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Petrology, Minerals chemistry and Geochemical relationships of the Sheared Gabbro Rocks in Alanah (Beesha) area within Erbil Governorate, NE Iraq

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Abstract

The current research is seeking to identify the petrography, mineralogy and geochemical relationships of Gabbro rocks in Besha area within Erbil Governorate, at the Unstable Shelf in Imbricate Zone. This study aims to determine the origin of the gabbroic rocks and their geochemical relationships.

The basic sheared gabbro rocks are exceptional in the studied area at Alanah (Beesha) in samples (B1, B2, B3, B6, and B8). The sheared gabbroic rocks contain fine to very fine crystals of plagioclase which is presenting as euhedral to subhedral tabular crystals and anhedral grains that cumulate and fractured by shearing stress that can be concentrically zoned as well as processing polysynthetic twins.

The gabbroic rocks in the area of study are characterized by moderate to high ranges of the loss on ignition. These variation values are a crude measuring of the rock alteration degree. Accordingly, all gabbro rocks types have been affected by the variable alteration degree. These gabbroic rocks exhibiting the tholeiitic geochemical features, with characterized by good trend of sub-alkaline tholeiitic in the total alkalis-silica and AFM relationships with the medium-K tholeiitic.

Generally, the most distinctive properties exhibiting by using spider diagrams of the gabbro rocks in the studied area are selected enrichment of the certain elements such as Sr, Ba and U, addition to relatively lack of enrichment of Zr, Y and Hf. These geochemical patterns and the variation of the HFSEs are exhibiting by the tholeiite rocks are characterization of the supra subduction Zone. In Addition to all analyzing opaque minerals in the sheared gabbro rocks of the area of study are representing alumina magnetite and secondary magnetite

Keywords: Petrology, Geochemical relationships, Sheared Gabbro, Erbil governorate.

بتروغرافية و كيميائية المعادن و العلاقات الجيوكيميائية لصخور الكابرو المهشم في منطقة الانه (بيشا) ضمن محافظة اربيل شمل شرق العراق

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الخلاصة

يسعى البحث الحالي إلى التعرف على العلاقات الصخرية والمعادن والجيوكيميائية لصخور الجابرو في منطقة بيشا ضمن محافظة أربيل، عند الجرف غير المستقر في منطقة إمبريكيت. تهدف هذه الدراسة إلى تحديد أصل الصخور الجابروية وعلاقاتها الجيوكيميائية. تعتبر صخور الجابرو المهشمة القاعدية استثنائية في منطقة الدراسة الانة (بيشة) في العينات (B1، B2، B3، B6، B8). تحتوي صخور الجابرويك المنفصلة على بلورات دقيقة إلى دقيقة جدًا من البلاجيوكلز والتي تظهر على شكل متساوية الاسطح إلى بلورات جدولية شبه متساوية الاسطح وحبيبات غير متساوية الاسطح تتراكم وتتكسر عن طريق إجهاد القص إجهاد القص الذي يمكن تقسيمه إلى مناطق متحدة المركز الى جانب معالجة التوائم متعددة الاصطناعية. تتميز صخور الجابرويك في منطقة الدراسة بنطاقات متوسطة إلى عالية من الفقد عند الاشتعال. قيم التباين هذه هي قياس أولي لدرجة تغير الصخور. وفقاً لذلك، وقد تأثرت جميع أنواع صخور الجابرو بدرجات التغير المتغيرة. تظهر هذه الصخور

الجابروية الخصائص الجيوكيميائية الثوليبتية، وتتميز بالاتجاه الجيد للثوليتيك شبه القلوي في علاقات القلويات-السيليكا الكلية وعلاقات AFM مع الثوليتيك المتوسط. بشكل عام فإن أكثر الخصائص المميزة التي تظهر باستخدام المخططات العنكبوتية لصخور الجابرو في منطقة الدراسة هي الإثراء المختار لبعض العناصر مثل Sr، Ba، U، بالإضافة إلى النقص النسبي في الإثراء لعناصر Zr، Y، Hf. هذه الأنماط الجيوكيميائية وتنوع HFSEs التي تظهرها صخور الثوليبت هي توصيف لمنطقة الاندساس أعلاه. بالإضافة إلى جميع المعادن المعتمة التي تم تحليلها في صخور الجابرو المنكسرة بمنطقة الدراسة وهي تمثل الألومينا الماجنتيت والماجنتيت الثانوي.

الكلمات المفتاحية: بتروغرافي، العلاقات الجيوكيميائية، الكابرو المهشم، محافظة اربيل.

Introduction

The Imbricate Zone in Iraqi part of the Zagros within the north and the northeastern of Iraq, was formed as result of many overriding nappes composed of complexes layered of ophiolite, pillow lavas and the Tertiary succession [1]. All these rock groups are separated by the crushing zones and thrusting zone [2]. The Iraqi Zagros Suture Zone (IZSZ) has been studied by many workers since it represents the collision zone between the Arabian Plate and the Iranian Plate in the northeastern part and the Arabian Plate and Turkish Plate in the northern [3, 4, 5 and 6].

A study of the Hasan bag Group (Late Cretaceous) and Walash-Naopurdan Group (Paleogene) which represent a volcanic and subvolcanic rocks is considered vital for the north and northeast parts of Iraq. This rock units are determining the time of the collisional stage between the continental plates of Arabian and Iranian. Access to this Iraqi part during the past four decades has been limited and difficult due to ongoing war and landmine threats making some areas virtually inaccessible to study. Nevertheless, some previous work (e.g. [2], [1], [7] and [8]) suggest that volcanic and volcano sedimentary rocks exist in the Iraqi Zagros Imbricate Zone were called the Hasanbag, Walash and Naopurdan Groups.

The section of Beesha is located near Alanah village at Longitude 44° 58” E and Latitude 36° 42” N, and is located within Erbil governorate. Topographically, the area is mountainous, consisting of the number of parallel ranges within the Zagros Mountains. There were many types of rocks of different color, size and external shape where there were igneous rocks above the base of a black color were is shared Gabbro rocks and igneous rocks of dark brown to black color were is Amphibolite rocks.

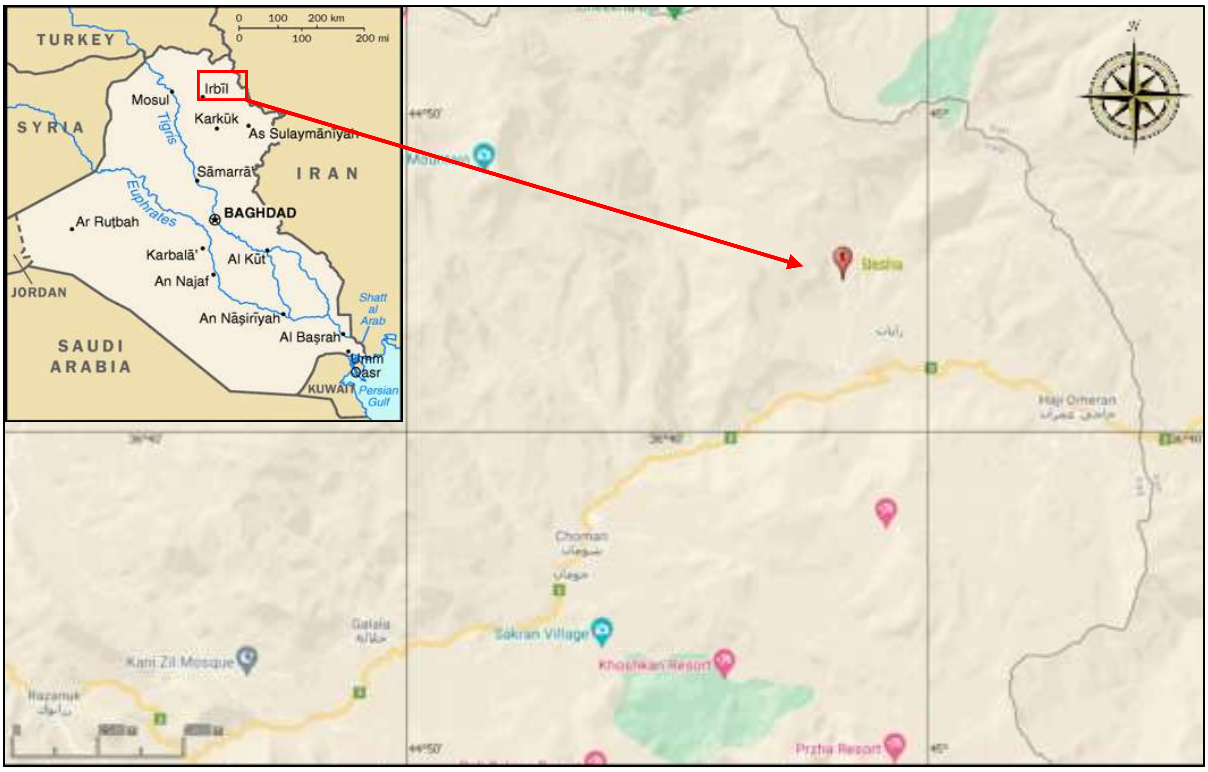


Figure 1: Location map of the studied area highlighted by the red rectangle shape

Materials and methods

Field work

Samples are collected 80 samples from Alanah (Beesha) area. This was achieved by a field trip using GPS to determine the accurate location of sample.

Laboratory work

Mineralogy

- Thin section. at the department of geology University of Ankara Golbasi Kampusu Turkey. Preparations in order to determine the mineral composition, texture and classification.
- SEM-EDX technique, at Scientific Research Center Soran University(SRC).

Geochemistry

- ICP-MS techniques. To elemental analysis and chemical analysis at the department of geology University of Ankara Golbasi Kampusu Turkey.

Geology of study area

Field work is one of the basic and important elements in all geological studies, through which the types of rocks, geological phenomena, and stratigraphic sequences of formations are determined, and the tectonic nature of the study area can be known. The field work of the study area was divided into two separate rounds, at a rate of four days for each round, for a total of eight days. Where five sections were chosen and identified for the present study.

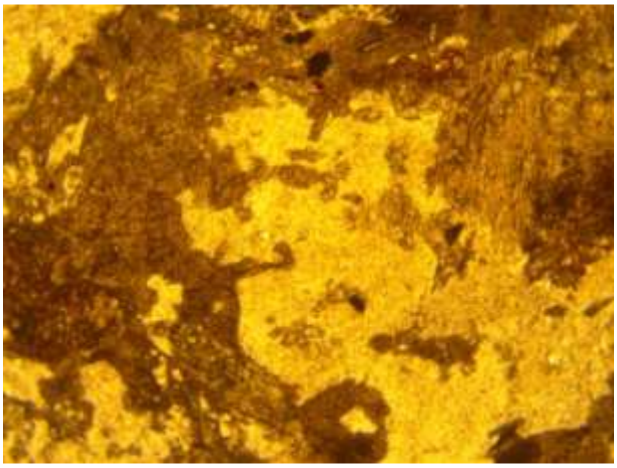
The field work was very arduous and was not without difficulties and risks. Most of the rocks were of high hardness, which required the use of battery-powered cutting machines in addition to the recognized hand tools of hammer and chisel.

The section of Beesha is located near Alanah village at Longitude 44° 58 E and Latitude 36° 42 N, where the section was studied and there were many types of rocks of different color, size and external shape where there were igneous rocks above the base of a black color were is shared Gabbro rocks (Fig. 2). All the previously mentioned rocks were of very high hardness as it was very difficult to break them and take samples from them.

Figure 2: sheared Gabbro rocks

Petrography of sheared Gabbro rock

The sheared gabbro is exceptional in study area at Alanah (Beesha) in samples (B1, B2, B3, B6, and B8). The sheared gabbroic rocks contain fine to very fine grain sized of plagioclase, amphibole and epidote minerals (Fig. 3). The presence of quartz according to [9] is related to the plagio-granite that is restricted to this study area. Epidote has a pink or orange color, and is the result of the plagioclase disintegration, which takes Ca, but if its color changes to yellow, this means the presence of Fe (Fig. 3). The amphibole minerals in some samples have a blue color, this is evidence of an increase in the proportion of Na (Fig. 4). The accessories minerals are representing by quartz, sphene and magnetite (Fig. 5).



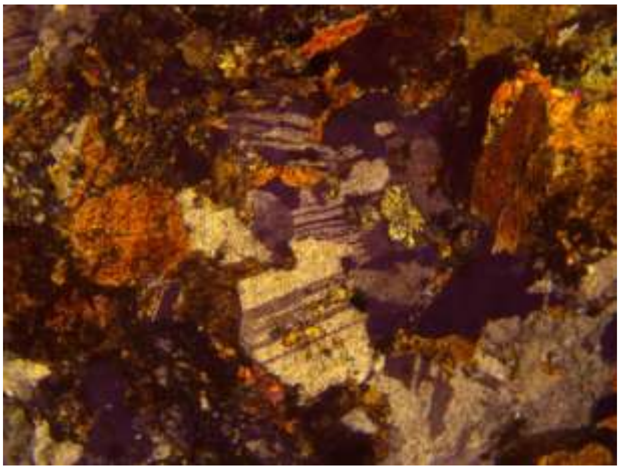


Figure 3: fine to very fine grains of plagioclase and amphibole. Sample B1, 5X

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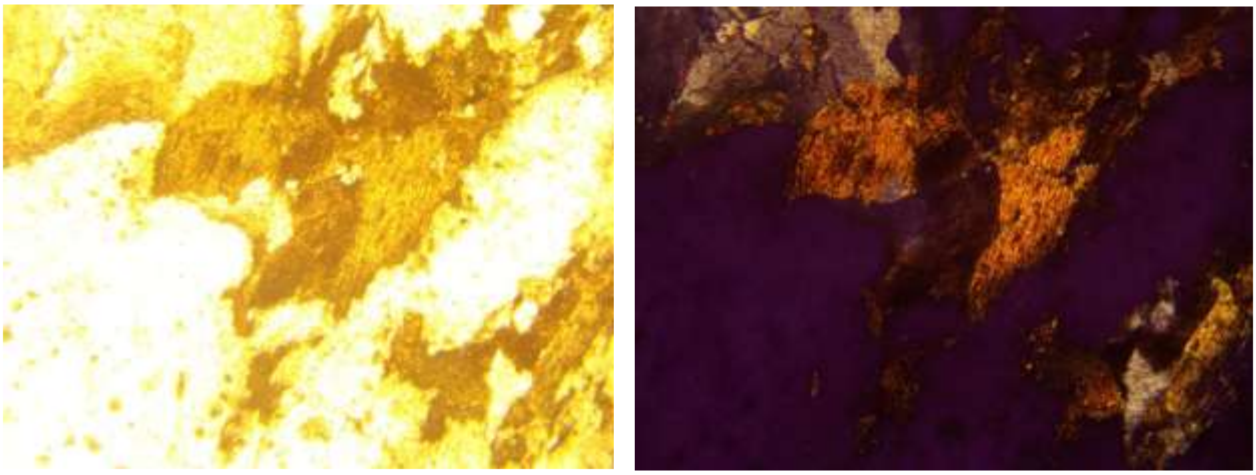

Figure 4: Blue color of amphibole minerals with increasing in the proportion of Na. Sample B2, 5X

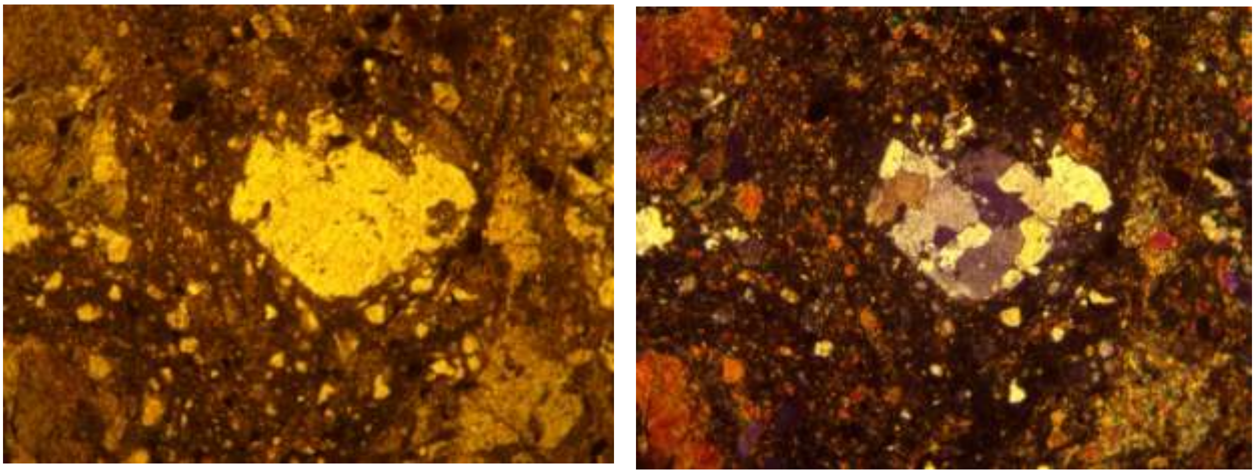

Figure 5: Accessory minerals quartz, sphene and magnetite. Sample B12, 5X

The phenocrysts of plagioclase are appeared to have originated during two crystal growth stages. Among minerals groundmass there appeared to be some textural evidence that pyroxene mineral began to crystallize before the plagioclase.

The plagioclase is not here Ca plagioclase, it is subjected to varying decomposition processes, where the mineral epidote is clearly present from the outside of the plagioclase granule to the inside. It has a yellowish green color and high relief. There is a large shaped rhombohedral granuleit contains the sericite mineral which is the nucleus of muscovite mineral. (Fig. 6).

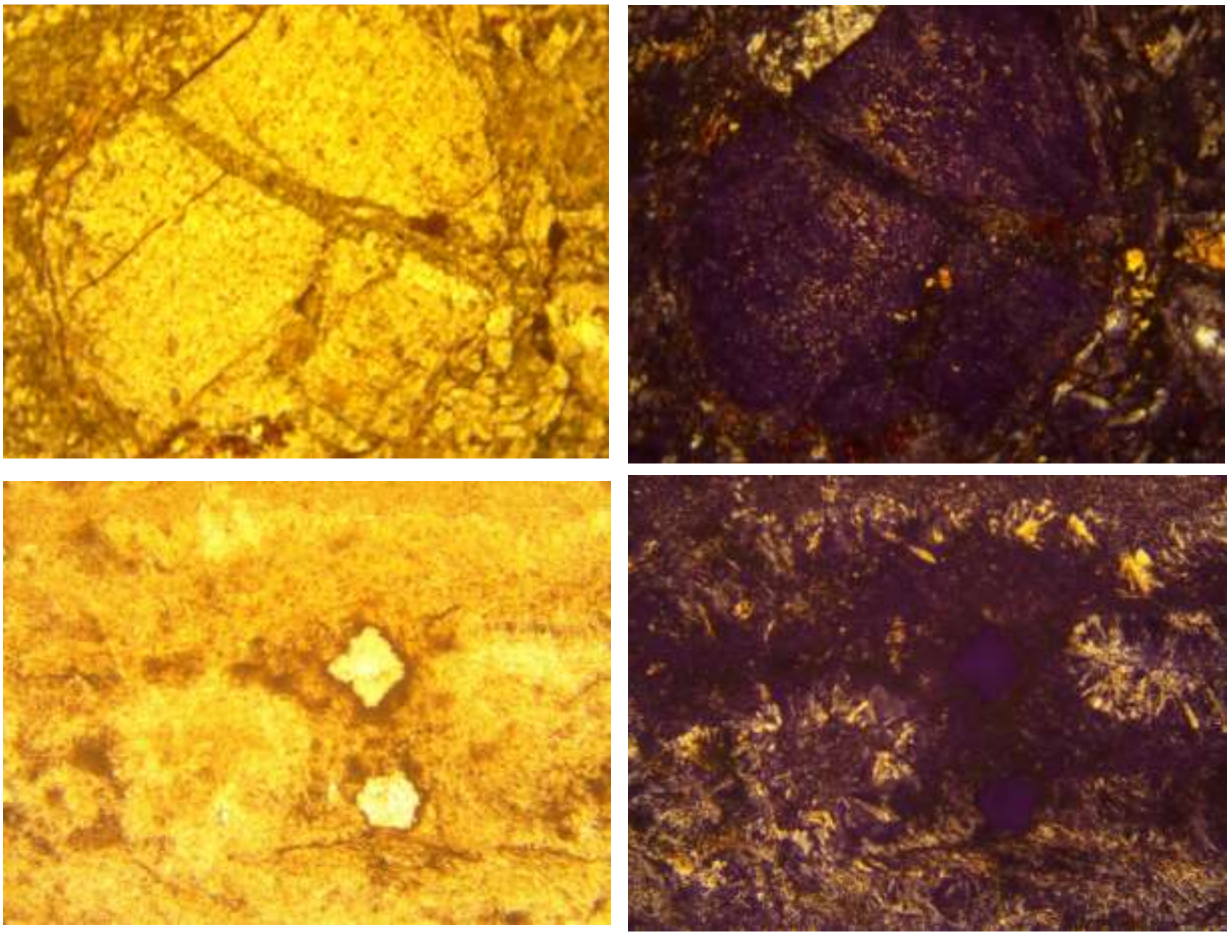

Figure 6: A rhombohedral granule it contains the sericite mineral which is the nucleus of muscovite mineral. Sample B10, 5X

Mineral chemistry of sheared gabbro rocks

Plagioclase, pyroxene, quartz, amphiboles, epidote and opaque minerals are analyzed. The plagioclases are Na rich and classify as (An_{57} – An_{62}) and represents labradorite (Table 1) (Fig. 7). The formation of sodic plagioclase of sheared gabbro rocks may be related to the process of partial crystallization [10]. The amphiboles composition was determined based on the classification of [11]. These data showing that the amphibole composition represented by actinolite (Fig. 8). The clinopyroxenitic of sheared gabbro rocks are classifying as a low value of Ti diopside according to [12], (Table 1-5), (Fig. 9). Ti values in clinopyroxene are reflecting the parent magma that generating the cumulate pile [13]. The clinopyroxentic are range of $Wo_{47.93}$ $En_{43.97}$ $Fs_{5.93}$ to $Wo_{48.72}$ $En_{45.35}$ $Fs_{7.99}$. (Table 1).

Table (1) Chemical composition (Wt%) of plagioclase in studied sheard gabbro, the chemical composition determined based on (8) oxygen

Oxides %	B1	B2	B6	B8
SiO_2	54.47	53.7	53.2	53.66
TiO_2	0.00	0.00	0.00	0.00
Al_2O_3	28.8	29.36	30.1	29.71
FeO	0.18	0.2	0.18	0.2
MnO	0.13	0.09	0.07	0.08
MgO	0.00	0.00	0.00	0.00
CaO	11.67	12.4	11.9	11.9
Na_2O	4.74	4.2	4.5	4.5
Total	9.99	9.99	9.99	100
Elements				
Si	2.456	2.428	2.405	2.438
Ti	0.00	0.00	0.00	0.00
Al	1.532	1.565	1.604	1.558
Fe^{+2}	0.007	0.008	0.007	0.008
Mn	0.005	0.003	0.003	0.003
Ca	0.564	0.601	0.576	0.579
Na	0.415	0.368	0.394	0.396
Total	4.98	4.97	4.99	4.98
Mineral Chemistry	An = 57.6 Ab = 42.4 Or = 0.0	An = 61.99 Ab = 38	An = 59.4 Ab = 40.6 Or = 0.0	An = 59.4 Ab = 40.6 Or = 0.0

Table (2) Clinopyroxene chemical composition in studied sheard gabbro, the chemical composition determined based on (6) oxygen

Oxides %	B1	B2	B6	B8
SiO_2	52.5	51.96	52.49	51.85
TiO_2	0.83	0.47	0.44	0.73
Al_2O_3	3.22	2.81	2.75	3.18
FeO	5.24	6.12	5.54	5.42
MnO	0.21	0.15	0.23	0.18
MgO	15.07	15.25	15.03	15.28
CaO	22.8	22.87	23.09	22.84
Na_2O	0.51	0.38	0.43	0.52
Total	100	100	100	100
Elements				
Si	1.920	1.909	1.929	1.901
Ti	0.023	0.013	0.012	0.020
Al	0.139	0.122	0.119	0.137
Fe^{+3}	0.011	0.06	0.03	0.057
Fe^{+2}	0.149	0.128	0.14	0.109
Mn	0.007	0.005	0.007	0.006
Ca	0.894	0.901	0.909	0.897
Na	0.036	0.027	0.031	0.037
Total	4	4	4	4

Mineral Chemistry	Wo = 47.93 En = 44.08 Fs = 7.99	Wo = 48.32 En = 44.83 Fs = 6.85	Wo = 48.55 En = 43.97 Fs = 7.48	Wo = 48.72 En = 45.35 Fs = 5.93

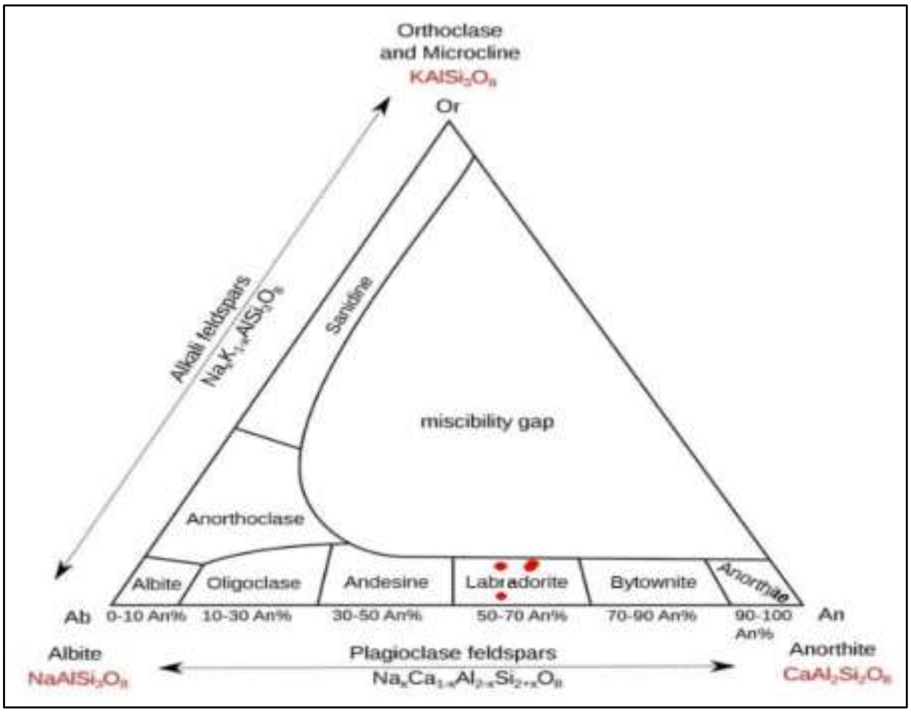

Figure 7: Composition of plagioclase (Wt%) in sheared gabbro rocks of studied area are from [14]

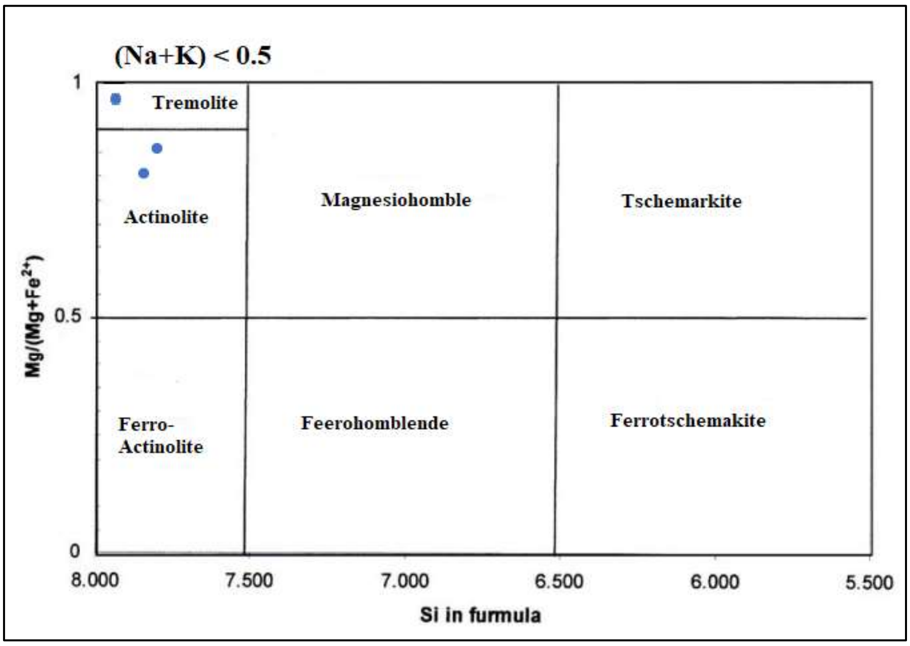

Figure 8: Composition of amphiboles in Alanah (Beesha) sheared gabbro rocks on the Si vs. Mg/ (Mg+Fe+2) diagram after [11]

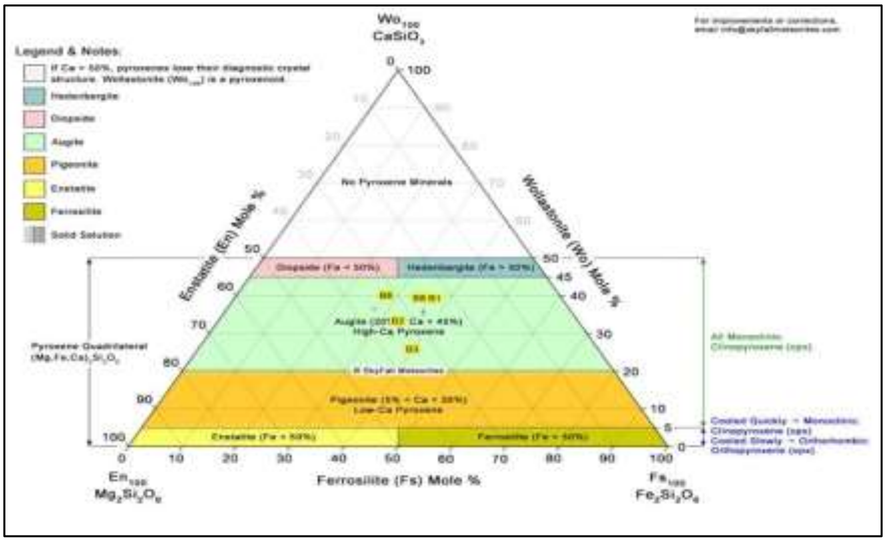

Figure 9: Pyroxene compositions of sheared gabbro rocks in general compositional of CaSiO3-MgSiO3-FeSiO3 field according to [14]

The opaque minerals composition is chromite if the Cr_2O_3 more than Al_2O_3+Fe_2O_3 and its spinel if the Fe_2O_3 less than Al_2O_3+FeO, whereas its magnetite if it Fe_2O_3 more than Al_2O_3+FeO [15]. all analyzing the opaque minerals in sheared gabbro rock of the study area representing alumina magnetite and secondary magnetite (Fig. 10).

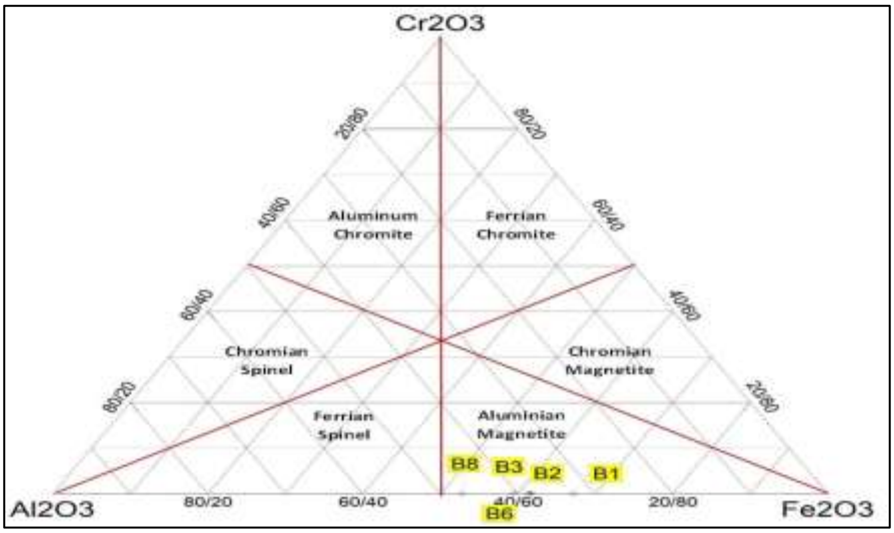

Figure 10: Cr2O3-Al2O3-Fe2O3 diagram opaque minerals of the sheared gabbro rocks, after [15]

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Geochemistry of sheared gabbro rocks

Major and trace elements of sheared gabbro rocks

The geochemical data were obtaining by using ICP-MS, for five samples from the sheared gabbro represented by B1, B2, B3, B6, and B8, and one sample from fine gabbro (dolorite) (B10), to analyzing of the rare earth and selected trace elements are given in the Tables (4 and 5). The complete compositions of the primary trace and rare earth rock elements were used to study gabbro rocks to identify the main features of the primary source of magmas and the processes that modify the primary compositions of magmas.

The SiO_2 content of gabbro rocks are range from 42.45 Wt. % to 48.28 Wt. %. Fe_2O_3 showing enrichment with differentiation ranges from 13.37 Wt. % to 19.58 Wt. %. The sheared gabbro rocks displaying rather low values of Al_2O_3 are ranges from 9.58 Wt. % to 11.96 Wt. %, and high CaO values from 9.99 to 14.22 Wt. %. Low values of Al_2O_3 content are increasing of the clinopyroxene at the expense of plagioclase mineral.

The study gabbroic rocks have a moderate to high ranges of LOI values with range from 3.44 Wt. % to 5.83 Wt. % (Table 4). This variation values are a crude measure of the degree of the alteration rock [16]. Accordingly, all gabbroic rocks types have been affected by variable alteration degree.

The TiO_2 are ranges from 1.33 Wt. % to 1.93 Wt. % this ranges suggested early precipitation of the Fe-Ti oxides [17]. P_2O_5 ranges from (0.159 Wt. % to 0.225 Wt. %).

The basic (sheared gabbro) have compositions comparable; enrichment in Fe_2O_3 relative to values of Na_2O, K_2O and MgO (Fig. 11) hence according to [18] diagram, it is classifying as a tholeiitic type. Plotting YTC (Y+Zr, TiO_2, Cr) diagram [19] in [20]. (Fig. 12) and P_2O_5 – Zr variation (Fig. 13) demonstrated the tholeiitic type characters of the study rocks.

Table (3) The major and trace results analysis (ICP-MS) (Wt%) of the study sheared gabbroic rocks

Rock type	Sheared Gabbro					Fine Gabbro (Dolerite)
Sample No.	B1	B2	B3	B6	B8	B10
SiO2	44.16	47.45	47.41	44.59	50.83	50.54
TiO2	1.944	1.767	2.044	1.828	1.40	1.12
Al2O3	9.963	11.242	11.42	10.70	12.59	15.98
Fe2O3	20.37	16.51	18.14	17.31	14.08	16.16
MnO	0.272	0.290	0.278	0.268	0.211	0.182
MgO	8.09	9.97	8.21	9.89	5.91	5.771
CaO	14.79	11.13	11.09	13.98	10.52	5.51
Na2O	0.198	1.12	1.21	0.96	3.72	4.13
K2O	0.205	0.494	0.188	0.458	0.729	0.605
Cr2O3	0.0107	0.0260	0.0182	0.0227	0.0089	0.0012
Total	100	100	100	100	100	100
Traces (ppm)						
Ni	67.2	69.9	58.9	100.5	73.7	138
Cr	13	15	12	17	10	11
Sc	41.5	53.3	49.6	52.8	45.4	62.3
Ba	7.5	28.6	26.7	14.3	7.4	27.7
La	10	7.6	7.7	19.6	19.6	22.9
Ce	5.2	10	15.3	5.8	4.8	5.7
V	319	315	223	244	201	215
Pb	0.8	1	1.2	0.8	0.7	0.6
Th	9.4	1.1	1.3	11	8.2	8.7
Zn	18.9	122.4	99.1	19.2	20.8	16.9
Zr	3.8	90.2	133.5	4.5	3.5	8.8
Ga	0.9	18.2	20.7	0.8	1.7	1.5
Y	107.5	45.3	50.1	105.5	77.8	67.7
Cu	109.1	74.5	114.4	126.8	81.9	89.4
Nb	3.8	3.7	6.6	3.7	3.9	3.2
Sr	53	76.4	119.2	45	38.4	22.1
Rb	232.9	6	1.6	101.3	252	215.2

Table (4) The REE results analysis (ICP-MS) (ppm) of the study sheared gabbroic rocks

Rock type	Sheared Gabbro					Fine Gabbro (Dolerite)
Sample No.	B1	B2	B3	B6	B8	B10
La	10	7.6	7.7	19.6	19.6	22.9
Ce	5.2	10	15.3	5.8	4.8	5.7
Pr	0.6	0.43	0.42	0.54	0.61	0.45
Nd	3.57	2.36	2.4	4.01	3.51	3.42
Sm	1.62	1.04	1.42	1.53	1.53	1.63
Eu	0.6	0.52	0.53	0.46	0.51	0.36
Gd	2.51	1.73	1.82	2.47	2.53	1.87
Tb	0.54	0.42	0.44	0.51	0.52	0.35
Dy	3.7	2.9	2.4	3.12	3.22	2.33
Ho	0.9	0.64	0.56	0.84	0.76	0.64
Er	2.51	1.91	2.32	2.63	2.64	2.67
Tm	0.42	0.32	0.42	0.35	0.43	0.43
Yb	2.37	1.94	1.85	2.41	2.34	1.94
Lu	0.37	0.35	0.4	0.5	0.5	0.4

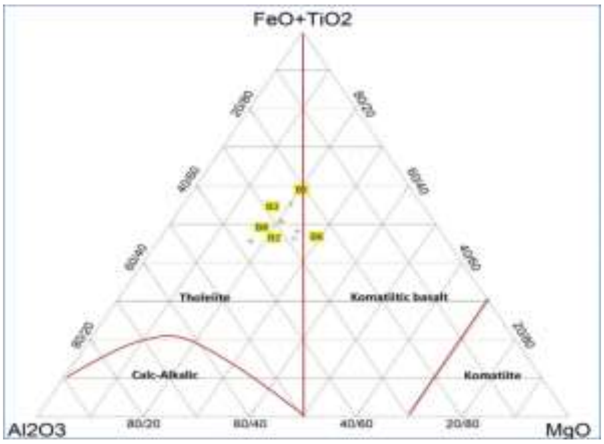


Figure 11: Plots of sheared gabbro rocks showing its tholeiitic character. [18]

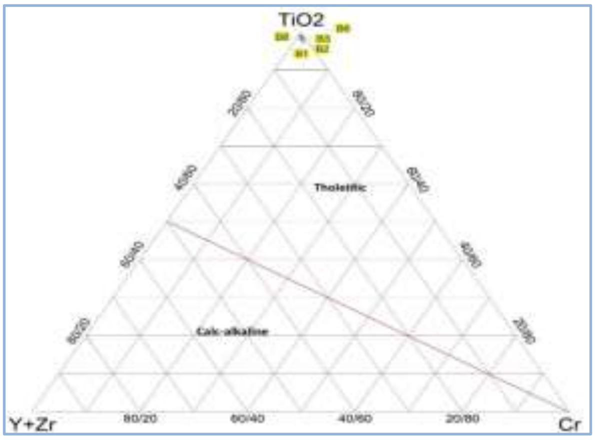


Figure 12: YTC diagram for sheared gabbro rocks of studied area indicating their tholeiitic affinity. [19] in [20]

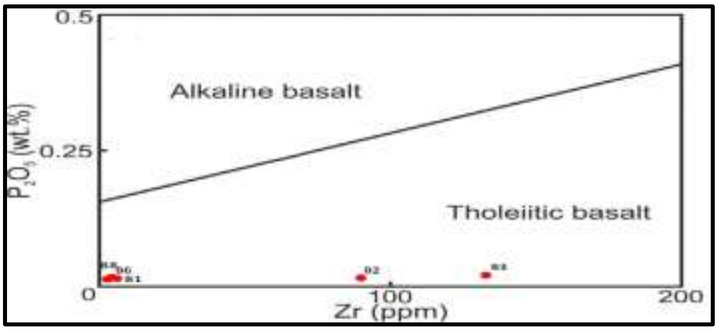


Figure 13: Zr- P2O5 showing the tholeiitic affinity of the study sheared gabbro rocks

The gabbro rocks determine the orientation of the alkali-like tholiites in the alkali silica aggregate and the AFM diagram (Fig. 14a and b). The tholeiite type is represented by the average K tholeiite (Fig. 14c). The geochemical behaviors of the major and trace elements are described using MgO values as an indicator of differentiation (Fig. 15). The values of TiO2, Al2O3, FeO and P2O5 show negative correlation with MgO.

The negative trend of MgO and CaO indicates magnesium depletion in clinopyroxene minerals with constant calcium content [21]. The negative relationship of MgO and TiO may be related to the early precipitation of iron and Ti oxides.

The relationship of MgO versus Ni and Cr (Fig. 16) indicates a positive relationship, while the elements such as Zr, Y, Ga and V show a negative relationship. Principal vs. MgO values reveal that much of the original geochemistry of gabbro rocks is affected by alteration and/or metamorphism [22].

Principal and trace element remobilization was tested using binary charts (Fig. 16) to determine the association with the Zr value, which is assumed to be immobile [23]. P2O5 and to a lesser extent, SiO2 and TiO2 show a positive relationship with Zr, while the MgO values show a negative relationship (Fig. 17).

The residual values of the oxides show a broad scattering pattern and poorly defined directions indicating possible secondary effects. The trace elements Sr, Ba and all HFSE and (Y, Hf and Nb) show a positive correlation (Fig. 18) [24].

The studied sheared algebraic rocks can be summarized as an increase in TiO, Zr, P2O5, Y, Ga and Sr with decreasing MgO and increasing Ni and Cr with increasing MgO (Fig. 15) and (Fig. 16). Partial crystallization of mineral phases such as olivine, clinopyroxene, and plagioclase can explain these chemical properties [25].

The MgO-Zr variation of the studied sheared gabbro rocks can be considered to be formed from a single source from primary magmas to mafic magmas through the process of partial crystallization (Fig. 16) [26].

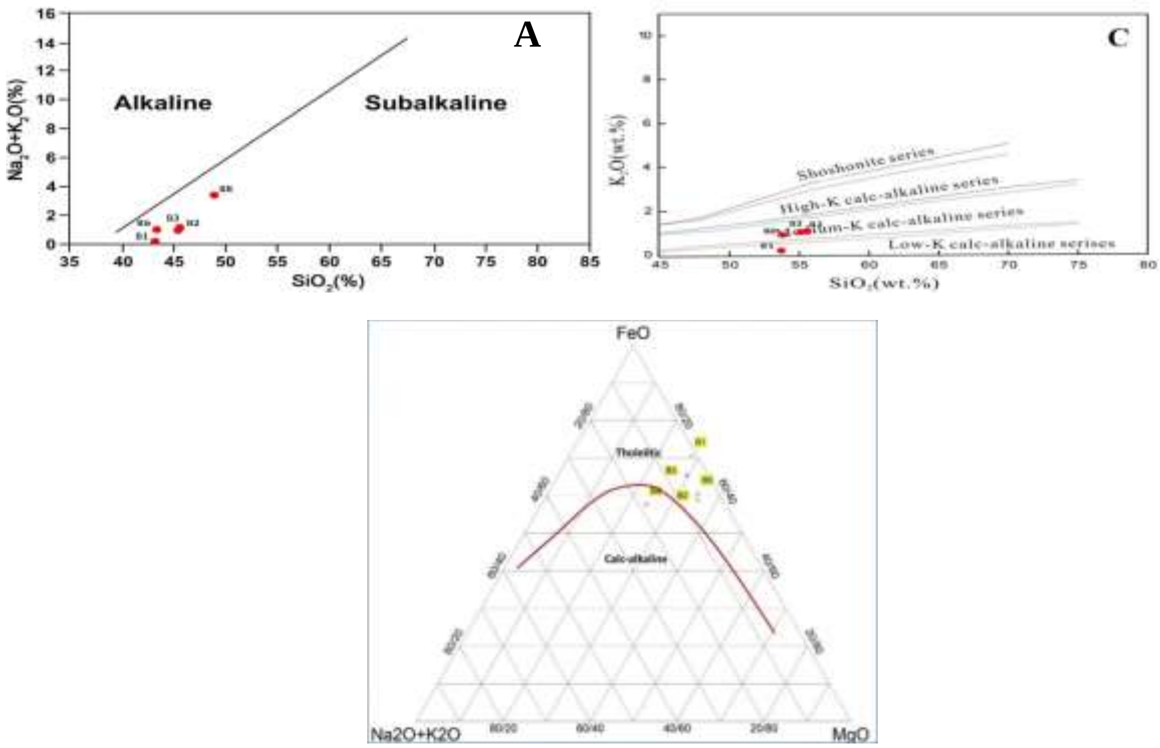
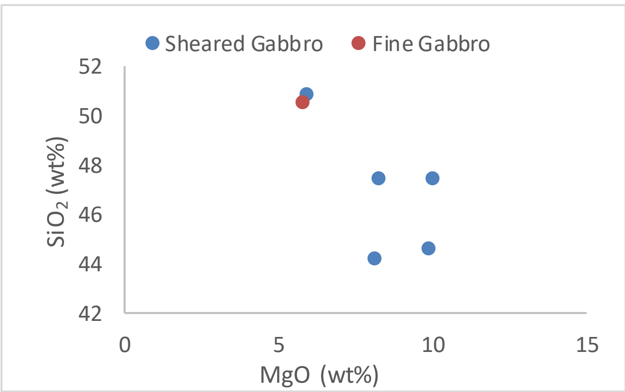
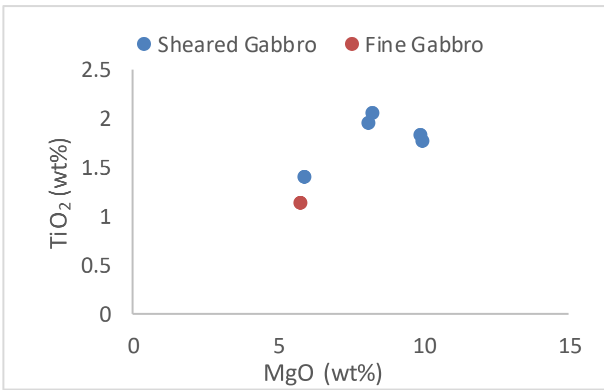


Figure 14: A: Total alkali vs. silica [28]. B: AFM [28]. C: K2O vs. silica [29] diagram of the sheared gabbro rocks samples from studied area





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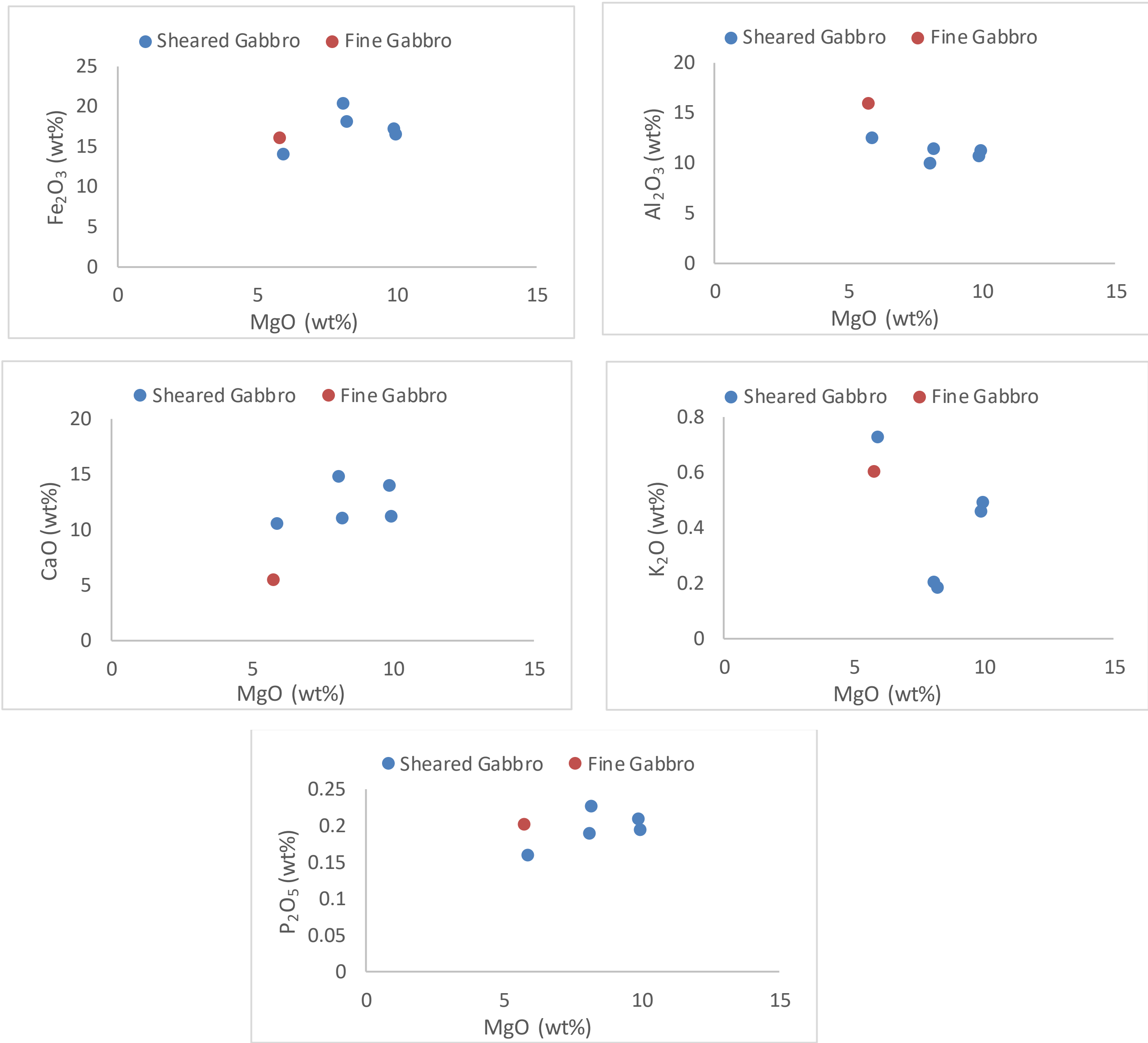
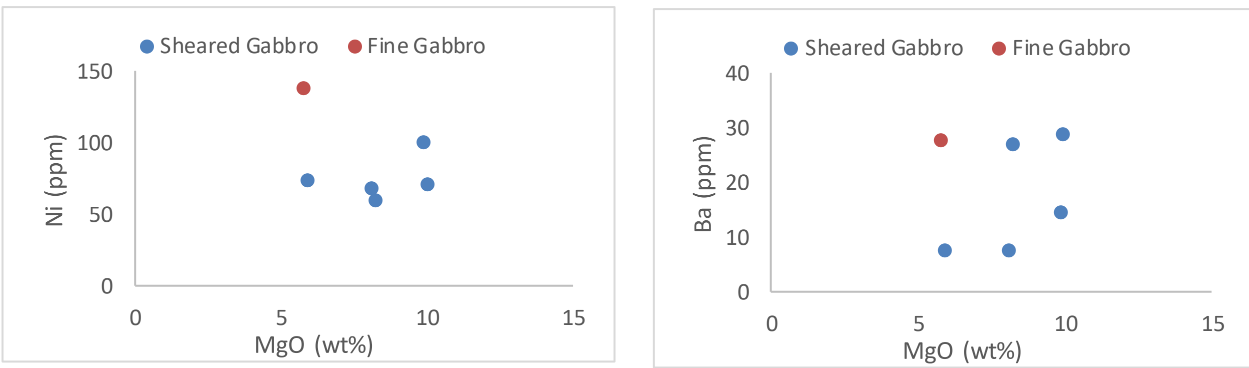
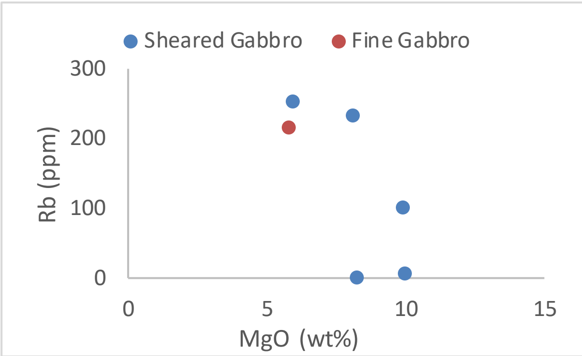
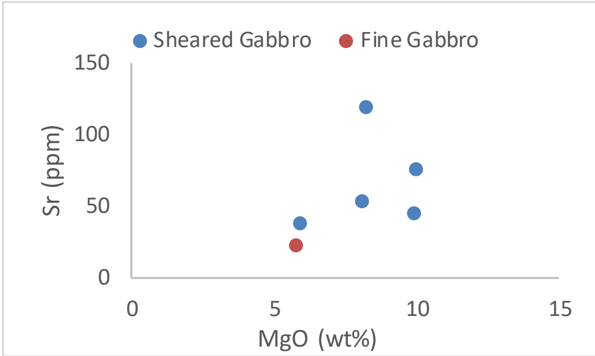
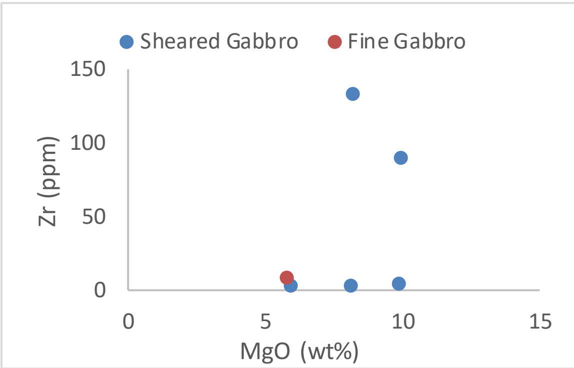


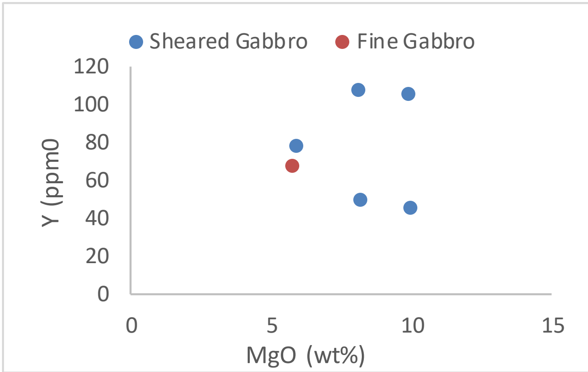
Figure 15: MgO vs major oxides plots of the study sheared gabbro rocks

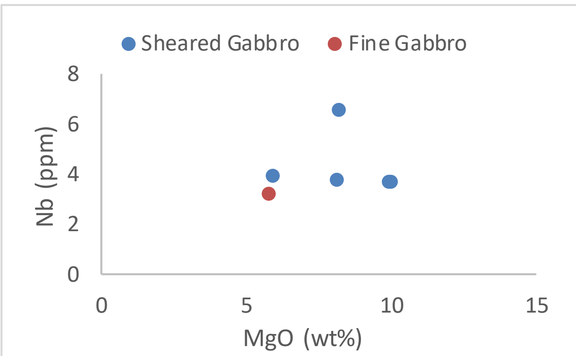


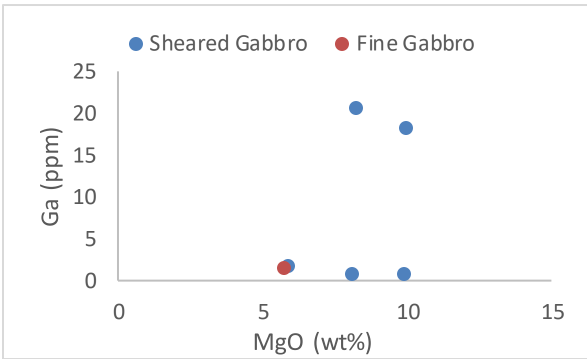

Sheared Gabbro
Fine Gabbro
Rb (ppm)
300
200
100
0
0
5
10
15
MgO (wt%)

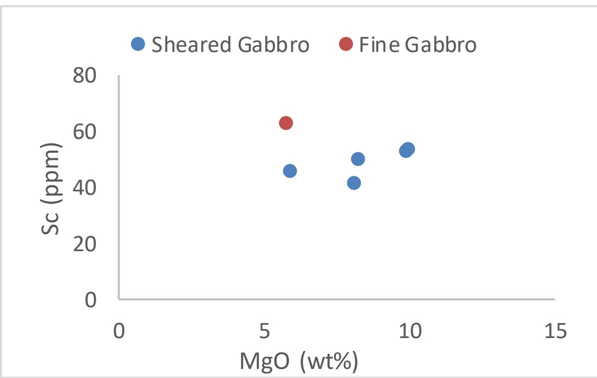

Sheared Gabbro
Fine Gabbro
Sr (ppm)
150
100
50
0
0
5
10
15
MgO (wt%)

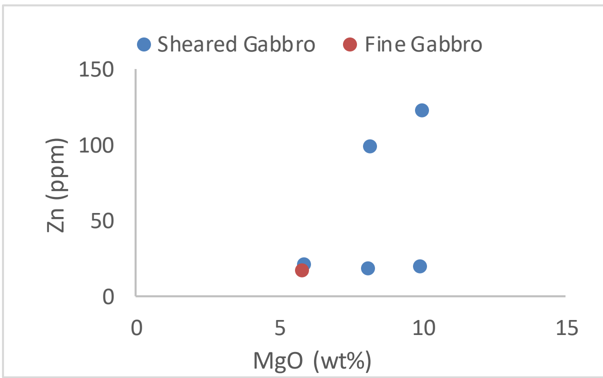

Sheared Gabbro
Fine Gabbro
Zr (ppm)
150
100
50
0
0
5
10
15
MgO (wt%)


Sheared Gabbro
Fine Gabbro
Y (ppm0
120
100
80
60
40
20
0
0
5
10
15
MgO (wt%)


Sheared Gabbro
Fine Gabbro
Nb (ppm)
8
6
4
2
0
0
5
10
15
MgO (wt%)


Sheared Gabbro
Fine Gabbro
Ga (ppm)
25
20
15
10
5
0
0
5
10
15
MgO (wt%)


Sheared Gabbro
Fine Gabbro
Sc (ppm)
80
60
40
20
0
0
5
10
15
MgO (wt%)


Sheared Gabbro
Fine Gabbro
Zn (ppm)
150
100
50
0
0
5
10
15
MgO (wt%)

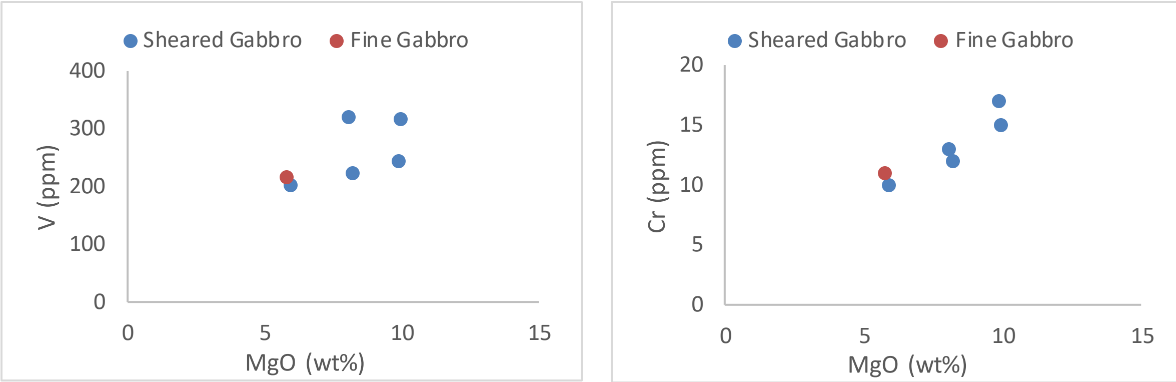
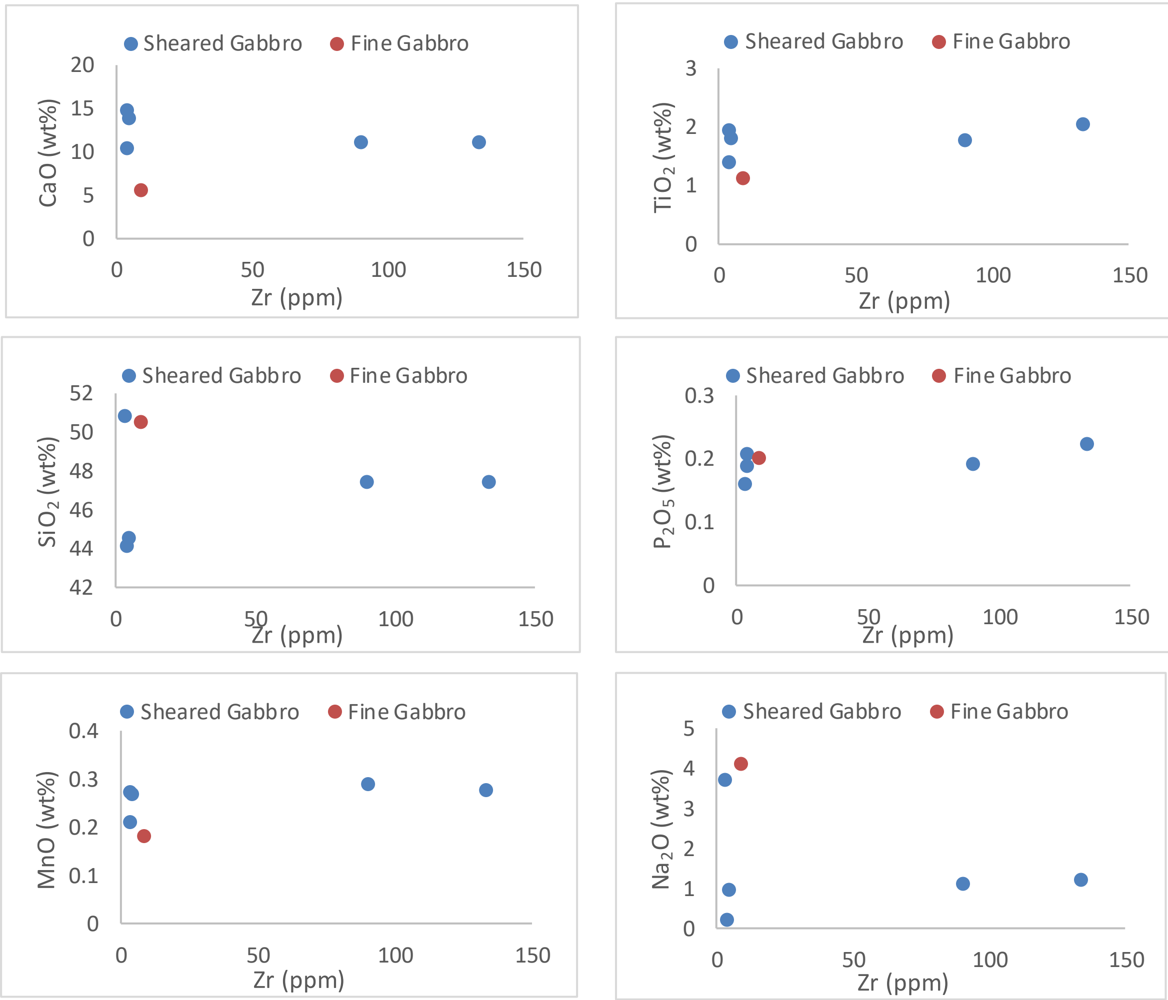


Figure 16: MgO vs. trace elements plots of the study sheared gabbro rocks



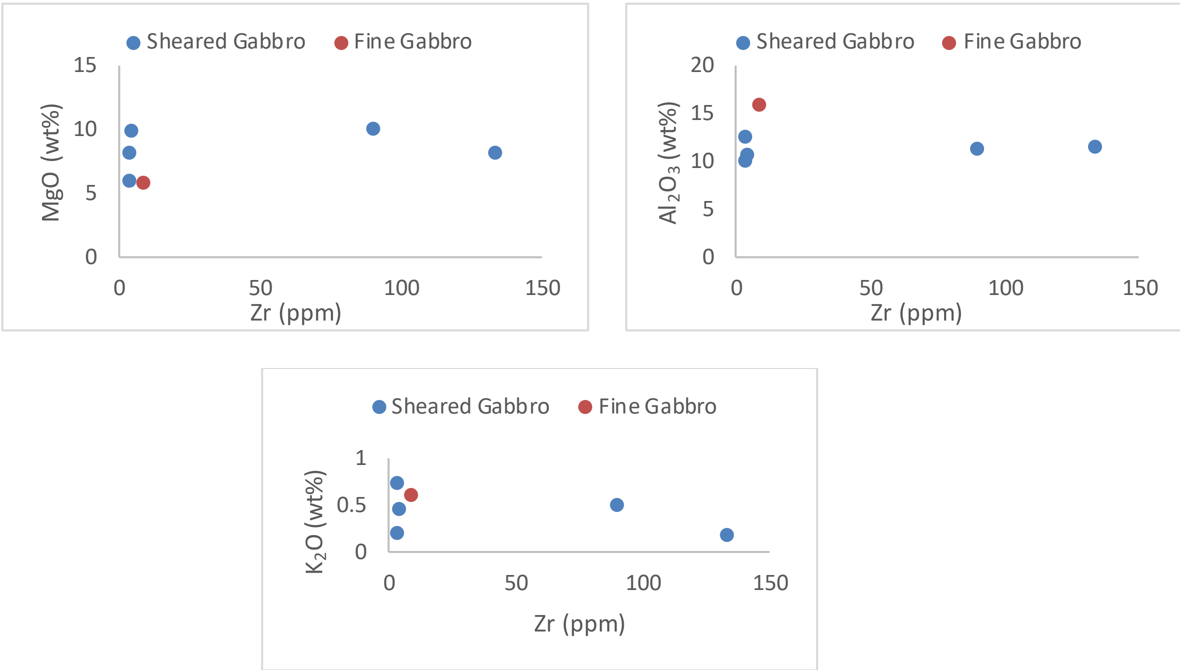
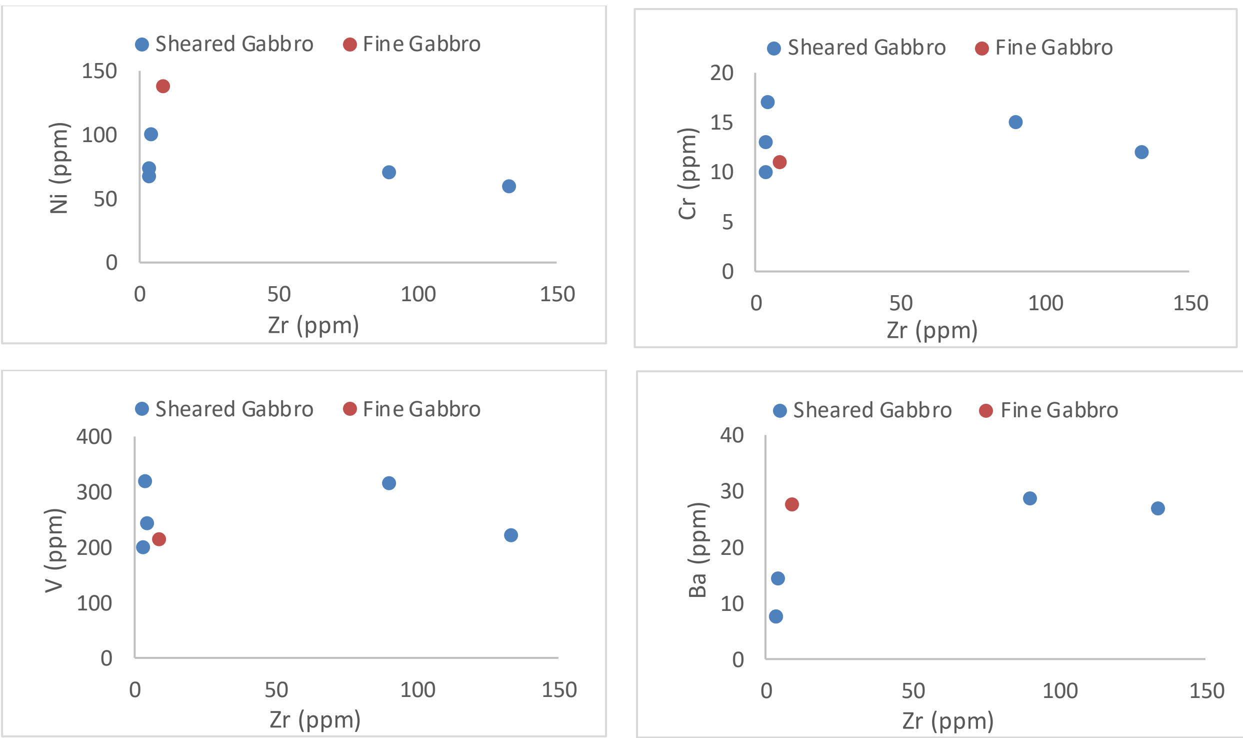


Figure 17: Zr vs. major elements plots for the study sheared gabbro



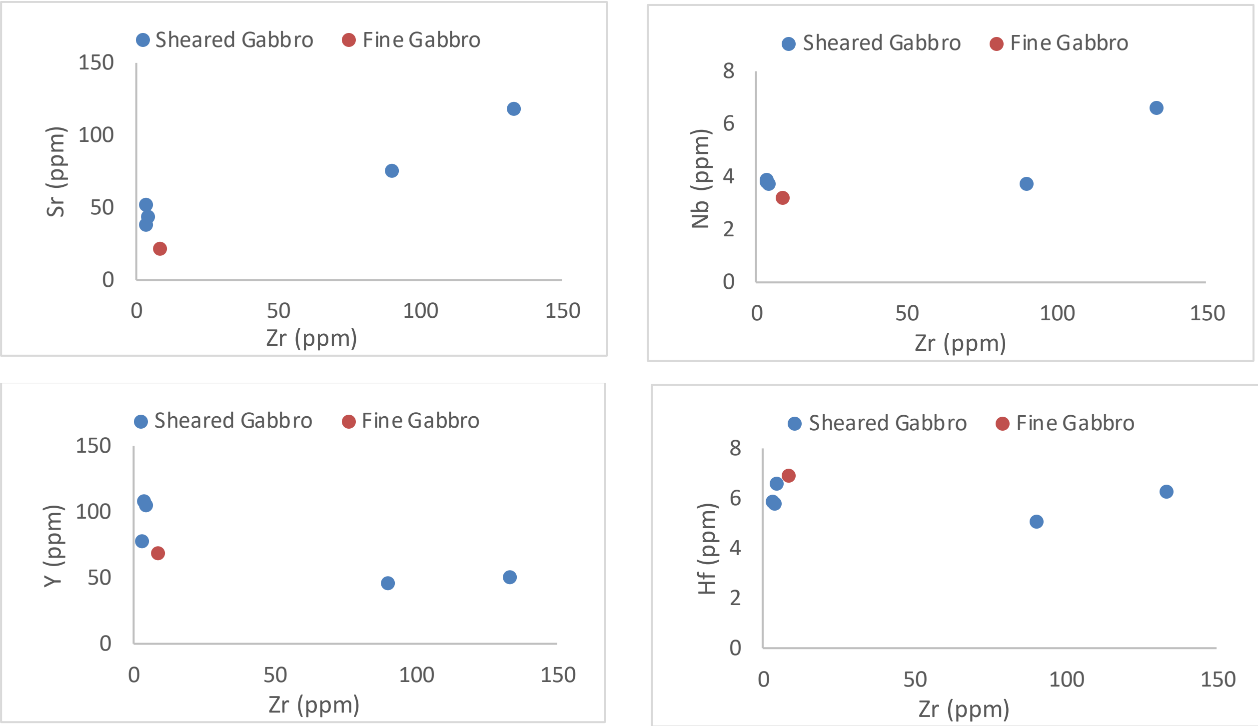


Figure 18: Zr vs. trace elements plots for the study sheared gabbro

REE and trace elements geochemistry of sheared gabbroic rocks

The alteration process and transformation effects on the chemistry of the rare earth elements for the study cut gabbro sheared rocks (Fig. 19). These plots show the dominance of REEs in gabbro rocks and it increased with increasing Zr values, indicating that the general REE trends did not change significantly through processes of modifications and transformations. Characteristics of the study are sheared gabbro rocks that show a geochemical feature of the tholitic (Table 3).

The chondrite patterns for normalizing the rare earth elements of the basic rocks are shown in Figure (20), which uses normalization values based on [30]. The positive anomaly of Eu relative to neighboring elements reflects the substitution of Eu for Ca in Ca-plagioclase minerals [32]. The general patterns of gabbro rocks are flat REE patterns. These flat-laying patterns are similar to tholitic island-arc (IAT)-forming rocks and subduction-related settings [33].

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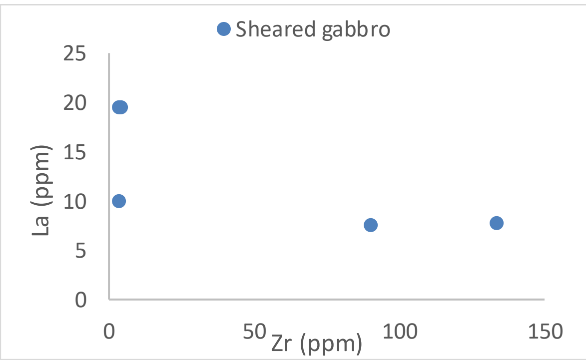
The patterns with multiple elements of spider diagram normalizing to the chondrite compositions are using the normalizing values based on [30] are shown in Figure (21).

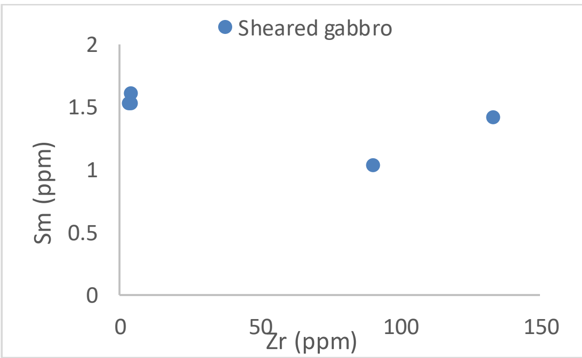
The relative depletion in LREE and Nb is suggesting an origin of the lower crustal source [34] and is typical for magma generation in the supra-subduction mantle wedges [35]. The selective enrichment of the Sr, Ba and lack of enrichment of others (Zr, Ti, Y) exhibited by the tholeiite type are characterizing of the supra-subduction zones (SSZ) condition where occurring of boninite and tholeiite magma mixing [13].

Another possible explanation for depletion of the HFSEs [36], involving crustal contaminated during the emplacements with the arc signature. On the other hand [37] it was suggested that the fractional crystallization in metamorphisms, and crustal contamination could be the source of the HFSEs depletions in the gabbro rock.

The HFSEs depleted in the study gabbro rocks can be evidencing in some diagrams according to the variation of Zr versus Nb (Fig. 18) which indicates that the process of fractional crystallization and the magmatic melting nature from which the study rocks were crystallized.

The properties exhibited by the spider diagram of the study gabbro rock are selective enrichment of certain elements (Sr, Ba and U) and the relative lacking of the enrichment of others (Zr, Y and Hf). These patterns and the HFSEs variations exhibiting by the tholeiite type are characterized by the supra subduction zone (SSZ) condition [13 and 38].





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E-ISSN: 2959-5568

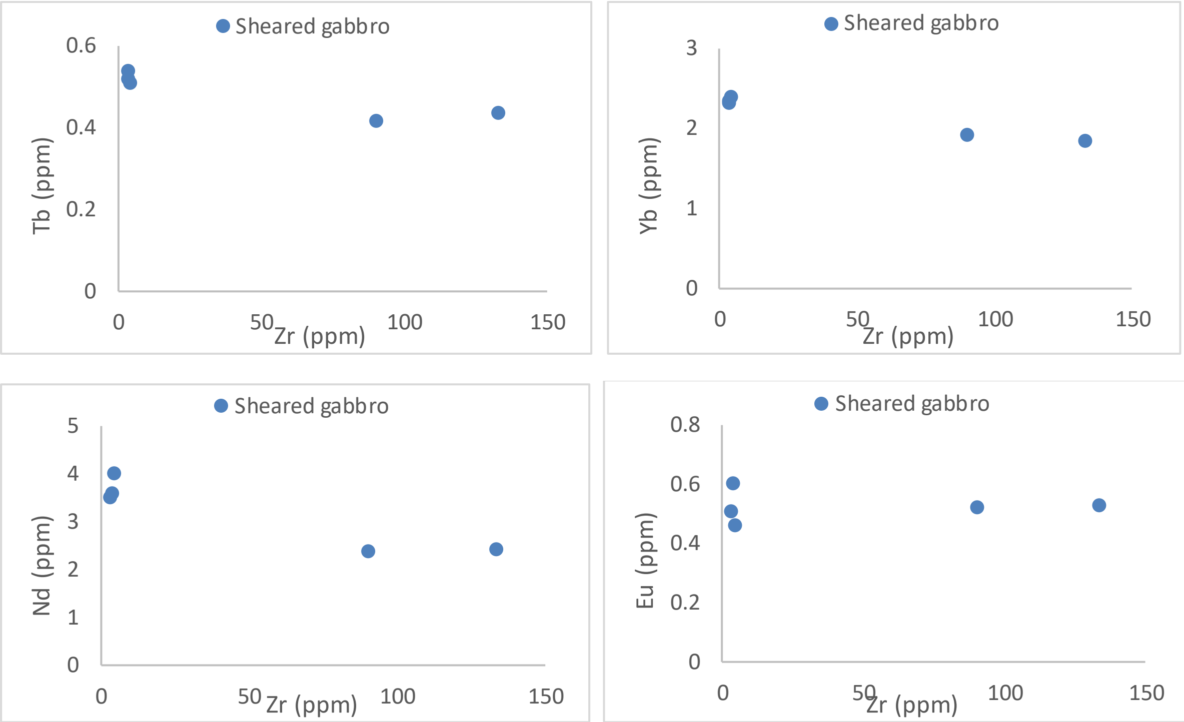

Figure 19: Zr vs. REE plots in the studied sheared gabbro

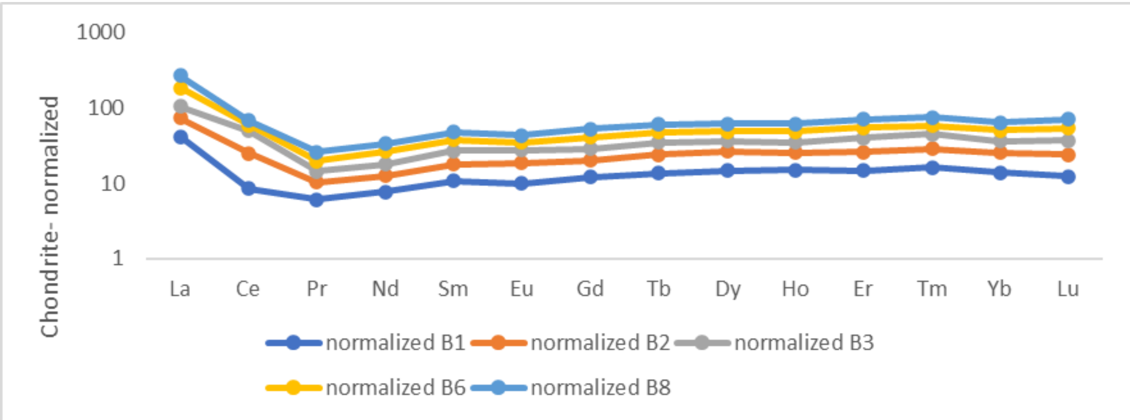

Figure 20: REE element Chondrite- normalized patterns of the sheared gabbro in the studied area

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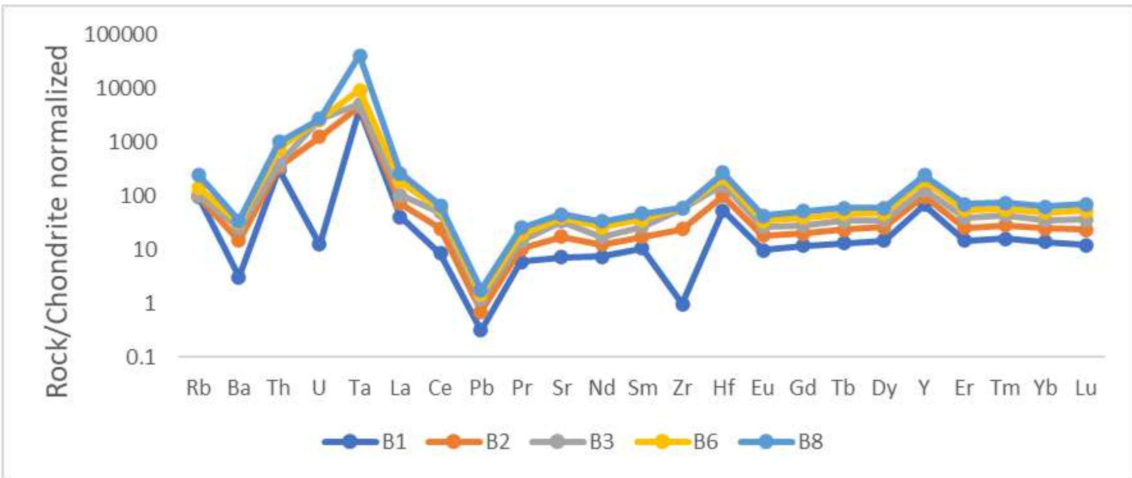

Figure 21: Trace and REE elements Chondrite- normalized of the sheared gabbro in the study area

Conclusions

The studied gabbroic rocks show a tholithic geochemical property, which is characterized by a good medium potassium tholithic pattern in the alkalinity, total silica and AFM diagrams.

The negative relationship between MgO and Zr is formed in gabbro rocks with early stage crystalline minerals such as pyroxene, zolivine and clagoclase minerals that form during magmatic differentiation.

The geochemical characteristics of the study summarize the sheared gabbro rocks as an increase in TiO2, Zr, P2O5, Y, Ga and Sr with decreasing MgO and increasing Ni and Cr with increasing MgO. The partial crystallization process of mineral phases such as olivine, clinopyroxene, and plagioclase can explain the geochemical features.

The variation of MgO-Zr values can be considered to be generated from a single primary source to a Mafic magma source through the partial crystallization (FC) process. The values of Al2O3 and CaO vs. MgO value undoubtedly show that the accumulation/fractionation of olivine and plagioclase minerals is dominant in the genesis of the study of sheared gabbro rocks. The process of partial crystallization occurred during solidification to the main magma source tholiite and modified its initial composition to produce the main body of gabbro rocks in the genesis of the studied rocks.

The spider figure shows the positive relationship between Ba, Sr and U with respect to the neighboring elements and variable degrees appear in all the studied rocks. The positive correlation of Sr can be explained by its substitution by Ca in plagioclase minerals. Furthermore, the enrichment of U in all studied rocks suggesting that the source may not have been physical enrichment in highly incompatible elements such as the upper crust.

Conservative element depletion is characterized by the separation of large ionic lithophiles LILEs (Cs, Rb, Ba, and Sr) and HFSEs during skid plate drying. Contamination of the shell during placement by the signature of the arc.

The most characteristic features shown by the study gabbro spider graphs are the selective enrichment of some elements such as Sr, Ba and U, as well as the relative lack of enrichment of others (Zr, Y and Hf). These patterns and the HFSE variations exhibited by the tholelite type characterize the subduction zone above.

References

1. T. Buday, The regional geology of Iraq, Stratigraphy and palenogeography, edited by I. M. Kassab, S. Z. Jassim, (Dar Al- Kutib pulblishing house, Mosel, Iraq, 1980), 445
2. GEOSURV. Baghdad, The geology of the Rania area, Manuscript report No.271, C. M. G.Bolton, (1958)
3. M. P.Searle, S. J. Lippard, J. D. Smewing, D. C. Rex, J GEOL SOC LONDON (1980)
4. H. A. Babaie, M. A. Gazi, Journal of Asian Earth Sciences, 19(1),61-76(2001)
5. Omrani J., Whitechurch H., Benoit M., Prouteau G. and Jolivet L., 2008. Arc-Magmatism and Subduction History beneath the Zagros Mountains, Iran: A New Report of Adakites and Geodynamic Consequences Lithos 106(3-4),380-398
6. K. J. Aswad, N. R. Hamah Aziz, H. A. Koyi, Geological Magazine, THEMATIC ISSUE: Geodynamic evolution of the Zagros 148(5-6), 819 – 837(2001)
7. T. Buday, S. Z. Jassim, The regional Geology of Iraq, 2, Tectonism, Magmatism and Metamorphism, edt. By I. M. Kassab, M. J. Abass, (Geological Survey and Mineral Investigation, Baghdad Iraq, 1987), 352
8. S. Z. Jassim, C. Goff, Geology of Iraq, (Dolin Prague and Moravian Museum Brno, 2006), 341

9. S. Z. Jassim, M. I. Al-Hassan, Geol. Soc. Iraq Journ., 169-210(1977)
10. M. Shawan, R. O. Leatherdale Maxeiner, K. M. Ansdell, northern Jour. Saskatchewan, Saskatchewan Geological Survey, 2, 1-17(2003)
11. B. E. Leak, A. R. Woolley, C. E. S. Arps, W. D. Birch, M. C. Gilbert, J. D. Grice, F. C. Hawthorne, A. Kato, H. J. Kisch, V. G. Krivovichev, K. Linthout, J. Laird, J. A. Mandarino, W. V. Maresch, E. H. Nickel, N. M. S. Rock, J. C. Schumacher, D. C. Smith, N. C. N. Stephenson, L. Ungaretti, E. J. W. Whittaker, G. Youzhi, Amer. Mineral., 82, 1019-1037(1997)
12. M. K. Yaliniz, M. C. Goncuoglu, Jour. Of Turk J. Earth Sci., 8,103-111(1999)
13. J. A. Pearce, S. J. Lippard, S. Robert, Characteristics and tectonic significance of Supra-subduction zone ophiolite, marginal basin geology, Vol.16, (Geol. Soc. Spec. Public. London, 1984), 77-94
14. C. Klein, Jr. C. S. Harlbut, Manual of Mineralogy, (John Wiley and Sons, New York, 1993), 681
15. R. E. Stevens, Composition of some chromites of the western hemisphere, Am. Mineral., Vol 29,1-34(1944)
16. O. Parlak, H. Yilmaz, D. Boztug, Jour. Of Earth Science (Turkish J. Earth Sci.), 15, 25-45(2006)
17. G. Duclaux, R. P. Menot, S. Guillot, Y. Agbossoumonde, N. ana Hilairet, Jou. Of Precambrian Research, 2720, 1-18(2006)
18. L. S. Jenson, Geological Report 66, 1-20(1976)
19. J. F. Davis, R.W. E. Grant, R. E. S. Whitehead, J. Earth. Sci., 16, 305-311(1979)
20. M. Shamim Khan, T. E. Smith, M. Raza, J. Huang, Jour. Of Gondwana Research, 8(4), 553-566(2005)
21. M. M. Sofy, Petrochemistry and petrogenesis of Bulfat mafic layered igneous intrusion around Herro (Qaladizeh)-Iraq Kurdistan, Msc. thesis, Salahaddin University-Erbil, 123(2003)
22. B. Yibas, W. U. Reimold, C. R. Anhaeusser, C. Koeberl, Jour. Precambrian Research, 121, 157-183(2003)
23. J. R. Cann, Earth Planet, Sci. Lett., 10, 7-11(1970)
24. O. Parlak, H. Yilmaz, D. Boztug, ,. Origin and tectonic significance of the metamorphic Sole and isolated dykes of divirgi ophiolite (Sivas, Turkey): Evadence for break-off prior to ophiolite emplacement, Jour. Of Earth Science (Turkish J. Earth Sci.), 15, 25-45(2006)
25. H. Rollinson, Using geochemical data evolution, presentation, and interpretation, (Wiley, New York,1993), 351
26. M. Wilson, Igneous Petrogenesis, A Global Tectonic Approch, (Unwin Hyman, London, 1989),400

27. T. N. Irvine, W. R. A. Baragar, Muskox Intrusion and Coppermine River Lavas, Northwestern Territories, Canda: 24th Internat. Geol. Congr., Montreal, Excutsion A29, Gudebook, 1972), 70
28. R. W. Le Maitre, P. Bateman, A. Dudek, J. Keller, J. Lameyre, M. J. LeBas, P. A. Sabine, R. Schmid, H. Sorenson, A. Streckeisen, A. R. Woolley, B. Zenettin, A. Classification of Igneous rocks and Glossary of Terms, Recommendations of the International Union of Geological Sciences, Subcommission on the Systematics of Igneous Rocks, Blackwell, Oxford, 1989), 193
29. H. S. T. C. O'Neill, H. Palme, Composition of the silicate Earth: implications for accretion and core formation. In The Earth's Mantle: Structure, Composition, and Evolution- the Ringwood, volume (ed l, Jackson), (Cambridge University Press Cambridge,1998), 3-126
30. S. M. McLennan, Review of Mineralogy, 21, 169-200(1989)
31. H. Rollinson, Using geochemical data evolution, presentation, and interpretation; Wiley, New York, 1993), 351
32. M. Shamim Khan, T. E. Smith, M. Raza, J. Huang, Jour. Of Gondwana Research, 8 (4),553-566(2005)
33. S. R. Taylor, S. M. McLennan, The Continental Crust: Its Composition and Evolution, (Blackwell, London, 1985), 312
34. G. Duclaux, R. P. Menot, S. Guillot, Y. Agbossoumonde, N. ana Hilairet, Jou. Of Precambrian Research, 2720, 1-18(2006)
35. R. E. Harmer, V. Gruenewaldt, Jour. Geol. S. Afrrica, 93,104-122(1991)
36. M. C. Johnson, T. Plank, Dehydration and melting experiments constrain the fate of subducted sediments, Geochemistry, Geophysics, and Geosystems, 1, (1999)
37. K. Resimic-Saric, A. Koroneos, V. Cvetkovic, K. Balgh, Jou. of Builetin of Geological Society of Greece, XXXVI, 597-606(2004)