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Occurrence of Phlogopite in Carbonatite and Associated Alkaline Rocks at Beldih, Purulia District, West Bengal, India.

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Abstract: *Beldih Apatite-Magnetite Mine, Situated In The South Purulia Shear Zone Is Characterised By Alkali Pyroxenite Associated With Carbonatites And Intruded Within Phyllites And Schists Of The Proterozoic Singhbhum Group Of Rocks. Mineralogically Alkali Pyroxenite Is Composed Of Augite, Aegirine Augite, Amphiboles, Phlogopitic Biotite, Calcite And Apatite As Major Constituents With Minor Amounts Of Opaque Minerals Whereas Carbonatite Is Composed Of Calcite Grains With Subordinate Amounts Of Apatite, Phlogopite, Tetra-Ferriphlogopite, Magnetite And Ilmenite. These Rocks Contain Appreciable Amounts Of Phlogopites With* Sio_2 *Ranging From 33.08-40.18 Wt%,* Al_2o_3 *From 6.84-11.41 Wt% ,* $Feo_{(Total)}$ *From 5.42-16.30 Wt%, Mgo From 14.34-21.38 Wt%,* K_2o *From 8.36-10.14 Wt%,* Na_2o *From 0.04-0.20 Wt%, Cao From 0.02-0.08 Wt%,* Tio_2 *From 0.01-0.07 Wt%, Whereas Mno, Bao And* Cr_2o_3 *Are Negligible. . The Occurrence Of These Minerals Are Considered To Be A Result Of Alkali Metasomatism (Or Phlogopitisation) Induced By The Alkali Rich Carbonatite Magma During The Process Of Its Crystallisation And Emplacement Within The Host Rocks.*

Keywords*- Alkali Pyroxenite,Carbonatites, Fenitization,South Purulia Shear Zone, Tetra-Ferriphlogopite*

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I. Introduction

The Study Area Beldih (Latitude 23°03′25″ N; Longitude 86°17′68″ E) Forms A Part Of The South Purulia Shear Zone (SPSZ) Which Trends ENE-WSW To EW To ESE –WNW And Extends From Tamar, Ranchi District Of Jharkhand In The West To Porapahar , Bankura District Of West Bengal In The East.The Shear Zone Roughly Marks The Contact Between Two Distinct And Geologically Different Domains- The Chhotanagpur Granite Gneissic Complex (CGGC) In The North And The North Singhbhum Proterozoic Mobile (NSMB)In The South. Alkaline Rocks Exposed In The Study Area Are Represented By Alkali Pyroxenite Which Are Associated With Carbonatites And Exhibit Intrusive Relationship With The Phyllites And Schists Of The Proterozoic Singhbhum Group Of Rocks. Within The Alkali Pyroxenite And The Carbonatites Of The Area Typical Occurrence Of Phlogopite And Tetra-Ferriphlogopite (Complex Hydrayed Silicates Of K, Mg And Al) Have Been Recorded. The Composition Of These Minerals Is Sensitive To Changes In Temperature, Pressure And Chemistry Of Their Crystallization Environment Which In Addition To Their Long Crystallization Span In Many Rock Types (Including Kimberlites And Carbonatites), Makes Them An Important Petrogenetic Indicator (Bagdasarov Et Al.[1],1985; Tischendorf Et Al.[2], 2001).In The Present Paper The Authors Have Dealt With The Petrography And Chemistry Of These Significant Mineral And An Attempt Has Been Made To Suggest Its Implication On The Genesis Of These Rocks.

II. Geological Setup

In The Regional Setup The Main Rock Types Exposed Along The Shear Zone (SPSZ) Include Granitoids Within The Singhbhum Group, Felsic Volcanics, Mafic-Ultramafic Suite, Metasedimentary Suite, Tourmalinite, Alkaline Suite Including Alkali Feldspar Granite And Syenite And Carbonatite And Silicified Rocks Such As Quartz Breccia And Mylonites Represented Mailly By Quartzite Mylonite (Acharyya Et Al.[3], 2006).The Nature Of The Shear Zone Has Been Described As Ductile To Brittle-Ductile (Pyne[4], 1992; Bhattacharya[5], 1989). Quartz-Apatite Rocks, Carbonatite And Syenites Are Significant Rocks Reported From Beldih Regions Along SPSZ (Baidya[6], 1992; Basu[7], 1993; Ghosh Roy And Sengupta[8], 1993; Vapnik Et Al.[9], 2007).The Study Area Comprises Of Ultramafic, Carbonatite, Metabasics, Tuffaceous Phyllites, Chlorite Mica Schist, Quartzite, Alkali Granite And Quartz-Magnetite-Apatite Rocks (Basu[7], 1993; Gupta And Basu[10], 2000; Acharyya, Et Al.[3], 2006; Vapnik , Et Al.[9], 2007;Fig.1).The Stratigraphic Sequence Of The Beldih Area Is Represented By Precambrian Rocks Which Are Mostly Ultramafic, Chlorite–Sericite Schists, Chlorite-Mica Schists, Quartzites, Alkali Granites, Amphibolites, And Chotanagpur Granite Gneisses (Acharyya Et Al.[3], 2006; Vapnik Et Al.[9], 2007).

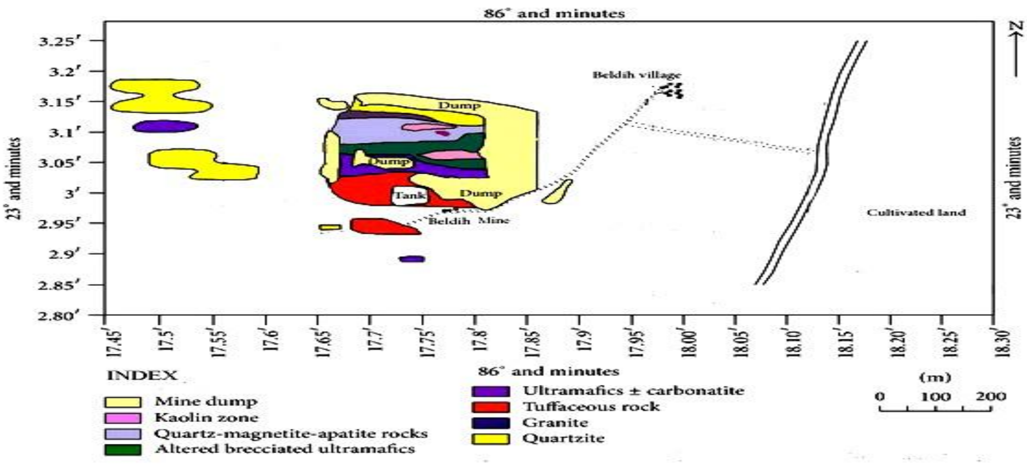

Figure 1:Geological Map Of The Study Area (Modified After V. J. Katti Et Al.[11],2010).

III. Mode Of Occurrence

The Exposures Of Carbonatite Are Found Only At Beldih.The Carbonatites Occur In The Form Of Fine Veins And Discontinuous Lenses.Carbonatites Exhibit Intrusive Relationship Into The Chlorite Phyllites Locally Grading Into Chlorite Schist Which In Turn Is Granitised To Varying Degrees. The Alkaline Rocks Exposed In The Area Are Represented By Alkali Pyroxenites Which Are Also Associated With Carbonatites. Intense Cataclasis In The Area Is Documented By Mylonitised Quartz And Quartz Breccia.

IV. Petrography

Alkali Pyroxenites (Carbonated)

Megascopically Alkali Pyroxenite Is Massive, Compact, Dark Coloured And Medium Grained Rock. In Thin Section It Is Composed Of Augite, Aegirine Augite, Amphiboles, Phlogopitic Biotite And Calcite, Apatite As Major Constituents With Minor Amounts Of Opaque Minerals.The Rock Contains Appreciable Amounts Of Phlogopite Grains Which Are Pleochroic In Shades From Pale Brownish To Pale Brownish Green And Exhibit Kinked Structure (Fig.2).

Carbonatites

Megascopically Carbonatite Is Light Coloured, Medium To Fine Grained Rock. Under The Microscope It Is Composed Of Euhedral To Subhedral Calcite Grains With Subordinate Amounts Of Apatite, Phlogopitie, Tetra-Ferriphlogopite, Magnetite And Ilmenite. Tetra-Ferriphlogopite Appears Scattered Within The Calcite Matrix. The Mineral Shows Pleochroic Shades Of Yellowish Red To Reddish Brown And The 'Reversed' Pleochroism (Fig.3) With The Scheme Of Absorption: $X > Y \geq Z$ (X= Deep Orange Red, Y = Orange Red, Z = Yellowish Red) And Very Low 2V Values Which Are The Diagnostic Of Tetra-Ferriphlogopite.

The Mineral Assemblage Seen In The Thin Section Is Supported By XRD Data Of Alkali Pyroxenite (Fig. 4a) And Carbonatite (Fig. 4b).

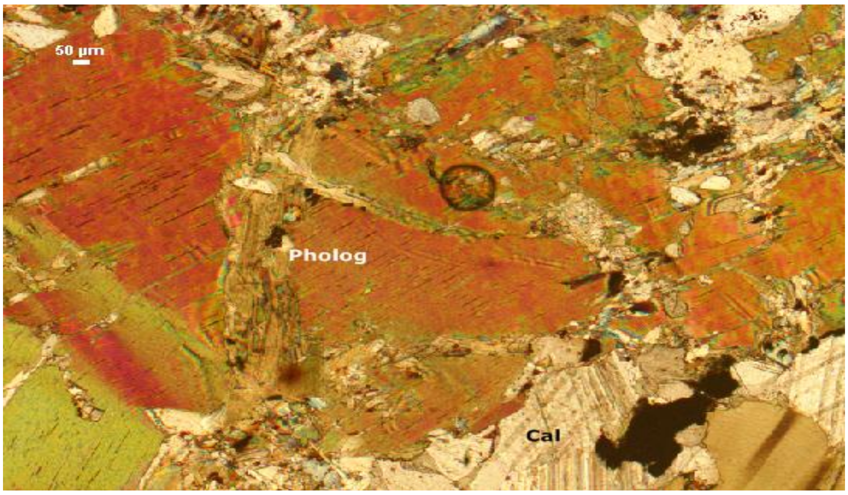

Figure 2: Photomicrograph Of Phlogopite Grain In Alkali Pyroxenite Showing Kinking.

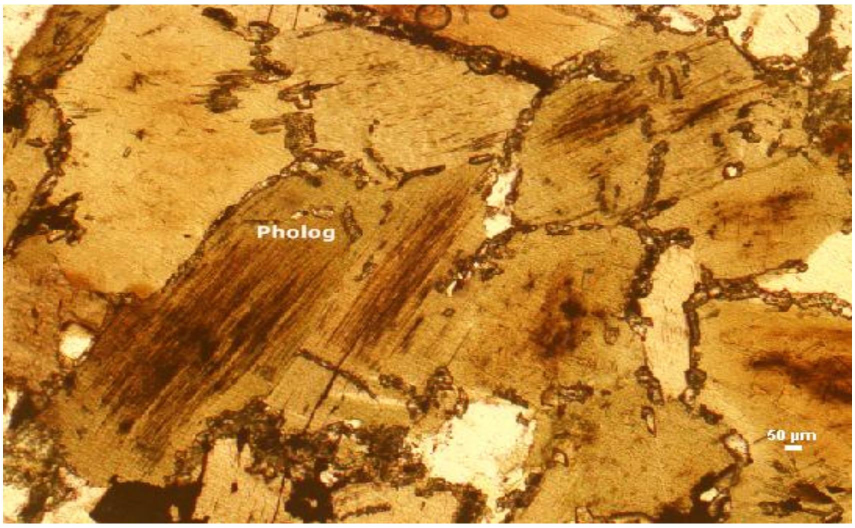

Figure 3: Photomicrograph Of Phlogopite Grain In Carbonatite Exhibiting Reverse Pleochroism As An Evidence Of Its Tetra-Ferriphlogopite Character.

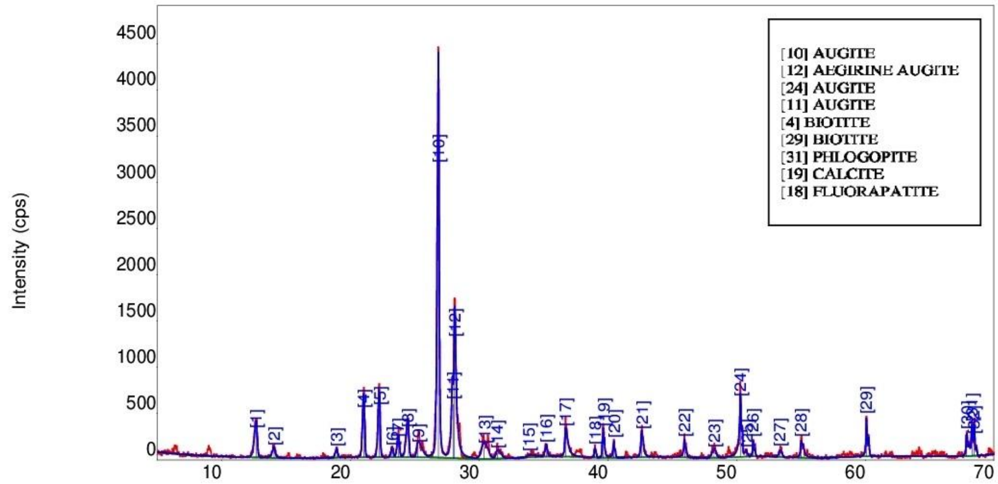

Figure: 4 (A)

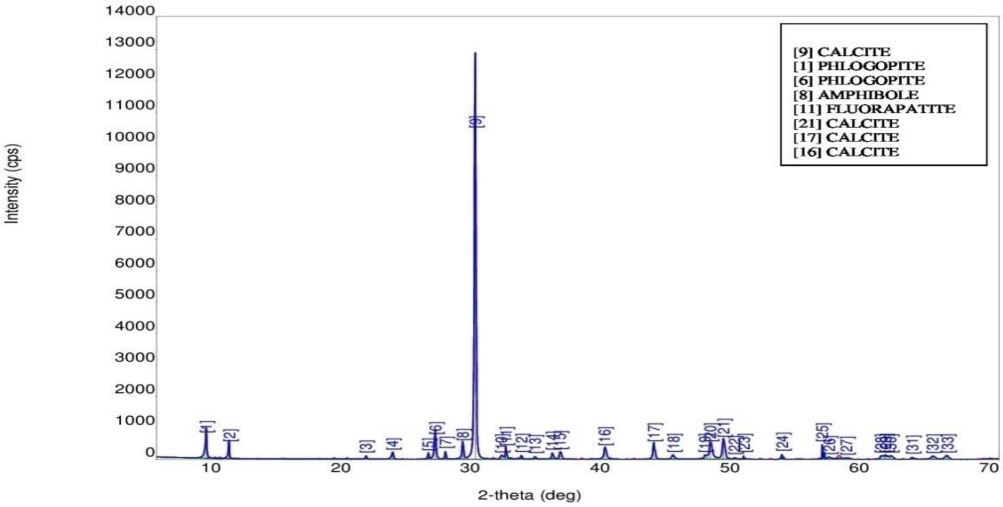

Figure: 4(B)

Figure 4 (A) And 4(B): XRD Pattern Exhibiting Different Mineral Ingredients In Alkali Pyroxenite And Carbonatite Respectively.

V. Chemistry

Quantitative Analysis Of 4 Number Of Representative Samples Of Phlogopite Was Carried Out Using SEM Equipped With An Energy Dispersive Spectrometer (SEM-EDS, ZESS-Bruker Make) Installed In The Institute Of Mineral Material Technology (IMMT) Bhubaneshwar At 25 KV Voltage And 11 Ma Current. Results Of Chemical Analysis Of The Studied Samples Are Presented In Table-I.

The Samples Contain Sio_2 Ranging From 33.08-40.18 Wt%, Al_2O_3 From 6.84-11.41 Wt% , $Feo_{(Total)}$ From 5.42-16.30 Wt%, Mgo From 14.34-21.38 Wt%, K_2O From 8.36-10.14 Wt%, Na_2O From 0.04-0.20 Wt%, Cao From 0.02-0.08 Wt%, Tio_2 From 0.01-0.07 Wt%, Whereas Mno, Bao And Cr_2o_3 Are Negligible.

Table I: ***Representative Major Element Compositions Of Phlogopite From Carbonatite Of Beldih, Purulia District, West Bengal.***

Major Oxides (Wt.%)	1	2	3	4
Sio_2	39.74	40.18	33.08	36.88
Tio_2	0.06	0.07	0.01	0.04
Al_2O_3	11.41	10.63	6.84	8.62
$Feo_{(T)}$	13.32	16.30	5.42	14.61
Mno	0.00	0.01	0.02	0.00
Mgo	19.03	21.38	14.34	16.16
Cao	0.05	0.08	0.02	0.04
Na_2O	0.07	0.20	0.04	0.08
K_2O	9.32	10.14	8.36	9.17
Bao	-	-	0.00	-
Cr_2o_3	-	-	-	-

VI. Discussion

The Occurrence Of Phlogopite And Tetra-Ferriphlogopite Micas In Carbonatite And Alkaline Rocks Have Been Well Documented In Various Carbonatite-Alkaline Complexes Of The World. A Common Feature Observed In Most Of These Complexes Is The Effect Of Alkali Metasomatism (Commonly Known As Fenitization) Induced By The Carbonatite Fluid On The Associated Rocks. Phlogopitization Of Pyroxenite Can Properly Be Referred To, However, As A Type Of Fenitization. It Is Clearly Related To The Intrusion Of Carbonatite Into Pyroxenite And Is Further Testimony To The Fact That Many Carbonatite Magmas Are Initially Alkalic But Loose Alkalies To The Surrounding Rocks And Crystallize As Calcitic And Dolomitic Carbonatite With Alkali Contents Restricted To The Amounts That Could Be Fixed As Micas, Pyroxenes Or Amphiboles (Gittins Et Al.[12],1975).The Occurrence Of Phlogopite Along With Sodic Pyroxenes In Alkali Pyroxenite Of The Study Area May Be Considered As A Consequence Of The Processs Of Phlogopitization By The Intrusive Carbonatite Magma.

Tetra-Ferriphlogopite Has Been Interpreted As Both A Result Of Post-Magmatic Processes (Araujo[13], 1996; Zaitsev And Polezhaeva[14], 1994; Mccormick And Heathcote[15], 1987;Mitchell[16], 1995) And Primary Crystallisation (Heathcote And Mccormick[17], 1989; Brod[18], 1999). In Many Cases, A Secondary Origin Is Supported By Petrographic Evidence, Such As Mantling Of Pre-Existing Phlogopite Crystals By Tetra-Ferriphlogopite, Sharp Compositional Changes And Various Disequilibrium Textures. Chemical Data Also Draw The Attention To The Transformation Of Phlogopite Into Tetra-Ferriphlogopite, The Latter Phase Mainly Occupying The Periphery Of Grains And/Or Being Concentrated Along The Cleavage Planes. In General, Early Phlogopite, A High Al_2O_3 And Low Iron Oxide Phase, Can Be Found Grading Progressively Into Tetra-Ferriphlogopite As A Result Of Al-Deficiency During The Magmatic Crystallization, Which Is In Turn Compensated By The Fe^{3+} Entry Occupying Tetrahedral Sites In The Mineral Structure.These Chemical Variations Are Followed By Optical Changes In The Mineral As Indicated By The Reverse Pleochroism Normally Exhibited By Tetra-Ferriphlogopites Of The Study Area. Similar Features Exhibited By Tetra-Ferriphlogopite Has Also Been Observed In Other Brazilian Alkaline-Carbonatite Occurrences (Morbidelli Et Al.[19],1997). Rimskaya-Korsakova And Sokolova[20], (1966) Regarded These Micas As An Independent Variety Namely Tetra-Ferriphlogopite In Which Al Is Replaced By Fe^{3+} (Kapustin,1980) And Subsequently Such Reversely Pleochroic Mica Was Found To Be Quite Common In Carbonatites And Associated Ultramafic Rocks (Rimskaya-Korsakova And Sokolova[20],1966; Faye And Hogarth[21],1969; Puustinen[22],1973;Kapustin[23],1980).

The Significance Of The Mineral Lies In The Fact That The Mere Presence Of This Rare Variety Of Phlogopite In A Carbonate Rock Would Suggest The Rock To Be A Probable Carbonatite. Field Evidence Depicting The Association Of Phlogopite Bearing Alkali Pyroxenites And Associated Tetra-Ferriphlogopite Bearing Carbonatites Coupled With Petrographic Observation, XRD And EPMA Data Merely Suggest That These Minerals Are Probably A Result Of Alkali Metasomatism (Or Phlogopitization) Induced By The Alkali Rich Carbonatite Magma During The Process Of Its Crystallisation And Emplacement Within The Host Rocks.

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