Petrology and geochemistry of the granitoids of the northern part of Adamawa Massif, N.E Nigeria

I.V. Haruna

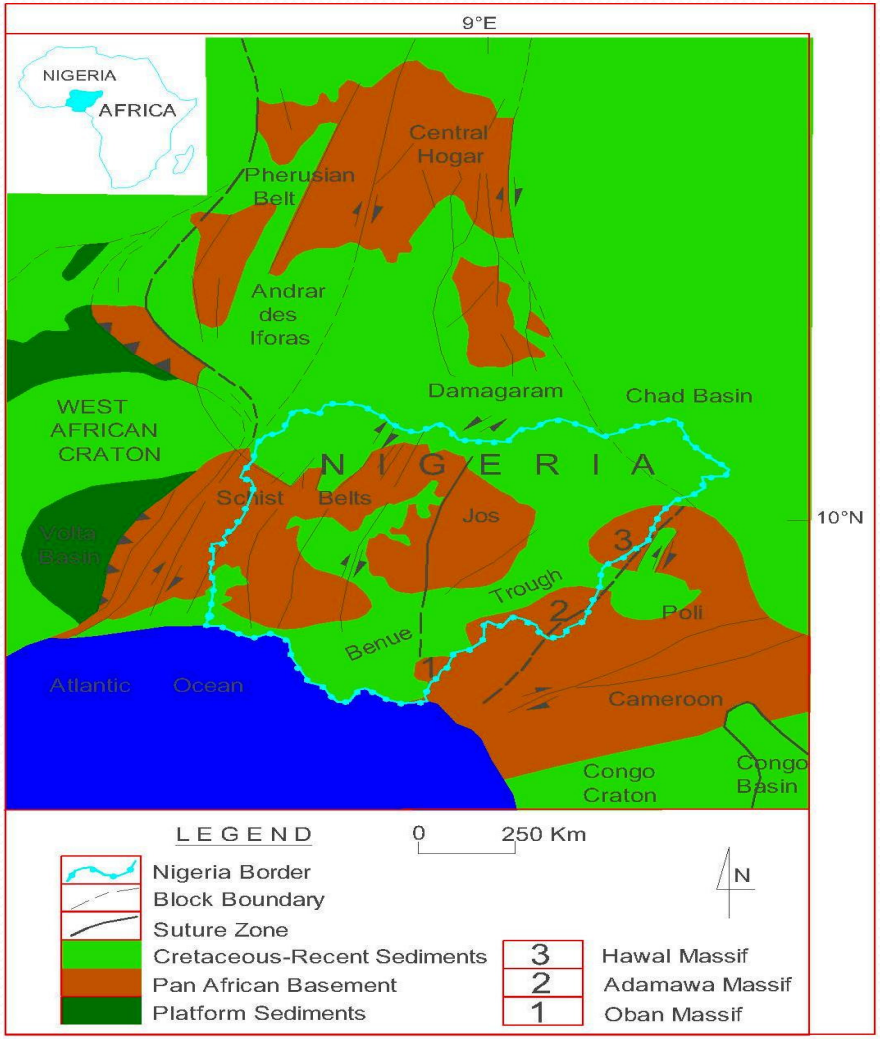
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ORDER OF PRESENTATION

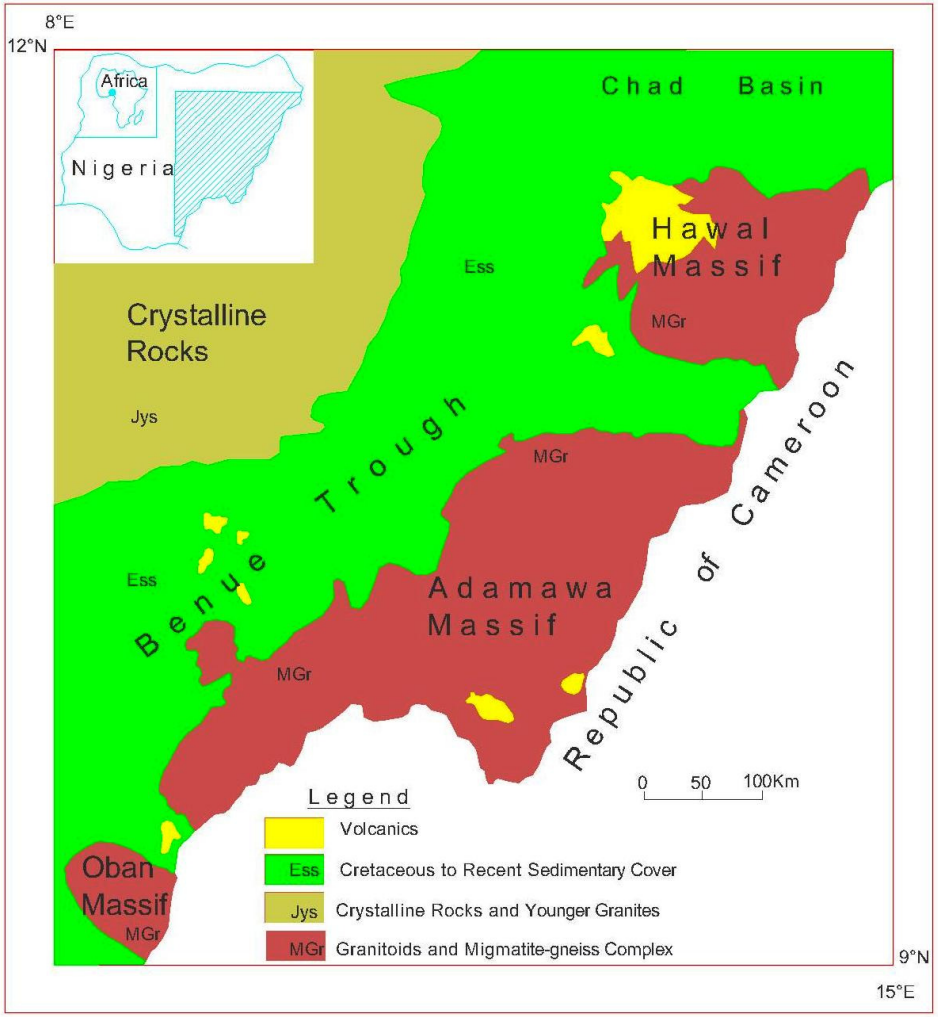
- Introduction
- Field relations and lithology
- Geochemistry
- Summary and Conclusion

Introduction

- West African Craton
- Tuareq Shield
- Congo Craton
- Regional geological setting of Nigeria (modified after Ferré et al., 1996)



Adamawa Massif



Objectives

- ✓Provide information on the field relations and lithology of the granitoids.
- ✓Provide major, trace and rare earth elements (REE) data on the rocks.
- ✓Use both the field and Geoochemical data to provide an insight into the petrogenesis of the rocks.

Field Relations and Lithology

- Scale 1:50,000
- The study shows that the area is underlain by: Porphyritic granite, Equigranular granite, Fine-grained granite, Granodiorite, Migmatite, Pegmatite

Plate 1. Porphyritic Granite

Observations

- Most abundance & most extensive
- Fsp phenocrysts in medium- to coarse-grained qtz matrix
- Size & density of phenocrysts reduces with distance from center of intrusion

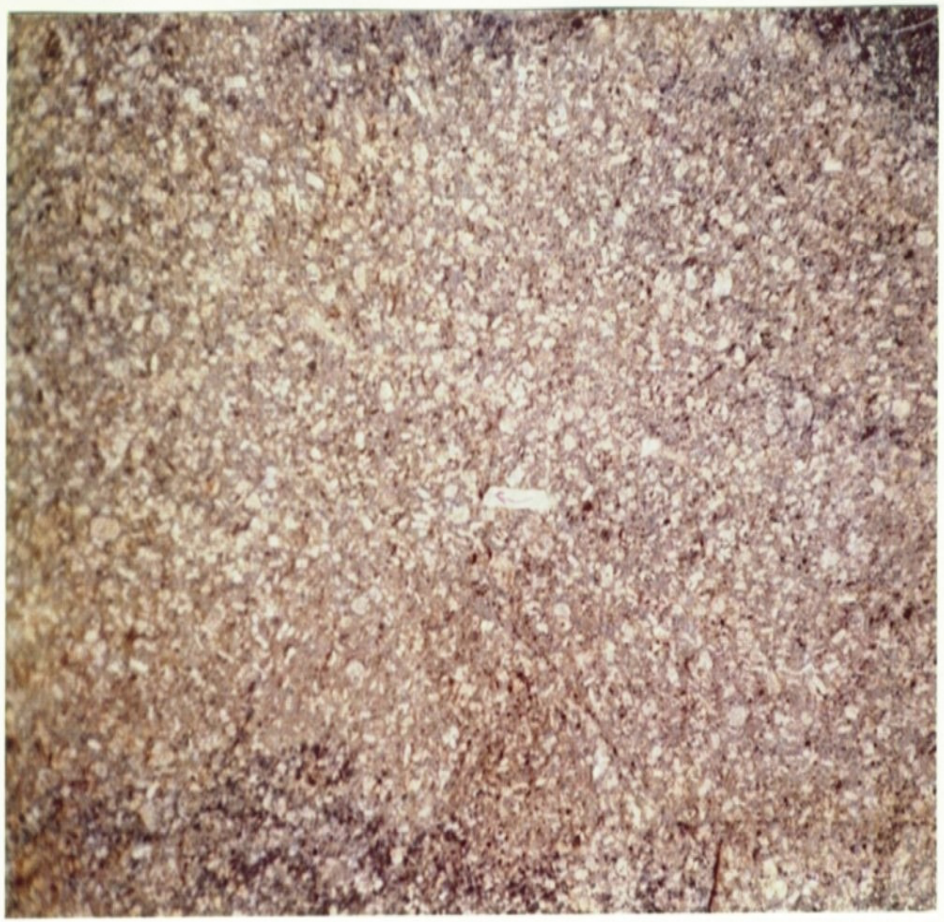


Plate 2. Porphyritic Granite

Observations

- Gradational contact between porphyritic & equigranular granites

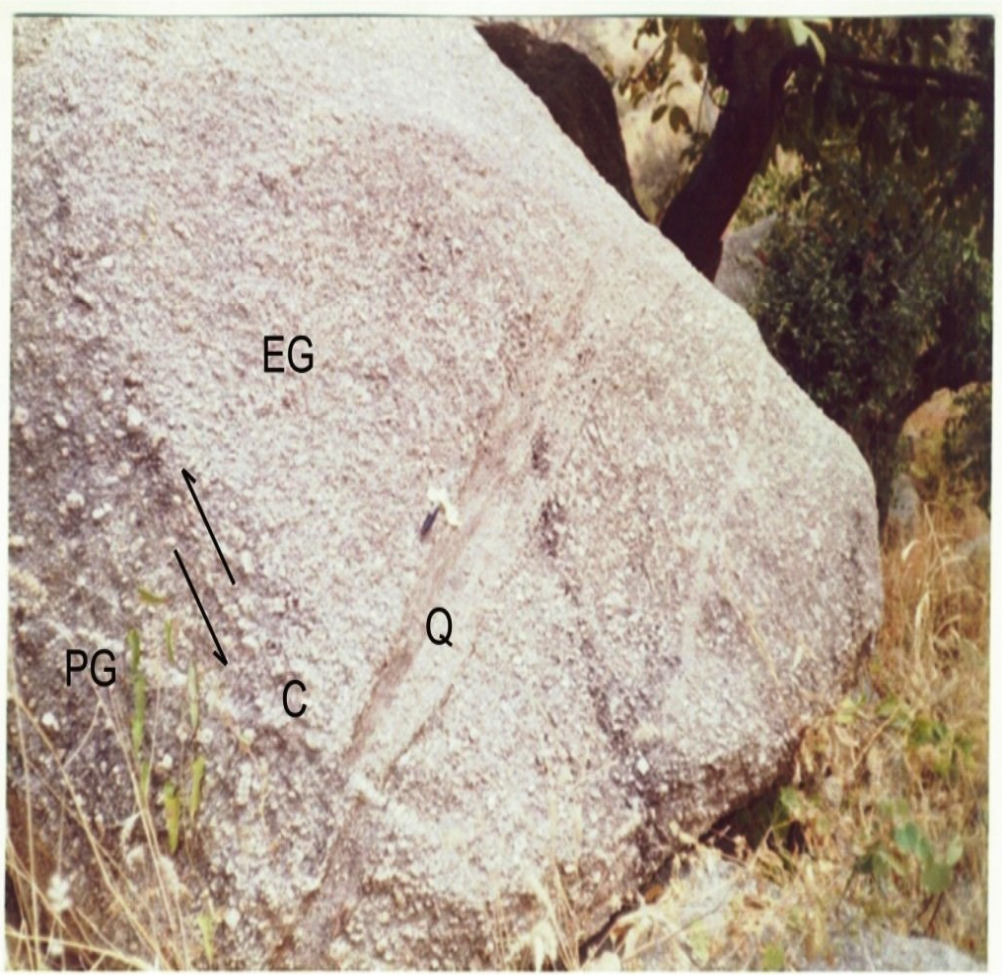


Plate 3. Equigranular & Porphyritic Granites

Observations

- Equigranular granite (EG) sharply separated from porphyritic granite (PG)

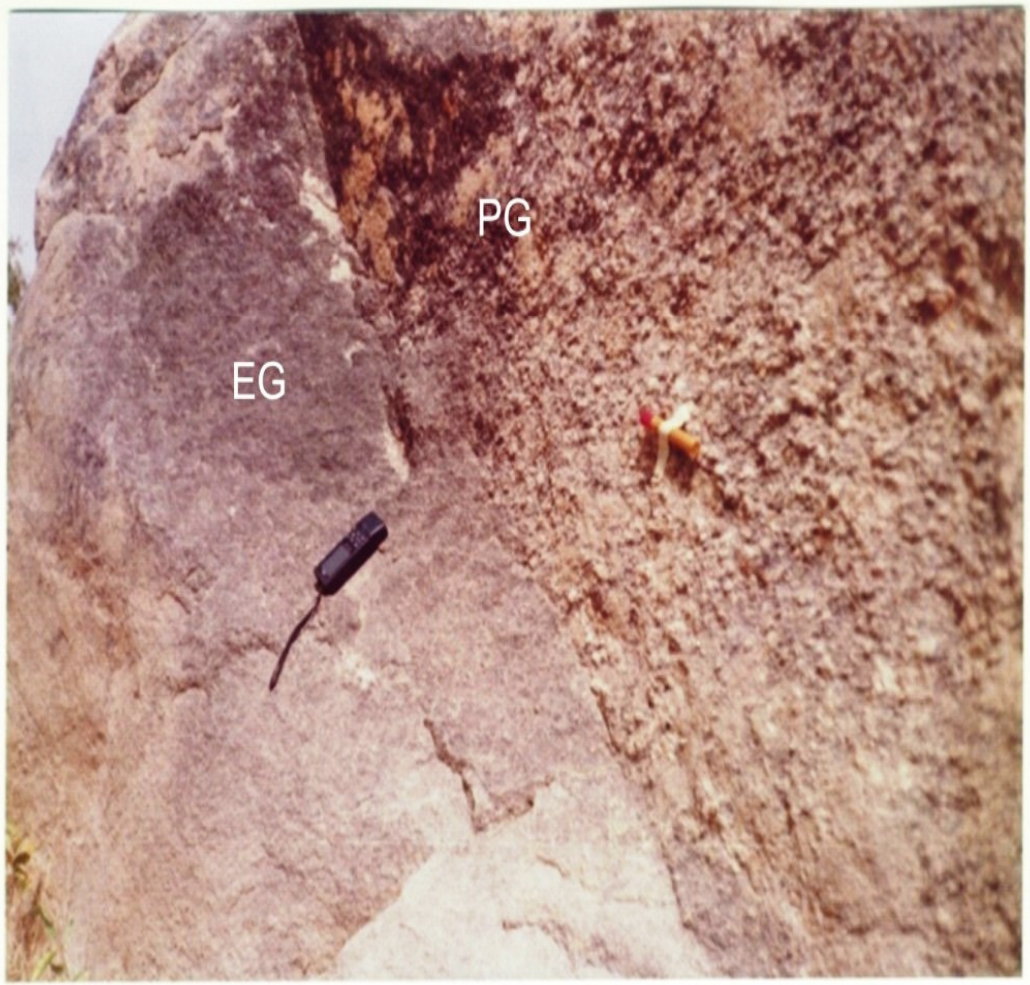


Plate 4. Equigranular Granite

Observations

- Mostly massive, with stopped blocks of unmelted materials
- Very few foliation defined by stretched biotite crystals

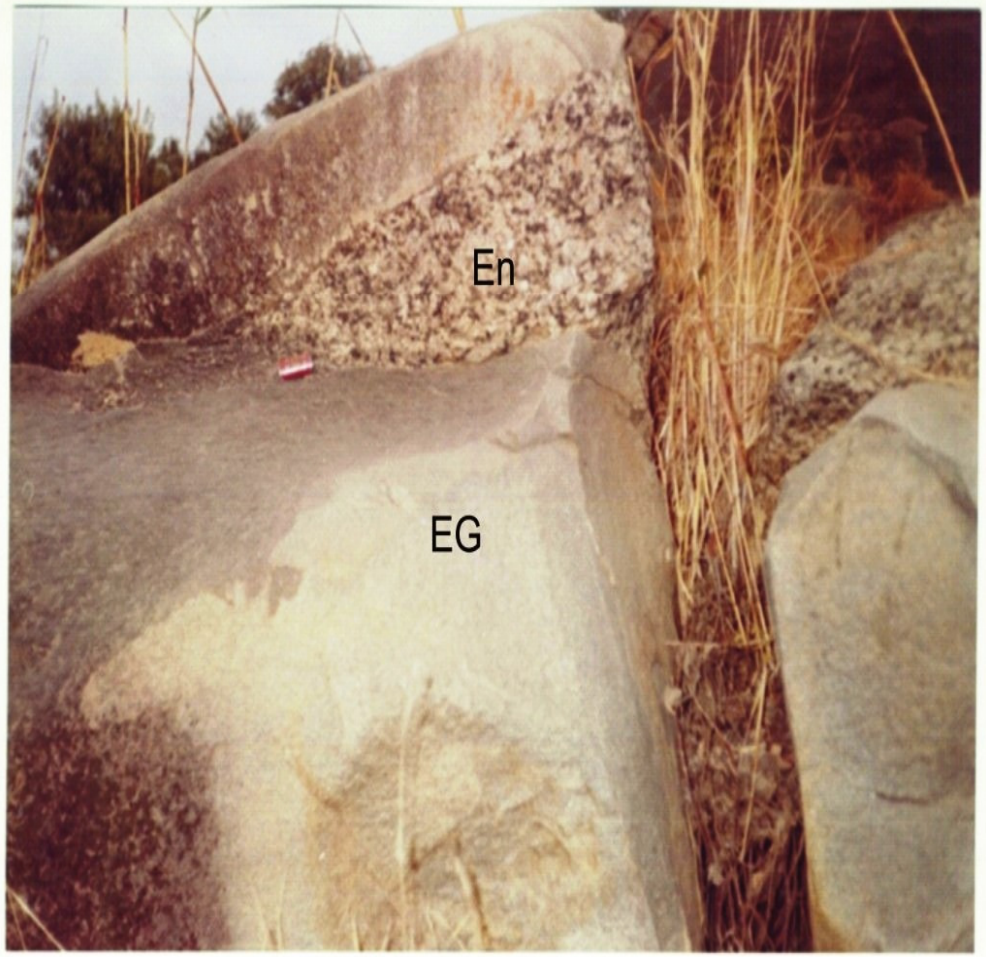


Plate 5. Enclaves within Equigranular Granite

- Fine-grained sub angular enclaves (En) within equigranular granite (EG)

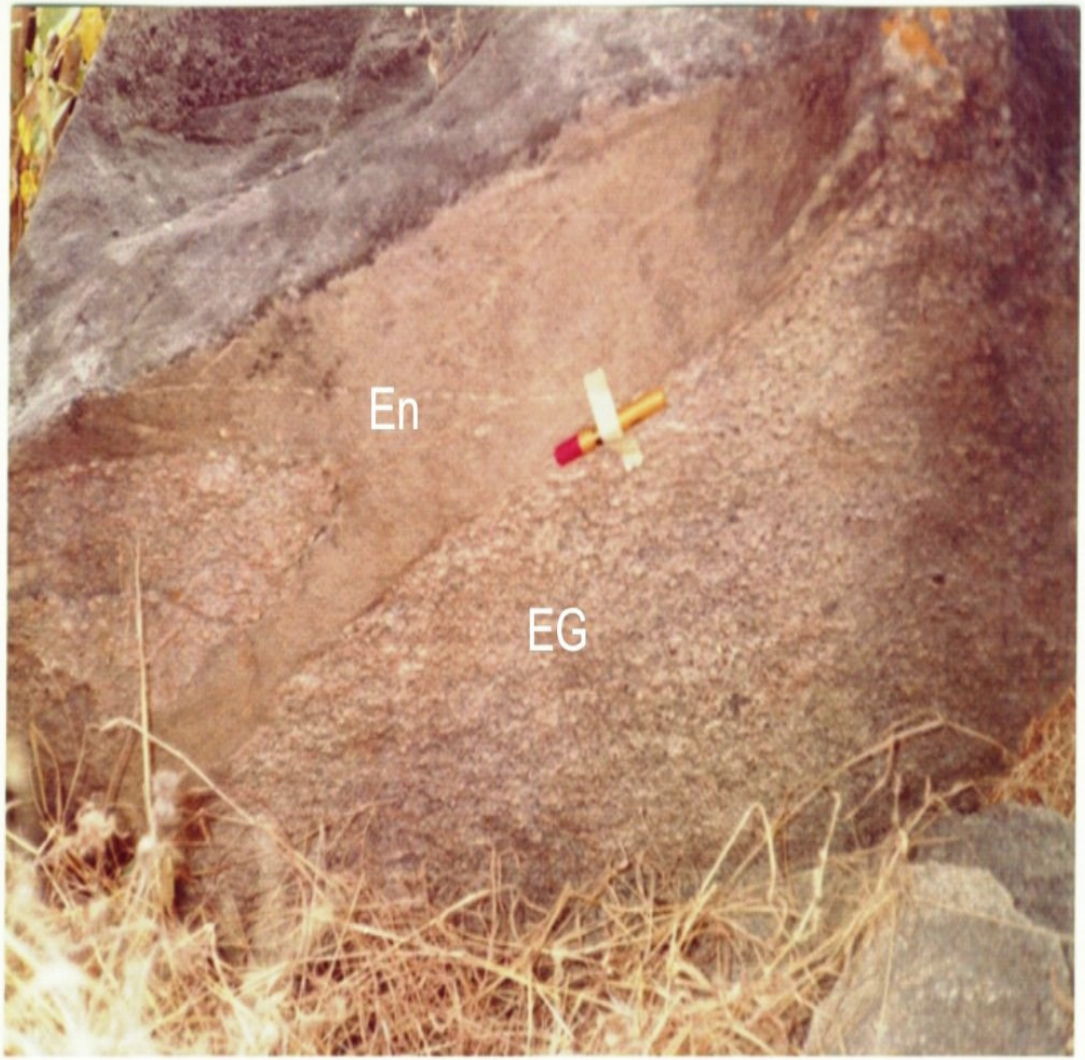


Plate 6. Fine-grained Granite

Observations

- Low-lying intrusions
- Pale brown to grey
- Little variation in appearance
- Numerous fractures/faults
- Subordinate occurrence



Plate 7. Granodiorite & Granite

Observations

- Gradational contact between granodiorite (GD) & granite (Gr)

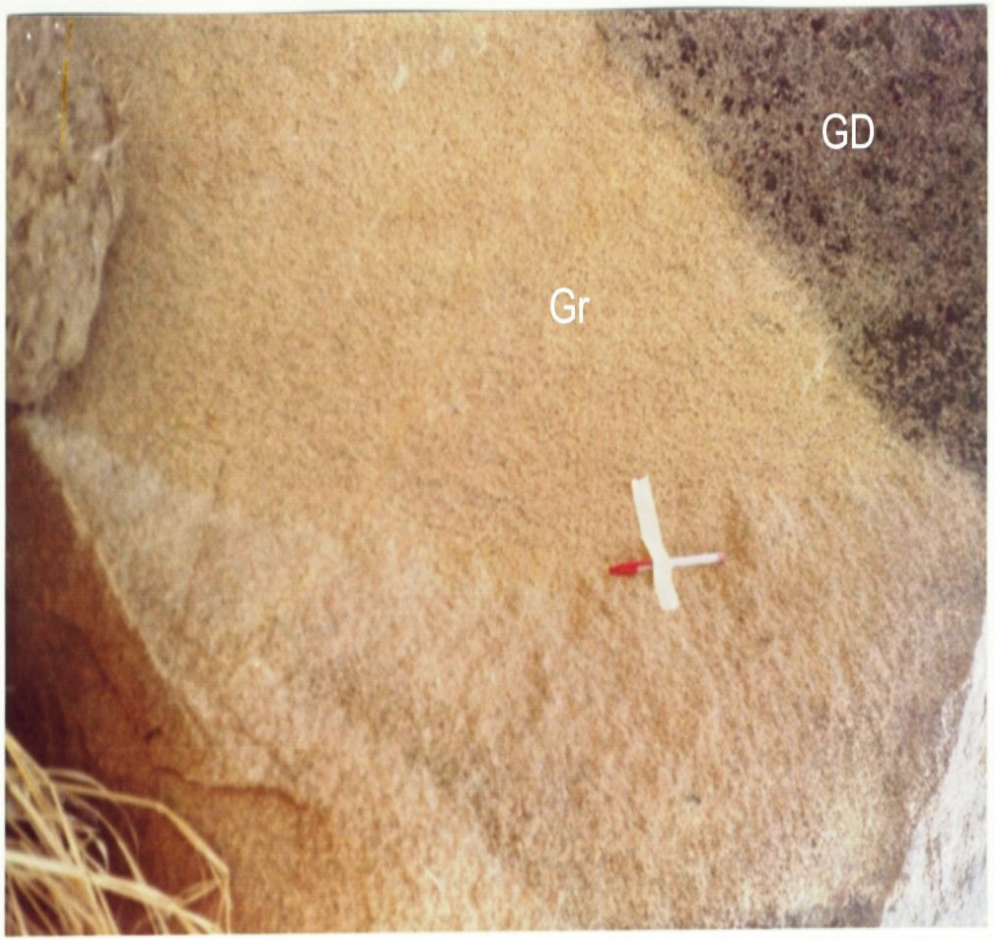


Plate 8. Granodiorite

Observations

- Massive and occur as elongate plutons with little foliations.
- Grey to dark grey with sub angular to sub rounded mafic enclaves

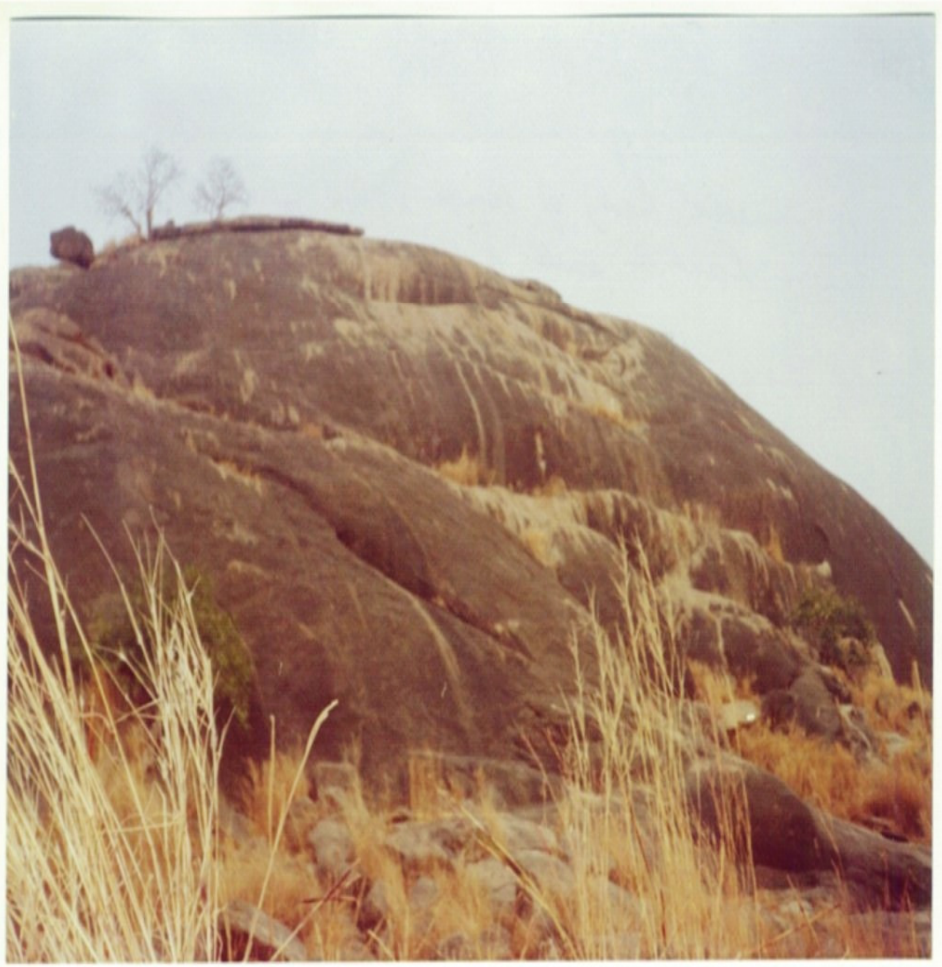


Plate 9. Migmatite

Observations

- Restricted occurrence
- Poorly foliated
- Flow structure xterised by ptymatic folding



Plate 10. Pegmatite

Observations

- Cross cutting vein-like pegmatite
- Graphic intergrowth of large quartz & fsp phenocrysts

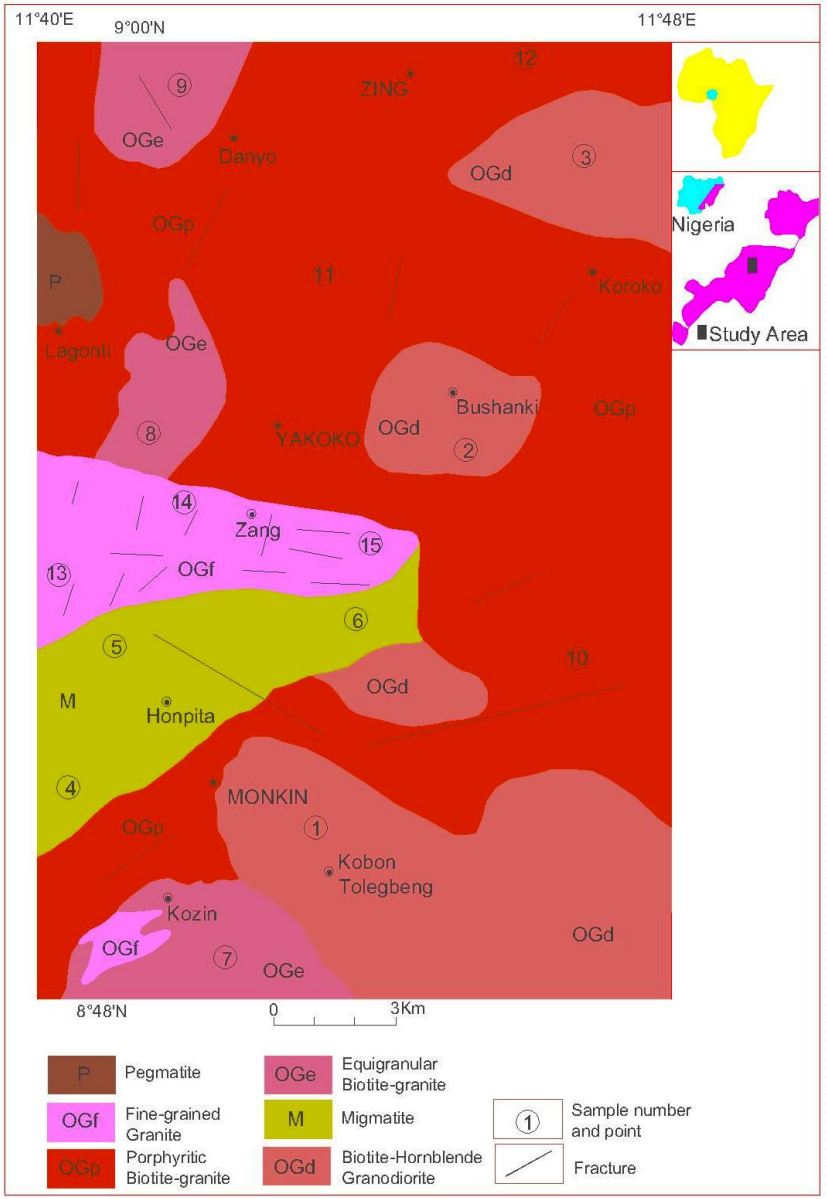


Inference

According to Chappell and White (1978), field characteristics such as the

- massiveness of the rocks, with little or no foliation and
- sub angular to sub rounded shaped enclaves
- paucity of banding,
- presence of large feldspar phenocryst are all suggestive of I-type granitoids.
- The dominance of gradational boundaries suggest that the rock units may be genetically related to a common source.

Geology of the Study Area



Petrography

- Selected samples judged to be representatives of the various rock units were subjected to microscopic study

Plate 4. Porphyritic Granite (Sample PG268M)

Observations

- Hollocrystalline texture
- Microphenocrysts of microcline (M) & plg (P)
- Myrmekitisation and sericitised edges common
- Anhedral opaques
- Magnification x40

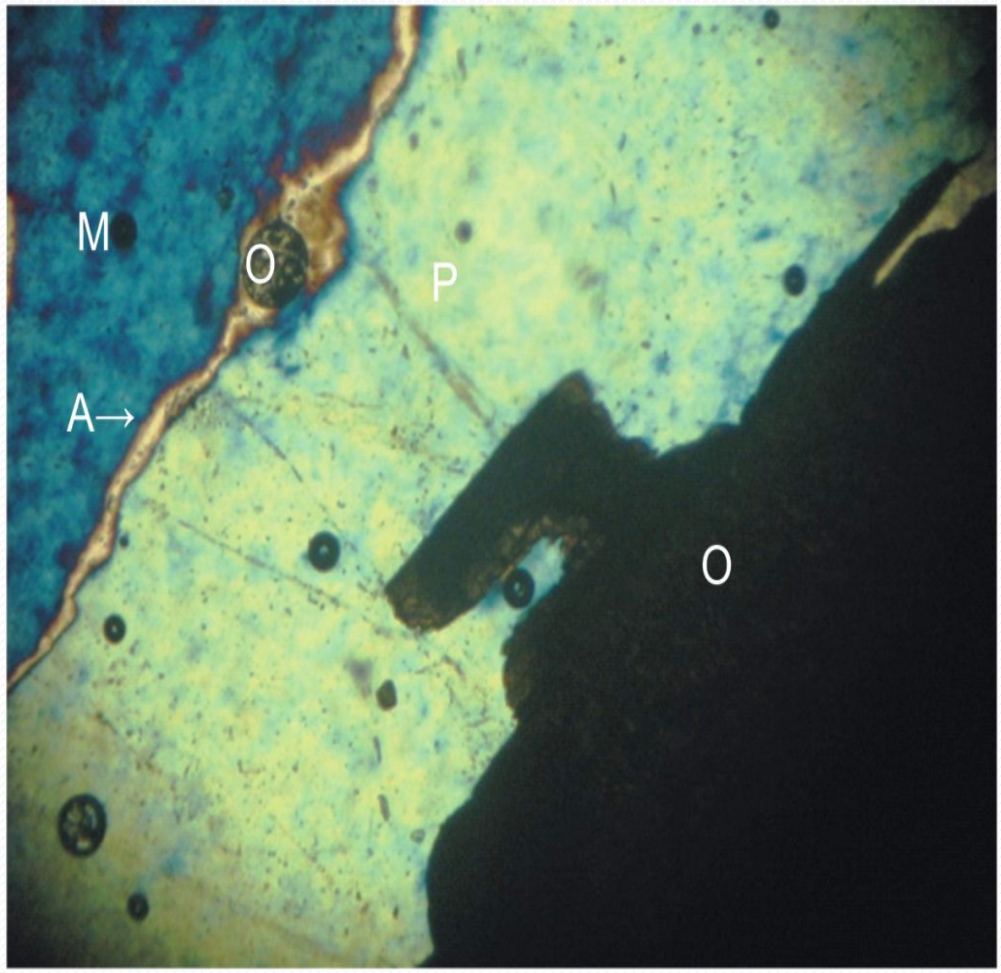


Plate 3. Equigranular Granite (Sample EG219Y)

Observations

- Hypidiomorphic-granular texture
- Microcline (M), plg (P) and biotite (B) form graphic texture with opaque inclusions.
- Opaques in clusters with zircon, apatite and sphene
- Magnification x40

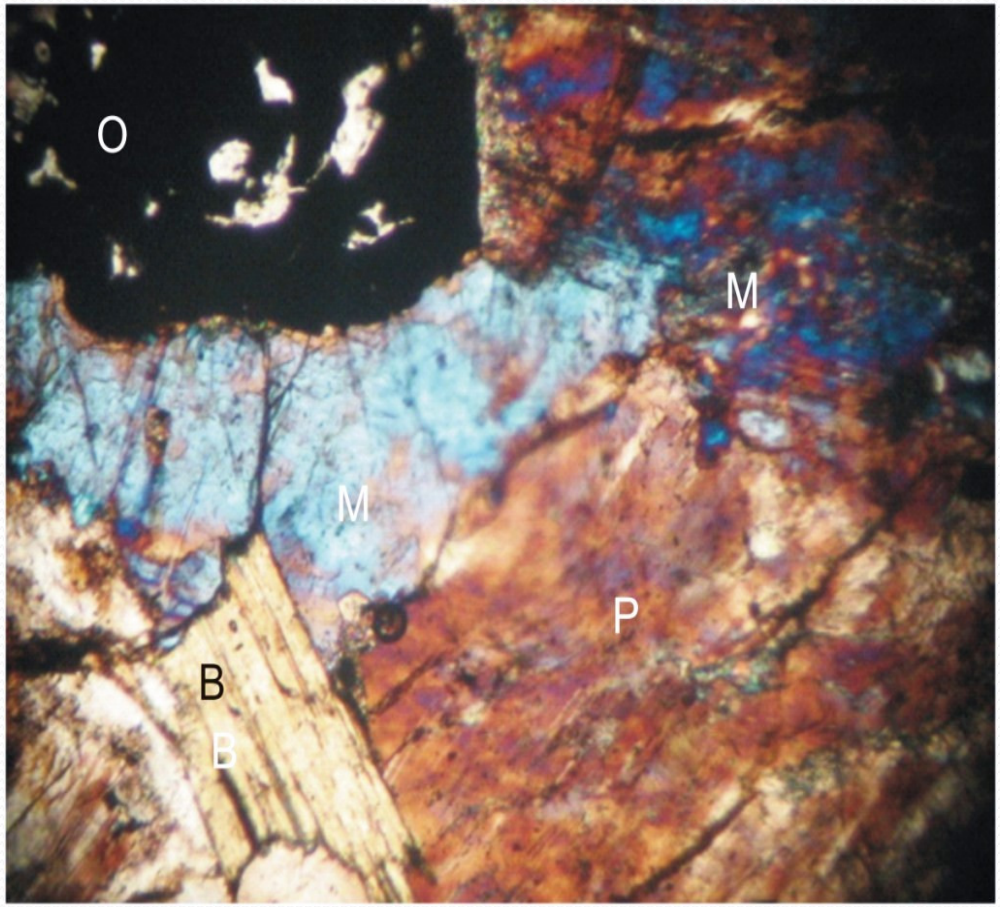


Plate 1. Granodiorite (Sample GD178M)

Observations

- Hypidiomorphic-granular texture
- Essential minerals: hornblende (H), Plg, biotite (B), microcline, quartz.
- Accessory Minerals: opaques, apatite, sphene
- Dark alteration rims
- Magnification x40

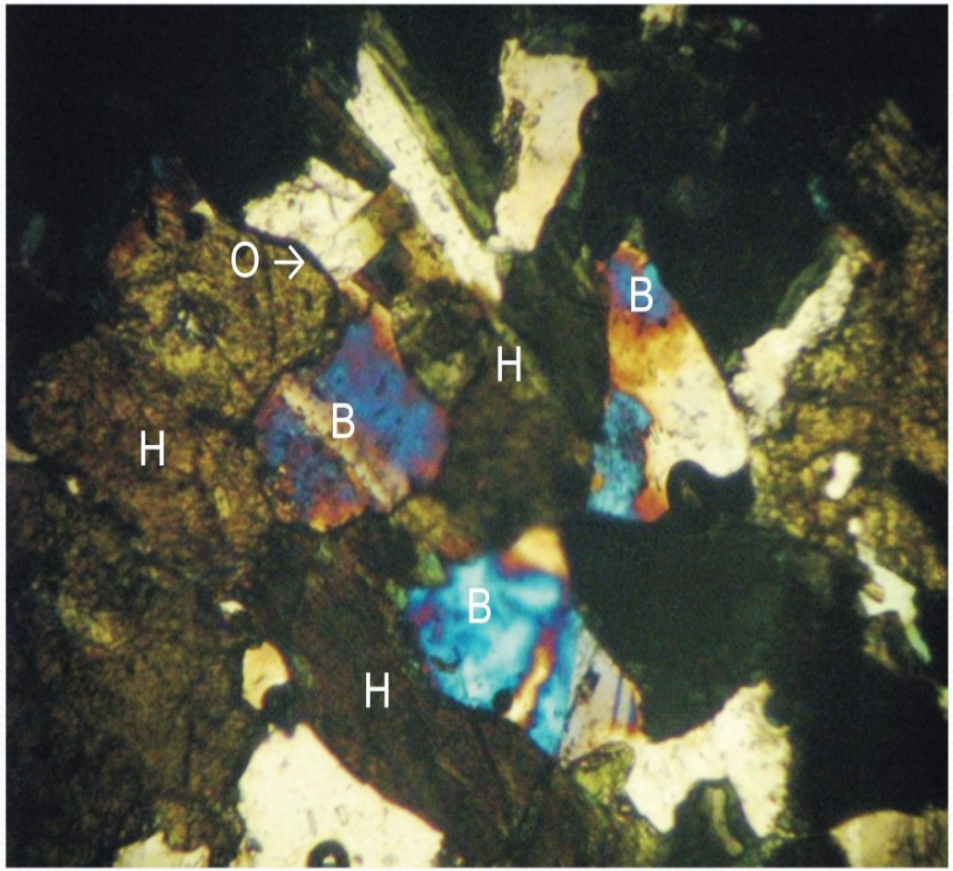


Plate 2. Migmatite (Sample AM078M)

Observations

- Hollocrystalline texture
- Subhedral and anhedral microcrystals of microcline & quartz separated by sericitised boundary
- Opaques occur in clusters
- Magnification x40

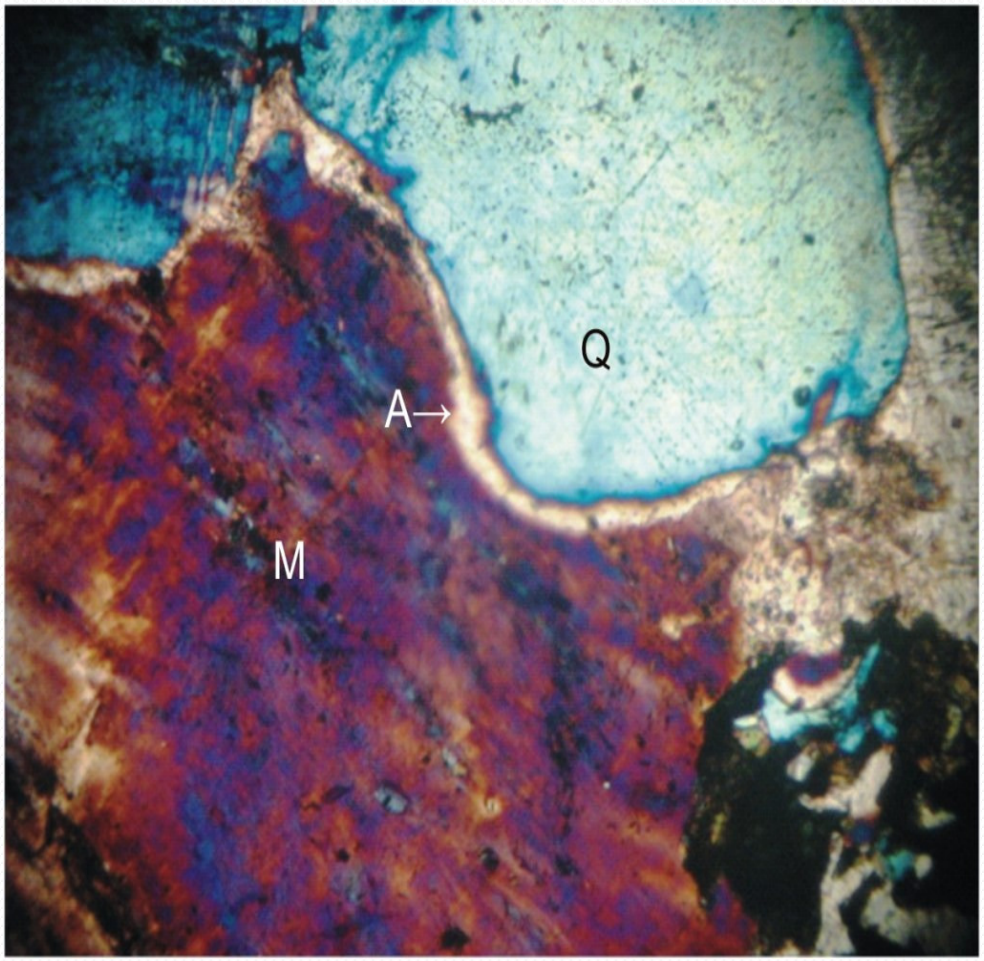
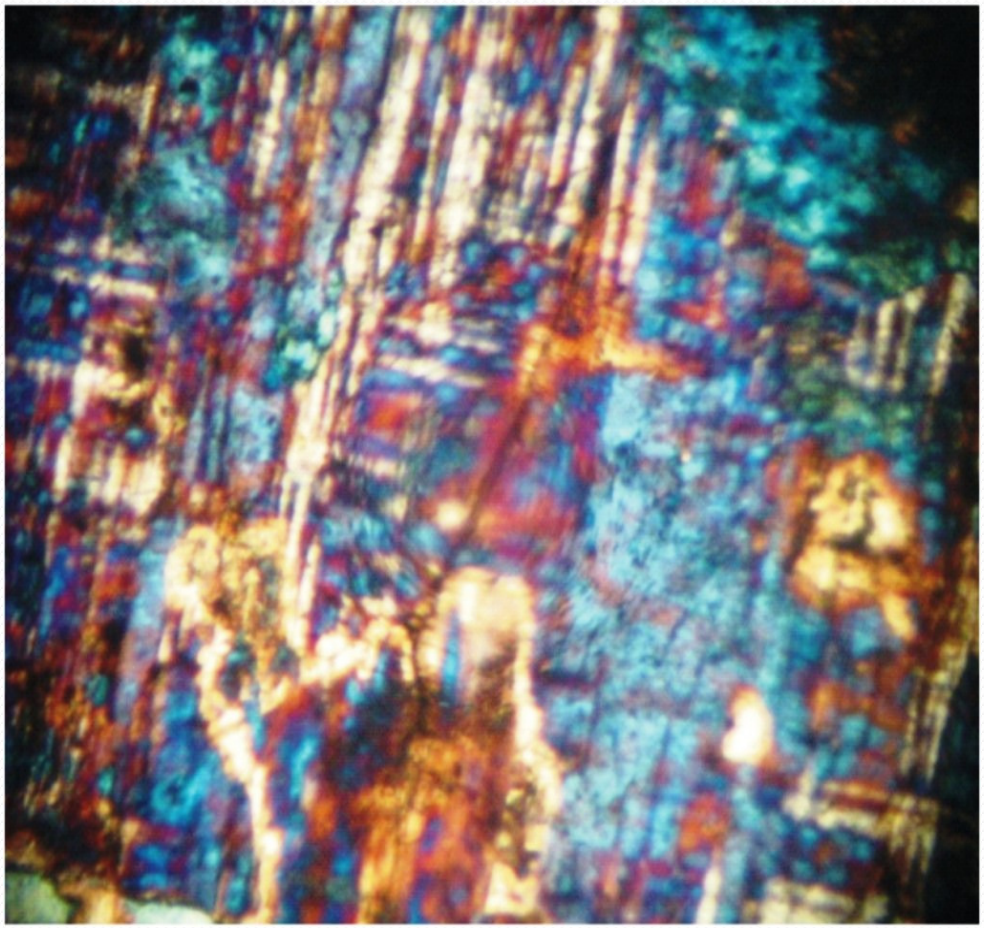


Plate 4. Fine-grained Granite (Sample FG253M)

Observations

- Cross-hatched twinning in microcline
- Microcline perthitised
- Perthites as sub-parallel irregular bands
- Magnification x40



Chief Points and Inference

- The granites are characterised by plagioclase, biotite and microcline with accessory sphene, apatite and zircon.
- The granodiorite is characterised by hornblende, plagioclase and biotite + accessory magnetite
- These are typical mineralogical features of I-type granitoids (Chappell and White, 1978)

Geochemistry

- Samples believed to be representatives of the different rock units in the study area were shipped to Activation Laboratory, Canada for the determination of:

1. Major elements (using Lithium Metaborate/Tetraborate Fusion ICP Whole Rock Package)
2. Trace elements (using Fusion ICP/MS package)
3. Rare Earth Elements (REE) (using Fusion ICP/MS package)

Major Elements Data

Table 1. Major elements (wt%) petrochemical data of the granitoids of Zing-Monkin area

Sample#→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SiO2	65.97	65.68	64.75	72.25	69.86	67.88	73.48	76.27	73.71	72.53	76.27	72.26	75	74.61	74.32
Al2O3	16.37	16.15	13.52	13.62	14.48	15.75	13.2	13.51	13.25	12.91	13.3	14.81	13.6	13.85	13.65
Fe2O3(T)	3.46	4	8.2	3.18	2.86	2.46	2.17	0.46	1.88	3.15	0.59	1.38	1.52	1.57	1.52
MnO	0.073	0.08	0.121	0.042	0.044	0.028	0.031	0.005	0.04	0.043	0.019	0.024	0.031	0.027	0.034
MgO	1.34	1.4	1.15	0.29	0.57	0.71	0.13	0.01	0.18	0.24	0.02	0.3	0.19	0.19	0.2
CaO	2.33	2.48	3.66	1.58	1.54	2.23	0.81	0.58	1.13	1.45	0.83	1.46	1.01	1.09	1.05
Na2O	4.18	4.28	2.71	2.65	3.52	3.75	3.11	3.9	2.89	2.46	4.12	3.49	3	3.09	3.02
K2O	4.76	4.24	4.32	6.37	5.49	5.16	6.06	5.28	5.66	6.01	4.51	5.92	5.6	5.81	5.57
TiO2	0.704	0.727	1.444	0.46	0.389	0.548	0.198	0.019	0.18	0.381	0.039	0.226	0.164	0.161	0.165
P2O5	0.28	0.3	0.48	0.11	0.11	0.15	0.05	0.01	0.05	0.09	0.02	0.08	0.04	0.05	0.05
LOI	0.52	0.56	0.24	0.43	0.4	0.42	0.5	0.33	0.48	0.36	0.17	0.52	0.47	0.44	0.45
Total	99.97	99.88	100.6	101	99.27	99.09	99.74	100.4	99.47	99.64	99.9	100.5	100.6	100.9	100

Sample 1 – 3 = granodiorite; sample 4 – 6 = migmatite; sample 7 – 9 = equigranular granite; sample 10 – 12 = porphyritic granite; sample 13 – 15 = fine-grained granite.

Calculated CIPW Normative Minerals

Table 2. CIPW normative minerals (%) of the granitoids of Zing-Monkin area

Sample #→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Apatite	0.66	0.71	1.14	0.26	0.26	0.36	0.12	0.02	0.12	0.21	0.05	0.19	0.09	0.12	0.12
Pyrite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chromite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fluorite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zircon	0.04	0.05	0.11	0.1	0.05	0.06	0.06	0.01	0.04	0.08	0.01	0.03	0.03	0.03	0.02
Ilmenite	0.16	0.17	0.26	0.09	0.09	0.06	0.07	0.01	0.09	0.09	0.04	0.05	0.07	0.06	0.07
Sphene	0	0	2.36	0.65	0	0	0	0	0	0.31	0	0	0	0	0
Orthoclase	28.13	25.06	25.53	37.64	32.44	30.49	35.81	31.2	33.45	35.52	26.65	34.98	33.09	34.33	32.92
Albite	35.37	36.22	22.93	22.42	29.78	31.73	26.32	33	24.45	20.82	34.86	29.53	25.38	26.15	25.55
Aegerine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anorthite	10.21	10.75	11.97	6.46	7.16	10.67	3.8	2.82	5.4	6.43	4	7.13	4.88	5.22	5.02
Corundum	0.6	0.58	0	0	0.12	0.08	0.13	0.35	0.39	0	0.18	0.05	0.81	0.57	0.81
Magnetite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hematite	4.46	4	8.2	3.18	2.86	2.46	2.17	0.46	1.88	3.15	0.59	1.38	1.52	1.57	1.52
Diopside	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypersthene	3.34	3.49	2.86	0.72	1.42	1.77	0.32	0.02	0.45	0.6	0.05	0.75	0.47	0.47	0.5
Wollastonite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quartz	17.02	17.81	24.81	29.01	24.42	20.63	30.34	32.14	32.62	31.96	33.29	25.77	33.72	31.86	32.96
Olivine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perovskite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rutile	0.62	0.64	0.35	0.15	0.34	0.52	0.16	0.01	0.14	0.2	0.02	0.2	0.13	0.13	0.13
Nepheline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca_Orthosilicate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kaliophilite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Na2SiO3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K_Meta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acmite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wt%_Oxides	100.7	99.6	100.6	100.7	99	99	99.3	100.1	99.1	99.5	99.7	100.2	100.2	100.5	99.7
Wt% Phase	100.6	99.5	100.5	100.70	99.00	98.80	99.30	100.10	99.00	99.40	99.70	100.10	100.20	100.50	99.60
D.I	80.52	79.09	73.27	89.07	86.64	82.85	92.47	96.34	90.52	88.3	94.8	90.28	92.19	92.34	91.43

Sample 1 – 3 = granodiorite; sample 4 – 6 = migmatite; sample 7 – 9 = equigranular granite; sample 10 – 12 = porphyritic granite; sample 13 – 15 = fine-grained granite.

Trace Elements Data

Table 3. Trace elements petrochemical (ppm) data for the for the granitoids of Zing-Monkin area

Sample#→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sc	11	12	16	7	4	3	3	2	4	6	3	1	3	3	3
Be	12	11	3	2	3	2	3	6	4	2	4	3	3	3	3
V	61	70	68	14	22	40	<5	<5	5	10	<5	21	5	9	6
Ba	1590	1254	1073	1012	786	1832	393	22	444	1078	36	1333	465	464	472
Sr	495	479	251	164	233	685	96	11	106	172	17	440	126	131	130
Y	33	33	63	62	27	11	24	45	98	47	22	13	14	18	32
Zr	213	268	569	480	266	297	293	67	196	393	49	136	129	140	123
Cr	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Co	17	14	23	13	15	15	14	18	17	16	18	19	11	14	15
Ni	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cu	<10	<10	<10	<10	10	<10	<10	<10	<10	<10	<10	<10	<10	10	<10
Zn	70	90	140	60	50	60	40	<30	40	80	<30	<30	<30	40	30
Ga	27	27	27	27	26	22	21	29	24	25	23	21	20	20	21
Ge	1	1	2	2	1	<1	1	2	2	2	1	1	1	1	1
As	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Rb	234	250	175	250	224	158	210	368	310	230	290	206	286	294	299
Nb	22	23	34	30	15	12	11	42	24	26	16	8	15	14	15
Mo	<2	<2	<2	<2	<2	<2	3	<2	<2	<2	<2	<2	<2	<2	<2
Ag	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
In	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Sn	4	5	5	3	3	4	3	2	7	4	3	4	5	5	5
Sb	<0.5	<0.5	<0.5	<0.5	<0.5	0.9	0.6	<0.5	<0.5	0.9	<0.5	<0.5	<0.5	1.5	<0.5
Cs	8.4	10.8	1.6	0.9	2.3	1.1	2.7	2.4	2.9	1.6	3.7	2.6	6	6.3	5.9
Hf	5.2	7.5	13.5	14.1	7.2	7.3	7.5	3.9	5.8	11.4	2.2	3.6	3.9	4.3	3.9
Ta	3.9	3.9	2.7	1.8	1.5	0.8	0.7	6.2	2.3	1.9	1.3	1.2	2	1.8	1.8
W	65	46	80	77	85	82	94	121	115	109	134	124	74	96	105
Tl	1.2	1.8	1.2	1.4	1.3	1.6	1.8	1.7	1.7	1.8	2.1	1.2	2.2	3.1	2.3
Pb	15	22	17	22	18	42	25	36	26	34	42	22	32	49	32
Bi	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Th	12.5	14.5	28.6	61.3	37.8	25.2	35.9	15.3	56.6	45.7	27.5	30.8	28.9	37.4	47
U	2.6	2.4	2.2	2.6	3	2.4	2.4	8.6	5	2.3	5	1.6	4.6	4.9	5.3

Sample 1 – 3 = granodiorite; sample 4 – 6 = migmatite; sample 7 – 9 = equigranular granite; sample 10 – 12 = porphyritic granite; sample 13 – 15 = fine-grained granite.

Rare Earth Elements (REE) Data

Table 4. Rare Earth Elements (ppm) petrochemical data for the granitoids of Zing-Monkin area

Sample#→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
La	49.3	51.6	103	203	86.7	66.1	82	8.1	78.5	185	4.6	38.6	40.4	48.2	57.8
Ce	114	122	228	411	140	130	168	11.9	176	368	9.7	72.9	87.3	99.5	120
Pr	13.3	13.1	25.9	44.5	17.1	13.8	17.8	2.05	19.4	38.4	1.37	6.86	9.15	10.9	12.4
Nd	44.8	48.3	89.1	143	53.3	39.5	54.7	10.9	65.2	122	7.9	20	30.1	36.8	43.8
Sm	9.4	10.6	18.4	29	10.4	6.7	9.9	3.5	13.6	21.9	2.9	3.3	6	7.2	8.7
Eu	1.95	2.12	2.82	2.21	1.32	1.42	0.85	0.13	0.84	2.31	0.16	0.76	0.56	0.59	0.6
Gd	7.7	7.6	15	18.7	7.2	3.6	6.7	5.3	12.6	13.8	3.3	2.6	3.9	4.9	6.7
Tb	1.1	1.1	2.1	2.5	1	0.4	0.9	1.2	2.2	1.8	0.6	0.4	0.6	0.7	1.1
Dy	5.6	6	11	13.2	5.1	2	4.9	8.4	13.2	9.4	4.1	2	3	3.7	6.4
Ho	1.1	1.2	2.1	2.4	1	0.4	0.9	1.9	2.9	1.8	0.8	0.4	0.5	0.7	1.4
Er	3.3	3.4	6.3	6.6	3.1	1.1	2.4	5.8	9.6	5.1	2.5	1.3	1.6	1.9	4.5
Tm	0.52	0.5	0.88	0.87	0.44	0.16	0.34	0.93	1.53	0.68	0.37	0.22	0.24	0.27	0.69
Yb	3.2	3	5.2	4.6	2.4	1.1	2.1	5.9	9.7	3.8	2.2	1.5	1.5	1.8	4.3
Lu	0.41	0.42	0.69	0.6	0.31	0.16	0.29	0.84	1.3	0.52	0.32	0.21	0.25	0.29	0.65
(Tb/Yb)N	1.46	1.56	1.72	2.31	1.77	1.55	1.82	0.87	0.97	2.02	1.16	1.13	1.70	1.65	1.09
(La/Yb)N	9.34	10.42	12.00	26.75	21.89	36.42	23.67	0.83	4.90	29.51	1.27	15.60	16.32	16.23	8.15
(La/Sm)N	2.88	2.67	3.07	3.84	4.57	5.41	4.54	1.27	3.17	4.63	0.87	6.42	3.69	3.67	3.64
Eu/Eu*	0.68	0.69	0.50	0.27	0.44	0.80	0.30	0.09	0.19	0.38	0.16	0.77	0.33	0.29	0.23

Sample 1 – 3 = granodiorite; sample 4 – 6 = migmatite; sample 7 – 9 = equigranular granite; sample 10 – 12 = porphyritic granite; sample 13 – 15 = fine-grained granite.

Some Major and Trace Elements Ratios

Table. Some major (wt %) and trace (ppm) elements ratios for the granitoids of Zing-Monkin area.

Sample #→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Na2O/K2O	0.88	1.01	0.63	0.42	0.64	0.73	0.51	0.74	0.51	0.41	0.91	0.59	0.54	0.53	0.54
Na2O/CaO	1.79	1.73	0.74	1.68	2.29	1.68	3.84	6.72	2.56	1.70	4.96	2.39	2.97	2.83	2.88
Na2O/Al2O3	0.26	0.27	0.20	0.19	0.24	0.24	0.24	0.29	0.22	0.19	0.31	0.24	0.22	0.22	0.22
K2O/Na2O	1.14	0.99	1.59	2.40	1.56	1.38	1.95	1.35	1.96	2.44	1.09	1.70	1.87	1.88	1.84
K2O/CaO	2.04	1.71	1.18	4.03	3.56	2.31	7.48	9.10	5.01	4.14	5.43	4.05	5.54	5.33	5.30
K2O/Al2O3	0.29	0.26	0.32	0.47	0.38	0.33	0.46	0.39	0.43	0.47	0.34	0.40	0.41	0.42	0.41
CaO/Na2O	0.56	0.58	1.35	0.60	0.44	0.59	0.26	0.15	0.39	0.59	0.20	0.42	0.34	0.35	0.35
CaO/Al2O3	0.14	0.15	0.27	0.12	0.11	0.14	0.06	0.04	0.09	0.11	0.06	0.10	0.07	0.08	0.08
Al2O3/TiO2	23.25	22.21	9.36	29.61	37.22	28.74	66.67	711.05	73.61	33.88	341.03	65.53	82.93	86.02	82.73
Fe2O3/MgO	3.33	2.86	7.13	10.97	5.02	3.46	16.69	46.00	10.44	13.13	29.50	4.60	8.00	8.26	7.60
Na2O/K2O	8.94	8.52	7.03	9.02	9.01	8.91	9.17	9.18	8.55	8.47	8.63	9.41	8.60	8.90	8.59
CaO+Na2O+K2O	11.27	11.00	10.69	10.60	10.55	11.14	9.98	9.76	9.68	9.92	9.46	10.87	9.61	9.99	9.64
A/NK	1.83	1.90	1.92	1.51	1.61	1.77	1.44	1.47	1.55	1.52	1.54	1.57	1.58	1.56	1.59
A/CNK	1.45	1.47	1.26	1.28	1.37	1.41	1.32	1.38	1.37	1.30	1.41	1.36	1.42	1.39	1.42
Ba/Rb	23.40	25.00	17.50	25.00	22.40	15.80	21.00	36.80	31.00	23.00	29.00	20.60	28.60	29.40	29.90
Rb/10	2.6	2.4	2.2	2.6	3.0	2.4	2.4	8.6	5.0	2.3	5.0	1.6	4.6	4.9	5.5
Rb/30	12.5	14.5	28.6	61.3	37.8	25.2	35.9	15.3	56.6	45.7	27.5	30.8	28.9	37.4	47.0
Rb/Sr	11.70	11.70	8.10	5.40	4.50	2.40	2.10	18.60	6.90	5.70	3.90	3.60	6.00	5.40	5.40
Th/U	4.81	6.04	13.00	23.58	12.60	10.50	14.96	1.78	11.32	19.87	5.50	19.25	6.28	7.63	8.55
K	39517..52	35200.48	35864.64	52883.74	45577.98	42838.32	50310.12	43834.56	46989.32	49895.02	37442.02	49147.84	46491.20	48234.62	46242.14
Ti	4220.48	4358.37	8656.78	2757.70	2332.06	3285.26	1187.01	113.91	1079.10	2284.10	233.81	1354.87	983.18	965.20	989.18
P	1221.98	1309.26	2096.82	480.06	480.06	654.63	218.21	43.64	218.21	392.78	87.28	349.14	174.57	218.21	218.21
Al	86638.23	85473.88	71554.60	72083.85	76635.40	83356.88	69861.00	71501.68	70125.63	68326.18	70390.25	78381.93	71978.00	73301.13	72242.63
Mg	8081.54	8443.40	6935.65	1748.99	3437.67	4282.01	784.03	60.31	1085.58	1447.44	120.62	1809.30	1145.89	1145.89	1206.20
Mn	565.39	619.60	937.15	325.29	340.78	216.86	240.10	38.73	309.80	333.04	147.16	185.88	240.10	209.12	263.33
Fe(3)	31194.58	27977.20	57353.26	22241.87	20003.70	17205.98	15177.63	3217.38	13149.28	22032.05	4126.64	9652.13	10631.34	10981.05	10631.34
Ca	16652.51	17724.56	26158.02	11292.26	11006.38	15937.81	5789.07	4145.26	8076.11	10363.15	5932.01	10434.62	7218.47	7790.23	7504.35
Si															

Sample 1 – 3 = granodiorite; sample 4 – 6 = migmatite; sample 7 – 9 = equigranular granite; sample 10 – 12 = porphyritic granite; sample 13 – 15 = fine-grained granite.

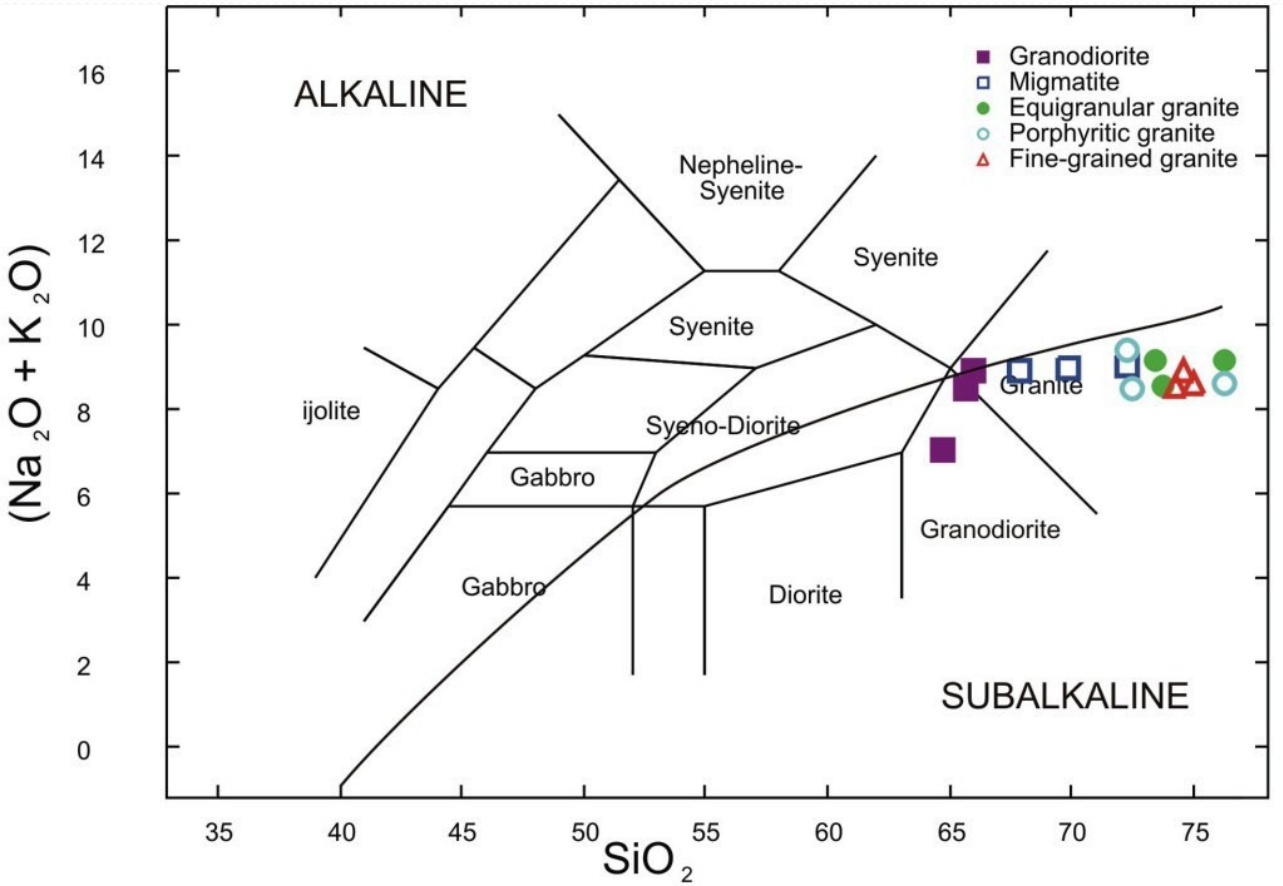
Classification

- To characterise the rocks petrologically, chemical classification scheme of Cox et al., (1979) was chosen.

Fig 1. Alkalies Vs Silica plot of Cox et al; (1979) for the granitoids of the study area

» Granite

» Granodiorite



Origin and Chemical Affinity

- Attempt was made to probe the chemical affinity and probable source of the granitoids.
- Here again, selected oxides pairs and ratios were plotted on binary and trivariate variation diagrams.

Fig. 2 K_2O Vs SiO_2 variation plot for the granitoids. Subdivision lines after Le Maitre (1989) and Rickwood (1989)

» High-K Calc-alkaline

» Medium-K Cala-alkaline

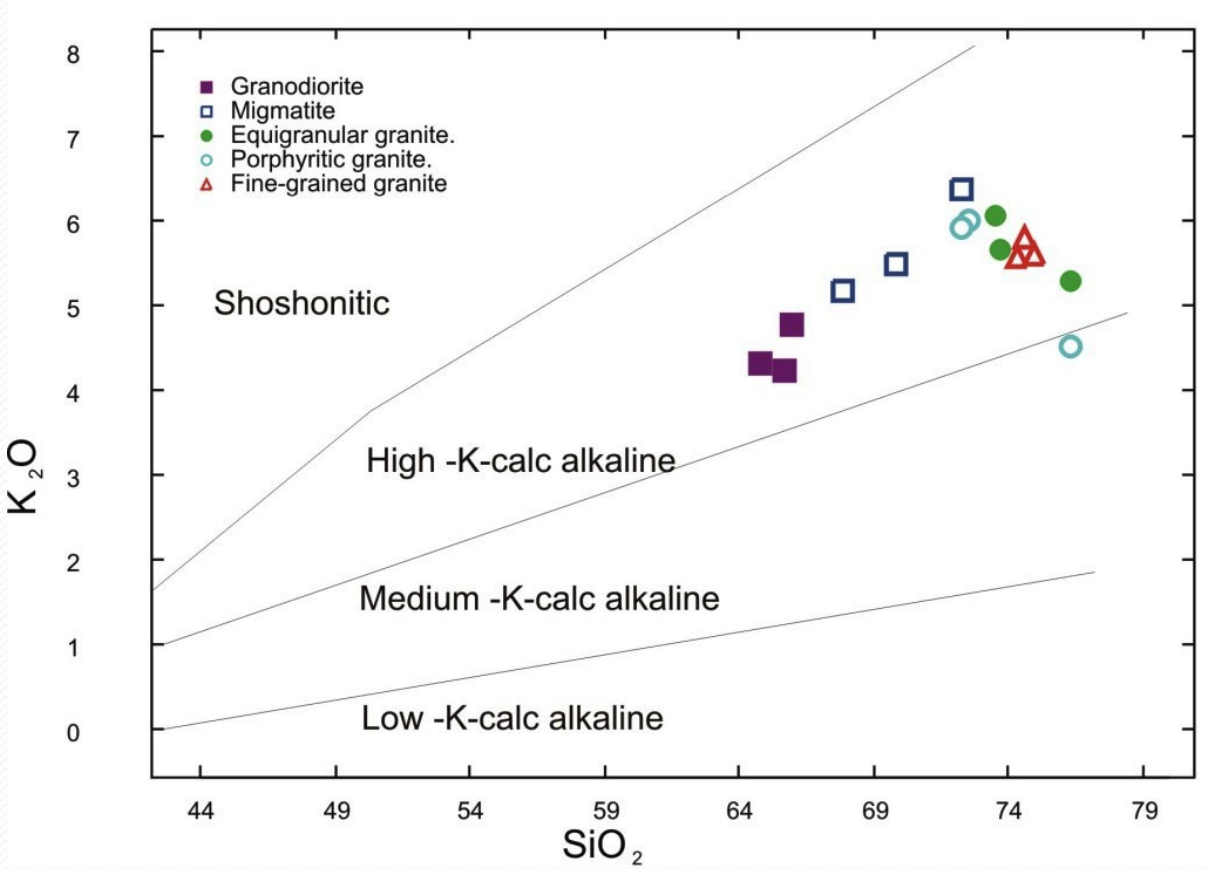


Fig. 3. AFM variation plot of Irvine and Baragar (1971) for the granitoids.

» Calc alkaline Signature

» Marked alkali enrichment

» Suppressed iron enrichment

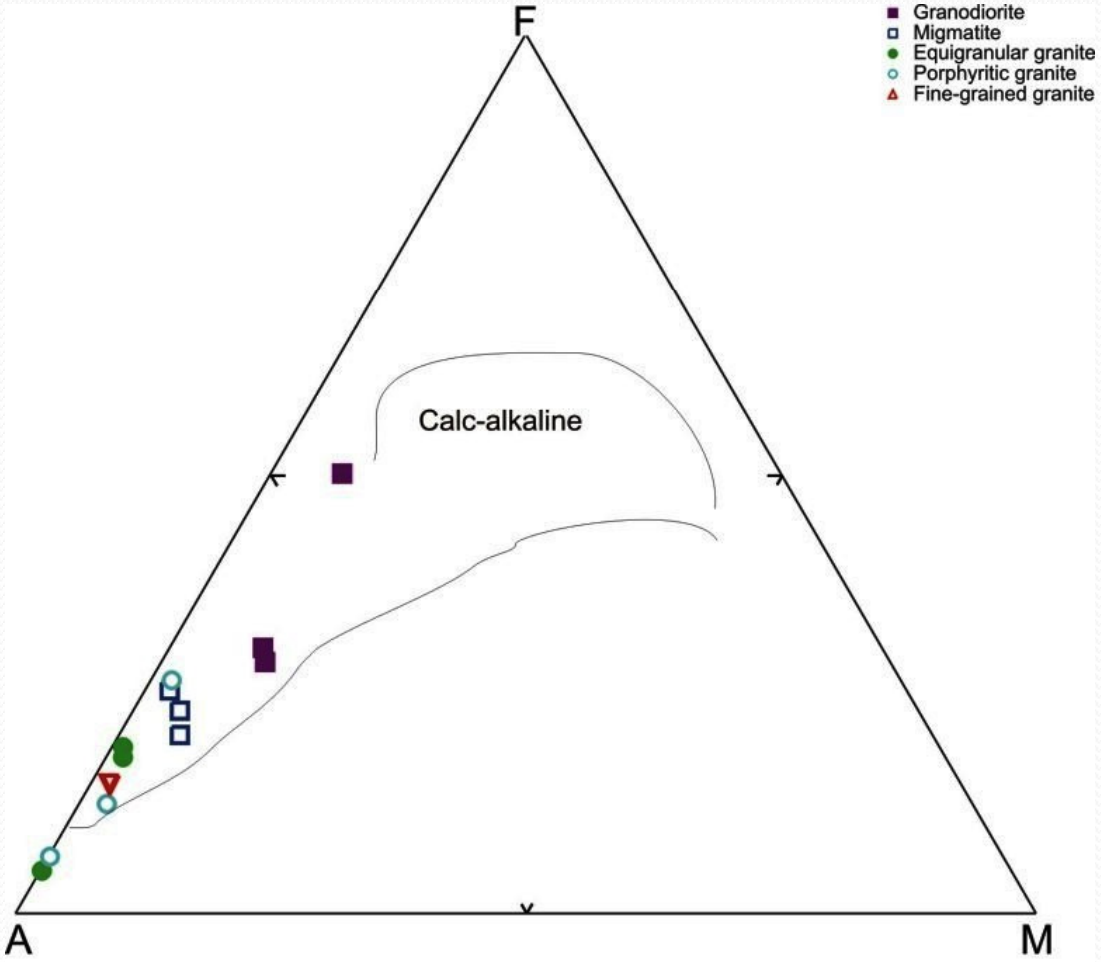


Fig. 4. A/Nk Vs ASI plot of Zen, (1986) for the granitoids.

» Samples divided between metaluminous and peraluminous fields

» Characteristic of rocks derived from igneous source (Chappell and White, 1974)

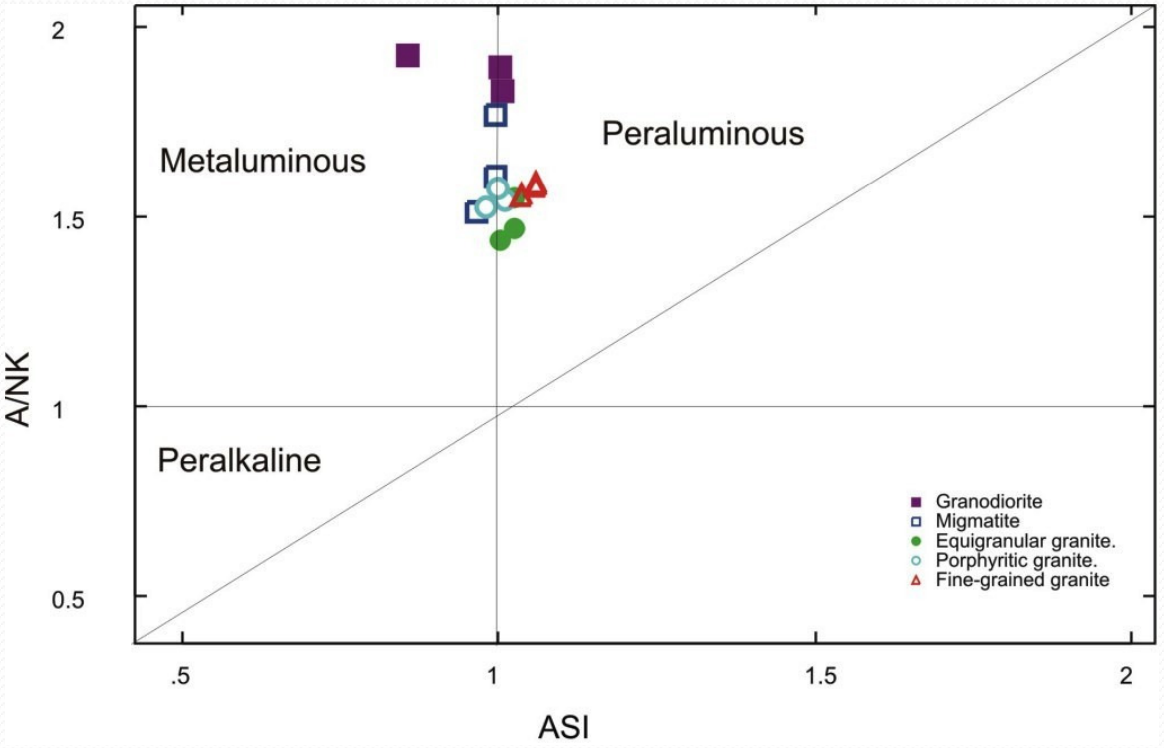
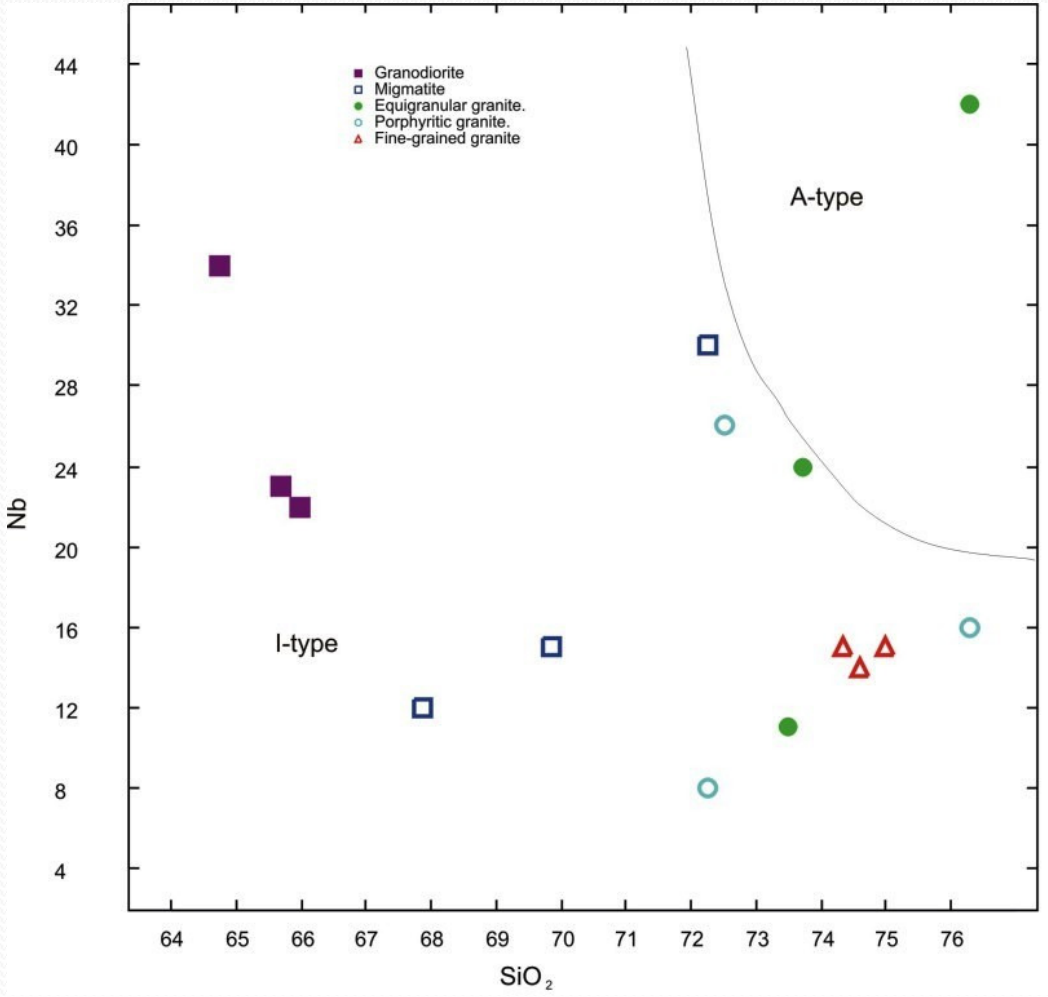


Fig. 5 Nb Vs SiO_2 variation plot for the granitoids. The fields of A- and I-type granites are after Kleeman and Twist, (1989)

» Igneous parentage is indicated

» Most samples in the field of I-Type granitoids



Chief Points and Inference

- The metaluminous to weakly peraluminous character,
- The smooth calc-alkaline trend
- The broad spectrum of composition spanning from mafic granodiorite through felsic granites
- Are all, chemical features of I-type granitoids (Irvine and Baragar, 1971, Chappell and White, 1977; Zen, 1986), formed in a subduction related setting (Kleeman and Twist, 1989).

Evolution

- To achieve this objective, various Harker-type variation plots of selected major oxides using SiO_2 as a fractionation index were adopted.

Fig. 1. SiO_2 Vs MgO variation plot for the granitoids.

» Coherent trend or clear liquid line of decent

» magma evolution trend from the most primitive unit to the most evolved unit

» Absence of separate groups

» Negative correlation

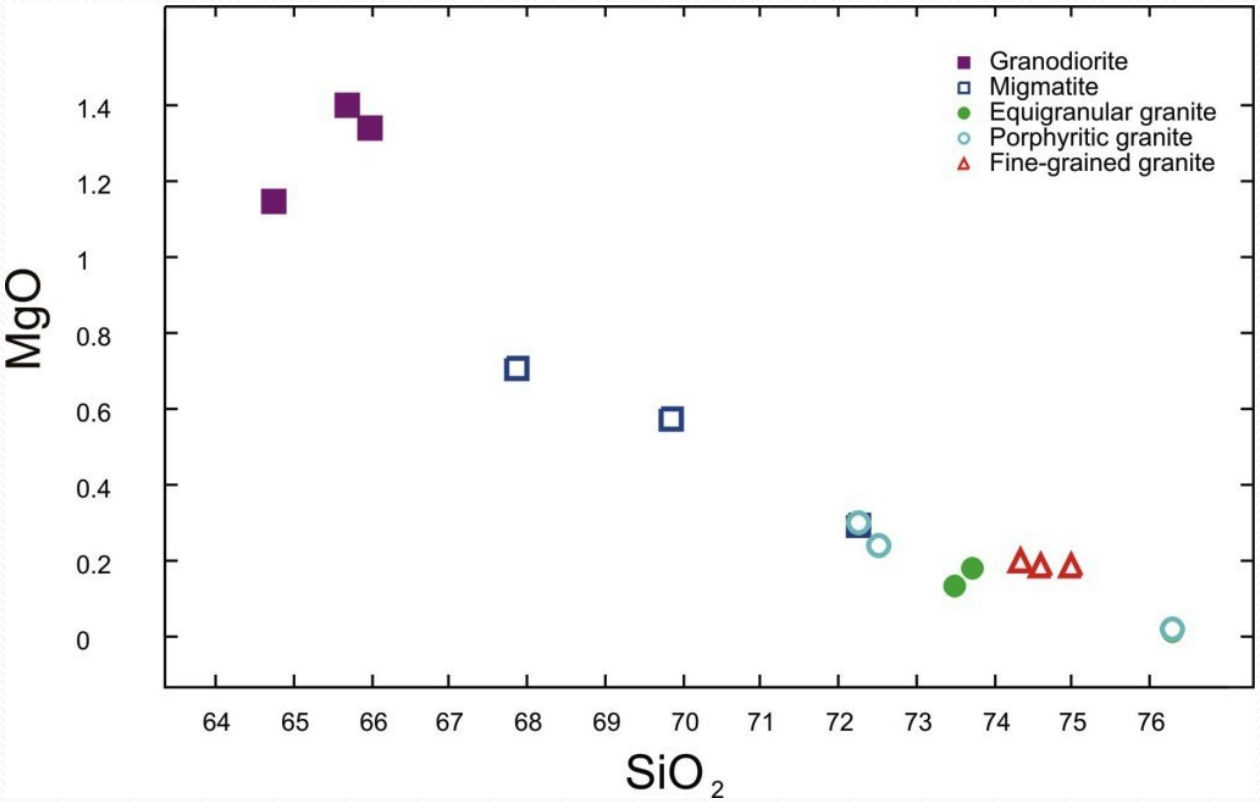


Fig. 2. SiO_2 Vs CaO variation plot for the granitoids.

» Coherent series or liquid line of descend

» Magma evolution trend from the most primitive unit to the most evolved unit

» Absence of separate groups

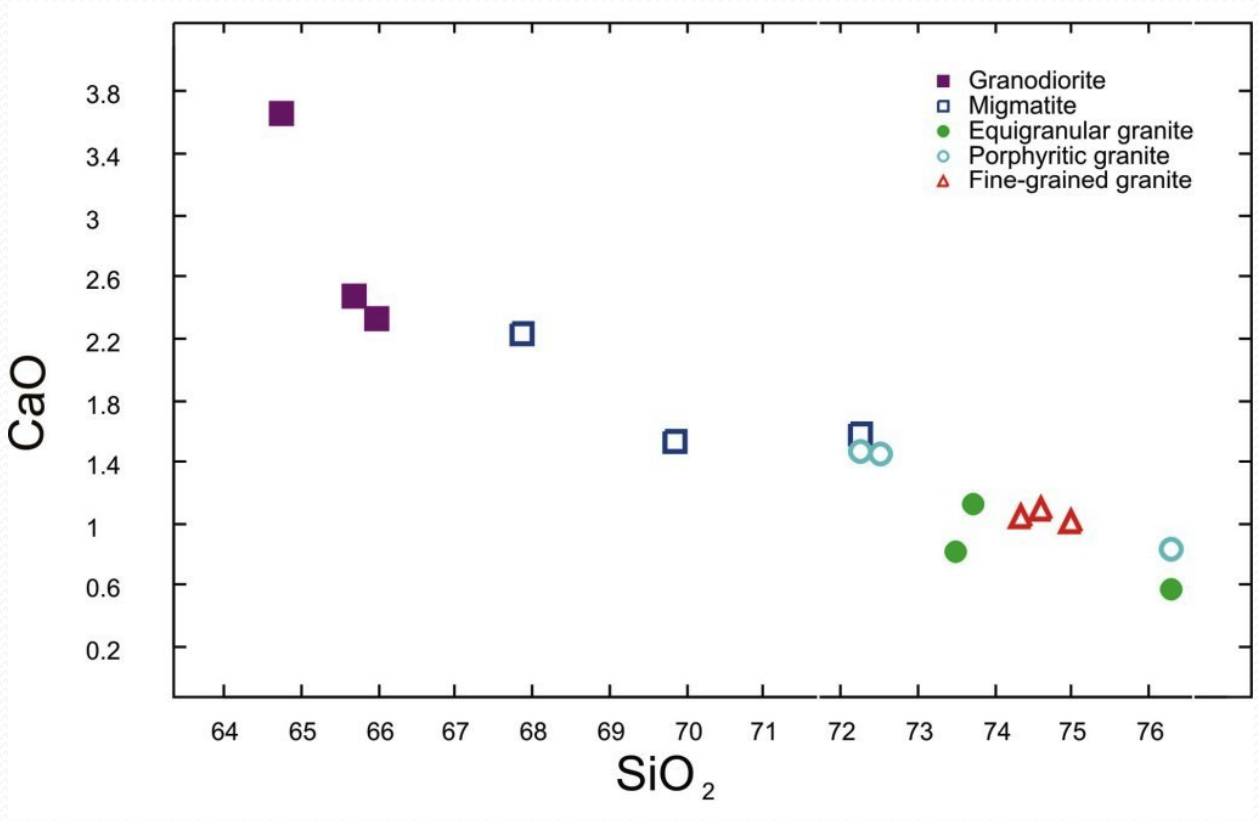


Fig. 3. SiO_2 Vs Fe_2O_3 variation plot for the granitoids.

» Coherent trend

» A clear liquid line of decent

» Absent of separate groups

» Negative correlation

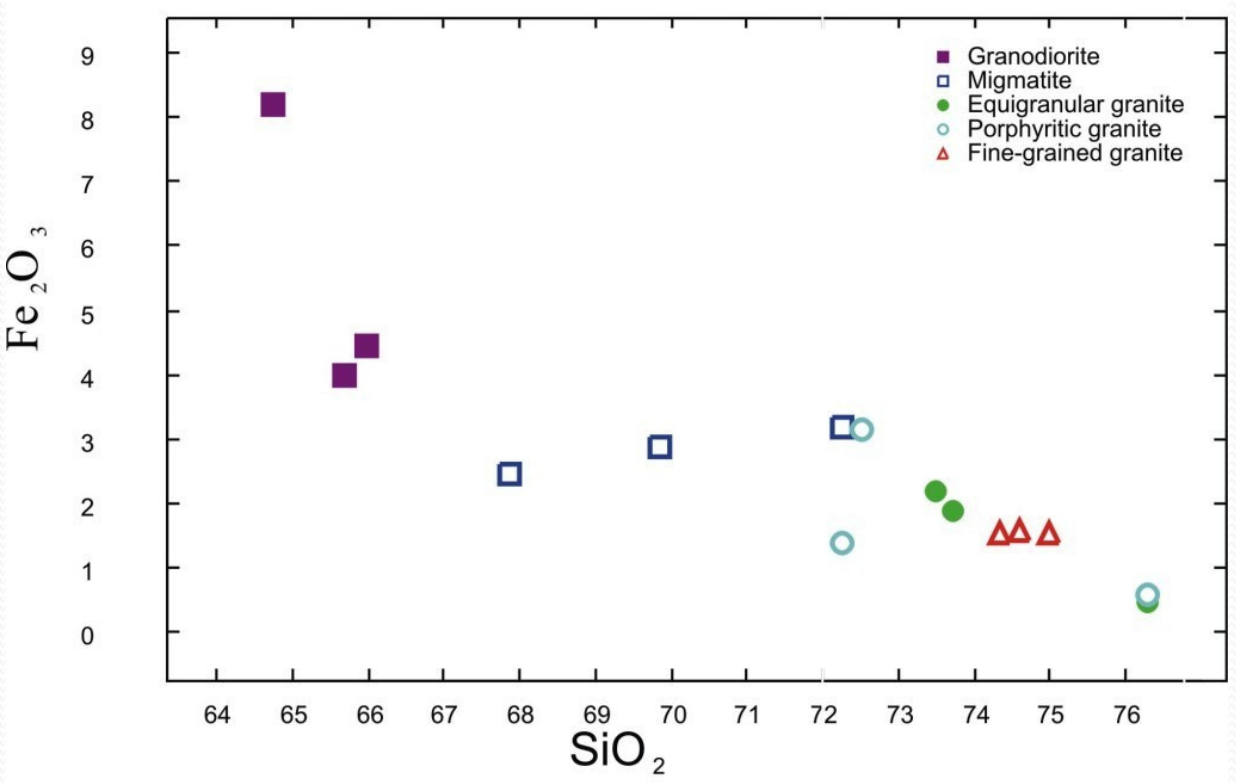


Fig. 4. SiO_2 Vs MnO variation plot for the granitoids.

» A clear liquid line of decent

» Absent of separate groups

» Negative correlation

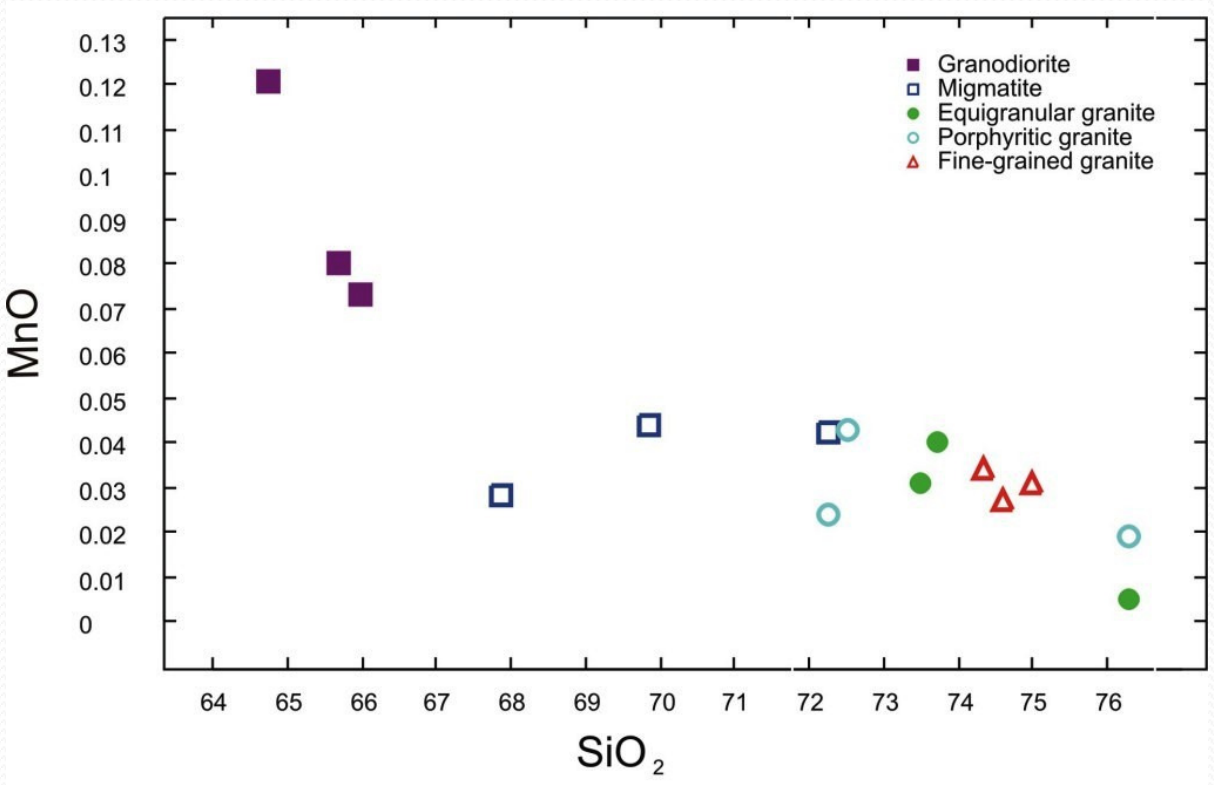


Fig. 5. SiO_2 Vs TiO_2 variation plot for the granitoids.

» Absence of separate groups

» Linear trend

» Negative correlation

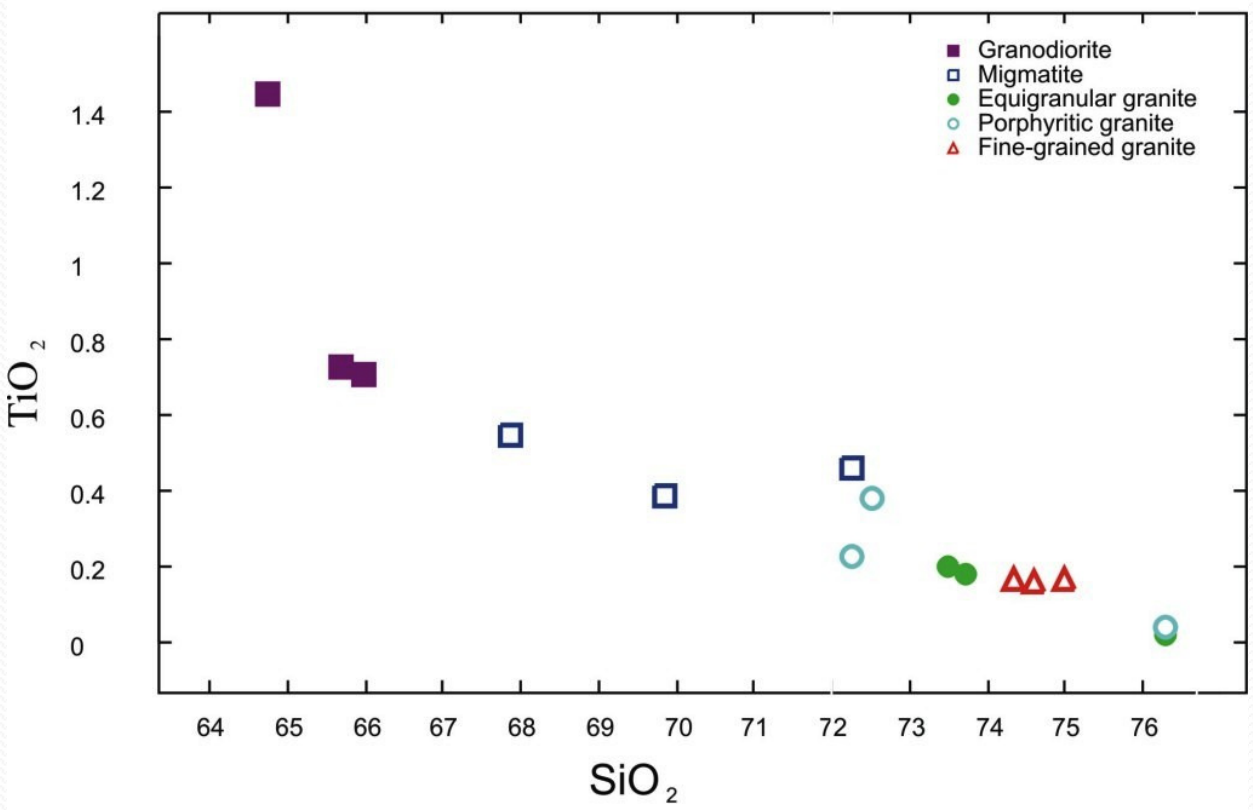


Fig. 6. SiO_2 Vs P_2O_5 variation plot for the granitoids

» Absence of separate groups

» Linear trend

» Negative correlation

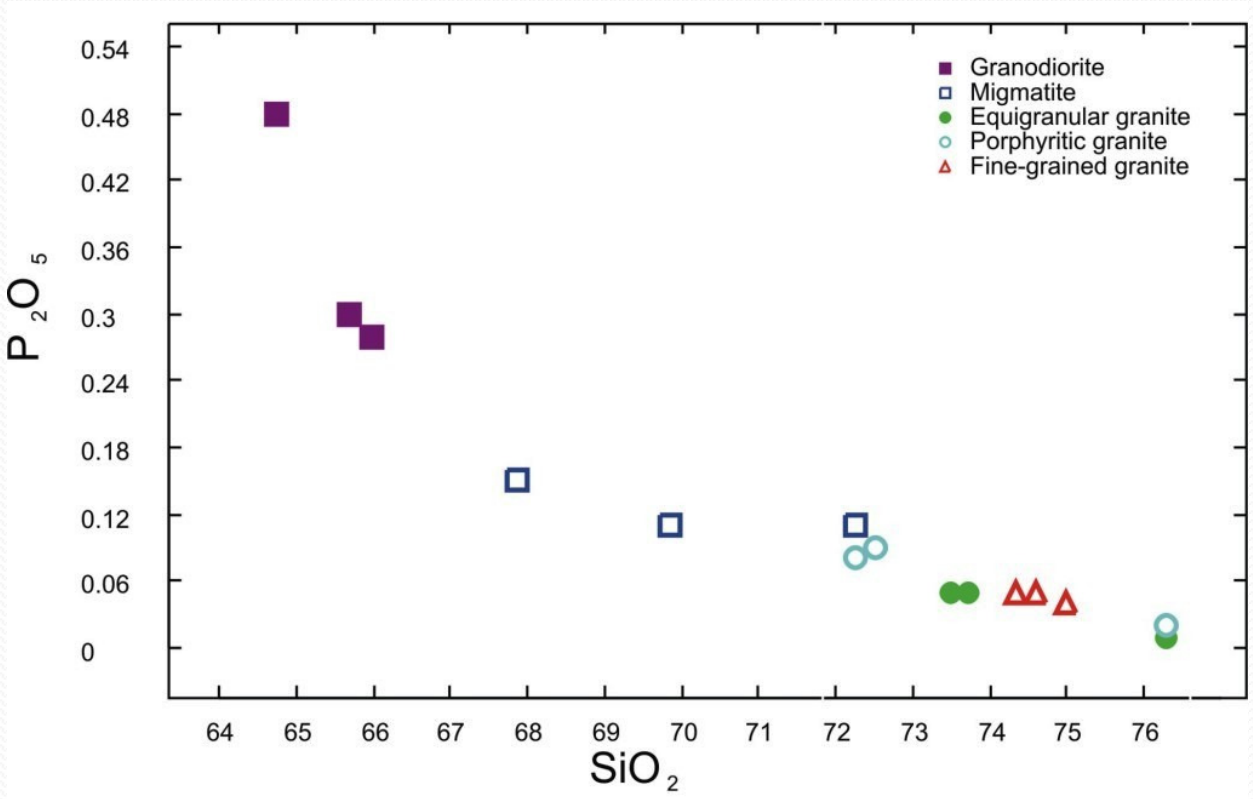


Fig. 7. SiO_2 Vs Na_2O variation plot for the granitoids

» Linear trend with some scattering but typical of Na_2O

» Absence of separate groups

» Weak negative correlation

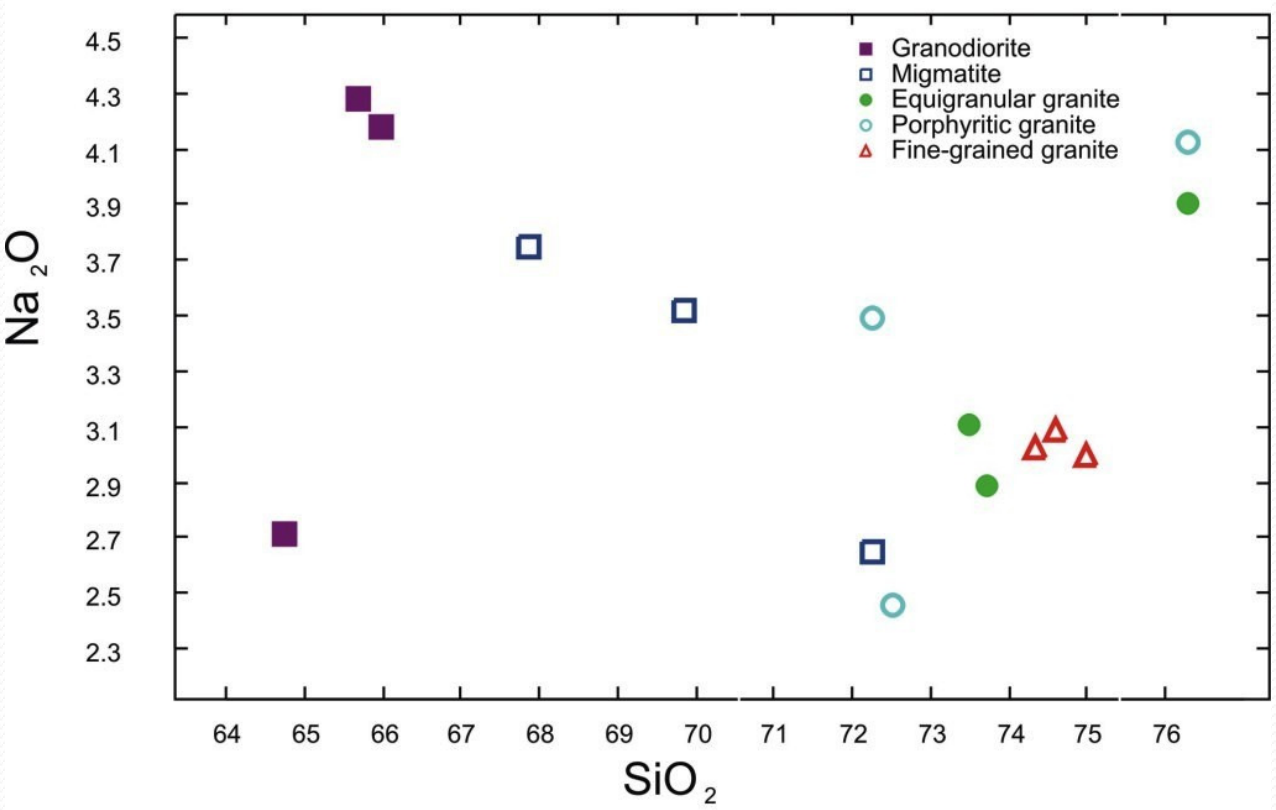


Fig. 8. SiO_2 Vs Al_2O_3 variation plot for the granitoids

» Linear trend with some scattering but typical of Al_2O_3

» Absence of separate groups

» Negative correlation

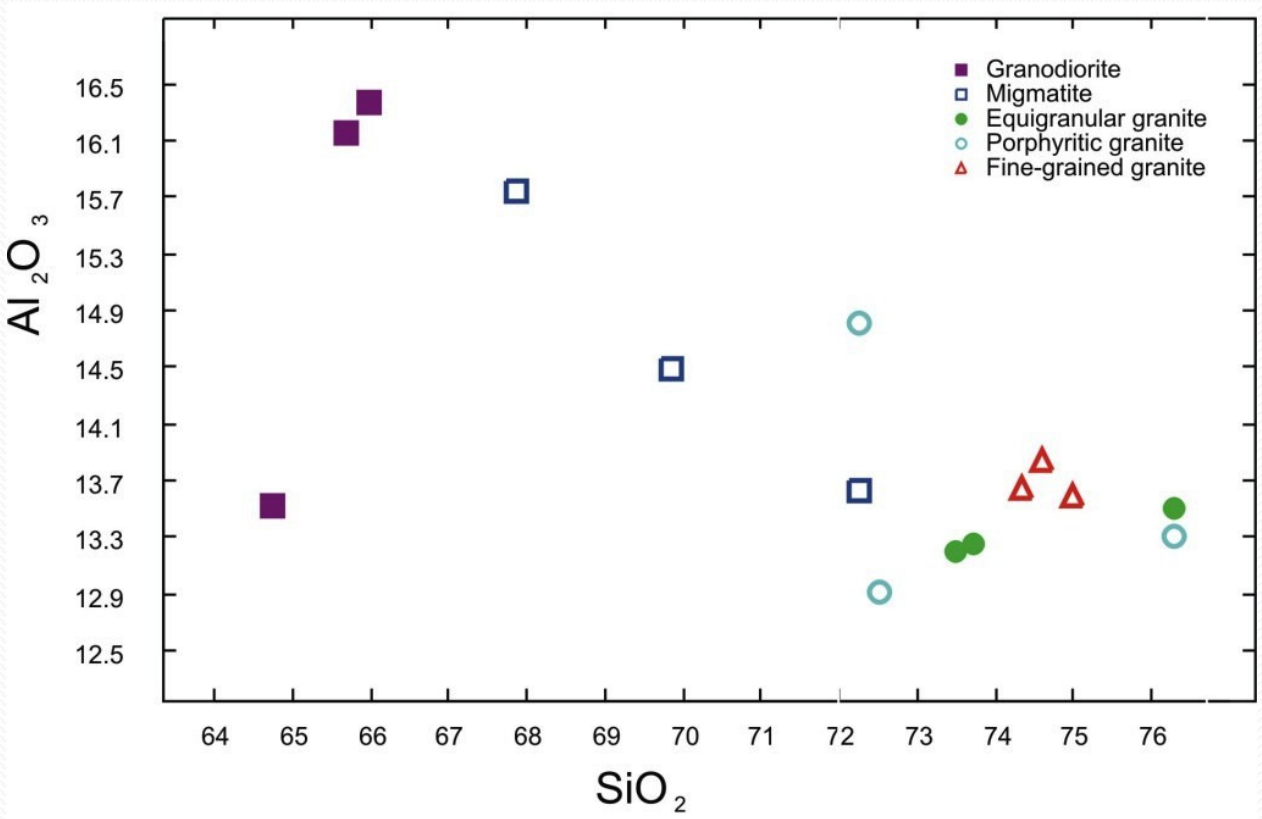


Fig. 9. SiO_2 Vs K_2O variation plot for the granitoids

» Linear trend of positive correlation

» magma evolution trend from the most primitive unit to the most evolved unit

» Absence of separate groups

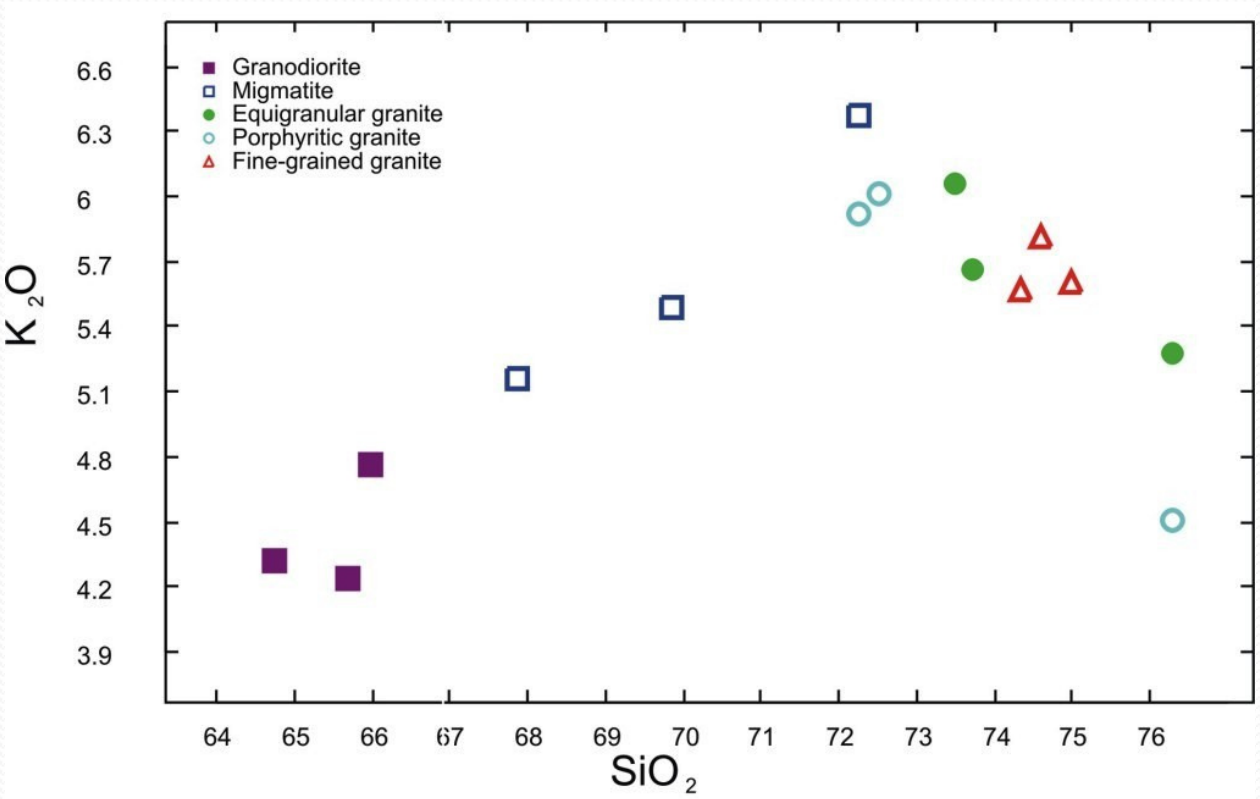
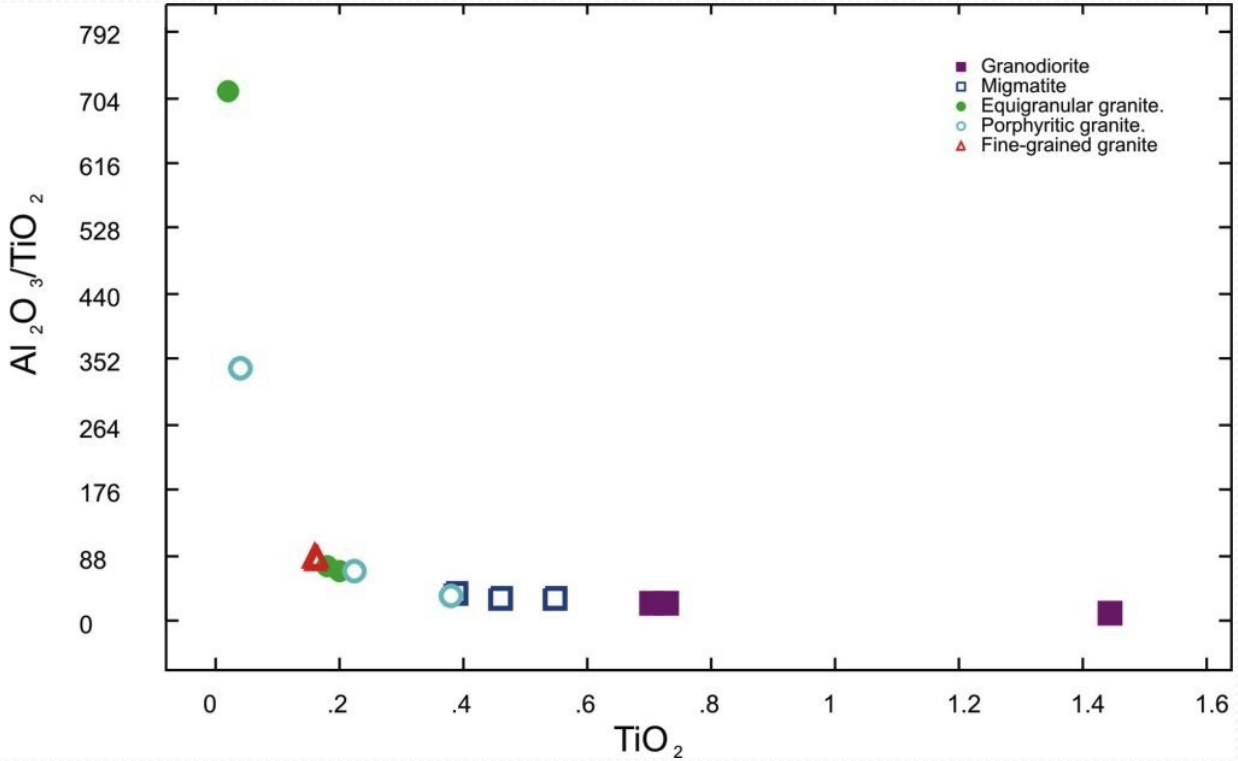


Fig. 10. Al_2O_3/TiO_2 Vs TiO_2 plot for the granitoids

» curvilinear trend

» Typical of magmatic differentiation

» Absence of separate groups



Chief Points and Inference

- The regular inter-element variations within and between the rock units,
- The linear or near linear Harker-type variation diagrams with clear absence of separate group.
- The curvilinear trend in a plot of TiO_2 Vs Al_2O_3/TiO_2,
- Are typical features of co-genetic rocks related by magmatic differentiation process, probably fractional crystallisation (Cox and Pankhurst, 1979., Wilson, 1989).

Tectonic setting

- To probe the tectonic settings, trace elements were plotted against one another as proposed by:
- Pearce et al (1984);
- Harris et al (1986), and
- Whalen et al (1987).

Fig. 1. Rb Vs (Y+Nb) of Pearce et al, (1984) for the granitoids

» Samples divided into WPG & ORG Groups

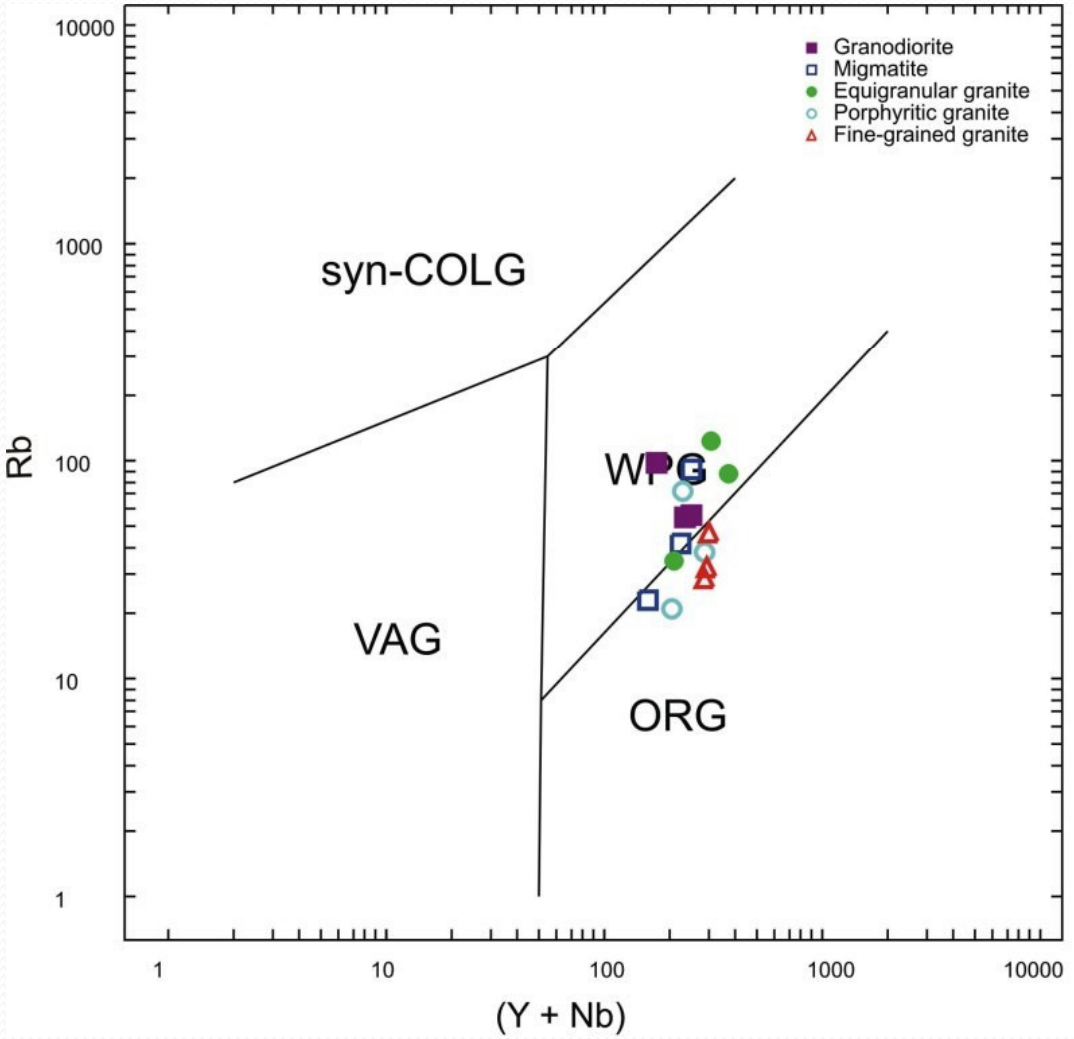


Fig. 2. Fig. Nb Vs Y of Pearce et al, (1984) for the granitoids

» Samples divided between WPG & Syn-COLG Regions

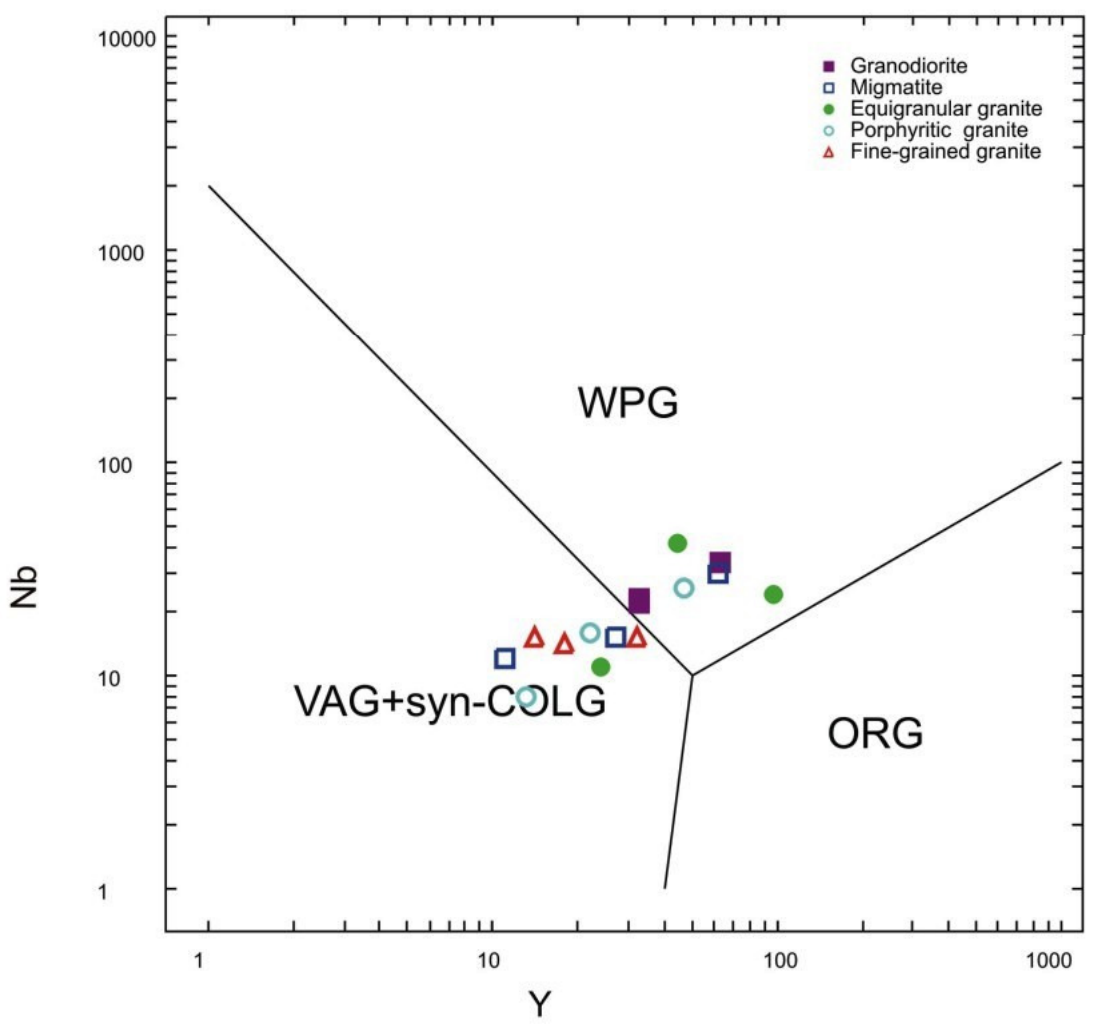


Fig. 3. Ta Vs Yb of Pearce et al, (1984) for the granitoids

» Samples shared between WPG, VAG and Syn-COLG Fields

» Most samples in WPG Group

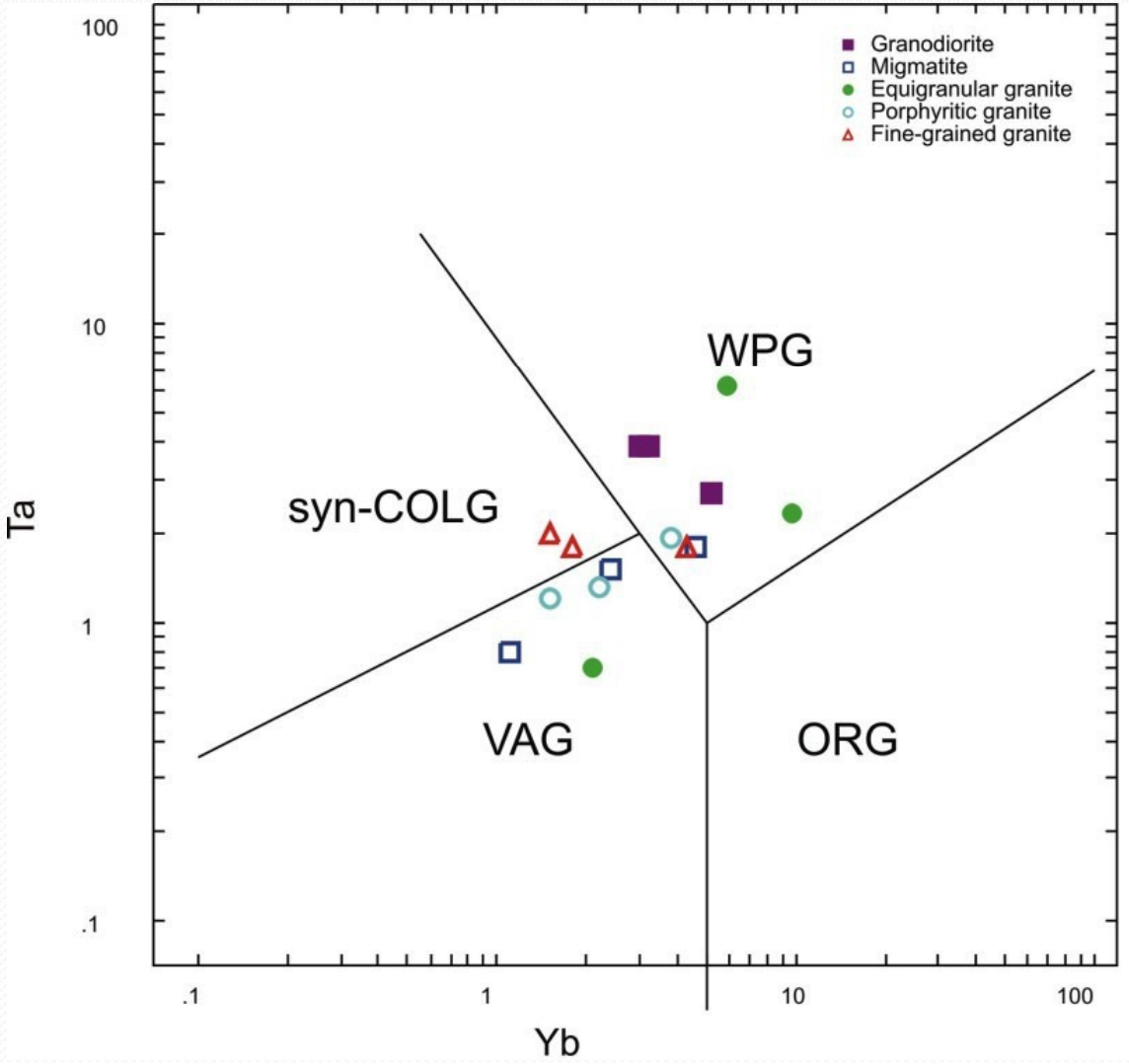


Fig. 4. Rb/10 – Hf – Ta*3 plot (after Harris et al; 1986) for the granitoids

» All samples in WPG Group

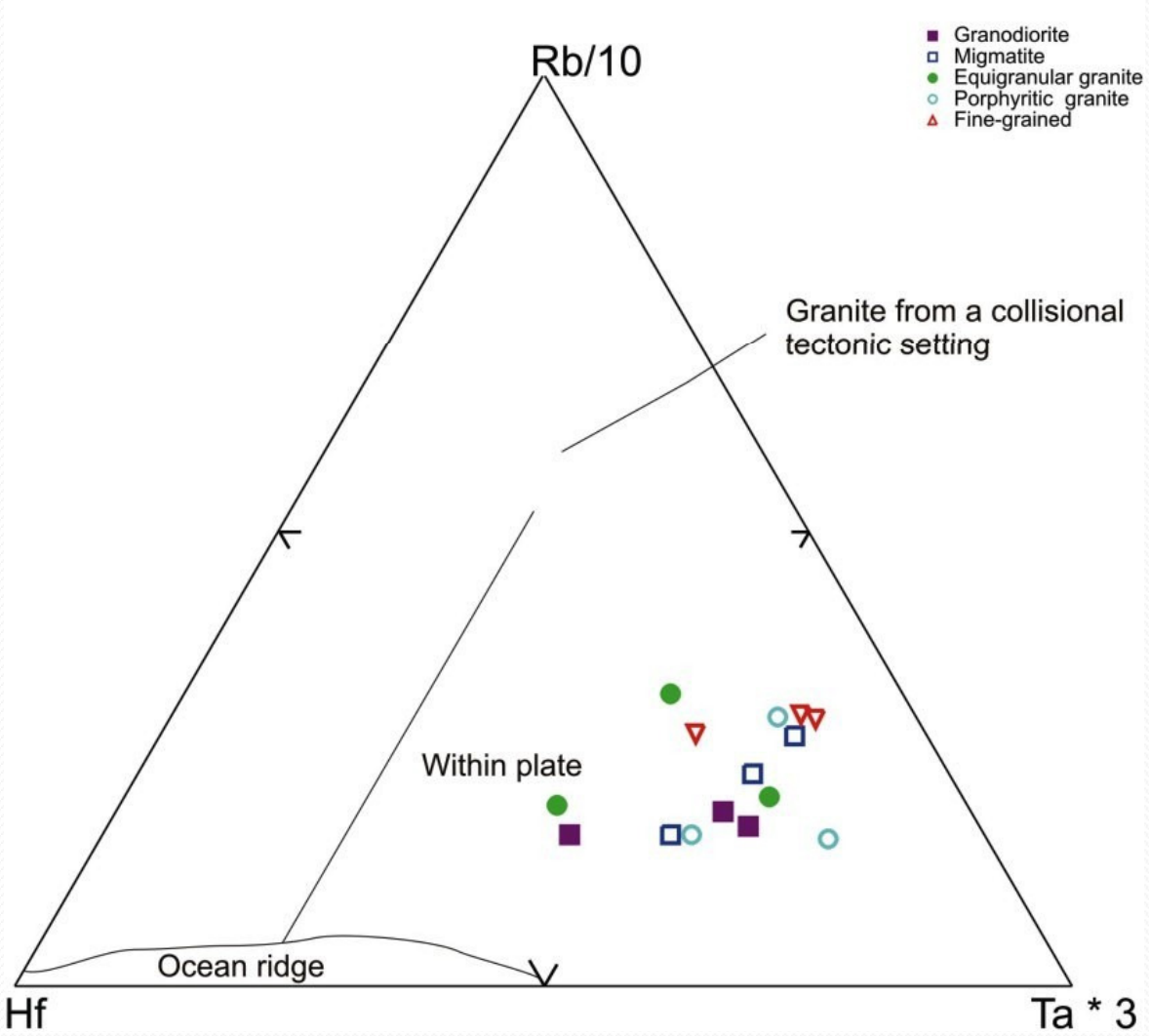
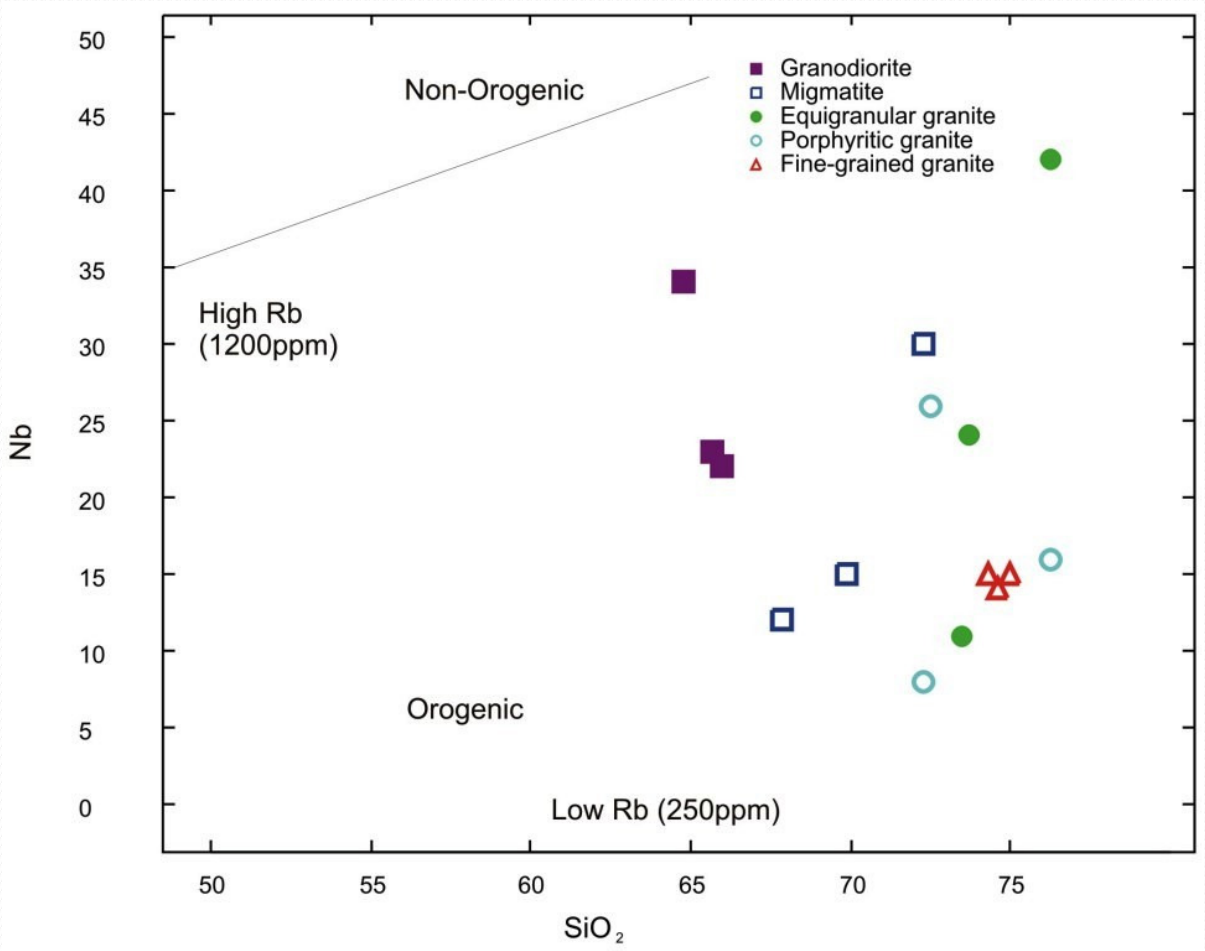


Fig. 5. Nb Vs SiO_2 variation plot (after Harris et al; 1986) for the granitoids

» Almost all the samples plot in orogenic granite field



Chief Points and Inference

- The figures indicate orogenic character with within-plate syn-collisional signatures.
- Collectively, the diagrams suggest that the granitoids are orogenic formed in a within plate, syn-collisional tectonic environment (Pearce et al, 1984; Harris et al., 1986).

Degree of Fractionation

- To compare the REE abundances of the granitoids graphically, and study the degree of fractionation, the concentrations of the REE were normalised to their abundances in chondritic meteorites as proposed by Sun and McDonald (1989) and to average continental crust according to Weaver and Tarney (1984)

Fig. 1. Chondrite-normalised REE for the granitoids (Sun & McDonald, 1989)

Strongly fractionated REE patterns

(La/Yb)N = 15.55

» Fractionated LREE enriched pattern (La/Sm)N = 3.62

» A nearly flat HREE pattern (Tb/Yb)N = 1.52

» Significant negative Eu anomalies (Eu/Eu* = 0.41)

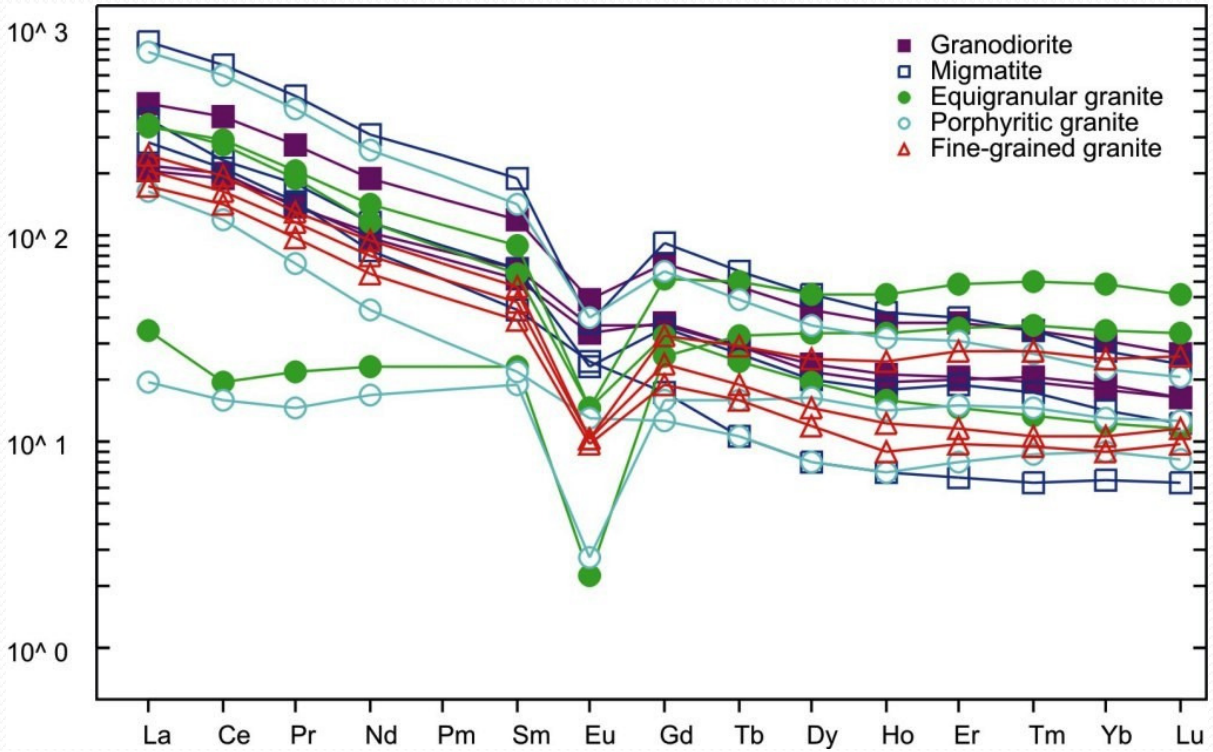
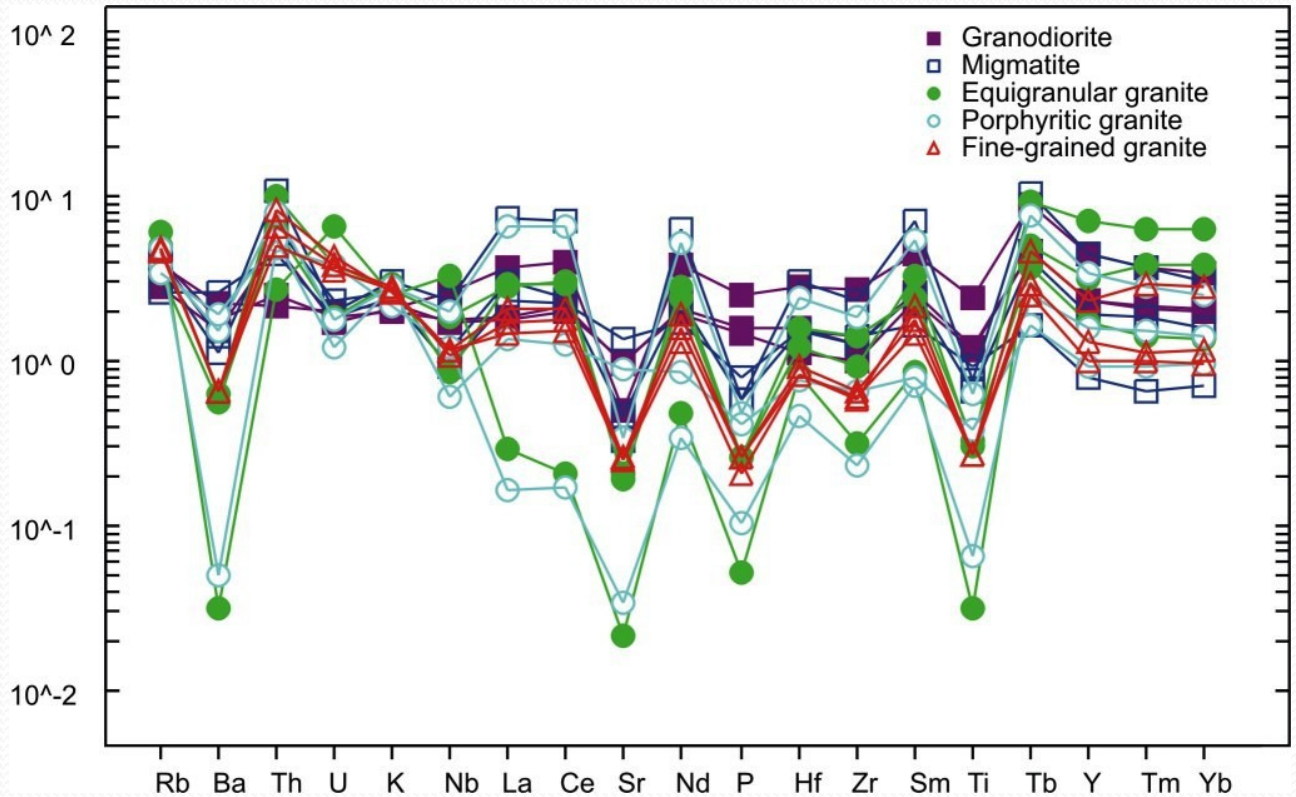


Fig. 2. REE for the granitoids normalised to average continental crust according to Weaver and Tarney (1984).

- Fractionation in Sr, Ba, Ti and P relative to Rb



Inference

- The strongly fractionated REEs with enriched LREEs and nearly flat HREEs
- The increasing negative Eu anomaly from the granodiorite to the granites.
- Are all indications that the fractionation of basic melt to yield silicic magma was dominated by the removal of plagioclase, and thus produce significant negative Eu anomalies (Hasken et al., 1968; Cox and Pankhurst, 1979; Sun & McDonald, 1989).

Summary

- Field & petrographic data indicate that:

1. The northern part of Adamawa Massif is underlain by: porphyritic granites, equigranular granites, fine-grained granite, granodiorite, migmatites, with subordinate pegmatites.
2. Rock units separated from one another by predominantly gradational contacts,
3. Essential minerals of hornblende, Plg, Biotite, K-Fsp and accessory apatite, sphene & zircon.
4. Rock units characterised mostly by mafic enclaves.

Summary Continues....

- Geochemical data indicates:

1. Systematic decrease in all the major oxides from granodiorite to granites except SiO_2 and K_2O which rise sympathetically.
2. Progressive decrease in trace elements from granodiorite through granites except Rb.
3. Strongly fractionated REEs with enriched LREEs and an increasing negative Eu anomaly from the granodiorite to the granites.
4. Calc-alkaline trends with metaluminous to weakly peraluminous character.
5. I-type affinity with within plate orogenic signatures.

Conclusion

- Based on the Field and Petrochemical characteristics:

1. The granitoids are probably I-type, generated in a within plate tectonic setting, and genetically related to a common source by fractional crystallisation, dominated by the removal from the melt, hornblende, plagioclase, biotite, K-Fsp, apatite, sphene and zircon.


THANKS
FOR
LISTENING

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- Mal. Suleiman, my field assistant

Fig. 2 Geology of Adamawa Massif (modified after the Geological Survey of Nigeria Agency, 2004)

- Hawal Masssif (studied)
- Oban Massif (well studied)
- Adamawa Massif (least studied)

