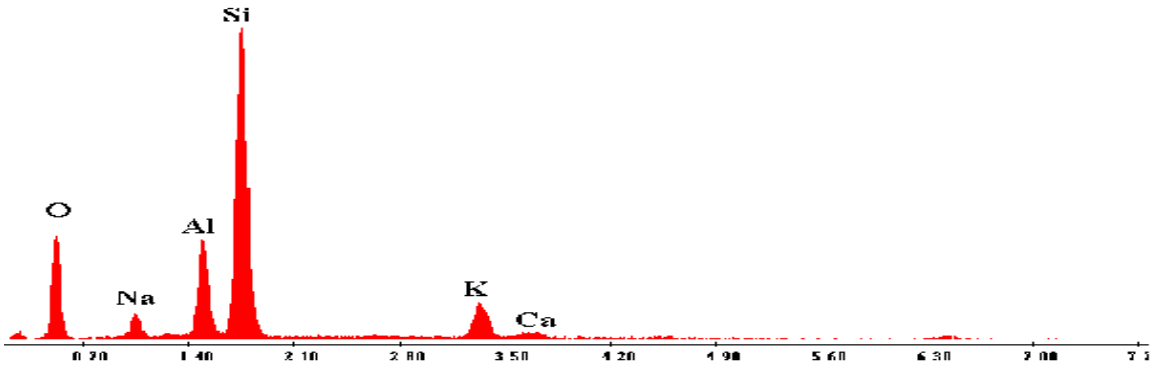

Figure 2a. Amount of elements in crystals in Damavand Trachyte rocks

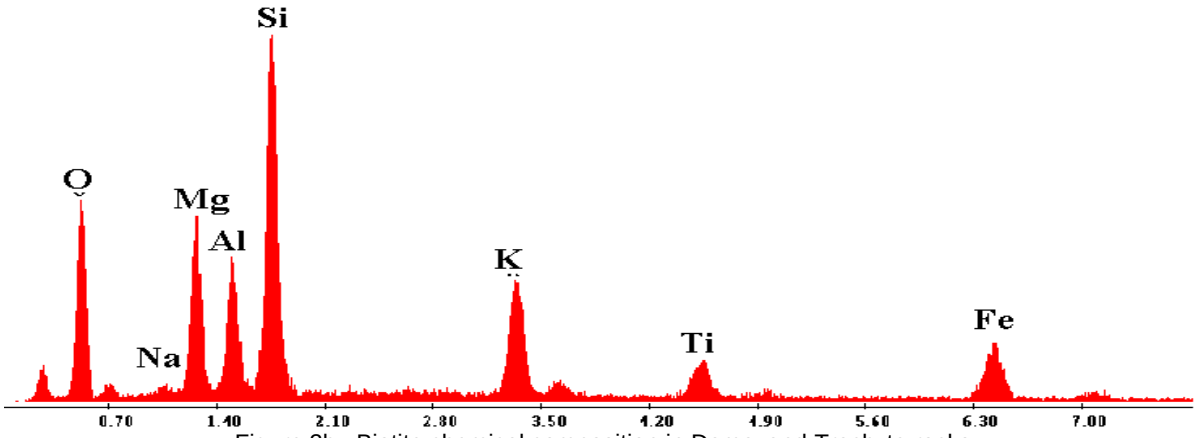

Figure 2b. Biotite chemical composition in Damavand Trachyte rocks

[1] Samples weigh without water

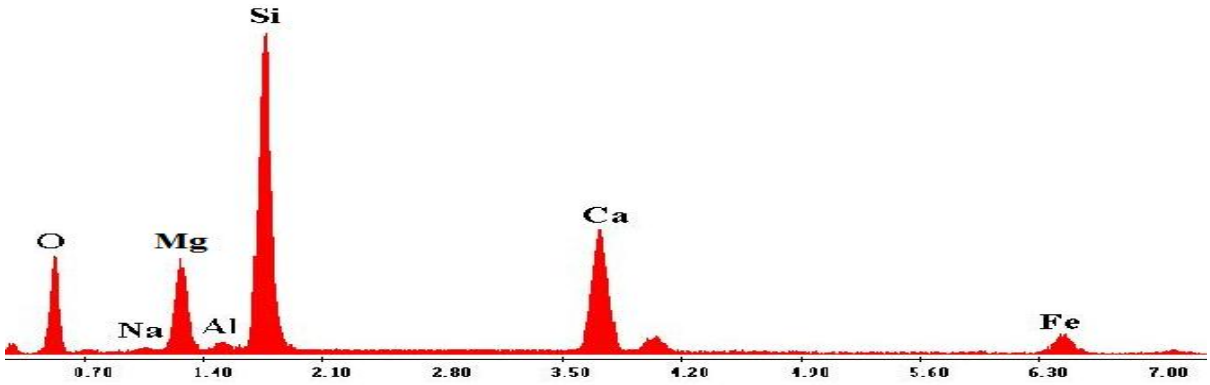

Figure 2c. Pyroxene chemical composition in Damavand Trachyte rocks

According to the rocks chemical classification in TAS diagram, the rocks have been classified from alkaline to acidic in accordance with changes of Sio2 weight percent and weight percent sum of Na2o+k2O. Therefore, Foidite has been placed in ultra-basic part and Rhyolite in acidic part. Considering Silica role in increasing strength of rocks against erosion, TAS diagram has been reclassified regarding Sio2 change in change domain of six weight percents and they have been weighted by allocated numbers. According to this weighting, regarding resistant against erosion, rocks are considered in range of very week (1) to very resistant (5). (Table 1)

Table1. Reclassification and determining the strength rate of external igneous rocks mineralogy regarding figure-3

Toughness Grade (Mineralogy Resistance)		Rock Type Based on TSA table	Rock Name Based on TSA table	Change Domain of Sio2 In TSA
Very Weak	1	Ultra-Alkaline	Foidite	<41
Very Weak	1	Ultra-Alkaline	Picrobasalt	41.3 - 45
Weak	2	Alkaline	Phono – tephrite	45-48.4
Weak	2	Alkali to Intermediate	Tephra – phonolite	48.4 – 52.5
Medium	3	Alkali to Intermediate	Phonolite	52.5 – 57.6
Weak-Medium	2-3	Alkaline	Basalt	45-52
Very Weak-Weak	1-2	Alkaline	Trachitebasalt	45- 49.4
Medium	3	Intermediate	Basalitic – andesite	52-57
Weak-Medium	2-3	Alkali to Intermediate	Basaltic – Trachyandesite	49.4 - 53
Medium-Resistant	3-4	Intermediate	Andesite	57 - 63
Medium	3	Intermediate	Trachyandesite	53-57.6
Resistant-Very Resistant	4-5	Acidic	Dacite	63-69
Very Resistant	5	Acidic - Intermediate	Trachyte – Trachydacite	61-69
Very Resistant	5	Acidic	Rhyolite	>70

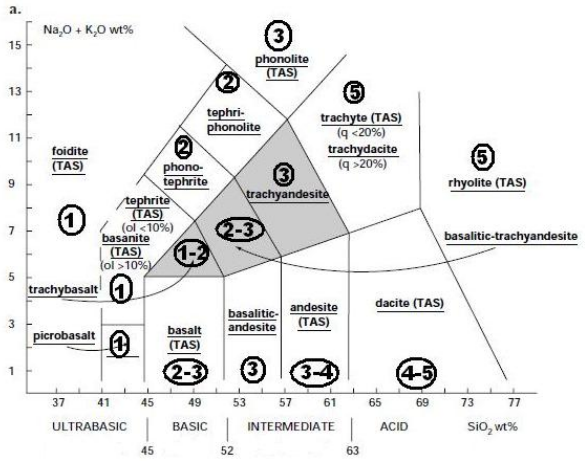

Figure3. Classification by International Union Ground Sciences for external igneous rocks on TAS diagram and its reclassification based on mineralogy strength rate (numbers in circles)

In order to use presented method, 11 samples of Damavand rocks have been selected which their chemical compositions have been provided by Davidson et al. (2004) and then, using TAS reclassified diagram on which strength ranging has been applied, strength rate of Damavand rocks against destruction and erosion have been specified (Table-2)

Table2. Determining the strength degree of 11 samples of Damavand rocks against destruction and erosion

Rock Type	Sio2 Amount (weight percent)	Na2+K2O (weight percent)	Rock Name in TAS diagram	Strength Degree Mineralogy
1	60.68	9.17	Trachyandesite	3
2	62.60	9.17	Trachydacite	5
3	59.18	8.89	Trachyandesite	3
4	60.63	9.14	Trachyandesite	3
5	61.20	9.18	Trachydacite	5
6	60.24	9.21	Trachyandesite	3
7	62.04	9.16	Trachydacite	5
8	59.39	9.23	Trachyandesite	3
9	61.32	9.18	Trachydacite	5
10	61.31	9	Trachydacite	5
11	60.13	8.97	Trachyandesite	3

Damavand rocks samples have been studied in other study by Emami (1989) and its rocks type plus amount of Sio2 have been determined. According to presented information, Damavand rocks toughness rate are determined based on TAS reclassified diagram. (Table-3)

Table 3. Determining the Damavand rocks strength degree based on TAS reclassified diagram.

Rock Name	Sio2 (weight percent)	Rocks Strength Degree	Rock Range by TAS diagram
Olivine-Trachybasalt	47.875	2	Alkali
Trachybasalt with Hornblende	50.4	2	Alkali
Trachyandesite	58.1	3	Intermediate
Trachyte with Pyroxene, Plagioclase Hornblende	60.1	4	Intermediate
Trachyte with hypresten	61	4	Intermediate
Trachyte with Biotite, Augite and Hornblende	61.3	4	Intermediate
Pumice	57.5	3	Intermediate
Slag (not included as rocks structure)	63	4	Intermediate
Tuff (with perpendicular structure)	About 60	4	Intermediate

Conforming Damavand rocks with TAS diagram (Table-2), it is concluded that Damavand rocks are ranged in toughness rate 3 (intermediate) and 5 (very resistant), and regarding table-3 Damavand rocks toughness rate are ranged by 2 (weak), 3(intermediate) and 4 (resistant). Olivine-Trachybasalt with 47.875 Silica weigh percent and Tuff and slag (as part of pyroclastic materials) with 60% weigh percent of Silica are the most resistant materials. Damavand rocks show a change domain from alkaline basalt and Trachyte and they are considered in basic to intermediate.

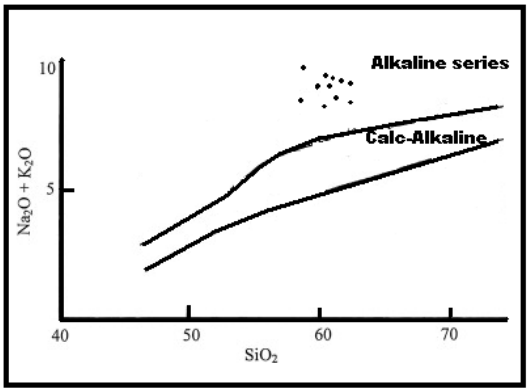

Figure4. Damavand Rocks Position on Kuno Diagram based on Table-2

According to this diagram, all Damavand rocks have been placed in Alkali series and rocks are ranged between alkaline basalt to Trachyte that it implies on magma differentiation in Damavand magma house.

Damavand Rocks Chemical Classification by Kuno Diagram

Kuno diagram has been used in order to determine Damavand rocks. This diagram has been extracted based on chemical changes of rocks such as weight precent of Sio2 and Na2+k2o based on Table-2 in which eleven samples of Damavand rocks have been studied and placed in diagram. (Figure 4)

DISCUSSION AND RESULTS

The strength of rocks against erosion is measurable considering an environment in which rocks have been located, and their physical characteristics such as mineralogy composition, tissue and structure. Study on Damavand rocks and around sides, show that there have been poor and strong magma activities alternatively as internal changes or eruption since quaternary periods. During this long periods that have lasted 1.5 million years until 7500 years ago (Davidson et al, 2004:27), Damavand rocks are different regarding chemical nature and minerals variety (Olivine, Hornblende, Plagioclase, Biotite etc.) (Table 2) and they don't expose equal resistance against erosion.

Study on Damavand rocks show that, basic, acidic and intermediate rocks have been formed during Damavand activities and pyroclastic rocks form a main part of volcanic products including pyroclastic flow deposits and pyroclastic flow deposits. As regard to eruption recurrence with long and different intervals, some parts such as Nandel, Hajidela which are remainders from Damavand old crater and have experienced 0.8 to 1.5 million years time intervals, (Figure 5) have various reactions in time and recurrence of eruption repeat and change in nature of external materials as well as southern domain that is young with 7500 years (Figure 6) and has mentioned differences in reactions.

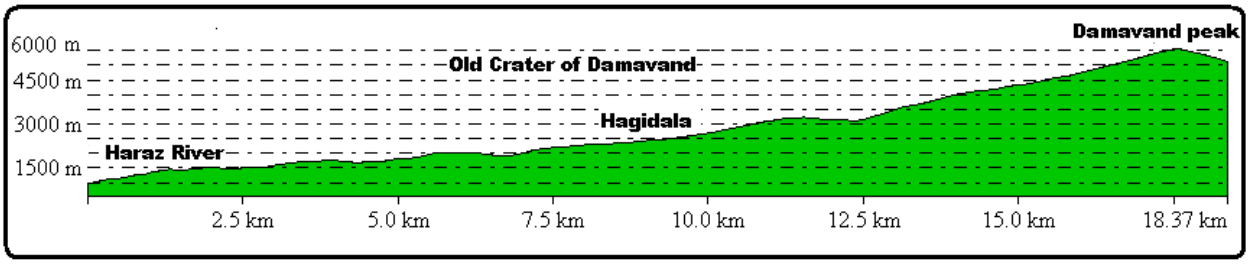

Figure5. Northeast side intersection of Damavand Volcanic Cone (Haraz river, Hajidela, Nandel, Damavand summit) Area of Damavand Old Crater (0.8 to 1.5 million years ago)

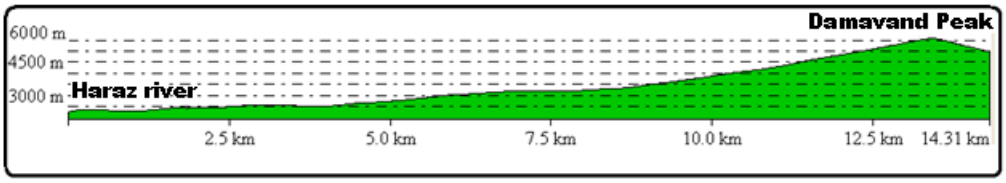

Figure6. Southern side intersection of Damavand Volcanic Cone (Lavas age: about 7500 years)

The northeast side intersection which is older has more fluctuations compared with southern side on which, ages differences, climate changes, eruption recurrence and rocks type and change of alkaline to basic are effective factors.

Mineralogy composition influence on Damavand rocks strength was determined in this paper by TAS diagram and it has been specified that Damavand rocks are ranged from alkaline to intermediate, and its Silica changes is ranged from 47.875 to 63 and their strength against erosion are extended from sensitive to resistant. (Table 2 & 3) Finally Silica-Alkaline (Kuno, 1959) diagram was used to determine position of Damavand rocks by which, Damavand volcanic rocks have been placed in range of Alkaline series and they show a contiguous limit from Alkali Basalt to Trachy. (Figure 4)

CONCLUSION

Rock units outcrop strength is changeable concerning erosion factors regarding time and place and amount of weathering and destruction of rock outcrops are reviewable in relation to lithological properties and their environments. TAS diagram which is related to external igneous rocks, was selected from offered IUGS classifications, and rocks strength against destruction were specified by diagram reclassification based on Sio2 and obtaining numerical value for each range in limit of 1 to 5, and their strength rates were determined by conforming Damavand rocks. Next, Silica-Alkaline diagram (Kuno) which is based on weight percent of N2o+K2o toward Sio2, has been used for better understanding of Damavand volcanic rocks situation.

According to TAS table, Damavand volcanic rocks are formed by different lavas that their chemical composition consists of a domain between Olivine-Trachybasalt to Trachyte. Damavand rocks were conformed to mentioned diagram (table-2) and the result is explained as follows:

Damavand rocks have been ranged by toughness rate n from 3 (middle) to 5 (very resistant) and considering table-3, their toughness rates are ranged in 2 (weak), 3 (intermediate) and 4 (resistant). The most resistant materials are Olivine-Trachybasalt with 48.875 weight percent and Tuff and slag (as part of pyroclastic materials) with 60 percent of Silica, and Damavand rocks show changes domain between Alkaline Basalt and Trachyte and are placed in range of alkaline to intermediate. Using Kuno diagram which is based on rocks chemical changes, Damavand rocks are considered in alkaline series and they show a contiguous limit from Alkali Basalt to Trachy. (Figure 4) Regarding geomorphological analysis, taking lithological properties into account is necessary to realize form, governing and effective processes that change and create shapes. So that, determining Damavand volcano rocks by mineralogy composition and quantitative chemical properties can be used to determine outcrops strength with respect to lithological properties against erosion and destruction.

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