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Geology And Geochemistry of Pohara- Gadpendhri Sillimanite and Pyrophyllite Deposit With Special Reference to the Concentration on Major Indusrtial Minerals

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Abstract

The area under investigation is exclusively metamorphic terrain. Main rock types exposed in the area are schist, phyllite, Quartzite's, Sillimanite, Pyrophyllite, Corundum. Theserock types belong to Sakoli Group. The ore body trends NNE - SSW and has steep dip varying from 60^0 to 70^0 towards West. Corundum is sporadically associated with sillimanite and the both are encased with Pyrophyllite in the form of isolated lensoid bodies.

Petrological studies of the different litho units reveal that area under investigation comprising mainly, Corundum, Sillimanite schist, Pyrophyllite schist, Quartzite-tourmaline schist.Major oxide chemistry of the host rocks highlighted that concentration of alumina increases with decreasing behavior of silica which ranges from approximately 20% - 80%. The area whereas silica 2% - 80%. Nearly all the litho-units in the area shows high concentration of alumina and silica which ranges from 16.20% -92.16 % and silica ranges from 1.93% to 76.0%. These are showing negative trend in sillimanite schist. The bivarient plot of SiO_2 versus K_2O for Pyrophyllite schist indicates negative correlation which concludes that alteration effect. Approximate content in the Sillimanite, Pyrophyllite schist and corundum is 0.6%, 0.35% and 0.24% respectively. The area is highly metamorphosed and slightly tectonically disturbed.

Key words: Sakoli Group, Pyrophyllite, Corundum, Metamorphic, Lensoid, Sillimanite Schist.

Introduction

Study area belongs to the Sakoli Group of Precambrian age having five litho units which are well exposed around the Pohra, Gadpendhri villages which includes mainly Quartzite, Quartz mica schist, Sillimanite schist, Sericites schist, pyrophyllite-Tourmaline schist and Corundum occur as a float deposit. Sillimanite and Quartzite occurs as a lensoid bodies. Economically it is the richest area for sillimanite. Corundum and pyrophyllite occur in fair amount approximately seven mining operation presently getting production of Sillimanite Kyanite, Pyrophyllite, and Quartzite like Pohra-Sillimanite Mine Gadpendhri East and West Sillimanite Pyrophyllite Mines, Kaneri pyrophyllite Mine Mendha Quartzite Mine, Powri Kyanite Girola kyanite Mine.

The study area situated around Pohra and Gadpendhri village, Lakhni Tehsil of Bhandara district of Maharashtra covering latitude $21^0 2' 0''$ and longitude $79^0 51' 0''$ and it is situated in survey of India. Toposheet No. 55 O/16. The nearest railway station is Bhandara Road which is approximately 35 km from the study area. The nearest airport at Nagpur is located at a distance of 98km from the area. The Sakoli Group of rocks was first mapped by Bhattacharjee[2] established stratigraphic succession of Sakoli Group and drew attention to triangular nature of exposers of Sakoli rocks and called it as Bhandara triangle. Bandopadhya B. K and Roy, A.[1], Roy *et al*.[6], gave a comprehensive account on geology of Sakoli fold belt Nagpur and Gadchiroli districts.Saha *et al*.[8] studied platinum group metal in Sakoli fold belt. Sarkar *et al*.[9] gave an account on Precambrian geochemistry of Nagpur-Bhandara-Durg. In few decades the work was under taken by Geological Survey of India by Bhoskar[4], Mahapatra[5], Bhoskar *et al*.[3].

Geology of the area :

Regionally the rock formation encountered to south – western part of Sakoli synclinorium constituting of Sakoli series rocks of Archean age. The area is exposed in large triangular outcrop and is also known as Bhandara Triangle. The types representing Sakoli series are phyllite, quartz-muscovite-schist, quartz – chlorite- schist, quartzite, quartz – kyanite, sillimanite – pyrophyllite – schist, amphibolites- schist.

The common rock types are phyllite, quartz-pyrophyllite-schist and quartzite. They have general strike direction is NNE-SSW and have steep dip towards west. Sillimanite-pyrophyllite is the major economic minerals formed by metamorphism of alumina rich sediments obtainable from the area. The Sakoli Group is considerable to be older than Sausar Group and younger than Amgaon Group (Fig.1). The Precambrian rocks of Sakoli Group were considered to be stratigraphic equivalent of Dharwar succession in South India, of early and middle Proterozoic age.

The area under investigation covers approximately 20sq. km of the area from Mendha-Gadpendhri through Pohra village. Litho-units have undergone intense metamorphism. The rock formations mainly comprise pyrophyllite schist, sillimanite schist, mica schist and quartzite. During the field work, six lenses of sillimanite schist have been delineated

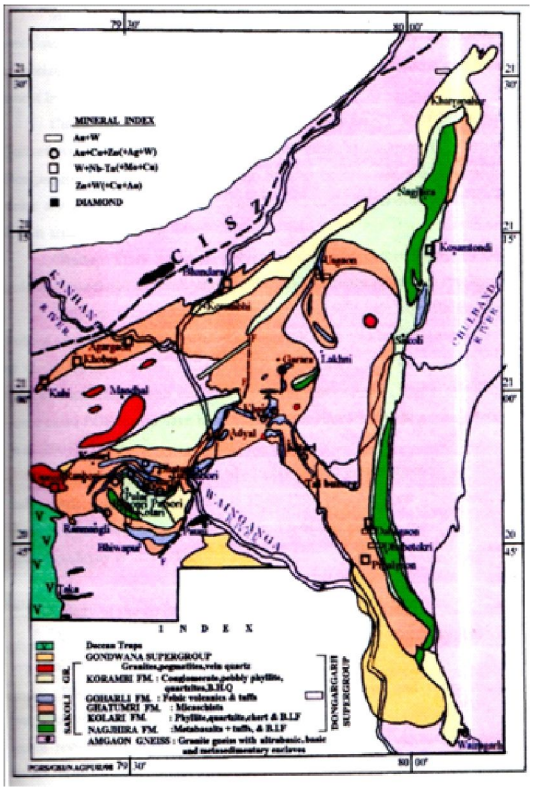

Fig.1. Geological Map of Sakoli Fold Belt

in the area. Almost vertically Pyrophyllite schist beds are mostly found at the 1km East of Pohra village in the mining quarry of MSMC. Corundum occurs as a float within both Sillimanite schist and pyrophyllite schist mineralization. The main Sillimanite schist and pyrophyllite schist bodies occur within quartzite and metasedimentary rock. Two sillimanite schist bodies occur mainly in the mining pit and Eastern and Western flank of the Gadpendhri hill. Different litho-units encountered, have been enlisted below.

Sillimanite schist :

It is generally white to grey and reddish brown in color. White color variety is massive. Fine to medium grained texture but brownish variety of Sillimanite is mostly granular. Minerlogically it consists of Sillimanite, Quartz and accessory Mica and Tourmaline. Sillimanite occurs in the form of ribbon like or fibrous aggregate of radial masses with quartz and feldspar (Fig. 2).

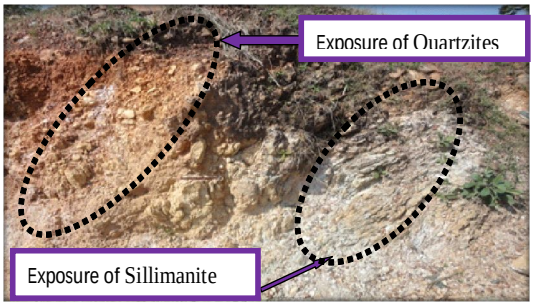

Fig.2 Location of Gadpendhri Sillimanite mine pit.

Pyrophyllite, Tourmaline mica schist :

It is dirty white in color predominantly made up of pyrophyllite and quartz. Mica, tourmaline sericite is a minor mineralogical constituent. In this litho unit pure pyrophyllite occur in bedded form. The color of pyrophyllite schist varies from whitish to greenish tint and brown is also found in some places. It is soft and low hardness. It is a translucent having vitreous to pearly luster and is very soft in nature. It is a hydrous alumino silicate and occurs as a compact aggregate.

Quartzite and Quartz mica schist :

It is a white- grayish in color. Quartz is the only main mineral constituent and mica as a accessory. Western part of Gadpendhri village is fully occupied by very big quartzite

Table. 1 The lithostratigraphical succession of Sakoli fold belt (after Roy *et al.*, 1995)

Gondwana Super Group		
Faulted contact		
Intrusive		Quartz veins, reefs and silicified zone, Alkali feldspar granite (Purkhabori granite), Pegmatite, tourmaline granite (Mandhal-Granite), Gabbro/ Dolerite (metamorphosed
	Pawni Formation	Slate, Phyllite, meta-arkose, quartzite, matrix supported conglomerate
	Bhiwapur Formation	Mainly metapelite+chloritoid andalusite garnet staurolite with inter bands of metamorphosed acid volcanic/ tuffs, minor psammites, exhalative sediments coticule, tourmaline), Banded Garnet, Amphibolites Rock (BGA), rare basic volcanic and syngenetic base metal (Zn, Cu) mineralization.
	Dhabetekri Formation	Mainly metabasalts with subordinate metapelites, chert bands and meta ultramafic rock.
	Gaikhuri Formation	Conglomerate, gritty quartzite, meta arkose, minor phyllite (at places carbonaceous) and Banded Ferruginous Quartzite (BIF)
		Tectonised Zone
Pre-Sakoli	Amgaon Gneissic Complex (AGC)	Gneisses and migmatites, granitoids, amphibolites, chromite bearing meta ultramafites and Pre-Sakoli supracrustal assemblages of high grade schist including quartzite, Kyanite and sillimanite schist, calc- silicate rocks , marble, cordierite-gedrite-anthophyllite schist, garnet- staurolite schist etc.

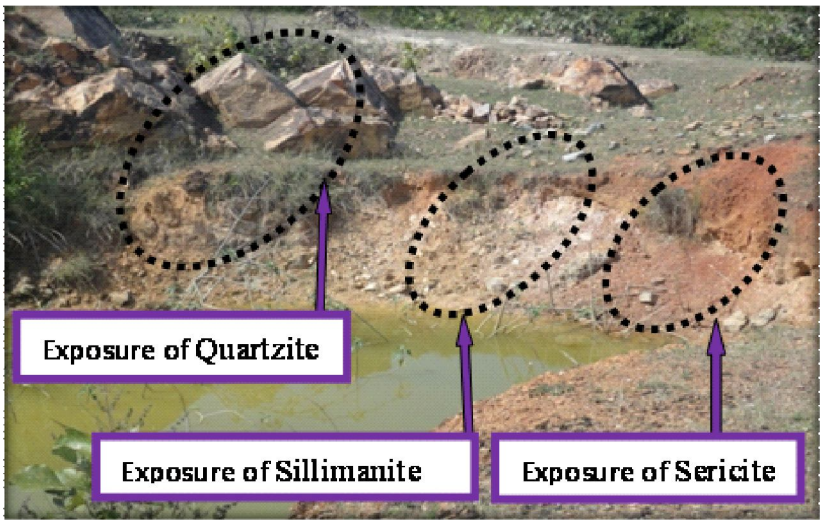

Fig. 3. Location of quartzite outcrop

hillock. In which sillimanite schist occurs as lenticular bodies (Fig. 3). Towards northern area of Gadpendhri village many quartzite outcrop are found. Foot wall and hanging wall of the Pohra sillimanite mine is made by quartz mica schist.

Corundum :

It occur as a float ore within Sillimanite schist and Pyrophyllite schist in Pohra Bodki hill mine and also found along the slopes of Gadpendhri hill (Fig.4). It mostly appears as a pyramidal crystals, commonly grayish, greenish to reddish in color. Black variety of corundum is found at western flank of Gadpendhri hill.

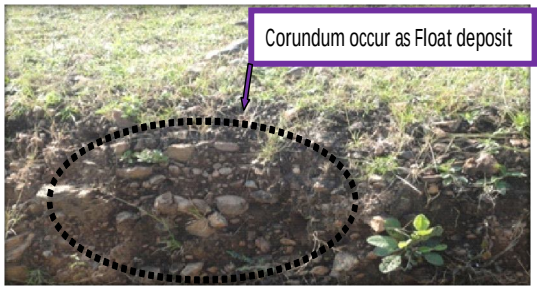

Fig. 4 Location of float ore of corundum

Petrography

Alumino silicate bearing metamorphosed zone of the Pohra and Gadpendhri area essentially consist of Quartzite, Quartz mica schist, sillimanite schist and pyrophyllite schist tourmaline mica schist.

Quartzite :

Photomicrograph of Quartzite illustrate that it is predominantly made by Quartz with very minor amount of muscovite. In plane polarized light Quartz is colorless. Crystals occur as hexagonal prism. It shows absence of cleavage. Relief is low (Fig. 5).

Sillimanite Schist :

Sillimanite schist is composed of sillimanite, quartz and mica. It shows prismatic and fibrous habit of sillimanite with parallel cleavage. Sillimanite show fairly high relief and extinction is parallel in longitudinal section and symmetrical in cross section (Fig. 6, A). Sillimanite is colorless in plane polarized light while it gives yellow-purple color in crossed nicols. In this rock sillimanite occur as coarse needles with generally parallel lineation in the plane of schistosity.

Pyrophyllite Schist :

Under plane polarized light pyrophyllite appears colorless. It has elongated habit with perfect cleavage. Pyrophyllite mineral show low-moderate relief with almost parallel extinction angle and schistosity with elongated grains of pyrophyllite(Fig.6, B). Pyrophyllite is colorless in plane polarized light and purple-yellowish color in crossed nicols.

Corundum :

Coarse to fine grain crystals of corundum with euhedral form, coarse corundum show pale yellow color in plane polarized light while dark yellow in crossed nicols (Fig. 7 C,D). The diagnostic property of corundum is shown by tabular- prismatic habit. It shows distinctly parallel cleavage with high relief. In plane polarized light corundum show good amount of Pleochroismwith fine grains of corundum (Fig.7 E, F).

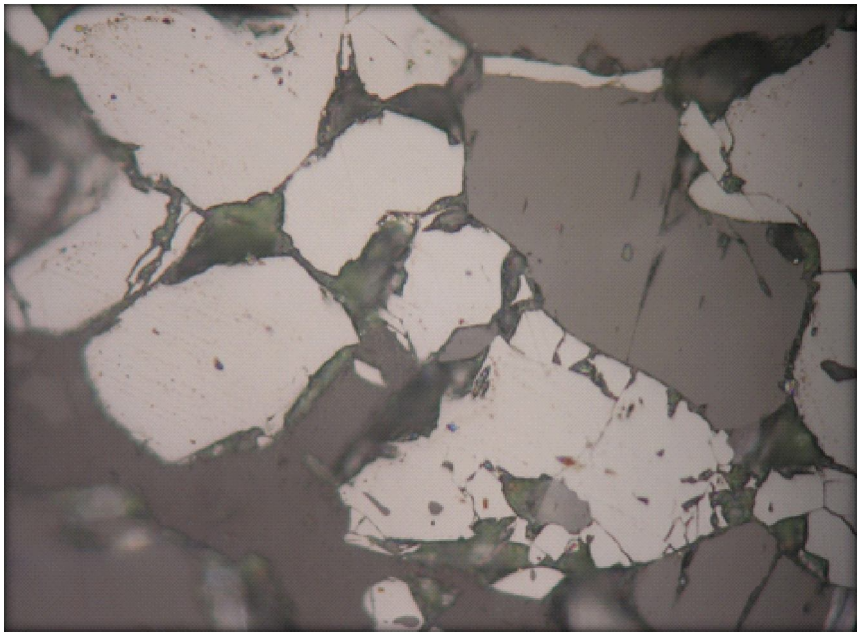

Fig. 5. Photomicrograph of Quartzite show anhedral grains of Quartz

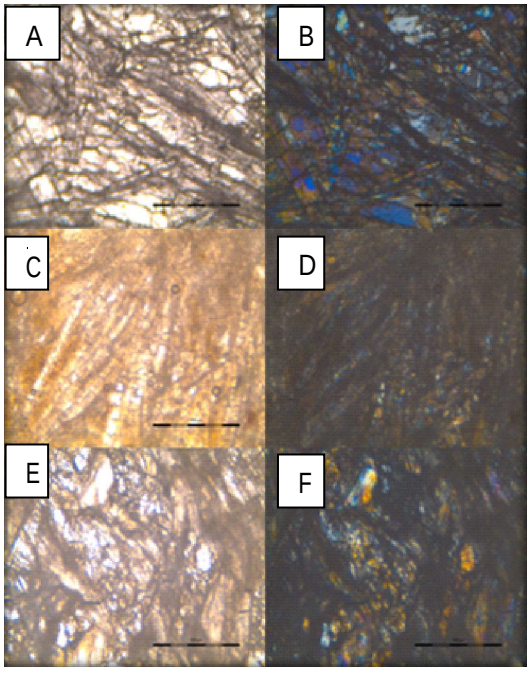

Fig.6. Showing Sillimanite schist in Plane Polarized light and crossed nicols

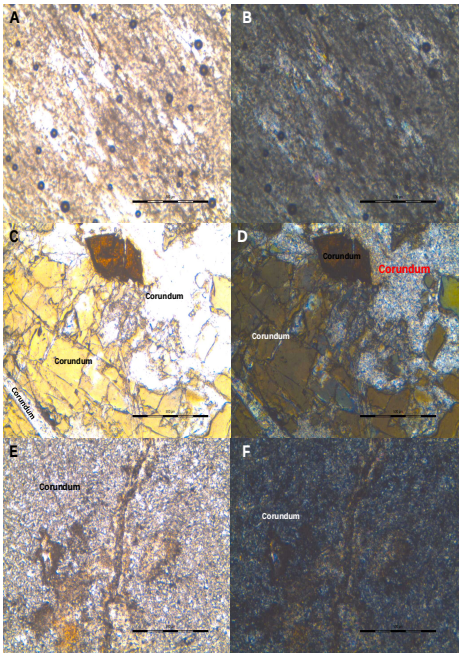

Fig.7 Shows Pyrophyllite and Corundum

Geochemistry :

Representative sample was collected from entire samples and prepared chips of one to five mm by coning and quartering method. Finally 200 mesh size powder was prepared by pulverizor. Sample pallets' were prepared for analysis by X- Ray F florescence spectrometry using baking of Boric Acid and processing it at 25tones of pressure. A hydraulic pressure was used to prepare the pallets for XRF analysis to determine major elements.

Whole rock geochemical analysis for the major element were determined by florescence spectrometry (XRF) using Philips MAGIX PRO (model PW 2440) fully automatic micro processor controlled at Indian Bureau of Mines, Nagpur.

Major Oxide Chemistry :

Major oxide chemistry of the sillimanite schist, Pyrophyllite schist, and corundum around the Pohra and Gadpendhri villages are provided in the Table no.2. From the chemical data it is observed that Silica and Alumina are the major elements with minor to trace amount of Fe, Ti, Ca, and Mg. Major Oxides of sillimanite schist, Pyrophyllite schist, and corundum analyzed by XRF to determine the major elemental behavior. All the litho units in this area have high concentration of Alumina and silica which ranges from 16.20% - 92.16% and SiO_2 ranges from 1.93%– 76.02%. Harker diagram of SiO_2 Vs Al_2O_3 show negative trend in sillimanite schist, Pyrophyllite schist, and corundum also (Fig. 8). In an ideal case the alumina content in a Pyrophyllite should be 28.3% stoichiometrically. The concentration of alumina and silica indicates presence of relatively pure Quartz in the Pyrophyllite mineralized zone is evidenced for high silica activity in the fluid face during pyrophyllitisation (Sykes and Moody, 1978).

Table 2. Major Oxides of Corundum and Sillimanite and Pyrophyllite Schist by using XRF

Major Oxides	PRC-1	PBC-2	PWC-3	PGC-4	PRS-1	PBS-2	PPS-3	PWFS-4	PWGS-5	PWPS-6	PEP-1	PGRP-2	PERP-3	PEDP-4	PWP-5
SiO_2%	1.93	16.34	13.99	15.75	37.88	35.71	36.94	34.57	36.94	45.25	63.03	48.10	72.38	76.02	51.44
Al_2O_3%	92.16	73.82	79.82	73.02	47.95	57.00	55.34	49.19	47.73	40.73	25.85	35.47	17.80	16.20	36.69
TiO_2%	0.04	0.14	0.04	0.06	0.08	0.02	0.25	0.36	0.10	0.08	0.47	0.17	0.97	1.55	0.40
Na_2O%	0.16	1.06	0.21	0.21	0.58	0.19	0.76	0.16	1.55	0.33	0.61	1.65	0.59	1.83	0.80
K_2O%	0.02	0.02	0.07	0.02	0.38	0.11	1.03	0.50	1.57	0.55	0.62	7.61	3.12	0.97	1.40
MgO%	0.05	1.28	0.06	1.66	0.10	0.07	0.14	0.04	0.10	0.02	0.30	0.30	0.22	0.11	0.20
CaO%	0.12	0.52	0.19	0.11	0.37	0.87	0.14	2.14	0.34	0.22	0.14	0.57	1.25	0.91	0.25
Fe_2O_3%	1.58	3.90	1.16	1.14	1.05	1.80	0.81	0.21	0.58	0.37	1.03	0.51	0.36	0.28	0.64
Cr_2O_3%	0.08	0.05	0.09	0.06	0.04	0.02	0.02	0.01	0.01	0.01	0.03	0.01	0.03	0.02	0.04
LOI%	3.63	2.22	4.08	5.26	11.19	4.24	4.37	10.26	8.23	5.22	4.82	4.93	1.58	1.02	7.90
Total %	99.80	99.35	99.71	100.29	99.65	100.03	99.80	97.74	97.15	98.78	99.90	99.82	98.30	98.91	99.76

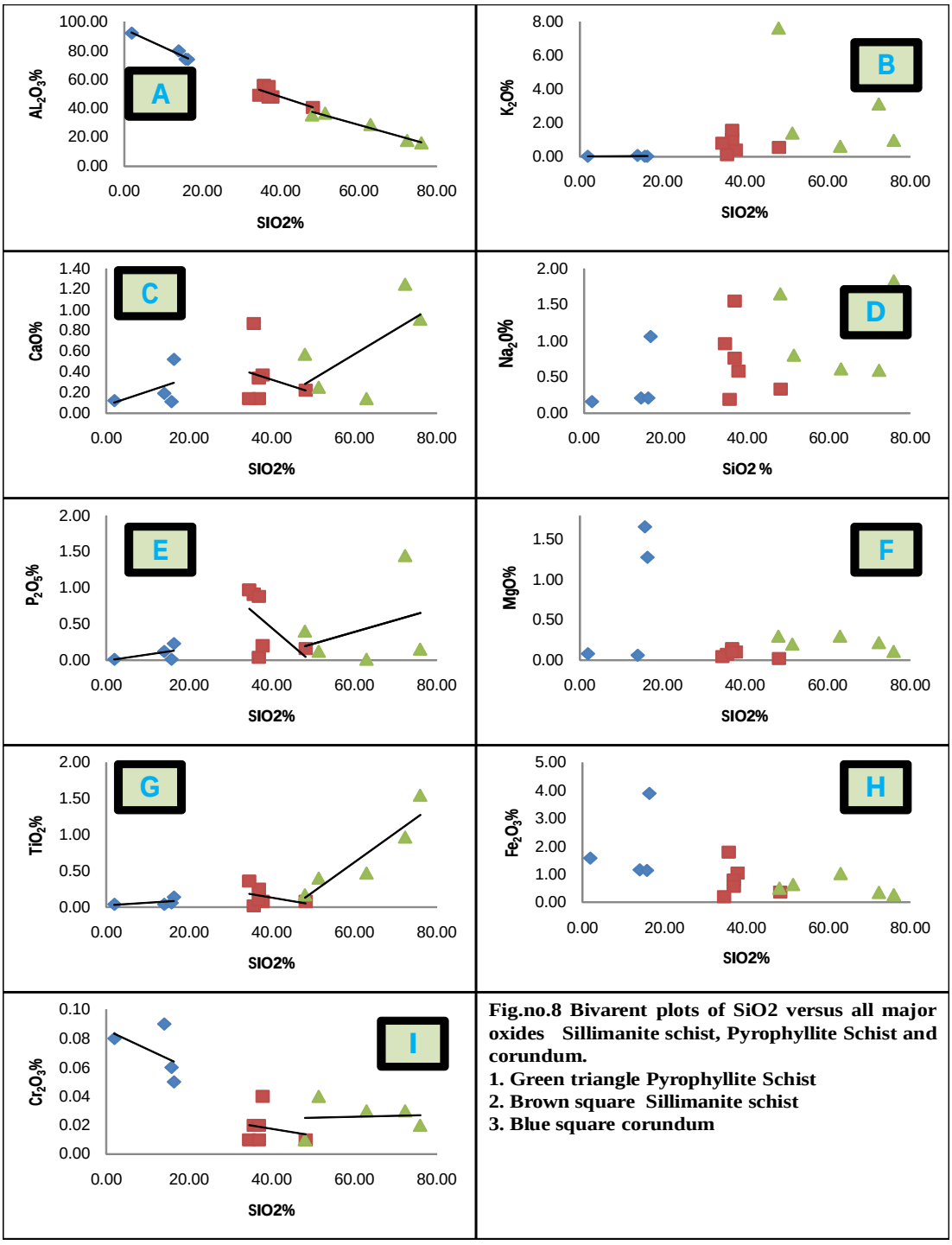

Fig.no.8 Bivarent plots of SiO2 versus all major oxides Sillimanite schist, Pyrophyllite Schist and corundum.
1. Green triangle Pyrophyllite Schist
2. Brown square Sillimanite schist
3. Blue square corundum

Bivarient plot (Fig.8, B) of SiO_2 Vs K_2O of Pyrophyllite schist indicates negative trend but do not show any relation in sillimanite and corundum. It may be due to alteration. K_2O in the Pyrophyllite schist ranges from 0.6% - 7.61% but the concentration of alkali is comparatively lesser in sillimanite schist. It varies from 0.11%- 1.57% while very negligible in corundum (Aprox. 0.03%).

Concentration of Na_2Oin corundum (0.16%-1.06%) where as in the sillimanite schist is 0.19%-1.55%and in the Pyrophyllite schist is 0.59%-1.83% shows that the concentration of Na_2O is higher than the concentration of K_2O in Pyrophyllite schist but reverse behavior is found in sillimanite schist. Nearly same concentration of Na_2O is found in the red, white and grey corundum (0.2%) but black corundum represents higher values of Na_2O(1.06%) and shows positive trend while negative trend in sillimanite schist and linear in Pyrophyllite schist (Fig.8, D).

Approximate content in the sillimanite schist, Pyrophyllite schist, and corundum is 0.6%, 0.35% and 0.24% respectively. Figure C indicates good correlation between SiO_2 and CaO in the Pyrophyllite schist, and corundum but negative relationship in the Sillimanite schist. Bivarient plot of SiO_2 Vs P_2O_5, SiO_2 Vs TiO_2, and SiO_2 Vs CaO shows identical trend in all the litho-unit. (Fig.8-C, E, G). P_2O_5 ranges from, in the Sillimanite schist (0.04%-0.97%) in Pyrophyllite schist (0.01%-1.45%) and in the corundum (0.01% - 0.23%).

TiO_2 ranges from 0.04%-1.14% in the corundum whereas 0.02%-0.36% in Sillimanite schist 0.17%-1.55% in Pyrophyllite schist.

Similar behavior between SiO_2 Vs MgO in the Pyrophyllite schist as well as in the sillimanite schist has been noticed (Fig.8, F). In which MgO content varies from 0.11%-0.3% and 0.02%-0.14% respectively. But in corundum MgO Vs SiO_2 indicates increasing trend.

The concentration of total (ferrous and ferric) in the corundum ranges from 1.14%-3.90%, 0.21%-1.08% in the sillimanite schist and 0.28%-1.03% in the Pyrophyllite schist. Behavior of Fe_2O_3Vs SiO_2 shows negative trend .Similar behavior is seen in the sillimanite as well as Pyrophyllite schist. But corundum shows positive trend.

The concentration of trace element Cr (Cr_2O_3) ranges from 0.05%-0.09%, 0.01%-0.04%and 0.01%-0.04% in the corundum, sillimanite schist, and Pyrophyllite schist respectively. It indicates almost same value in all the litho units. But show different trends (Fig.8, I).

Conclusion

Study area around Pohra-Gadpendhri forms a part of Sakoli fold belt of Bhandara district, Maharashtra. Regionally the Sakoli fold belt consists of huge volcano-sedimentary sequence, which has been subjected to different phase of deformation and regional metamorphism. Major chemistry of the rocks concludes the relationship between Sillimanite, Pyrophyllite, and Corundum with respect to silica and alumina. Nearly all the litho-units in the area shows high concentration of alumina and silica

which ranges from 16.20% -92.16 % and silica ranges from 1.93% to 76.0%. These are showing negative trend in sillimanite schist. The bivarient plot of SiO_2 versus K_2O for Pyrophyllite schist indicates negative correlation which concludes that alteration effect. Approximate content in the Sillimanite, Pyrophyllite schist and corundum is 0.6%, 0.35% and 0.24% respectively. The Harker diagram of SiO_2 versus CaO shows negative correlation which exhibits almost similar behavior during alteration and their rate of removal from the parent rock is almost in same order. Plot of SiO_2 versus P_2O_5, TiO_2 and CaO show similar trend in all the litho units. The concentration of total ferrous and ferric in the corundum ranges from 1.14% – 3.90 %.

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