GEOCHEMISTRY, S-TYPE , CLASSIFICATION AND PETROGRAPHY OF GRANITES FROM IDANRE, ONDO STATE, SOUTH WEST , NIGERIA.

Obasi, Romanus Ayoola
Department of Geology. Ekiti State University,
PMB 5363, Ado-Ekiti, Ekiti State Nigeria.
Corresponding author: Romanus Obasi. E.mail: romanus914@yahoo.com,
Phone number: 07032448351

Abstract-The study of the geochemistry, S-type classification and petrography of Idanre granite was undertaken. Eighteen granite samples were analysed for their major, trace and rare earth elements using X-Ray Fluorescence (XRF) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) respectively. The SiO2 contents range between 61.05 and 74.56 Wt % , Al2O3 (11.92 - 15.80 Wt %) , K2O (4.87- 6.55 Wt %), Na2O (2.45-3.51%) and (Na2O + K2O) 8.04 -9.31 Wt. %. The alumina saturation index (ASI) defined by molecular ratio Al2O3/Na2O +K2O +CaO is greater than unity (one) in all the rock samples by values ranging from 1.28 to 1.34 wt % implying that the granitic rocks are peraluminous . Low concentrations of CaO (1.05-3.60), MgO (0.23-1.77), Fe2O3 (1.98-6.81), and low ratio of Na2O/K2O are attributes of peraluminous rocks. The minerals contained in Idanre granite are microcline, plagioclase, biotite and mica as well as moderate silica and all these are characteristic features of a peraluminous and S-type granitic rock. Result analysis showed enrichment of high field strength elements; Zr (155.10-772.02ppm), Nb (18.05-45.14),Y(12.14-46.63 ppm) and Th (16.48-82.52ppm), and depletion of high rare earth elements. These traits showed melts that are characteristic features of the upper crustal domain.

Index Terms: Peraluminous, S-type classification, metasedimentary, crustal sources

1.0 : Introduction

Different granitic classifications have been suggested by different scholars using different criteria. Petrographic classification of granitoids based upon their modal abundances of quartz, plagioclase and alkali feldspar has been used by Streckeisen (1967). Granitoids generally come from mixtures of mantle-derived mafic melts and melts of crustal rocks that may or may not contain metasedimentary components (John & Wooden, 1990; Miller *et al.*, 1990). Granites have been classified based on their modal composition, location within the crust, their chemical composition and mineralogy as well as tectonic regime to make deductions about their origin. The use of the aluminum saturation index, (ASI) which is expressed in the micas and minor minerals in the rock is becoming popular as it is related to the magma sources and the conditions of melting. The alumina saturation index (ASI) defined by molecular ratio $Al_2O_3/Na_2O + K_2O + CaO$ has been used to classify the granitic rocks as peraluminous and as S-type rock. Rocks can be characterized by the abundance of the major oxides within them. For example, low concentrations of CaO, MgO , Fe_2O_3, as well as low ratio of Na_2O/K_2O are attributes of peraluminous rocks (Cerny, *et al.*,1981 and Longstaff, 1982). Similarly, when the ratio of $Na_2O + K_2O + CaO/Al_2O_3$ is less than unity (ratio < 1), it confirms the peraluminous character of the rock (Pearce et al.,1984). These attributes have been applied in the classification of Idanre granites.

Romanus Obasi Ayoola is presently a Reader in the Department of Geology of the Ekiti State University, Ado-Ekiti., Ekiti State, Nigeria.

2.0: Materials and Methods:dd3\

2.1: Field study

The field data (Table1) indicates the physical study of the rock and the data comprising the co-ordinates, colour, texture, mineralogy, sample locations and rock height. The texture of the granite varies from fine-medium to coarse grains. The colour differences also occur among the granite according to the mineral contents.

Table 1

Field data collection.

SAMPLE NUMBER	COORDINATES	COLOUR	TEXTURE	MINEROLOGY	LOCATION	NATURE OF OUTCROP
L1	N07°06'42.4" E005°06'55.7"	Dark grey and white	Fine grain	Biotite, quartz and feldspar	Few meters from Alade round about	Low lying
L2	N07°06'43.4" E005°06'59.7"	Pink, black and white	Porphyritic	k-feldspar, biotite, muscovite and quartz	Opp. Methodist church, Idanre	Low lying
L3	N07°06'34.1" E005°07'49.6"	Pink, black and white	Coarse	K-feldspar, biotite, muscovite, and quartz	90, Awolata street, Idanre	Low lying
L4	N07°06'20.3" E005°08'29.9"	Pink, black and white	Coarse	K-feldspar, biotite, muscovite, and quartz	Awolata street, Idanre	Low lying
L5	N07°06'23.5" E005°08'49.8"	Grey, Black and white	Coarse	Fieldspar, Biotile, Quartz	Igbo Oba Road, Idanre	Low lying
L6	N07°06'23.6" E005°08'59.8"	Pink, black and white	Porphyritic	K-feldspar, biotite, Muscovite and Quartz	Igbo Oba Road, Idanre	Low lying
L7	N07°06'03.7" E005°08'44.5"	Grey, white and black	Coarse	Feldspar, Biotite and Quartz	Basic health centre area, Idanre	Low lying
L8	N07°05'53.1" E005°08'51.2"	Pink, white and black	Porphyritic	K-feldspar, Biotite and Quartz	Olofin Anglican Grammar School	Low lying
L9	N07°07'28.7" E005°06'22.1"	Pink, white and black	Porphyritic	K-feldspar, Biotite and Quartz	Olofin, IdanreOdeja	Low lying
L10	N07°06'27.5" E005°07'44.2"	Pink, white and black	Porphyritic	K-feldspar, Biotite and Quartz	Odeja Part II	Low lying
SAMPLE NUMBER	COORDINATES	COLOUR	TEXTURE	MINEROLOGY	LOCATION	NATURE OF OUTCROP
L12	N07°05'26.0" E005°09'00.9"	White and Black	Medium grained	Biotite, Quartz and Feldspar	Opa Road, Idanre	Low lying
L13	N07°04'55.1" E005°08'52.0"	Pink and Black	Porphyritic	K-Feldspar, Quartz and Biotite	Kaduna Sawmill, Opa, Idanre	Low lying
L14	N07°04'49.4" E005°08'36.4"	Pink, Grey and Black	Coarse	K-Feldspar, Quartz and Biotite	Under bridge, Apefon Road, Idanre	Low lying
L15	N07°04'49.4" E005°06'25.4"	Pink, Grey and Black	Coarse	K-Feldspar, Quartz and Biotite	Odoji Road, near the resort centre	Low lying
L16	N07°06'33.5" E005°05'54.5"	Pink, Black and White	Porphyritic	K-Feldspar, Quartz, Biotite and Muscovite	Odoji Road	Low lying
L17	N07°06'33.6" E005°05'15.0"	Pink, Black and White	Porphyritic	K-Feldspar, Quartz, Biotite and Muscovite	Odoji Road	Low lying
L18	N07°08'26.0" E005°05'58.7"	Black and White	Medium grain	Quartz, Biotite, Muscovite and Feldspar	Mama Chikodi Restaurant Road Alade	Low lying

2.2 : Analytical methods

Eighteen (18) samples were powdered to less than 200 mesh for whole- rock analyses and they were performed at the Central laboratory of the Stellenbosch University, South Africa. Whole-rock major element compositions were determined by XRF spectrometry on a PANalytical Axios Wavelength Dispersive Spectrometer following the proposal of Fairchild et al., (1999). The gas-flow

ISSN 2229-5518

proportional counter uses a 90% Argon-10% methane mixture of gas. Major elements were analyzed on a fused glass disk using a 2.4kW Rhodium tube. The trace element concentrations were determined by inductively coupled plasma-mass spectrometry (ICP-MS). Major and trace element abundances were determined using a PS-950 X-ray fluorescence (XRF) and a 7500a La-ICP-MS, respectively. The results of the analysis are presented in Table 2. The concentration of the control standards that were used in the calibration procedures for major element analyses fit the range of concentration of the samples. Amongst these standards were NIM-G (Granite from the Council for Mineral Technology, South Africa) and BE-N (Basalt from the International Working Group).

3.0: Results and Discussion.

Table 2

Geochemical composition of Granite from Idanre, Ondo State.

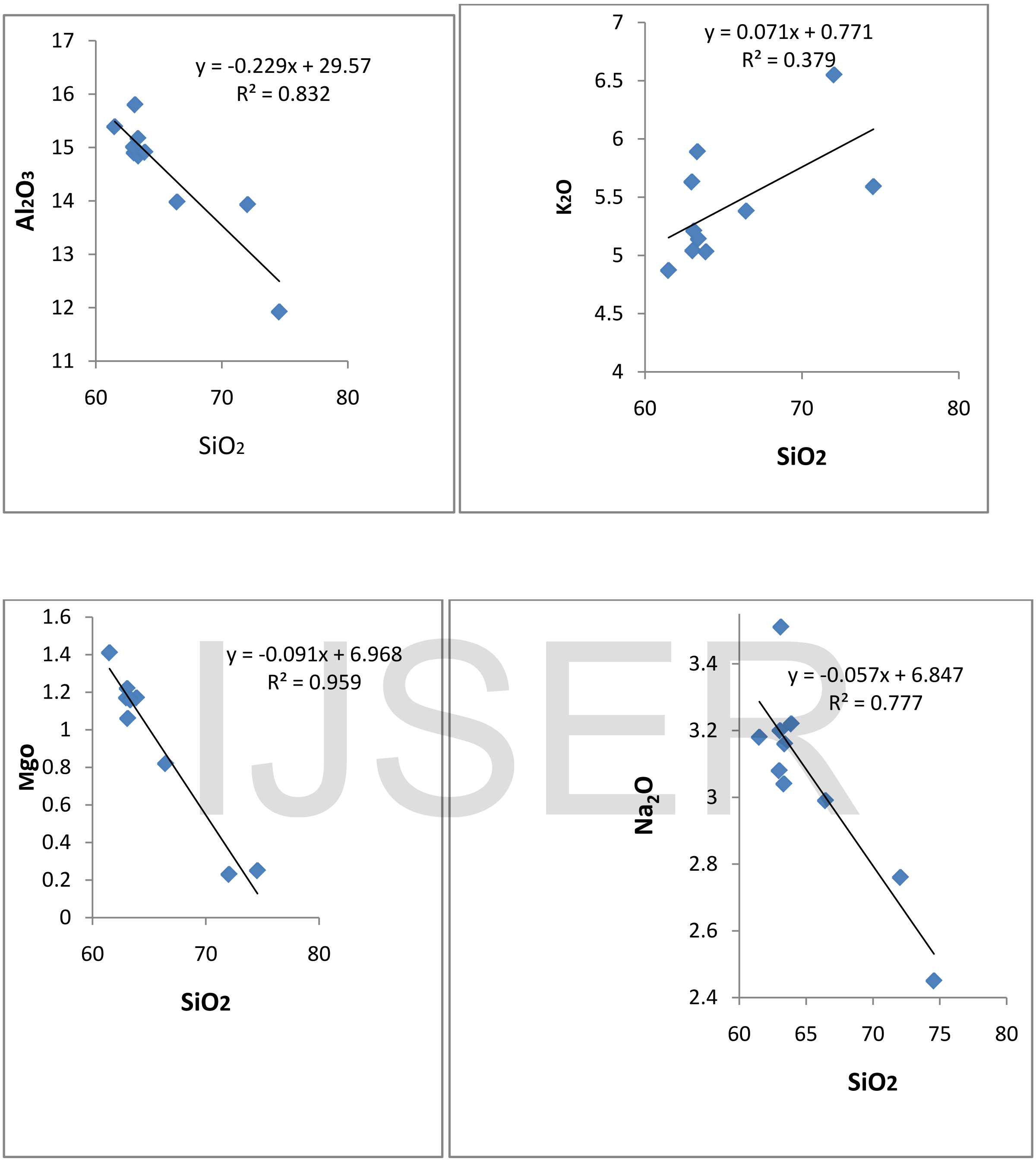
oxides	1	2	3	4	5	6	7	8	9	10
SiO_2	74.56	63.40	63.05	66.45	63.89	62.99	63.34	61.50	72.05	63.11
Al_2O_3	11.92	14.84	14.90	13.98	14.91	15.01	15.17	15.39	13.93	15.80
K_2O	5.59	5.14	5.04	5.38	5.03	5.63	5.89	4.87	6.55	5.21
Na_2O	2.45	3.16	3.20	2.99	3.22	3.08	3.04	3.18	2.76	3.51
Fe_2O_3	2.49	6.34	6.81	5.69	6.31	6.44	6.12	7.22	1.98	6.03
MgO	0.25	1.16	1.22	0.82	1.77	1.17	1.16	1.41	0.23	1.06
P_2O_5	0.05	0.34	0.36	0.22	0.32	0.32	0.32	0.43	0.06	0.28
CaO	1.13	3.13	3.26	2.51	3.04	3.03	2.82	3.60	1.05	3.15
TiO_2	0.27	1.02	1.09	0.80	1.08	1.04	1.00	1.33	0.21	0.93
Cr_2O_3	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
L.O.I	0.48	0.59	0.35	0.61	0.26	0.49	0.42	0.63	0.21	0.35
MnO	0.03	0.07	0.08	0.07	0.08	0.05	0.07	0.09	0.03	0.07
Sum of conc.	99.22	99.20	99.31	99.53	99.31	99.28	99.35	99.38	99.06	99.50

Table 2 shows the major elements composition of the Idanre granites. The SiO_2 contents range between 61.05 and 74.56 Wt % (Av 65.43%) corresponding to an intermediate to acid composition The concentration of Al_2O_3 varies between 11.92 and 15.80 Wt % (Av 14.59 Wt %,) similar to those of calc-alkaline rocks series. K_2O ranges from 4.87 to 6.55 Wt % (Av 5.43%) , Na_2O (2.45-3.51%) , and a total alkali content (Na_2O + K_2O) of 8.04 -9.31 Wt. %. MnO and P_2O_5 concentrations are less than 0.5 wt. %, and loss on ignition (LOI) values are 0.35-0.63 wt.%.

These data are used in the construction of several discrimination and variation diagrams in order to classify the rocks, decipher their geochemical nature and show the tectonic setting of the rocks. Figure 1 indicates various Harker variation plots of some major oxides against SiO_2 Most of the major oxides, NaO_2 MgO, TiO_2, Fe_2O_3, Al_2O_3 and CaO show negative linear trends with SiO_2 except K_2O which showed strong positive linear trend with $SiO_{2.}$ The negative linear trends of these oxides show chemical affinity in their own way thus suggesting their derivation from the same source or same

ISSN 2229-5518

parent magma. However, the positive trend of K_2O implies different sources of material input since the samples are randomly scattered (Fig 1).



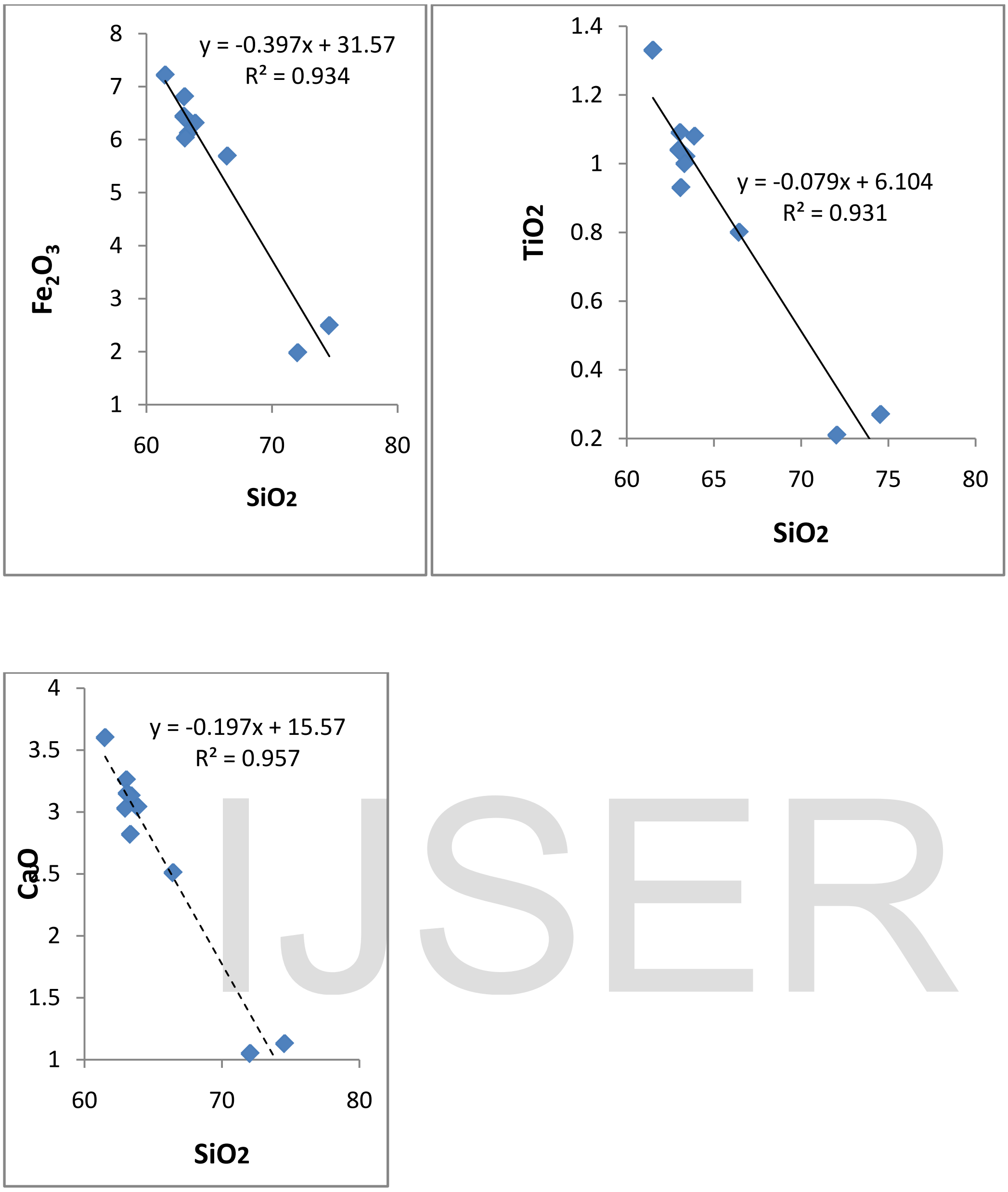


Figure 1: Harker variation diagrams; silica (SiO_2 wt %) plotted against a range of major oxides (in wt %) for the granite of the study area.

Table 3: Major oxides with some ratios.

Oxides	1	2	3	4	5	6	7	8	9	10
SiO_2	74.56	63.40	63.05	66.45	63.89	62.99	63.34	61.50	72.05	63.11
Al_2O_3	11.92	14.84	14.90	13.98	14.91	15.01	15.17	15.39	13.93	15.80
K_2O	5.59	5.14	5.04	5.38	5.03	5.63	5.89	4.87	6.55	5.21
Na_2O	2.45	3.16	3.20	2.99	3.22	3.08	3.04	3.18	2.76	3.51
Fe_2O_3	2.49	6.34	6.81	5.69	6.31	6.44	6.12	7.22	1.98	6.03
MgO	0.25	1.16	1.22	0.82	1.77	1.17	1.16	1.41	0.23	1.06
P_2O_5	0.05	0.34	0.36	0.22	0.32	0.32	0.32	0.43	0.06	0.28
CaO	1.13	3.13	3.26	2.51	3.04	3.03	2.82	3.60	1.05	3.15
TiO_2	0.27	1.02	1.09	0.80	1.08	1.04	1.00	1.33	0.21	0.93
Cr_2O_3	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00

L.O.I	0.48	0.59	0.35	0.61	0.26	0.49	0.42	0.63	0.21	0.35
MnO	0.03	0.07	0.08	0.07	0.08	0.05	0.07	0.09	0.03	0.07
Sum of conc.	99.22	99.20	99.31	99.53	99.31	99.28	99.35	99.38	99.06	99.50
Na_2O/ K_2O	0.43	0.61	0.63	0.55	0.64	0.54	0.51	0.65	0.42	0.67
$Al_2O_3/Na_2O+ CaO+ K_2O$	1.29	1.29	1.30	1.28	1.32	1.27	1.29	1.32	1.34	1.33
Excess of Al_2O_3 over $Na_2O+ CaO+ K_2O$	2.75	3.41	3.4	3.1	3.62	3.27	3.42	3.74	3.57	3.93
$Na_2O+CaO+ K_2O/ Al_2O_3$	0.76	0.77	0.77	0.78	0.75	0.78	0.77	0.76	0.74	0.75
Na_2O+K_2O/ Al_2O_3	0.67	0.55	0.55	0.59	0.55	0.58	0.58	0.52	0.66	0.55
K_2O/Na_2O	2.28	1.63	1.58	1.8	1.56	1.83	1.94	1.53	2.37	1.48

Table 3 displays geochemical data showing the ratios of Na_2O/K_2O, $Al_2O_3/Na_2O +K_2O +CaO$, $Na_2O+ CaO+ K_2O/ Al_2O_3$, and $Na_2O +K_2O/ Al_2O_3$ for the various samples. .The ratio of Na_2O/K_2O in the rocks ranges between 0.42 and 0.67. The alumina saturation index (ASI) defined by molecular ratio $Al_2O_3/Na_2O +K_2O +CaO$ is greater than unity (one) in all the rock samples by values ranging from 1.28 to 1.34 wt% implying that the granitic rocks are peraluminous. Rocks can be characterized by the abundance of the major oxides within them. For example, low concentrations of CaO (1.05-3.60), MgO (0.23-1.77), Fe_2O_3 (1.98-6.81), as well as low ratio of Na_2O/K_2O are attributes of peraluminous rocks (Cerny,et al;1981 and Longstaff, 1982). Similarly, when the ratio of $Na_2O + K_2O +CaO/Al_2O_3$ is less than unity (ratio < 1) such as this (0.75 - 0.77), it confirms the peraluminous character of the rock (Pearce et al.,1984). Rocks which have the above characteristics are rich in albite ($NaAlSi_3O_8$), potassium feldspar ($KAlSi_3O_8$) and quartz (SiO_2). In peraluminous or alumina-oversaturated rocks, excess alumina is accommodated in micas, especially muscovite, in addition to Al-rich biotite, and in aluminous accessory minerals such as cordierite, sillimanite, tourmaline, corundum and topaz, (Myron, 2001). Zen (1988) equally pointed that rocks which have ASI > 1 are corundum-normative, meaning that they have more Al than can be accommodated in feldspars and that they must have another aluminous phase present, .in which case in the more strongly peraluminous granites, the phase can be muscovite, cordierite, garnet or an Al_2SiO_5 polymorph. The minerals microcline, plagioclase, biotite and mica as well as moderate silica are all characteristic features of a peraluminous and S-type granitic rock. The plot of Al_2O_3 /(Na_2O + K_2O) versus Al_2O_3/(Na_2O +K_2O +CaO) of Maniar and Piccoli (1989) shows that the coarse granites plot mainly in the peraluminous field, (Fig 2). Wilson (1991) postulated that peraluminous granites contain crustal or sedimentary materials in their original magma.

3.1: Geochemical Classification of the granites

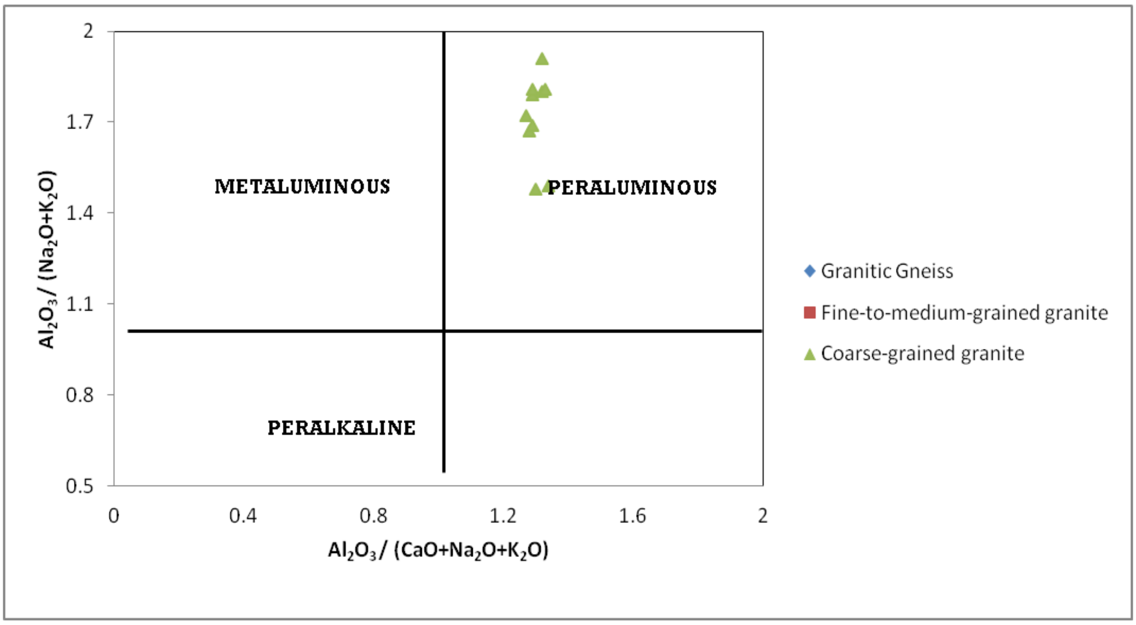


Fig 2: Al_2O_3 /(Na_2O + K_2O) versus Al_2O_3/(Na_2O +K_2O +CaO) molecular plot (After Maniar and Piccoli, 1989).

S-type granitoids are derived from the partial melting of sedimentary and metasedimentary rock and they are more common in collision zones. However, Chappell & White, (1974), strongly pointed out that peraluminous melts may have formed by melting of biotite-bearing metaluminous felsic rocks (Miller, 1985) or even by water-excess melting of mafic rocks (Ellis & Thompson, 1986), and that they are also formed from a sedimentary source. Petro et al., 1979; Maniar and Piccoli, 1989; Barbarin, 1990, 1999 pointed out that the use of the alkali–lime index (ALI) of the rock Al_2O_3>(Na_2O + K_2O –CaO), expresses the compositions and abundances of the feldspars in the rock and that these are related to the sources of the magma and conditions of melting .

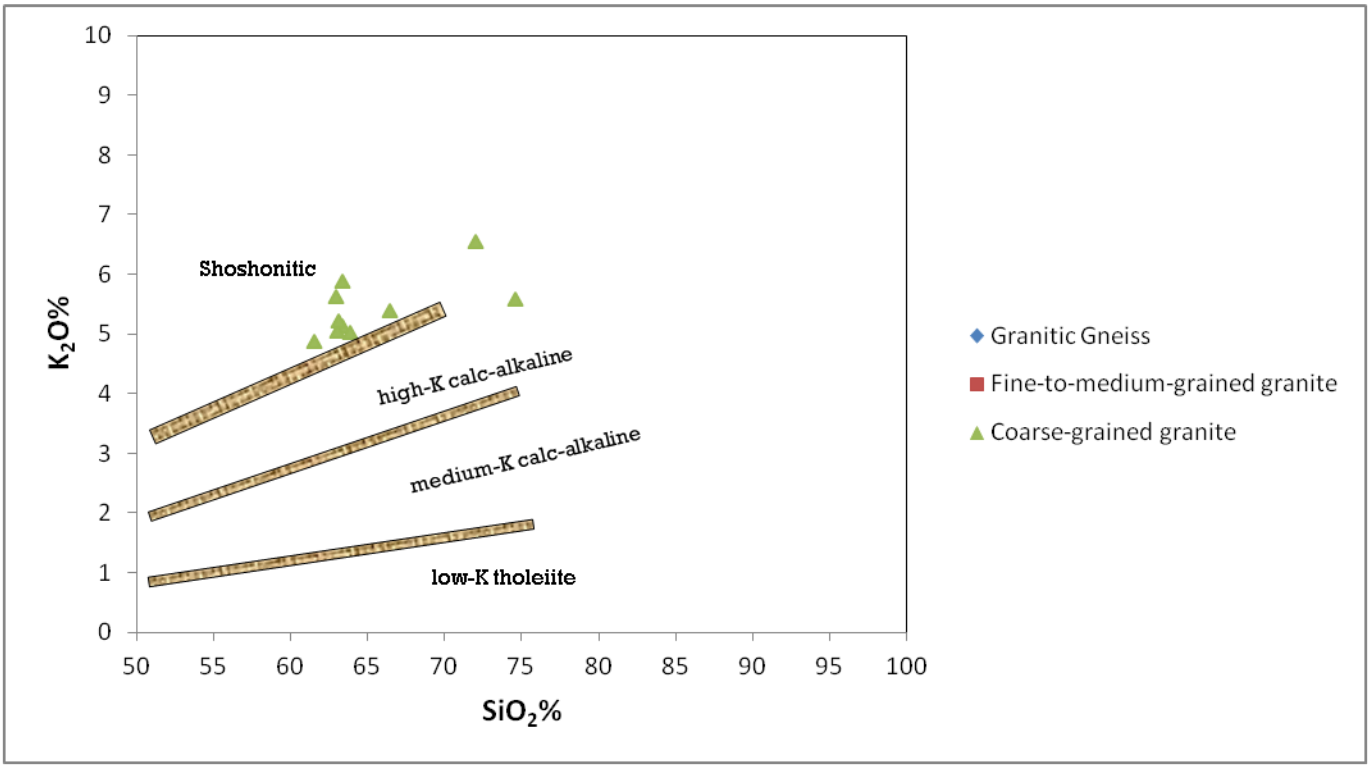


Fig 3: K_2O versus SiO_2 plot (After Rickwood,1989, Peccerillo & Taylor 1976) to distinguish various series of tholeiite, calc-alkaline and shoshonitic rocks.)

The plot of K_2O versus SiO_2 shows that the coarse grained granite plotted on the shoshonitic field while only one sample plotted on the high K -calc alkaline field (Figure 3). On the plot of Na_2O +K_2O against SiO_2 ,the samples fall in the field of granite and quartz monzonite, (Figure 4). Quartz monzonite or adamellite is an intrusive, felsic, igneous rock that has an approximately equal proportion of orthoclase and plagioclase feldspars. It is typically a light coloured phaneritic (coarse-grained) to porphyritic granitic rock

.

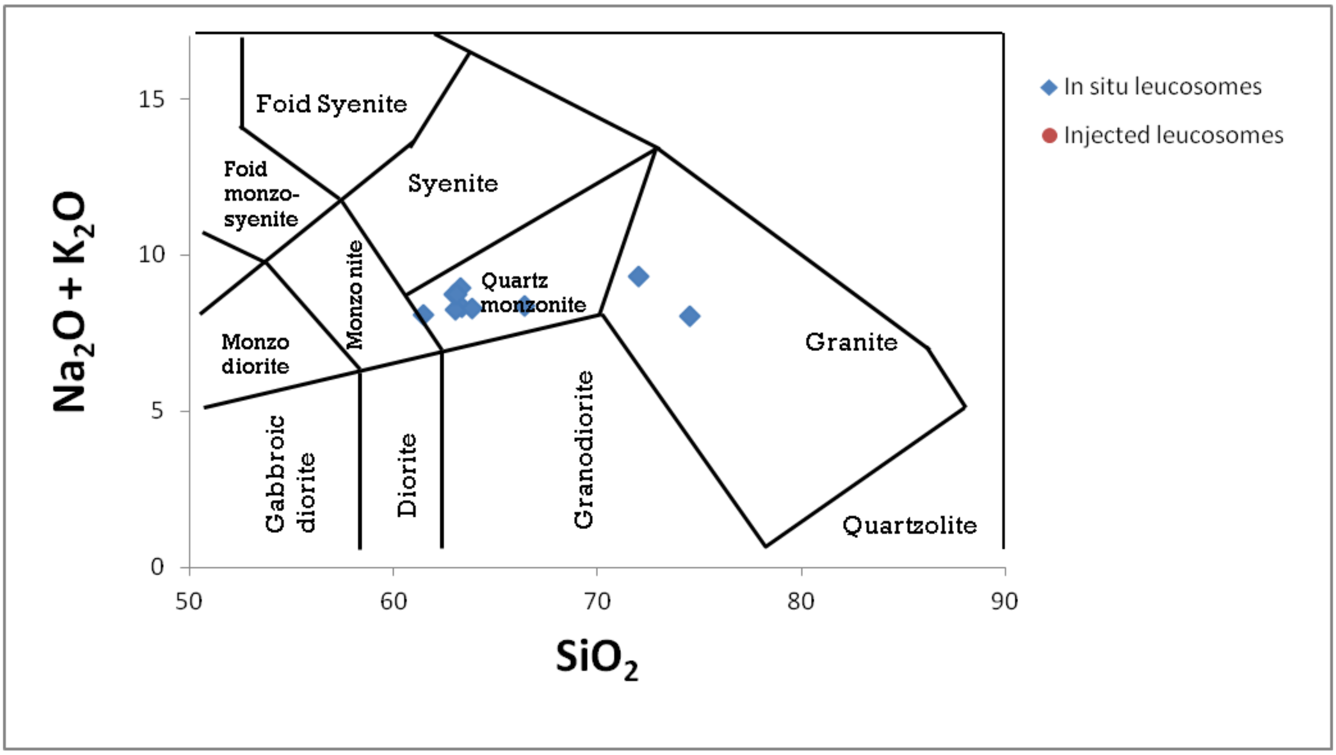


Fig.4: Plot of $Na_2O + K_2O$ against SiO_2.

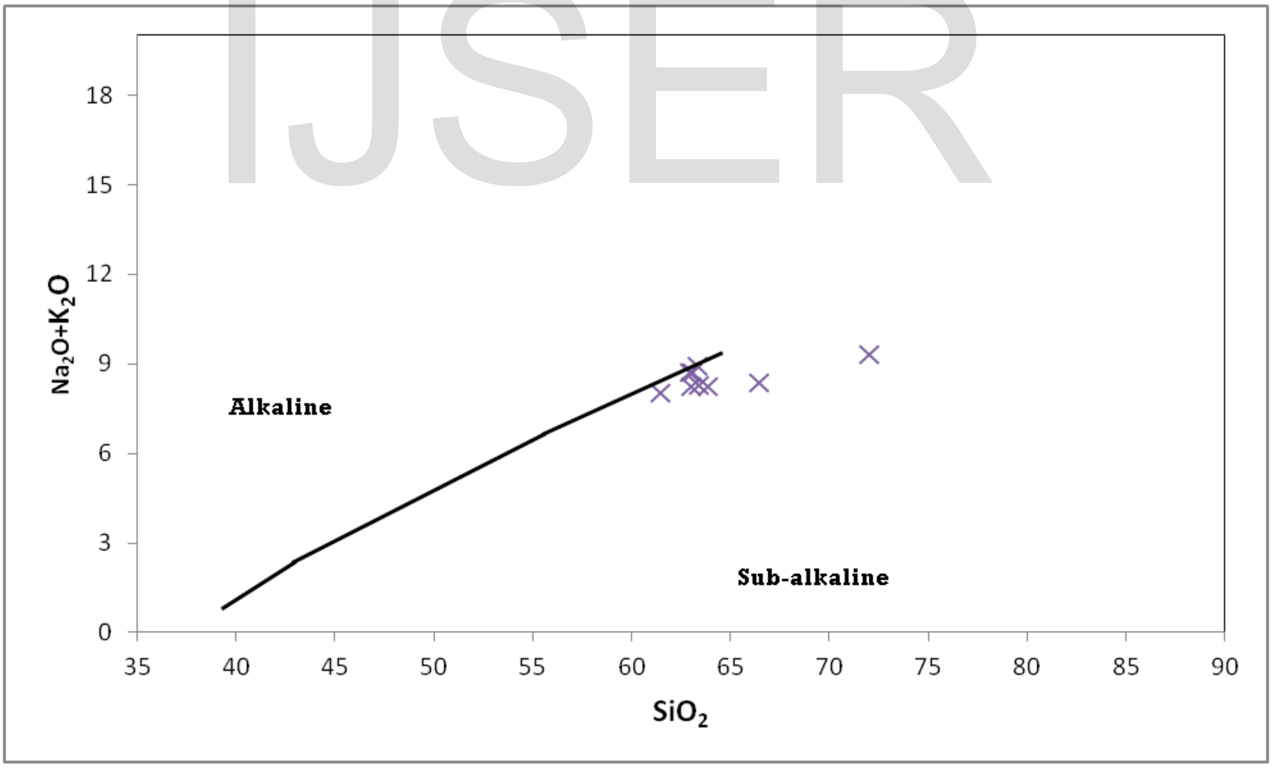


Fig.5: Alkali-SiO_2 discrimination diagram for the Idanre granite (after Irvine and Baragar, 1971)

3.2: Modified alkali–lime index (MALI**)**

Using the classification model of Irvine and Baragar (1971), as shown in Figure 5, the granites are subalkaline. The rocks can further be classified as calcic based on the cross-plots of $Na_2O + K_2O$ versus SiO_2 of Peacock, (1931), Irvine and Baragar , (1971), (Figure 6).

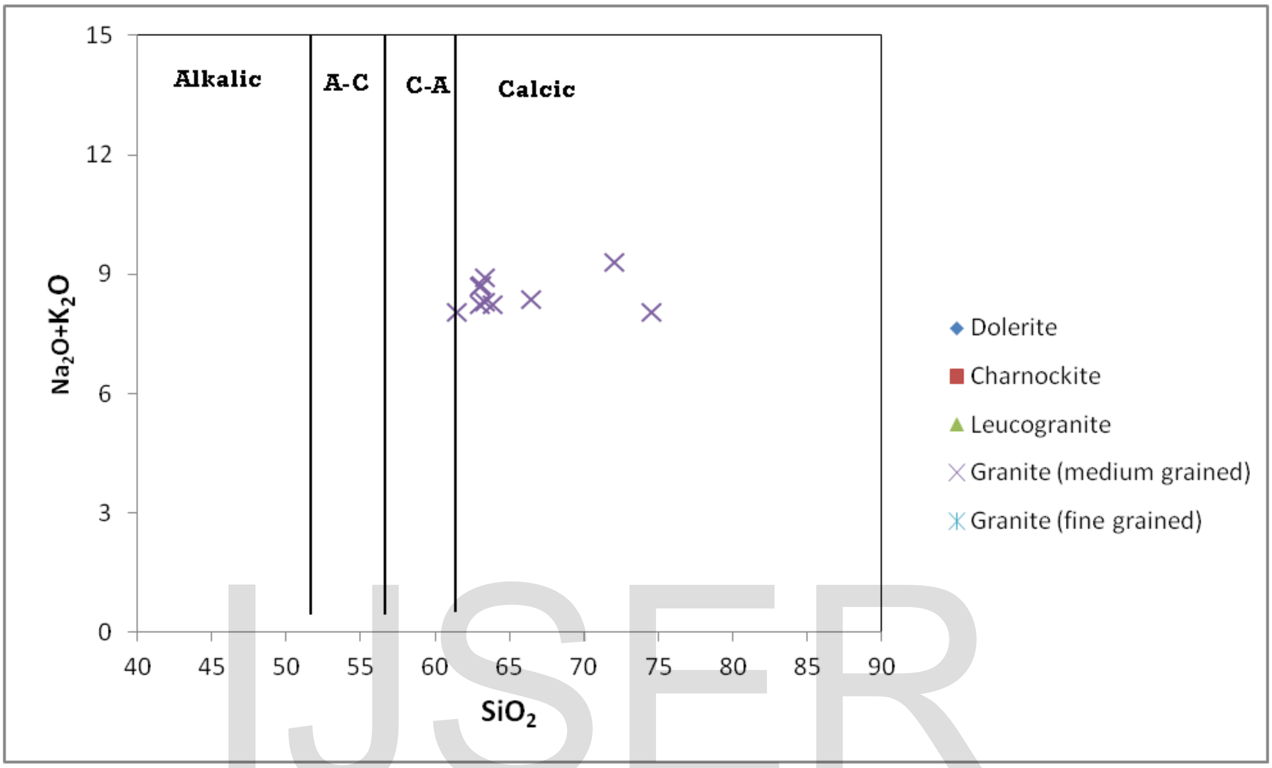


Fig.6 : Classification of rock from Idanre based on plots of $Na_2O + K_2O$ versus SiO_2 (after Peacock, 1931; Irvine and Baragar,1971).

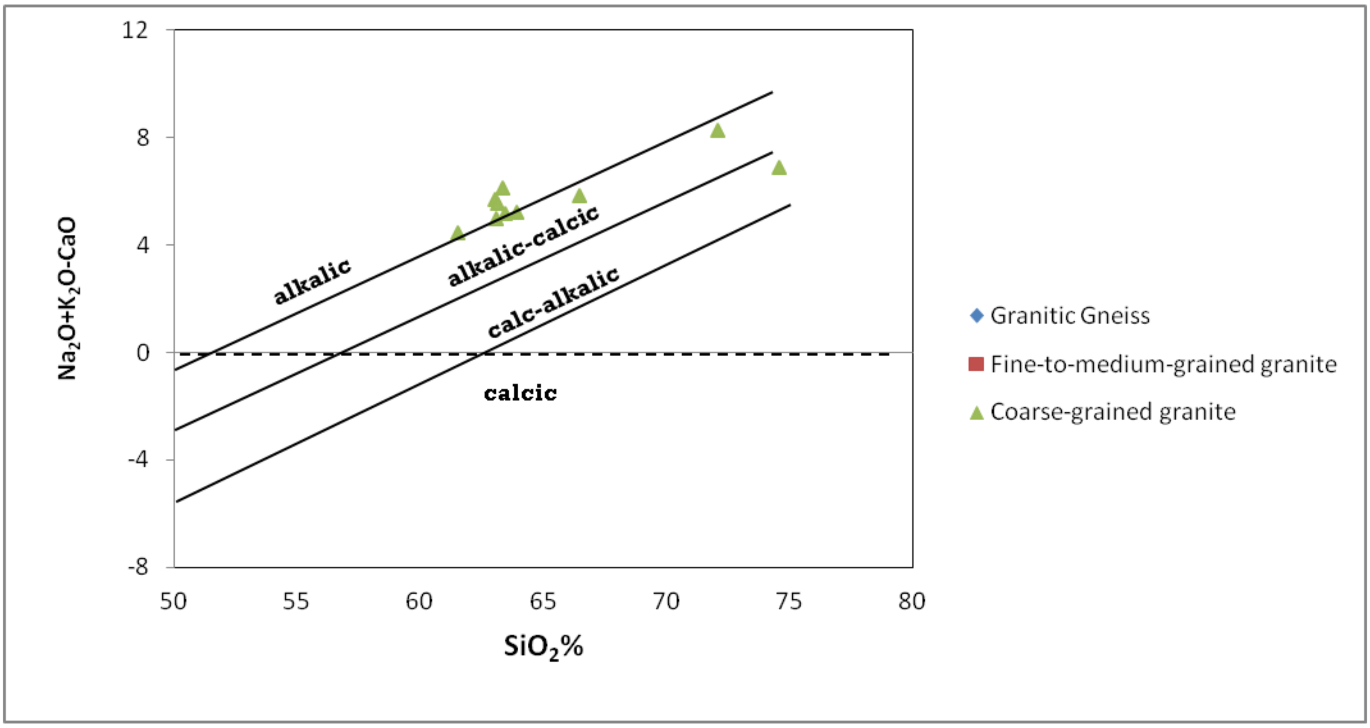


Fig.7 : Na_2O+K_2O-CaO versus SiO_2 plot (after Frost *et al*, 2001).

Using the plot of Na_2O+K_2O-CaO against SiO_2 of Frost *et al.*, (2001), the granites samples fall in the alkalic, alkalic-calcic fields with a sample falling in the calc-alkalic field (Figure.7). Peacock (1931) initially separated volcanic suites into four classes according to the alkali–lime index, that is, the SiO_2 content at which Na_2O + K_2O in a suite of lavas equalled CaO. Those suites that have an alkali–lime index >61 are calcic, those where it is between 56 and 61 are calc-alkalic, those where it is between 51 and 56 are alkali–calcic and those where it is <51 are alkalic. Although this scheme has become difficult to apply but a new scheme using the variables SiO_2, CaO, and Na_2O + K_2O and introduced as Na_2O + K_2O – CaO has been modified and named as modified alkali–lime index (MALI). This modified alkali–lime index increases with increasing weight percent SiO_2. The plotting of the granite samples in the different fields as shown in figure 7 means that they are produced from different igneous fractionating processes or they may have been derived from mixed sources of materials in the magma that formed the rock.

3.3: Trace and Rare Earth Elements Characteristics

Table 4 shows the data for the trace elements in the granite suite. The data show an appreciable abundance of Ba (654.07-1660.7ppm), Rb(153.01-304.81), Sr (109.28-414.81 ppm) and Pb (21.56--255.66 ppm), and all the large ion lithophile (LIL) elements. Also of high concentrations, are Ni (13.59-17-04) and Zn (36.35-126.46). It is to be noted that the high field strength elements (HFSE) such as Zr (155.10-772.02ppm), Nb (18.05-45.14), Y (12.14-46.63 ppm) and Th (16.48-82.52ppm) are also enriched. The data show also that the light rare earth elements (LREE: La, Ce, Nd, Sm) starting with La contents range from 56.04 to

195.77 ppm, Ce (106.77-368.51) ,Nd (11.81-129.58), and Sm (6.40.20.22 ppm) , respectively and they are generally high in abundance in contrast to the depleted heavy rare earth elements (HREE). The Idanre granite samples which exhibit peraluminous character, enrichments of LILE, HFSE and LREE show characteristic features suggestive of the upper crustal domain. The presence of these characteristic attributes in a rock show melts that are derived from the crustal domain also.

Table 4

Trace element geochemistry.

Trace Elements	1	2	3	4	5	6	7	8	9	10
Ba	935.5	1451.7	1475.8	1078.6	1433.9	1660.7	1737.9	1620.9	654.07	1453.3
Co	200.53	137.6	100.24	64.90	100.1	90.7	91.4	90.4	112.5	92.2
Cs	0.50	0.33	0.40	0.29	0.38	0.33	0.41	0.24	0.59	0.31
Cr	35.92	46.60	36.45	58.80	29.60	37.36	3 8.56	40.37	28.97	39.16
Cu	28.78	770.54	88.05	98.12	15.95	49.09	51.59	146.51	351.64	0.31
Mo	11.18	4.05	4.56	12.85	2.71	3.75	4.30	5.00	3.02	7.24
Ni	15.50	16.99	14.14	16.36	14.11	15.37	14.05	17.04	13.64	13.59
Nb	17.99	37.24	42.02	45.14	40.10	41.79	37.16	43.47	18.05	39.66
Pb	27.94	21.56	22.91	25.22	22.55	23.52	23.92	22.15	32.26	235.66
Rb	239.65	165.65	169.81	181.39	170.98	174.53	179.44	153.01	304.81	172.54
Sc	7.51	13.87	15.41	13.44	13.88	13.54	12.96	15.20	6.72	13.27
Sr	109.28	347.02	343.57	250.71	347.24	364.20	328.15	414.81	144.79	349.09
V	12.00	54.47	57.60	31.74	55.36	56.05	53.46	73.06	14.22	41.48
Y	21.56	41.46	46.14	46.63	41.60	40.50	37.97	43.43	12.14	41.53
Zn	47.79	107.68	119.84	99.54	113.47	114.58	107.34	126.46	36.35	106.90
	253.86	572.31	600.17	706.10	608.26	582.55	547.07	772.02	155.10	712.21

Coish, 1977; Winchester and Floyd, 1977; Pearce and Cann, 1973); Mullen, (1983) and Seewald et al., (1990) suggested that elements K, Ba, Sr, Cs and Rb with high ionic potentials are mobile, while Ta, Nb, Cr, Co, Ni, V, and REEs are stable during greenschist- and amphibolite- facies metamorphism. These mobile elements, Ba (654.07-1660.7), Rb (153.01-304.81), Cs (0.24-0.59), and Sr (109.28-414.81) appear to be relatively enriched despite their movement during crystallisation of mafic minerals or alteration of feldspar while the stable elements such as Ta (0.55-1.75), Nb (17.99-45.14ppm), Cr (28.97-58.80ppm), Ni (13.59-17.04ppm), and V (12.00-73.06ppm) have depleted values. (Table 4).

Table 5

The rare earth elements (REE) in the granites.

REE	1	2	3	4	5	6	7	8	9	10
Ce	246.92	276.42	257.01	368.51	342.97	286.54	275.44	348.45	106.77	288.81
Dy	4.68	8.58	9.87	10.16	8.81	8.33	2.92	8.85	2.92	8.56
Eu	1.11	2.65	2.67	2.44	2.71	2.70	2.79	3.03	0.93	2.93
Er	2.24	4.10	4.57	4.54	4.23	3.82	3.72	4.30	1.16	3.99
Gd	7.04	12.23	14.01	14.34	13.27	13.10	11.64	13.70	4.35	12.88
Hf	6.87	13.38	14.22	16.52	14.02	13.69	12.77	17.18	4.48	16.42
Ho	0.83	1.52	1.77	1.76	1.63	1.47	1.40	1.60	0.45	1.54
La	133.53	143.46	126.71	195.77	184.26	149.54	144.37	182.77	56.04	149.47
Lu	0.28	0.46	0.52	0.52	0.45	0.43	0.43	0.48	0.10	0.44
Nd	75.87	108.06	106.03	129.58	120.45	108.58	102.76	126.97	36.80	11.81
Pr	24.73	30.02	29.09	38.70	35.88	30.57	29.53	37.28	11.22	31.71
Sm	10.86	17.71	18.13	20.22	17.37	16.41	15.98	20.21	6.40	17.49
Ta	0.61	1.31	1.60	1.46	1.51	1.43	1.33	1.75	0.55	1.34
Tb	0.87	1.66	1.80	1.92	1.59	1.57	1.54	1.72	0.53	1.65
Th	82.52	18.16	16.48	41.39	27.30	18.73	18.53	22.17	33.65	20.80
Tm	0.29	0.57	0.56	0.55	0.55	0.53	0.51	0.53	0.15	0.49
U	8.14	1.27	1.36	1.35	1.25	1.14	1.22	0.64	2.42	1.61
Yb	1.90	3.15	3.99	3.41	3.56	3.24	3.16	3.39	0.76	3.29

The heavy rare earth elements (HREE: Gd, Tb, Dy, Yb and Lu) are depleted in their concentrations. (Table 5:). The ratios of Y/Nb and Nb/Y are in the range of 0.67-1.19 and 0.83-1.48 respectively. The ratios of La/Sc (8.22-17.78), La/Th (1.62-8.24), and La/Y (2. 75-6.19) are moderately high.

4.0: Petrography.

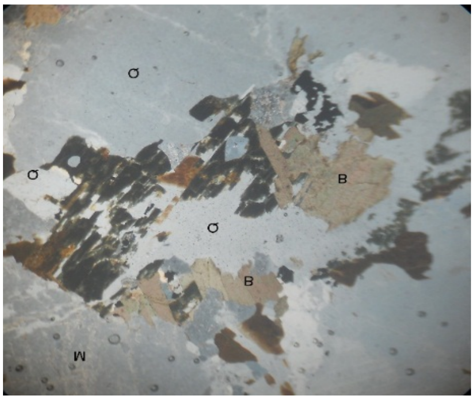
The thin sections (Plates 1-4) of the granite shows the various mineral grains/crystals of quartz, feldspar (microcline and plagioclase), biotite and opaque minerals. Microcline and quartz occur as large porphyritic crystals. Biotite content is low (8.2-19.3) compared to quartz (22.2-25.5) and plagioclase feldspar (26.1-33.8) (Table 6). They occur in different orientations with mineral alignment poorly developed. Plagioclase is seen in large crystals with its characteristic features of twinning in some of the samples (Plates e & f). Accessory mineral like hornblende (a ferromagnesian mineral) is observed. Quartz and feldspars (plagioclase, mica & microcline) alone constitute over 70 % of the rock while minerals such as garnet and magnetite constitute the opaque minerals. The minerals contained in Idanre granite are as shown in Table 6.

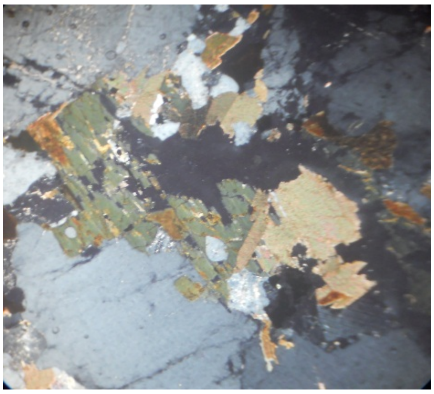
ISSN 2229-5518

Table 6
Mineral composition of the Idanre granite .

Samples	Quartz	Microcline	Plagioclase	Biotite	Hornblende	Mica	Opaque
1	23.2	20.0	28.3	18.4	8.2	1.1	0.8
2	25.5	31.0	30.1	8.2	4.5	0.1	0.6
3	24.5	23.8	32.0	12.6	6.4	0.5	0.2
6	22.2	20.3	30.1	19.3	7.7	--	0.4
7	24.4	32.1	22.5	12.3	5.7	2.4	0.6
9	24.3	22.4	32.8	12.4	7.4	--	0.7
10	25.1	19.8	33.8	14.4	5.6	0.5	0.8
12	25.3	20.1	30.1	15.4	6.4	2.1	0.6
13	25.2	33.1	26.1	10.5	4.5	--	0.6
18	24.1	22.4	33.1	12.3	5.5	2.1	0.5

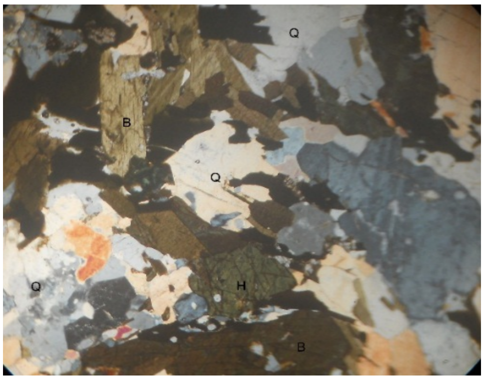
Quartz, feldspars, hornblende, biotite and some opaque minerals are the major minerals identified in the granites . The feldspars are large, well-formed crystals of both microcline and plagioclase with carls - bard twinning. The hornblende content in the granite is low. Quartz occurs as irregular masses of colourless and unaltered grains. Biotite is mainly the green and brown coloured minerals with medium relief. Most of the granites as shown by the thin sections show medium and porphyritic textures. In almost all the photomicrographs, quartz form the dominant mineral followed by the feldspars. All the quartz grains display low first order interference colour. Biotite displays the anomalous red colour interference when viewed under the microscope (Plates 1-4).

(a) 

(b) 

Plates: Photomicrograph of samples (a) under crossed polarized light (XPL), Disoriented or sheared (b) Plane polarized light (PPL). Medium grains of quartz (Q), Biotite (B), microcline (M))

ISSN 2229-5518

(c) 

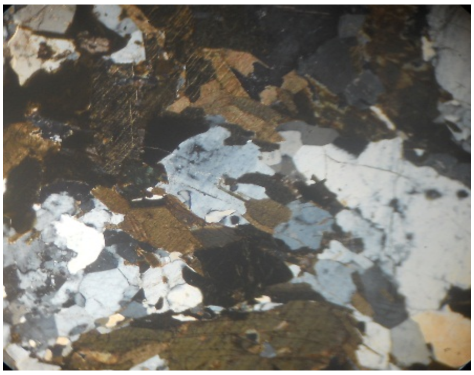
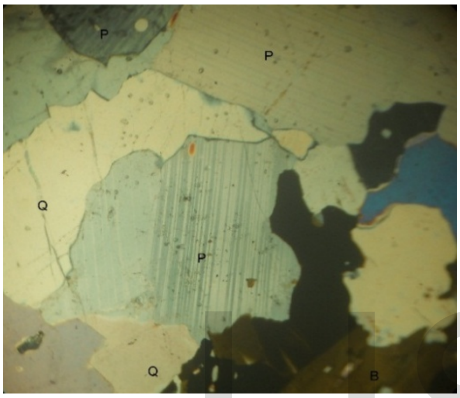
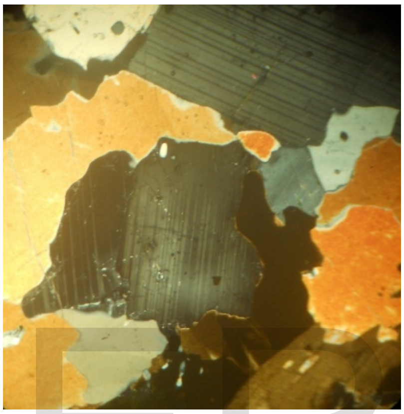
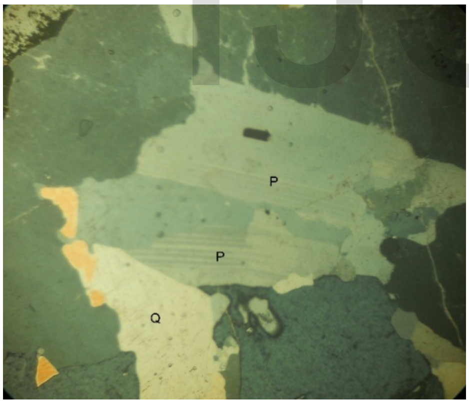
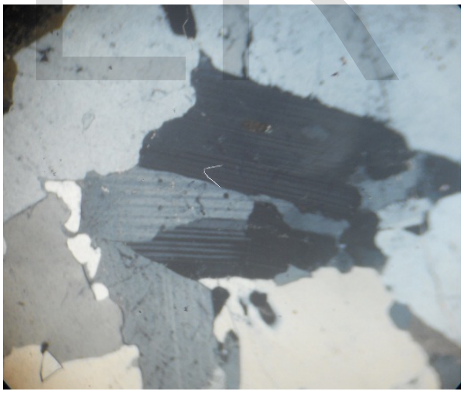
(d) 

Plate 2: Photomicrograph (c & d) under crossed polarized light and XPL showing Porphyritic crystals of quartz (Q), biotite (B), hornblende (H)

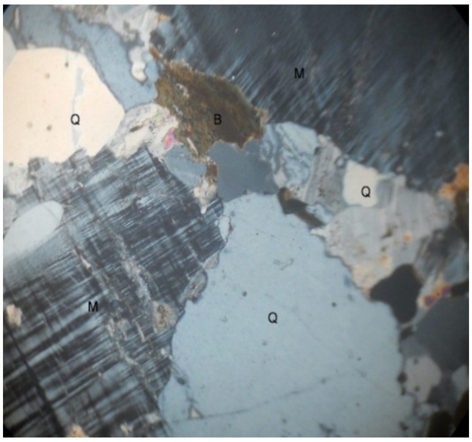
e) 

(f) 

(g) 

(h) 

Plates 3: Photomicrograph (e-h).

(i) 

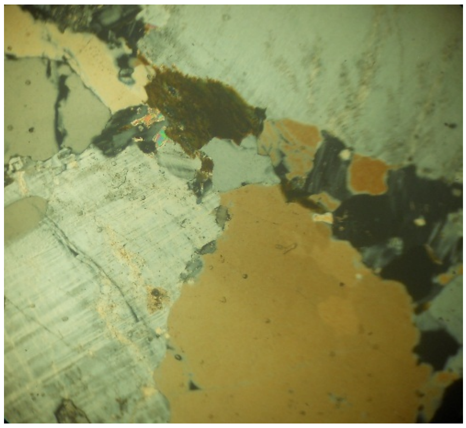
(j 

Plate 4 : Photomicrographs of samples; (g) shows an E-W orientation of the plagioclase, (h) shows two flanking plagioclase being intruded by another crystal of plagioclase, (i), shows a NE-SW orientation of plagioclase, being penetrated by a large crystal of quartz (j) porphyritic textured crystals of quartz (Q), biotite (B), and mica (M)) with twinning plagioclase being conspicuously displayed.

5.0. Provenance and Tectonic setting.

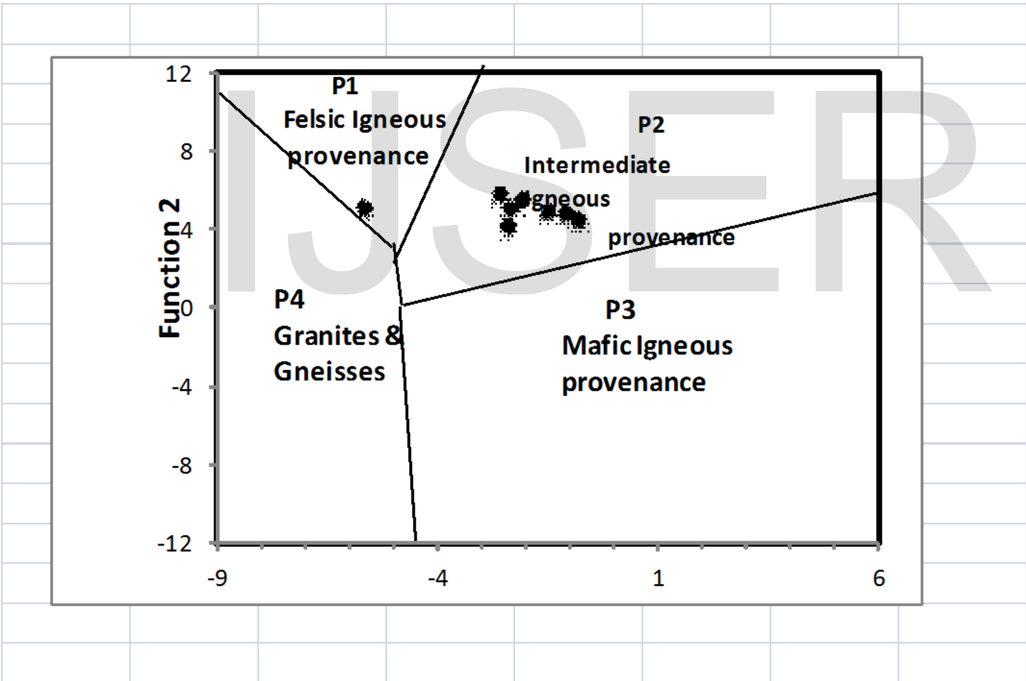


Fig.8: The Discriminant Function plot with major elements for provenance signatures (after Roser and Korsch, 1988)

The discriminant function plot of Roser and Korsch (1988) in Figure 8, defined four (4) main provenances: mafic igneous provenance; intermediate igneous provenance; felsic igneous provenance; and quartzose sedimentary provenance. The plots of the granites from Idanre fall majorly in the intermediate igneous provenance field demonstrating that they are derived from a silicic crystalline (plutonic-metamorphic) source with a minor fall in the felsic igneous provenance.

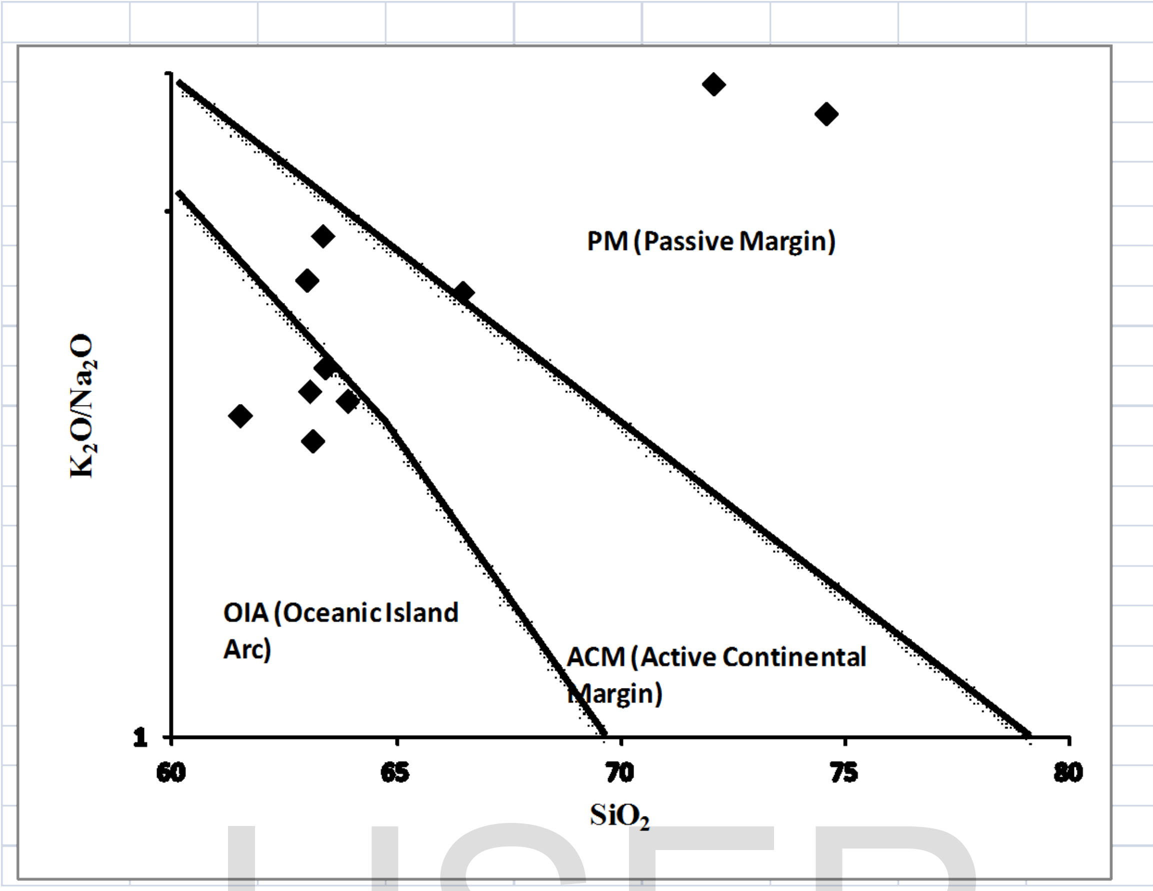


Fig. 9 : Tectonic discrimination plot for the granite (after Roser and Korsch, 1986).

Roser and Korsch (1986) proposed a tectonic discrimination diagram using K_2O/Na_2O ratio against SiO_2 (Fig 9) to determine the tectonic setting of rocks. The cross plots are used to discriminate between samples deposited in the passive continental Margin, active continental margin and the oceanic island arc. The studied samples plotted across all the tectonic settings concentrating more in the oceanic island arc.

6.0: Discussion and Conclusion

The granite from Idanre shows a strong crystallization from a peraluminous melt. TiO_2, MgO and CaO contents are low due to their removal during crystallization of mafic minerals. Na_2O and Sr are also lost during the alteration of feldspar to clay minerals. Low concentrations of CaO (1.05-3.60), MgO (0.23-1.77), Fe_2O_3 (1.98-6.81), as well as low ratio of Na_2O/K_2O are attributes of peraluminous rocks (Cerny,et al;1981 and Longstaff, 1982). Similarly, when the ratio of Na_2O + K_2O +CaO/Al_2O_3 is less than unity (ratio < 1) such as this (0.75 - 0.77), it confirms the peraluminous character and S-Type of the Idanre granite (Pearce et al.,1984). The mineralogy reflects the major-element compositions. The mineral composition of the granite comprise muscovite, microcline, plagioclase, biotite and plagioclase feldspar (mica) as well as ilmenite as opaque mineral. The geochemical characteristics of peraluminous granites control their mineralogy. Ilmenite is the opaque phase characteristic of S-type rocks. White & Chappell (1977), Flood & Shaw (1975) and Green (1976) have implied that some aspects of the mineralogy of S-type granites are inherited from the magma's source rocks. The plot of Al_2O_3 /(Na_2O + K_2O) versus Al_2O_3/(Na_2O +K_2O +CaO) of Maniar and Piccoli (1989) confirms the peraluminnous and S-type class of the Idanre granite. Wilson (1991) postulated that peraluminuos granites contain crustal or sedimentary materials in their original magma derived from partial melting of sedimentary and metasedimentary rock in subduction zone. The provenance plots of the granites from Idanre show that the samples fall majorly in the intermediate igneous provenance and marginally in the felsic igneous fields suggesting the magma derivation from a silicic crystalline (plutonic-metamorphic) and an Fe-poor sources. The plots on the tectonic settings cut across the passive margin, active continental margin and the oceanic island arc suggesting a mixture of magma inputs and depositions . A cross-plot of the major oxides showing different trends affirms the mixtures of magma sources. John and Wooden, 1990; Miller et al., 1990 pointed out that granitoids rarely come from single sources, but instead are mixtures of mantle-derived mafic melts and melts of crustal rocks that may or may not contain metasedimentary components. Miller, (1985) however, stated that similar granitic compositions can be produced by partial melting of a variety of sources

Acknowledgement

I have to acknowledge Mr Akinola and his project students working under me in preparing the samples for geochemical analysis in South Africa. I wish also to thank Mrs Riana of the University of Stellenbosch laboratory for the speedy release of the resu

References.

[1] Barbarin B. 1990. Granitoids: main petrogenetic classification in relation to origin and tectonic setting. Geological Journal. 25: 227-238.

[2] Cerny P., Trueman D.L., Zaehlke D.V., Goad B.E., Paul B.J. 1981. Catlake-Winnipe River and the Wekusko lake pegmatite fields, Manitoba. Energy and Mines, Economic Geology. Vol.80, 216-219.

[3] Coish R.A. 1977. Ocean floor metamorphism in the Betts Cove Ophiolite, Newfoundland. Contributions to Mineralogy and Petrology. 60, 277-302.

[4] Fairchild I., Graham H., Martin Q., Maurice T. 1999. Chemical Analysis of Sedimentary Rocks in:Technique in Sedimentology (ed. T. Maurice). pp. 274-354.

[5] Flood R.H., Snew S.E. 1975. A cordierite bearing granite suite from the New England batholith, N.S.W., Australia. Contr. Mineral. Petrology. 52: 157-164.

[6] Frost B.R., Arculus R.J., Barnes C.G., Collins W.J., Ellis D.J., Frost C.D. 2001. A geochemical classification of granitic rocks. Journal of Petrology. 42,2033-2048.

GnBrN T.H. 1976. Experimental generation of cordierite, - or garnet-bearing granitic liquids from a pelitic composition. Geology 4: 85-88.

Guilmette C., Hébert R., Wang C.S., Villeneuve M., 2009. Geochemistry and geochronology of the metamorphic sole underlying the Xigaze Ophiolite, Yarlung Zangbo Suture Zone, South Tibet. Lithos, 112:149-162.

Irvine T.N., Barager W.R.A. 1971. A guide to the chemical classification of the common volcanic rocks. Canadian Journal of Earth Science. 8: 523-548.

John B.E., Wooden J. 1990. Petrology and geochemistry of the metaluminous to peraluminous Chemehuevi Mountains Plutonic suite, southeastern California. In: Anderson, J. L. (ed.) The Nature and Origin of Cordilleran Magmatism. Geological Society of America, Memoir 174, 71–98.

Longstaffe F.J. 1982. Stable isotope in the granite pegmatite and related rocks. Mineralogical Association of Canada. Short course Handbook. Vol. 6. 373-404.

Maniar P.D., Piccoli P.M. 1989. Tectonic discrimination of granitoids. Geological Society of America Bulletin 101, 635–643.

Miller C.F. 1985. Are strongly peraluminous magmas derived from pelitic sedimentary sources? Journal of Geology 93, 673–689.

Miller C.F., Wooden J.F., Bennett V.C., Wright J.E., Solomon G.C., Hurst R.W. 1990. Range batholith, southeastern California; isotopic constraints. In: Anderson, J. L. (ed.). The Nature and Origin of Cordilleran Magmatism. Geological Society of America, Memoir 174, 99–109.

Mullen E.D. 1983. MnO-TiO2-P2O5: a minor element discriminant for basaltic rocks of oceanic environments and its implications for petrogenesis: Earth and Planetary Science Letters. 62: 53-62.

Peacock M.A. 1931. Classification of igneous rock series. Journal of Geology 39, 54–67.

Pearce J.A., Harris N.B.W., Tindle, A.G. (1984). Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. Journal of Petrology 25, 956–983.

Pearce J.A., Cann J.R. 1973. Tectonic setting of basic volcanic rocks determined using trace element analyses. Earth and Planetary Science Letters, 19, 290-300. http://dx.doi.org/10.1016/0012-821X(73)90129-5

Pearce J.A., Harris N.B.W., Tindle A.G. 1984. Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. Journal of Petrology. 25: 956-9

Peccerillo A., Taylor S.R. 1976. Geochemistry of Eocene calc-alkaline volcanic rocks from the Kastamonu area, Northern Turkey. Contributions to Mineralogy and Petrology 58, 63–81.

Richwood P.C. 1989. Boundary lines within petrologic diagrams which use oxides of major and minor elements. Lithos. 22, 247-263.

Roser B.P., Korsch R.J. 1986. Determination of tectonic setting of sandstone- mudstone suites using SiO2 content and K2O/Na2O ratio. J. Geol. Vol. 94: 635-650.

Roser B.P. Korsch R.J. 1988. Provenance signature of sandstone-mudstone suite determined using discriminant function analysis of major element data. Chem. Geol, Vol.67:119-139.

Seewald, J.S and Seyfried, W.E ,1990. The effect of temperature on metal mobility insubsea floor hydrothermal system.: onstraints from basalt alteration experiments. Earth planet Sci. Lett., 101, 388-403.

Streckeisen A. 1967. Classification and nomenclature of igneous rocks. Final report of an inquiry. Neues Jahrbuch für Mineralogie, Abhandlungen 107, 144–204.

Winchester J.A., Floyd P.A. 1977. Geochemical discrimination of different magma series and their differentiation products using immobile elements. Chemical Geology. 20: 325–343.

White A.J.R., Chappell B.W. 1977. Ultrametamorphism and granitoid genesis. Tectonophysics 43, 7–22.

Wilson M. 1991. Igneous Petrogenesis Global Tectonic Approach, Harpar Collins Academy, London Second impression pp. 227-241.

Zen E. 1988. Phase relations of peraluminous granitic rocks and their petrogenetic implications. Annual Review of Earth and Planetary Sciences 16, 21–52.