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Preliminary Petrological Studies of Basement Rocks, Thar Coal Basin, Thar Parkar District, Sindh, Pakistan

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Abstract

The basement rocks encountered in exploratory boreholes drilled for exploration and evaluation of coal deposits in Thar Parkar district, Sindh Pakistan have formed the basis for present studies. The basement complex was penetrated through eighteen boreholes at drill depth range from 112 to 279 meters. These rocks were identified in field as Pink and Grey Granites.. The basement rocks are of Igneous as well as metamorphic origin. The Igneous rocks identified petrographically are Alkali-feldspar Granite, Granodiorite, Rhyolite, Rhyodacite and Aplite while that of metamorphic origin is Plagioclase Hornblende Gneiss. These rocks are termed as Thar Granitoids. The chemical data plotted in various binary and ternary diagrams suggests that the Thar Granitoids are (1) in general peraluminous in nature (2) restricted to psuedoternary minimum at moderate water pressure.

Keywords: *Thar coal field, Thar Granitoids, Borehole samples petrography.*

1. Introduction

During coal exploration programme several bore holes were drilled primarily for the appraisal of coal deposit. The basement complex was penetrated through eighteen holes namely TP-2, TP-3, TP-6, TP-14, STP-5, STP-6, STP-10, SB-11, SB-12, SB-14, SB-19, SB-19, SB-24, SB-25, SB-26, ST-11, ST-13, ST-24 and ST-27 (Fasset & Durrani, 1994; Alam et.al., 1996 & 1998) at drill depths range from 112 to 279 meters. The present studies are based on the basement rocks core samples from eight bore holes only i.e; TP-14, TP-2, TP-3, TP-6, STP-6, TP-3, STP-5, SB-26 and SB-11 of Thar coal basin hereafter referred to as Thar Granitoids.

2. Study Area

The Thar coalfield is located in the Thar Desert, south east of Sindh province, Pakistan. It is 50 Km from Mirpurkhas town and co-ordinates $24^{0}30^{/}$ N to $25^{0}45^{/}$N (latitudes) and $69^{0}45^{/}$E to $71^{0}00^{/}$ (longitudes). The Thar area is connected by metalled roads from Karachi.

3. Previous Investigation

Studies undertaken during coal exploration programme were limited to geology, chemistry and geophysical studies (Fasset & Durrani, 1994; Alam et.al., 1994, 1996, 1998 & 2002).

Petrographic studies of basement rocks encountered in Thar coal basin has not been covered previously. Present study is an introductory type of work and more detail work is recommended.

4. General Geology

The area is mainly covered by the thick sequence of recent sand dunes. The first geological subsurface information is from oil & gas exploratory drill hole-Nabisor 1 on the western edge of the desert (location marked in Fig.2). At this drill site the sedimentary sequence is nearly 4,000M thick but has not penetrated the basement. The oldest rock encountered in the hole is triassic in age (Fig.2). The geological cross section of the area as interpreted from the boreholes geological and geophysical logs shows that the sedimentary rock sequence thins markedly from west to east (Fig.2b) and the Thar basin of Paleocene age rest directly on Precambrian basement rocks. The generalized picture of the stratigraphical units as encountered in drill holes are shown in Table 1.

5. Sampling and analytical work

The basement complex was penetrated through eighteen boreholes at drill depth range from 112 to 279 meters namely TP-2, TP-3, TP-6, TP-14, STP-5, STP-6, STP-10, SB-11, SB-12, SB-14, SB-19, SB-19, SB-24, SB-25, SB-26, ST-11, ST-13, ST-24 and ST-27. The present studies are based on the basement rocks core samples from eight bore holes only i.e; TP-14, TP-2, TP-3, TP-6, STP-6, TP-3, STP-5, SB-26 and SB-11 (Fig. 1b) of Thar coal basin hereafter referred to as Thar Granitoids. Selected samples were analyzed (wet

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chemistry) for major elements. SiO_2 was determined gravimetrically, Al_2O_3 by difference i.e., R_2O_3 (Fe_2O_3+ TiO_2), Fe_2O_3(total), P_2O_5, TiO_2 by calorimetric method, CaO & MgO by titration of EDTA, Na_2O, K_2O, FeO and MnO_2 by atomic absorption spectrophotometer, H_2O- was estimated by drying the rock powder at 105^o C and ignition loss was measured at 900^oC. Analytical results of Thar Granitoids are shown in Table 3 CIPW norms have been calculated and are given in the Table 4.

6. Petrography

The petrographic studies involve both mega- and microscopic studies. The megascopic studies include the studies of samples under simple stereomicroscope with magnification upto 40X. The microscopic studies cover the study of thin sections under polarized microscope. Selective samples of pink and grey granites representing Thar Granitoids was also analyzed modally (Table 2).

- **Thar Granitoids**

The petrographic studies are based on the core samples from eight bore holes only i.e. TP-14, TP-2, TP-6, STP-6, TP-3, STP-5, SB-26 and SB-11. In all 15 representative samples comprising igneous and metamorphic rocks were collected from the above-mentioned holes. The rocks studied are identified as pink granite, grey granite, granodiorite, rhyolite, aplite, rhyodacite, and plagioclase hornblende gneiss (Fig. 3).

Table1. Stratigraphy of the area

Formation	Age	Lithology
Dune sand	Recent Unconformity	Sand, salt and clay
Alluvial deposits	Sub-recent Unconformity	Sandstone, siltstone, clay mottled
Bara Formation	Paleocene to Early Eocene Unconformity	Claystone, shale, sandstone, coal, carboniferous claystone
Basement complex	Pre-Cambrian	Igneous and metamorphic rocks

Table 2. Modal analysis of rocks from the Thar Granitoids

	Gray Granite	Pink Granite	Granodiorite	Aplite
Quartz	37.40	40.35	34.19	44.08
Perthite	32.53	45.62	-	29.32
K-feldspar	-	-	15.21	-
Antiperthite	25.70	9.30	-	20.39
Rim Albite	2.13	0.67	-	1.51
Plagioclase	-	-	45.80	
Biotite	-	-	-	0.16
Chlorite		-	3.04	-
Epidote	0.41	0.12	-	0.22
Fluorite		0.89	1.76	
Quartz intergrowth	0.83	-	-	3.65
Carbonate	0.3	-	-	-
Vein silica	0.28	0.03	-	-
Magnetite	1.10	2.14 (0paque with silica and alteration patch)	-	0.67

Table 3. Chemical composition of Thar Basement rocks: Grey Granite (GG), Pink Granite (PG), Granodiorite (Gr), Rhyolite (Rh), Aplite (Ap) and Metamorphic rocks (Mt).

Sample Number	TP-3/ *207.1	TP-3/ 206.77	TP-3/ 206.7	TP-2/ 189.7	TP-2/ 190.92	SB-26/ 225.55	SB-11/ 245.0	TP-6/ 146.88	TP-6/ 145.69	TP-2/ 196.36	STP-6/ 111.14	TP-14/279.27
Rock type	GG	GG	GG	PG	PG	PG	PG	Gr	Gr	Rh	Ap	Mt
Wt percent												
SiO_2	71.88	71.80	70.58	66.92	68.85	71.48	58.30	71.84	70.74	70.64	68.92	56.15
Al_2O_3	16.73	18.42	16.35	18.23	17.02	17.15	24.58	17.15	17.71	18.85	18.36	18.80
Fe2O3	0.62	2.56	1.61	1.71	2.93	1.04	2.00	1.04	0.49	1.74	2.48	1.98
FeO	1.58	0.14	1.29	1.58	0.07	0.39	1.72	0.39	0.21	0.21	0.32	5.52
CaO	0.84	BDL	BDL	1.68	0.84	2.38	3.90	2.38	BDL	0.30	1.96	8.03
MgO	0.40	0.40	0.20	0.60	0.20	BDL	0.60	BDL	2.20	0.20	BDL	3.22
Na_2O	3.59	2.02	1.85	5.00	4.95	4.51	5.96	4.51	4.82	5.22	3.22	3.88
K_2O	3.12	3.20	4.20	3.22	3.50	2.40	0.99	2.40	1.81	1.30	3.12	0.60
MnO_2	0.56	0.10	0.31	0.95	0.31	0.49	1.20	0.49	0.66	0.12	0.65	1.42
TiO_2	0.24	0.12	0.20	0.32	0.09	0.20	0.58	0.02	0.11	0.06	0.22	0.30
P_2O_5	0.07	0.05	0.06	0.08	0.24	0.04	0.35	0.04	0.03	0.21	0.05	0.10
H_2O+	0.65	1.10	3.24	0.56	1.20	0.39	1.60	0.39	0.70	1.20	1.24	1.20
H_20-	0.40	1.20	0.40	0.30	0.30	0.12	0.30	0.12	0.20	0.02	0.20	0.90
ppm												
Pb	5	5	5	6	6	4	7	4	6	6	7	7
Cr	1050	425	900	825	1020	750	750	750	1150	790	1120	390
Ni	395	450	525	375	475	335	560	335	450	470	500	620
Co	390	385	590	310	420	375	480	375	460	460	530	625
Li	2	9	6	6	4	2	3	2	6	5	2	3

*Depth in meters

- **Pink Granite**

Pink granites were encountered in TP-2, SB-11, and SB-26.

The texture of the rocks is in general medium to coarse grained, interlocked and hypidiomorphic granitic. However, the rock sample of SB 11/245M has hybridized texture i.e. it is partly coarse-grained hypidiomorphic granular and in part fine to coarse-grained inequigranular seriate texture. The sample of SB-26 shows moderate to intense fracturing and breaking of grains alongwith silicification (Plate l A). The major minerals are perthites, quartz and antiperthites, with minor ferromagnesians. Quartz is present both as mono- and polycrystalline crystals showing undulatory extinction (Plate l B). The secondary quartz as fine aggregates is common along weak zones. Perthites are predominantly string type. At some places microperthite are also present. The K-feldspar is either dominantly microcline (Plate II a) with subordinate orthoclase (in TP-2) or it is only orthoclase (in SB-11). Graphic growths are occasionally observed. Perthites are weakly to moderately alter to clay. Silicification is present along fractures (Plate ll. B). Antiperthites are characterized by the chequer board albite twinning, however the plagioclase shows combined albite carlsbad twinning (Plate IlI A). The graphic growths are rarely observed. The grains are weakly altered to sericite along core. At the contact of antiperthite and perthite double rows rims of albite (Plate II B) as well as continuous rims of albite are present. Ferromagnesian mineral of primary nature is not common but locally olive green primary hornblende with partial alteration into biotite and sieved quartz is present as minor constituent not more than 5 % in SB-11 (Plate III B) In other samples (TP-2 and SB-26) fine aggregates of biotite, chlorite, epidote magnetite and rutile present as concentrational patches (Plate IV A) which are possibly after some ferromagnesian minerals, however, no relict textures were noted. Secondary epidote is locally present as fracture filling. Interstitial grains of light green fluorite are the rare constituent observed only in SB-26 (Plate I A). The fine euhedral zircon grains are rarely present as accessory mineral. Magnetite subhedral fine disseminations are rarely present.

- **Grey Granite**

There is no significant textural and mineralogical difference from the Pink Granite above defined. This rock is encountered in TP-3. The rock is grey, fresh, interlocked, coarse-grained hypidiomorphic granular and medium grained. The minerals it consists of are quartz, perthite, and antiperthite with minor ferromagnesians. The quartz is common as interlocked grains with undulatory extinction. Secondary quartz as veins/fracture fillings is also present. Perthites: They are predominantly of string type. The K. feldspar is microcline (Plate IV B) subordinating by orthoclase (Plate V A). Silicification as fine aggregates is common along weak zones. Antiperthites: chequer board albite twinning marks the antiperthitic growth. The plagioclase is distinctly twinned (combined albite carlsbad). At the rims of the grains double rows of albite are present. The graphic intergrowth with quartz is rare. The grains are weakly altered to sericite. Iron stains are observed at some places. Fine aggregates of magnetite, carbonates, quartz, & epidote are present as irregular patches likely to be an alteration product of some ferromagnesian mineral, however no relict present. Fine euhedral grains of zircon are present as accessory constituent. Secondary epidote is locally present along weak zones.

- **Granodiorite**

The granodiorite was encountered in TP-6 (Fig. 3). The rock is dark yellowish orange, fine to medium hypidiomorphic. The rock is dominantly composed of quartz, plagioclase, K-feldspar and minor ferromagnesian. Quartz: It is present as interlocked grains with symmetrical extinction. Plagioclase is commonly present with distinct combined albite carlsbad twinning. Myrmekitic intergrowth is occasionally present on the boundaries of the grains. It is weakly to moderately altered to sericite, chlorite & epidote (Plate V B). Perthites are dominantly of string type with flame perthites at places. K. feldspar is orthoclase. Ferromagnesians are present as fine aggregates of biotite, chlorite, epidote, magnetite & quartz (Plate VI A) with pseudomorph after hornblende. Fluorite colourless grains are rarely present (Plate VI A).

Table 4. CIPW Norms of Pink & Grey granites from Thar Basement

Minerals	Grey Granite		Pink Granite	
	Range	Aver. n*=3	Range	Aver. n=4
Qtz	35.57-47.89	42.44	11.7-45.99	25.86
An	0-3.74	1.24	2.62-17.43	10.53
Ab	16.37-30.48	21.43	5.96-42.26	24.43
Or	18.58-26.04	21.26	19.07-51.37	27.88
C	6.10-11.7	9.02	3.64-8.72	6.04
Hm	0-2.17	0.72	0-2.15	0.78
Mt	0.61-0.92	0.81	1.17-2.96	2.16
Ill	0.11-0.20	0.16	0.02-0.50	0.28
Ap	0-0.16	0.05	0.19-0.85	0.47
Hy	0-4.27	1.76	0-4.07	1.42
En	0-1.01	0.34	0-0.51	0.13
Fs				

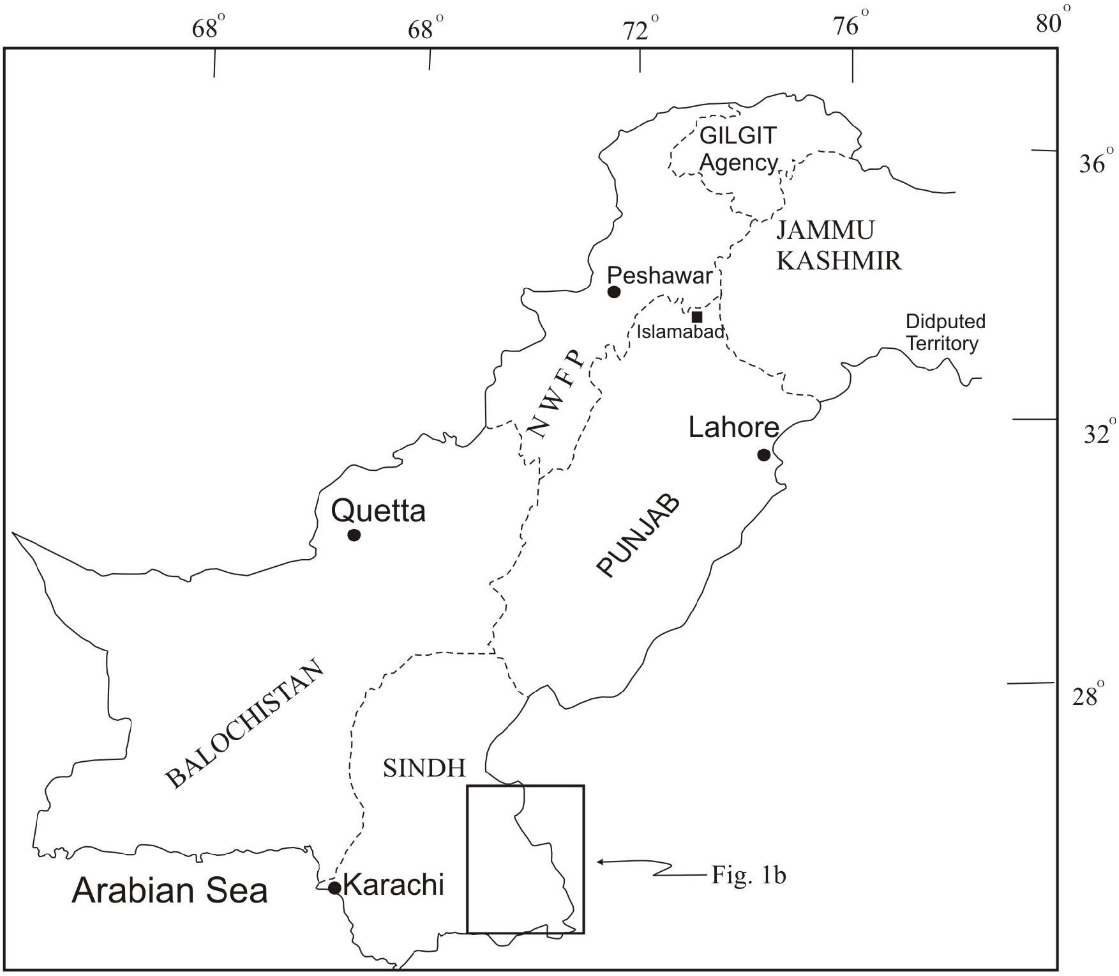


Fig. 1a. Location map of study area

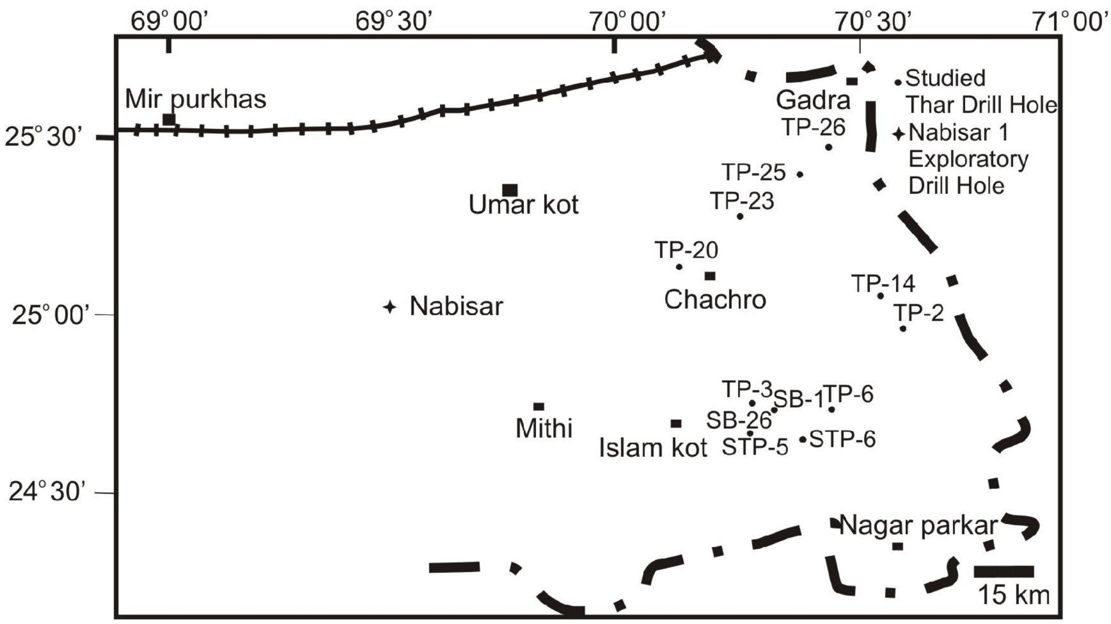


Fig. 1b. Location of reference and studied bore holes

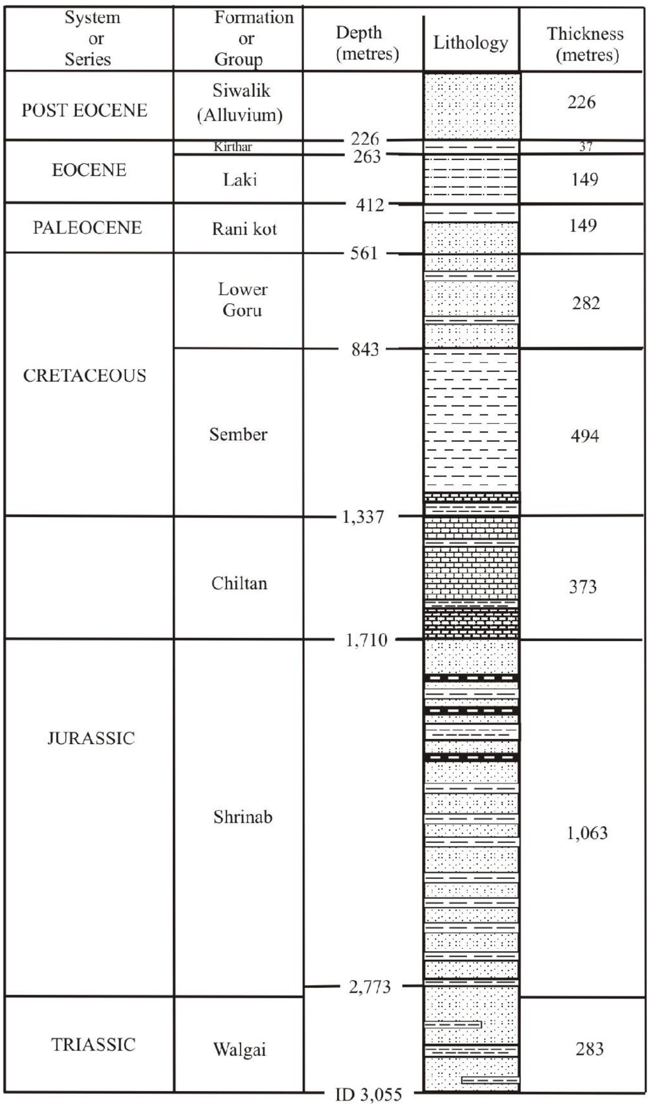


Fig. 2a. Stratigraphic column at Nabisar 1 Oil and Gas test hole. Source U. S. Geological Survey, Open file report, 1984.

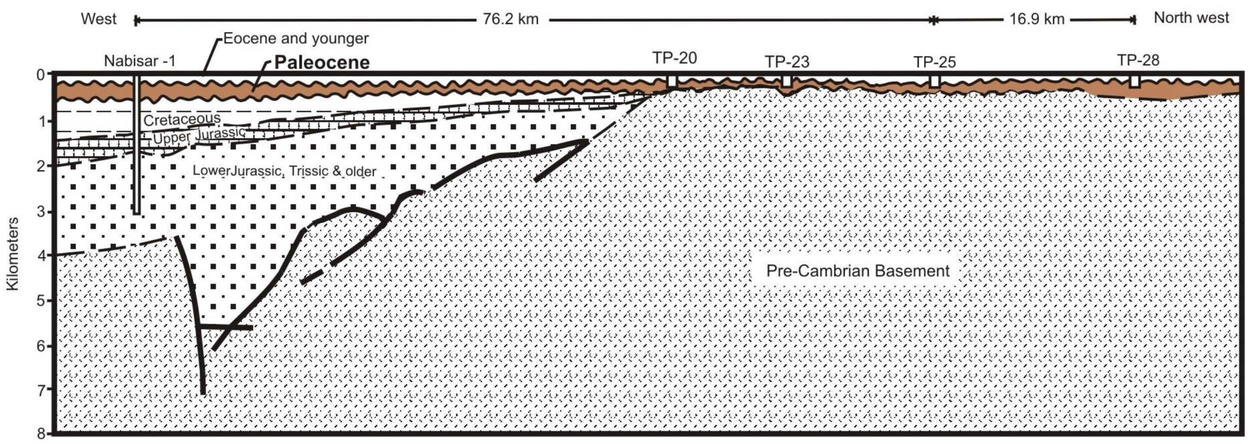


Fig. 2b. Schematic Diagram for Thar Basin: Paleocene rocks (coal bearing) directly overlies on basement rocks, Control established from Nabisar-1, T_p-20, T_p-23, T_p-25 & T_p-28 drill holes. (modified after U. S. Geological Survey, open file report 94-167, 1994)

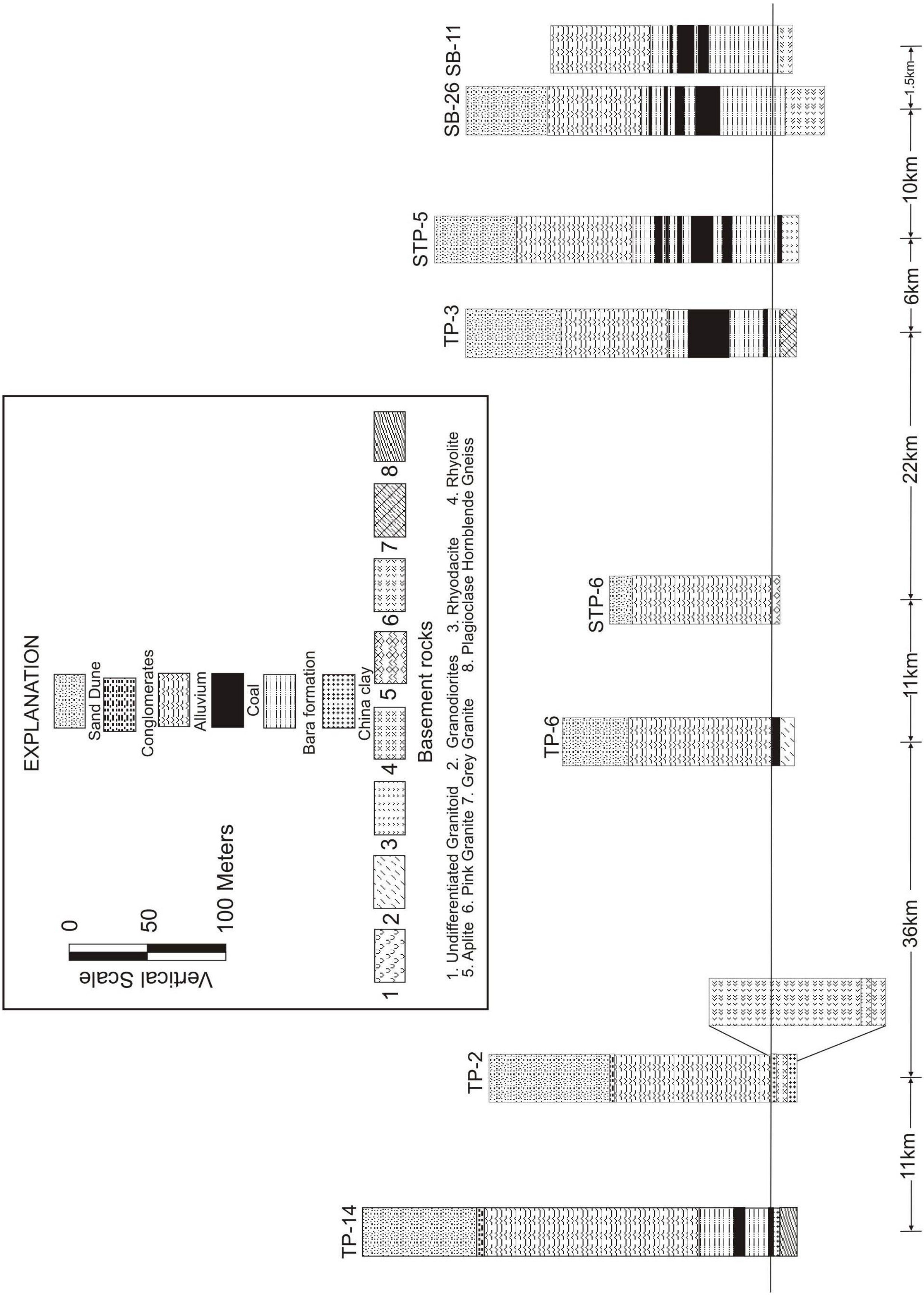


Fig. 3. Correlation diagram of Basement rocks based on petrographic studies.

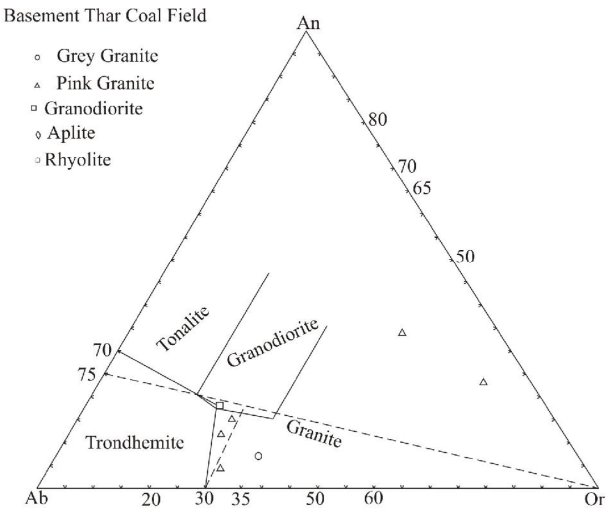


Fig. 4. The classification of granitic rocks according to their molecular normative AN-AB or composition after Baker (1979), The original field of Conner (1965) are shown by broken line.

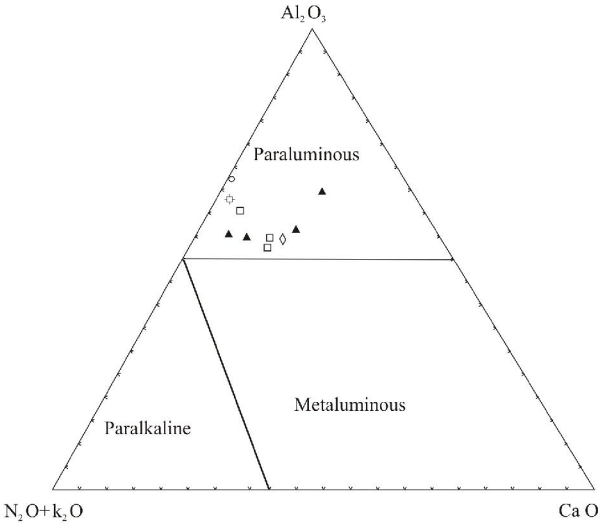


Fig. 5. Molar plots of Thar granitoid on ternary system after Power, 1983.

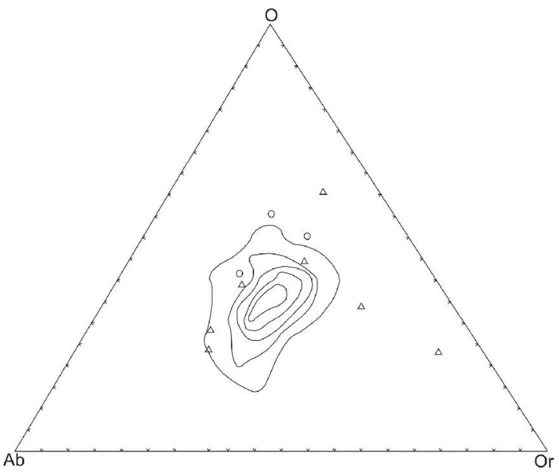


Fig. 6. The distribution of Normative Quartz, Albite and Orthoclase in Plutonic Rocks after Brown & Tuttle (1958).

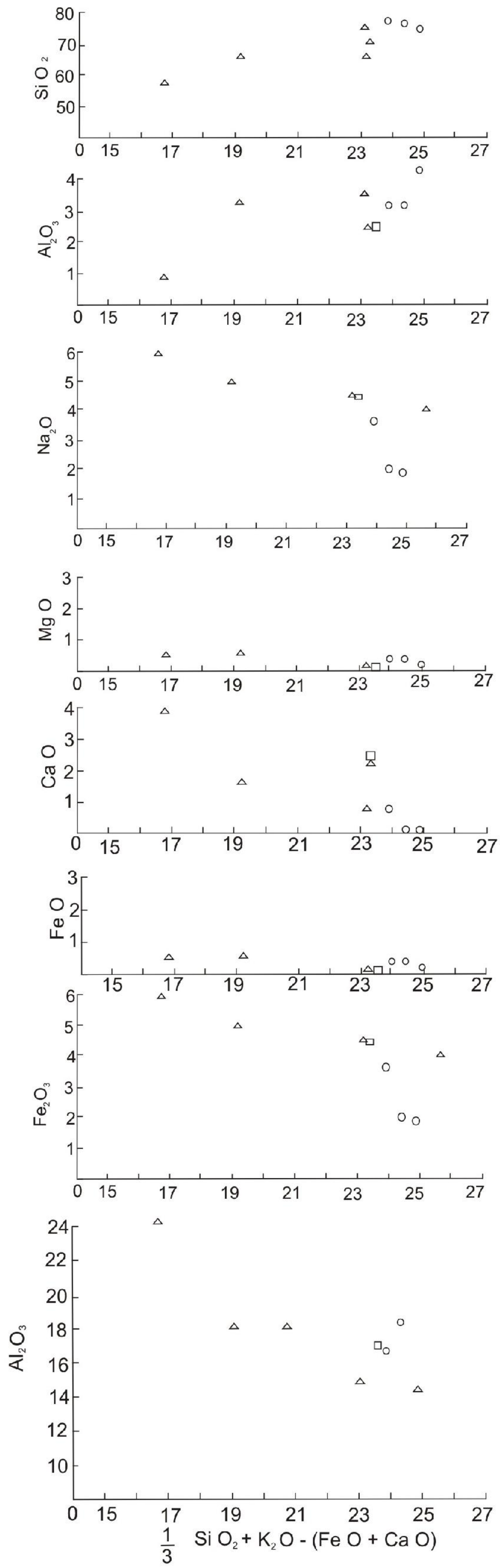
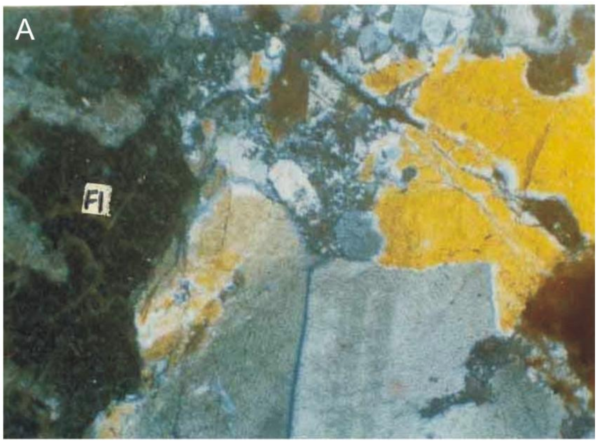


Fig. 7. Larsen (1938) type Oxide variation diagram for analyzed rocks.

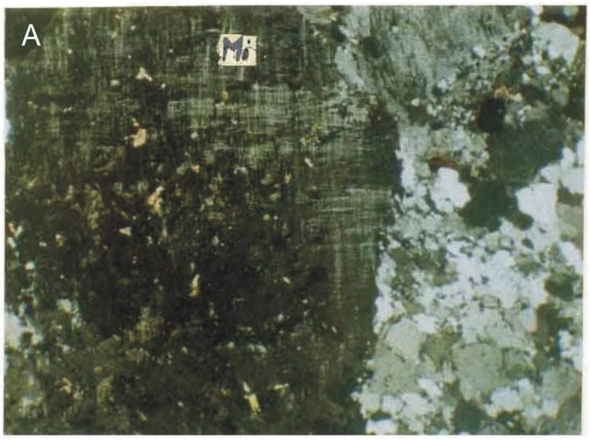
Plate I



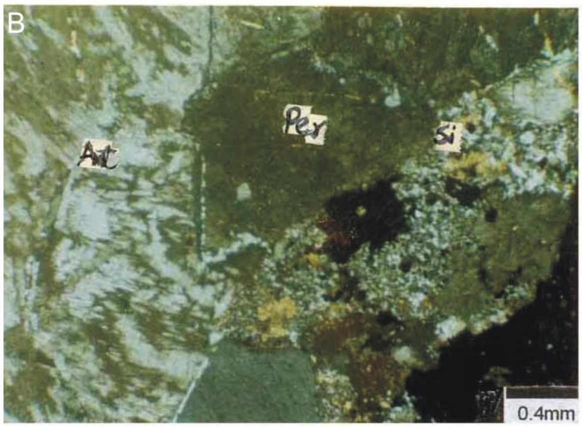
A. The photographs shows the obliterated/deformed texture. The isotropic grain of Fluorite (Fl) is seen on left side of photograph. Thar Drill Hole SB-26, depth 225.55M. Pol.Lt. Bar scale.

B. The photograph shows fractured strained coarse Quartz grain. The fine grained secondary Quartz (Qt) is present along fractures. Thar Drill hole TP-2, Depth 190.92. Pol. Lt. Bar scale.

Plate II

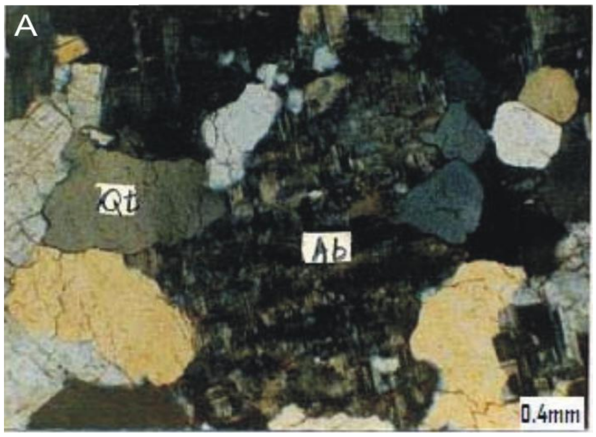


A. The photographs shows perthite (Per) and Antiperthite (Ant) with double rows of Albite rims optically continuous with opposite grains (Qt) in the core. Thar drill hole Tp-2, Depth-195.86M.Pol.Lt.

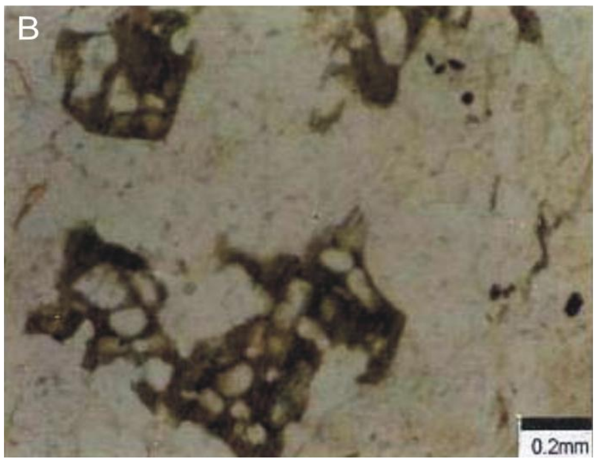


B. The photograph shows Perthite (Per) and Antiperthites (Ant) with double rows of Albite rims optically continous with opposite grains. Note the secondary silicification patch (si) with opaque, carbonates and Rutile. Drill Hole T_p-2, Depth 189.70M. Pol. Lt.

Plate III

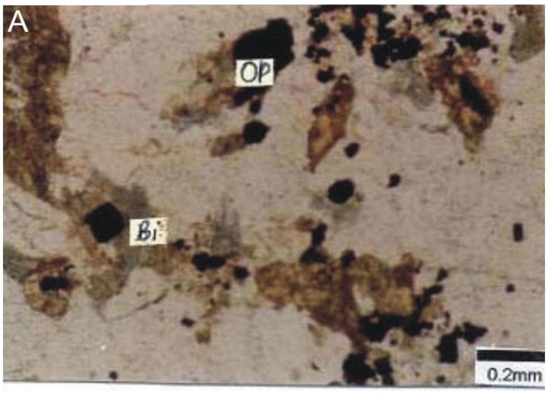


A. The photograph shows the antiperthitic growth with typical chequer board Albite twinning (Ab). The interlocked grains of Quartz (Qt) is also seen on the right side of photograph. Thar drill hole SB-11, Depth-245M. Pol.Lt.

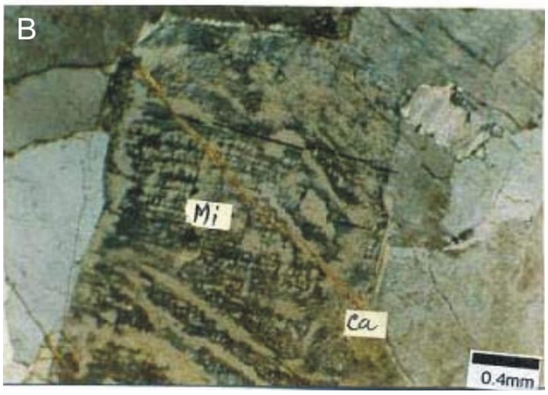


B. The photograph shows the tabular grains of Biotite commonly sieved by Quartz. Thar Drill Hole SB-11 Depth-245M, crossed nicols.

Plate IV

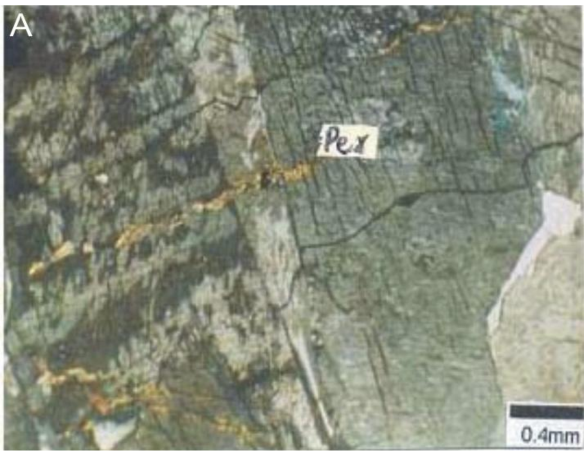


A. The photograph shows coarse tabular grain of Microcline Perthite with cross hatched twinning (Mi). The grains are commonly fractured. The carbonates veinlets (ca) are also visible. Thar Drill hole TP-3. Depth 205.17 to 207.11M Pol. Lt.

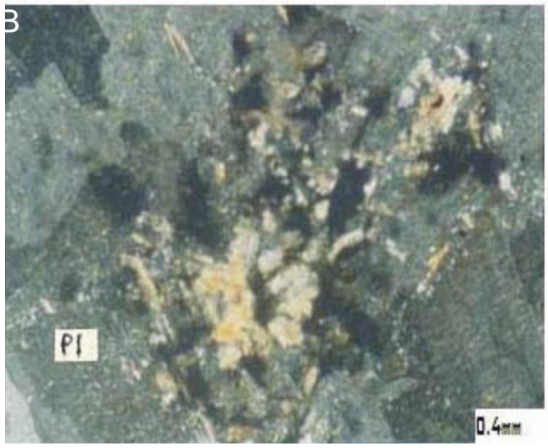


B. The photograph shows coarse tabular grain of Microcline Perthite with cross hatched twinning (Mi). The grains are commonly fractured. The carbonates veinlets (ca) are also visible. Thar Drill hole TP-3. Depth 205.17 to 207.11M Pol. Lt.

Plate V

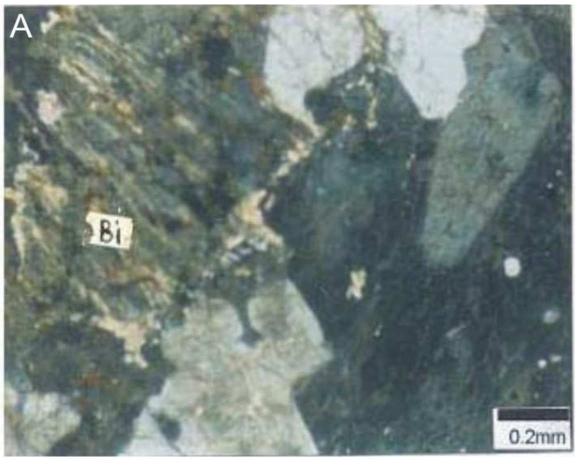


A. The photograph shows coarse grained lath shaped Orthoclase (Or) withperthitic growth (per). The carbonatesare visible as fracture filling. Thar Drill Hole TP-3. Depth 205.17 to 207.11M Pol. Lt.

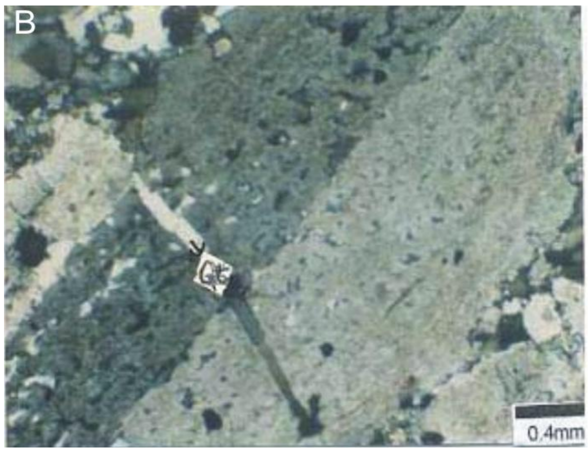


B. The photograph shows the alteration of Plagioclase (Pl) into sericite, Chlorite & Epidote. Thar Drill hole TP-6. Depth 146M pol.Lt.

Plate VI

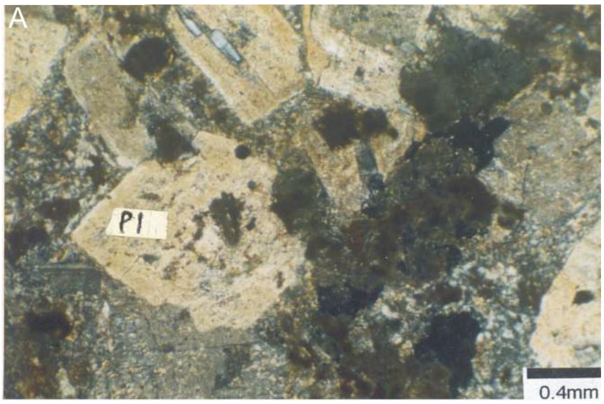


A. The photograph shows Biotite (Bi) with partial alteration into chlorite. The isotropic grain of Flourite (Fl) is also visible. Thar Drill hole TP-6. Depth 146.88M Pol.Lt.

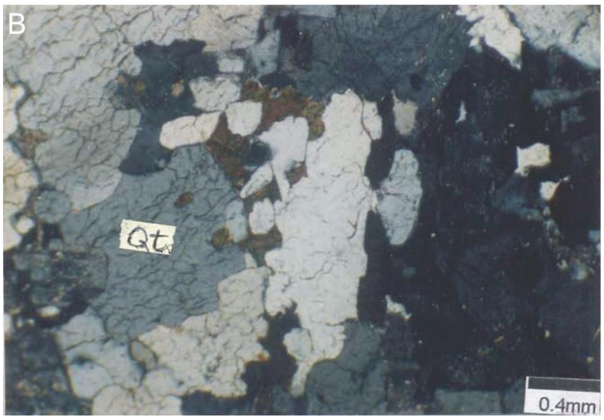


B. The photograph shows the phenocryst of plagioclase with the graphic intergrowth. The boundaries corroded by groundmass are also seen. The veinlets of Quartz (Qt) is visible. Thar Drill Hole TP-2. Depth 196.42M Pol. Lt.

Plate VII



A. The photograph shows the glomeroporphyritic texture in which phenocysts are clustered. The glomerocrysts seen in the photograph are of Plagioclase (Pl). Thar Drill Hole STP-5 Depth 230.91M. Pol. Lt.



B. The photograph shows the aplitic mixture of Perthites, Antiperthites, Quartz and Biotite. Fine fractures in Quartz (Qt) are also visible in the photograph. Thar Drill hole STP-6. Depth 111.14M. Pol. Lt.

- **Rhyolite:**

Rhyolite was encountered in TP-2 as dykes within the Pink Granite (Fig. 3).
The texture of the rock is medium to fine grained porphyritic.
Quartz, microcline and plagioclase are present as phenocrysts. Quartz with undulatory extinction is commonly present as clusters. Microcline is present with typical cross-hatched twinning. Its boundaries are commonly corroded by groundmass. Graphic intergrowths are common (Plate VI B). Plagioclase occurs commonly with distinct combined albite carlsbad and rarely pericline twinning. The grain boundaries are mostly corroded by groundmass. The plagioclase is weakly altered to sericite.

Groundmass: It is fine grained granular aggregates mainly consists of quartz, plagioclase, biotite with partial alteration to chlorite, silica and opaque grains Rutile with partial alteration to leucoxene are present as accessory mineral.

- **Rhyodacite:**

Rhyodacite was encountered in STP-5 (Fig.3). The rocks are partially to completely altered, The alteration is more intense in the upper part with its textures completely obliterated. The samples from lower unaltered part exhibit glomeroporphyritic texture (Plate VII A).

The glomerocrysts are medium to coarse-grained quartz and plagioclase. The quartz grains are relatively coarser than plagioclase and are deeply embayed in ground mass. Plagioclase is tabular and lath shaped, well twinned, zoned and partly altered to sericite (Plate VII A).

The groundmass is partly glassy showing fluidal texture and partly fine aggregates of quartz and sericite. Irregular smoky grains of leucoxene are present in dissemination.

- **Aplite:**

Aplite was encountered in drill hole STP-6 (Fig. 3).
The rock is brownish pink, medium grained allotriomorphic granular (Plate.Vllb).
The mineral constituents are quartz, perthite, antiperthite and minor ferromagnesian.
Quartz grains show fine network of fractures (Plate VII B) and its grains are commonly present as clusters.
The perthite is of string type. The K. feldspar is orthoclase. Locally blebs of quartz are present in perthite. The perthite grains are weakly sericitized.
The antiperthites are present with chequer board albite twinning. The plagioclase is distinctly twinned (combined albite carlsbad twinning & rarely pericline).
At the contact of perthites and antiperthites single and double rows of Albite are present optically continuous to the plagioclase.
Biotite is present as aggregates of fine flakes, suspected to be secondary after some ferromagnesian minerals. It is strongly pleochroic from straw yellow to brown (Plate Vll B).
Fine grained epidote as aggregates are the minor constituent.
Magnetite as fine disseminations and clusters is the common accessory mineral.

- **Plagioclase Hornblende Gneiss:**

Plagioclase Hornblende Gneiss was encountered in TP-14 (Fig. 3).
It is medium grained, banded with nematoblastic texture.
The mineral constituents are plagioclase, K. feldspar, quartz and hornblende. Plagioclase is tabular with

indistinct twinning and is moderately to strongly altered into sericite.
K feldspar is fine grained, irregular in shape and untwined. Dense graphic growth is common.
Quartz: It occurs as concentration patches of fine grains. At places it shows wavy extinction.
Hornblende occurs as nematoblast arranged in branching needles, strongly pleochroic from yellow green to dark green. It is weakly altered to epidote and moderately to biotite & chlorite.
Magnetite as euhedral to subhedral fine grains is common as disseminations.

7. Geochemistry

Following detailed petrography of core samples of Thar Granitoids selected samples were analyzed (wet chemistry) for major elements. SiO_2 was determined gravimetrically, Al_2O_3 by difference i.e., R_2O_3 (Fe_2O_3+ TiO_2) , Fe_2O_3(total), , P_2O_5, TiO_2 by calorimetric method, CaO & MgO by titration of EDTA, Na_2O, K_2O, FeO and MnO_2 by atomic absorption spectrophotometer, H_2O- was estimated by drying the rock powder at 105^o C and ignition loss was measured at 900^oC.

Analytical results of Thar Granitoids are shown in Table 3 CIPW norms have been calculated and are given in the Table 4.

The differentiation Indices (Thornton and Tuttle, 1960) of Thar Granitoids, Alkali Feldspar Granites range from73.52 to 88.69, Granodiorite from 82.87 to 83.99 showing the compositions are well evolved. The chemical data of the Thar Granitoids is used to plot binary and ternary diagrams. All the diagrams show the close clustering. The plots of molecular normative An - Ab - Or composition (after Barker, 1979) in Fig. 4 shows that the Tp - 2 & Tp-3 are in the field of granites and the rocks of Tp-6 fall in the field of granodiorite. These are compatible to the petrography of the samples. The molar plot in the ternary system Al_2O_3 - (Na_2O + K_2O) - CaO (Fig. 5) is showing peraluminous character of the suites.

The plots of normative percentages of quartz - orthoclase - albite of Thar Granitoids (both pink & grey) (Fig. 6) in triangular diagram after Tuttle & Bowen 1958 restricted to the region of psuedoternary minimum at a moderate water pressure.

The plots of Larsen index (1/3 SiO_2 + K_2O - (FeO + MgO + CaO) versus major oxides of Thar Granitoids are presented in Fig.7. It show the positive relationship, with SiO_2 while other oxides Al_2O_3, Fe_2O_3, FeO, CaO, Na_2O & K_2O show inverse relationship, however, the rocks of the suites show close clustering due to more or less similar compositions.

8. Conclusions

The basement rocks encountered in exploratory bore holes drilled for exploration and evaluation of coal deposits in Thar Parkar district, Sindh, Pakistan have formed the basis of this project. The present report is of preliminary nature based on petrological studies of selective samples from eight bore holes of Thar coal basin. The rocks identified are Alkali Feldspar Granite, Granodiorite, Rhyolite, Rhyodacite, Aplite, and Plagioclase Hornblende Gneiss described as Thar Granitoids. The classification of granitic rocks according to their molecular normative An -Ab -Or composition after Barker (1979) is plotted in Fig.4. It shows that the Alkali Feldspar Granites and Granodiorite fall in their respective fields which support our petrographic studies.

The mineralogical data shows that feldspars are exsolved and present in the form of perthites and antiperthitic growths. The presence of one feldspar (perthite or exsolution) shows that the granites are hypersolvus. The C.I.P.W norms calculated on the basis of chemical composition of Thar Granitoids yield normative corundum indicating their peraluminous in character. This is confirmed by molar plot in the ternary system Al_2O_3 -(N_2O + K_2O) -CaO (Fig.5)
The normative percentages of quartz -orthoclase -albite of Thar Granitoids plotted in triangular diagram (Tuttle & Bowen, 1958) (Fig.6) are restricted to the region of psuedoternary minimum at moderate water pressures except the samples from the contacts and altered ones.
The Larsen Index versus major oxides is plotted in Larsen variation diagram (Fig. 7). It shows the positive correlation with SiO_2 and inverse relation with Al_2O_3, FeO, Fe_2O_3, CaO, Na_2O, and K_2O.

The mineralogical and chemical data and its interpretations on the basis of various binary and ternary phase diagrams suggest that the Thar Granitoids are magmatic rocks of peraluminous nature.

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