CHAPTER-5

CHEMICAL ANALYTICAL TECHNIQUES AND CHEMICAL DATA

CHAPTER – 5

GEOCHEMICAL ANALYTICAL TECHNIQUES AND CHEMICAL DATA

5.1 INTRODUCTION

Generally the geochemical studies are aimed towards understanding the evolutionary history of given group of rocks. In recent times the application and interpretation of trace element, REE and isotope data have become inevitable for understanding the nature and origin of rocks. In fact, the combination of REE, isotopes and elemental data has resulted in a highly reliable and reasonable modeling of the geological and geochemical processes. Using these geochemical data it is possible for us to pick-up signatures of rock forming geological processes.

Fractional crystallization, partial melting and assimilation are the processes, which are influencing the chemistry of a rock during igneous activity. During metamorphism, the whole rock composition gets changed according to varying P.T.t. regime. These changes can be felt by understanding the ratios and abundances of various elements occluded in the rocks (Newton, 1990). However, the

composition of sediment is affected by a very large number of parameters and hence should be studied in great detail with several types of techniques.

The concentrations of Rare Earth Elements in a given rock can be very successfully used to model the exogenic geochemical processes of the study area (Taylor and McLennan, 1988). Similarly the trace elements like Ni and Cr have also been successfully employed to demonstrate the characteristics of the source area (Condie and Wronkiewicz, 1990). In the present study, the major element geochemical abundances by wet chemistry procedure; trace element concentrations from AAS and REE from ICP were determined for the rocks around Tiruchirapalli. The details regarding the instrumentation, accuracy, reproducibility and precision of the data presented are described below.

5.2 SAMPLE PREPARATION

About 200 fresh rock samples from different lithological units were collected. After thorough petrographic and modal analyses about twenty-five samples representing the common variants of each suite of rocks were selected from them for analysis. Extreme caution was taken to collect fresh samples, which have not been affected by

alteration. For petrochemical studies, samples weighing about 2 kilograms were crushed into small pieces in hard steel mortar manually and were pulverized in a hard steel automatic rotary grinder to 200 meshes. After coning and quartering, about 50 grams of sample was taken and ground to a fine size (about 300 meshes) with the help of agate mortar. The samples were dried at 110° C in an oven before analysing for major, minor and trace elements.

5.2.1 SAMPLE PREPARATION PROCEDURE FOR WET CHEMICAL ANALYSIS USING AAS AND ICP.

SOLUTION – A

The sample of weight of 0.6 gram, which was ground to a fine size of 300 meshes, was fused with 20 to 25 pellets of sodium hydroxide in a nickel crucible. This was dissolved in 20 milliliter of 1:1 HCl and heated for about half an hour till a clear solution was obtained and then made to one litre after complete cooling.

SOLUTION –B

Half gram of sample was taken in a Teflon beaker of 100 ml capacity with 10 ml of Hydrofluoric acid (48%) and 5 to 7 drops of concentrated Sulfuric acid. The beaker was kept on water bath and heated to almost dryness. About 10 ml of 1:1 nitric acid was added at

this stage and the contents were heated again till a clear solution was obtained. This was then converted to 250 ml.

SOLUTION –C

The solution for trace element estimation was prepared in a way similar to Solution B, except that instead of 0.5gm of sample, 1.0 gram of the sample was taken and in place of H_2SO_4 about 8 drops of concentrated HCl was added. After cooling, the volume was made to 100ml and the solution was kept in a polypropylene bottle.

5.3 UV-SPECTROPHOTOMETER (UVS)

A Shimadzu double beam spectrophotometer model UV-190 was used for SiO_2, Al_2O_3, Fe_2O_3 (T), P_2O_5, and TiO2 determinations (Shapiro and Brannock, 1962). The instrument comprises of tungsten lamp for radiation in visible range and a deuterium lamp for ultraviolet radiation. Both lamps cover the complete range of wavelengths suitable for elements analysed. Absorbance and concentrations of standards and samples were measured under identical conditions.

5.4 ATOMIC ABSORPTION SPECTROPHOTOMETER (AAS)

A Varian-Techntron model AA6 (D) atomic absorption spectrophotometer was used for determining other major, minor and

trace elements. It has modulated hollow cathode lamp, the light from which passes through a flame where the sample to be analysed was nebulized. This light then passes through a monochromator (wavelength selector), which isolates the required resonance line onto a photo multiplier tube detector, which on amplification gives the output on a digital display in the form of concentration of absorbance. Air-acetylene gas mixture was used for determination of MgO, CaO, Na_2O, K_2O, MnO, Rb, Li, and Ni. Nitrous oxide–acetylene gas mixture was used for measurements of abundance of refractory elements such as Ba, Sr and a few other trace elements. Concentrations in unknown solutions were estimated in comparison with the international standards.

In all the instrumental methods, international standards were used for calibrations and the samples and standards were analysed under identical conditions.

Silica and alumina were determined from solution-A (Shapiro and Brannock, 1962), using UV-Spectrophotometer. The CaO, MgO, Na_2O, K_2O and MnO were estimated by AAS from Solution-B. Lanthanum solution was added for Ca and Mg estimation as the releasing agent for these elements. Rb, Li and Sr were estimated by

adding La and K solutions as suppressing and releasing agents. Details of the instrumental parameters and the sensitivity levels of different elements are given in Table 5.A. The precision and accuracy of different methods is better than ± 5% for most of the major and trace elements, except for a few elements that were present in very small quantity, as determined by analyzing standards.

5.5 INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETER (ICP-MS)

The estimation of rare earth elements was carried out using Inductively Coupled Plasma-Mass Spectrometer, VG Plasma-Quad (ICP-MS). This consists of a load coil, torch and RF generator. Mass spectrometer unit includes a high performance and high sensitivity quadruple mass filter. The ion detection system and the data acquisition system consist of a channeltron type electron multiplier and a multi channel analyzer. An online IBM-PC/XT microcomputer facilitates data acquisition, processing and storage.

Sample solutions (0.1%) were prepared by HF-HNO_3 acid decomposition. Indium was chosen as internal standard due to its low abundance in silicate minerals. All samples contained 100 ng /ml of this standard. ^{115}**In** was used to monitor signal drift during the

TABLE - 5.A

INSTRUMENTAL PARAMETERS

Elements	Equipment used	Wave length (nm)	Slit (nm)	Detective limit (ppm)
SiO_2	UV-VS *	640.0	1.0	10
Al_2O_3	-do-	475.0	1.0	10
TiO_2	-do-	400.0	1.0	20
Fe_2O_3 T	-do-	560.0	0.5	10
Na_2O	-do- **	569.6	0.2	5
K_2O	-do-	769.9	0.5	5
MnO	-do-	279.5	0.2	1
Ni	-do-	232.0	0.1	1
Co	-do-	240.7	0.1	1
Cr	-do-	525.4	0.2	2
Cu	-do-	328.8	0.2	1
Pb	-do-	217.0	1.0	1
Sr	-do-	460.7	0.2	5
Rb	-do-	780.1	0.2	1
Zn	-do-	213.9	0.5	1
Li	-do-	670.9	1.0	1

* UV-Visible Spectrophotometer

** Atomic Absorption Spectrophotometer

analysis. After maximizing the mass spectrometer for maximum signal on ^{115}**In,** using single ion mode, the system was operated on mass scanning mode in the mass range m/z 113-176 covering all the 14-REE and internal standard. Since barium oxide and REE oxides peak can potentially produce signals at several masses including the monoisotopic masses of ^{159} Tb, ^{165}Ho and ^{169}Tm, the oxide formation levels of REE were checked on barium, which were 0.2%.

The detection limit was calculated using the count rate obtained on 0.1% of solution of standards. The elemental concentrations for international reference rock standards such as JG1, JB and JG1a using two standard calibration curves were in good agreement with the published data of Balaram et al., (1990). Precision was better than 5% RSD (Relative Standard Deviation) for all the elements. The operating parameters of the ICP-MS instrument used for REE are summarized below.

In all, about twenty four samples have been analysed for Major oxides, about fifteen samples for Trace and Rare Earth Elements. The samples are numbered from R-1 to R-24 and their chemical data are tabulated (Table-5.1 to Table-5.14). The contents that are not determined are denoted as ND in the tables.

1. PLASMA

Power	1.35 KW
Nebulizer gas	0.75 lit/min
Aux-flow rate	0.5 lit/min
Coolant flow rate	13 lit/min
Sample uptake rate	1 ml/min
Sampling depth above load coil	10 mm

2. MS CONDITIONS

Vacuum stage 1	2.5 m. bar
Vacuum stage 2	10^{-4} m. bar
Vacuum stage 3	2×10^{-6} m. bar

3. SCAN CONDITIONS

Mass range	113-179 amu
Number of scans	120
Dwell time / channel	500 s
Number of channels used	2048

TABLE- 5.1

MAJOR OXIDE COMPOSITION OF BASIC GRANULITES FROM TIRUCHIRAPALLI AND OTHER AREAS

Oxides	1	2	3	4	X	Y	Z
SiO_2	49.95	48.35	47.67	49.99	47.07	49.70	46.28
TiO_2	1.21	2.73	3.01	1.17	3.01	1.23	0.67
Al_2O_3	13.27	15.87	14.70	14.11	14.72	12.20	10.59
Fe_2O_3	2.86	3.69	4.77	2.33	4.67	14.84	2.82
FeO	10.54	7.98	7.58	8.21	7.58	ND	9.72
MnO	0.22	0.13	0.09	0.13	0.09	0.02	0.22
MgO	8.19	7.15	6.12	8.41	5.92	7.41	10.50
CaO	11.05	9.79	12.03	13.62	12.63	9.95	13.49
Na_2O	2.00	2.95	2.32	1.21	2.52	2.45	0.96
K_2O	0.50	0.56	0.67	0.05	0.97	0.85	0.11
P_2O_5	0.08	0.15	0.34	0.11	0.44	0.14	Nil
Total	99.87	99.35	99.30	99.34	99.62	98.97	95.36

1,2,3,4: Basic granulites of Tiruchirapalli

X; Basic granulites of Manapparai (Subramanian 1992)

Y; Basic granulites of Pallavaram (Weaver 1980)

Z; Komatiite of Barberton, South Africa (Viljoen & Viljoen, 1969)

TABLE-5.2

TRACE ELEMENT COMPOSITIONS OF BASIC GRANULITES

FROM TIRUCHIRAPALLI AND OTHER AREAS

Elements	R-1	R-2	R-3	R-4	X	Y
Rb	01	01	04	03	01	09
Sr	121	115	125	120	131	128
Pb	02	01	Nil	02	02	06
Ba	154	135	185	170	308	171
Cu	45	65	49	56	49	ND
Co	35	52	48	78	78	ND
Ni	78	88	90	102	78	103
Cr	190	170	154	205	200	222
Zn	110	92	105	98	92	105

R-1,R-2,R-3,R-4: Basic granulites of Tiruchirapalli

X; Basic granulites of Manapparai (Subramanian 1992)

Y; Basic granulites of Pallavaram (Weaver 1980)

TABLE-5.3

REE DATA OF BASIC GRANULITES
FROM TIRUCHIRAPALLI
(VALUES IN PPM)

REE	R-1	REE	R-1
La	8.50	Ho	0.95
Ce	14.90	Er	2.25
Pr	1.79	Tm	0.30
Nd	30.75	Yb	1.98
Sm	2.95	Lu	0.38
Eu	0.95	Total REE	72.72
Gd	3.20	LREE	59.84
Tb	0.95	HREE	12.88
Dy	2.87	LREE/HREE	4.65

TABLE –5.4

MAJOR OXIDE COMPOSITION OF CHARNOCKITES FROM TIRUCHIRAPALLI

Oxides	R-5	R-6	R-7	R-8	R-9	R-10	R-11	R-12
SiO_2	73.44	65.44	63.24	78.61	73.74	70.01	75.00	70.78
TiO_2	Nil	Nil	0.02	Nil	0.03	0.07	0.07	0.17
Al_2O_3	7.01	9.96	10.85	10.47	10.61	10.85	10.70	11.78
Fe_2O_3	1.24	1.02	2.44	1.25	1.05	1.61	0.30	0.59
FeO	1.07	0.87	1.39	1.06	0.86	1.17	0.20	0.59
MnO	Bdl.	Bdl.	Bdl.	Bdl.	Bdl.	Bdl.	Bdl.	Bdl.
MgO	5.08	4.54	6.68	2.50	4.06	4.33	4.05	4.28
CaO	4.28	7.96	6.68	3.49	4.84	6.04	3.53	5.99
Na_2O	4.31	5.22	3.68	1.47	1.05	2.94	2.70	2.77
K_2O	3.59	4.99	5.02	1.08	2.73	2.94	3.55	2.77
P_2O_5	Nil	0.01	Nil	0.08	0.02	0.04	0.40	0.01
Total	100.02	100.01	100.00	100.01	98.99	100.00	100.50	99.73

Bdl.; below detectable limit.

TABLE-5.5

TRACE ELEMENT COMPOSITIONS OF CHARNOCKITES.

FROM TIRUCHIRAPALLI (VALUES IN PPM)

Elements	R-5	R-6	R-7	R-8	R-9	R-12
Scandium	16.60	13.00	6.56	6.83	5.91	3.45
Vanadium	33.50	59.80	18.60	18.10	9.59	8.82
Chromium	5.36	33.70	3.12	9.21	1.67	1.18
Cobalt	8.60	15.70	3.04	1.98	2.59	1.33
Nickel	5.99	9.76	3.10	4.14	3.99	3.01
Copper	9.45	3.03	10.80	3.91	5.61	2.60
Zinc	106.00	67.20	64.20	82.50	82.80	50.70
Gallium	24.30	19.40	18.60	20.50	17.90	16.00
Rubidium	124.00	103.00	131.00	189.00	152.00	191.00
Strontium	149.00	191.00	77.60	66.90	87.10	77.60
Zirconium	475.00	374.00	369.00	945.00	1422.00	1546.00
Niobium	4.33	1.79	3.01	5.68	1.81	1.57
Cesium	Nil	0.01	Nil	0.08	0.41	0.06
Barium	2377.00	2295.00	1371.79	1919.00	1728.00	1166.00
Hafnium	4.13	2.22	3.69	10.60	19.80	15.70
Tantalum	1.33	0.45	0.49	2.86	0.31	0.50
Lead	40.10	30.00	23.50	43.00	30.10	34.00

TABLE-5.6

REE DATA OF CHARNOCKITES
FROM TIRUCHIRAPALLI
(VALUES IN PPM)

REE	R-5	R-6	R-7	R-8	R-9	R-12
La	185.00	60.50	60.70	128.00	84.00	78.00
Ce	305.00	101.00	110.00	212.00	113.00	146.00
Pr	35.90	11.70	12.30	24.20	12.30	14.80
Nd	143.00	49.70	47.30	98.60	56.20	46.80
Sm	21.10	8.38	7.00	15.80	7.00	6.91
Eu	3.97	2.88	1.56	2.21	1.94	0.94
Gd	19.40	7.95	7.27	16.30	8.06	6.71
Tb	2.69	1.24	1.18	2.06	1.20	1.25
Dy	18.80	9.66	7.25	15.20	7.70	7.62
Ho	2.32	1.18	0.95	2.10	0.98	1.27
Er	12.50	8.06	5.24	10.70	6.25	6.96
Tm	0.69	0.49	0.33	0.56	0.23	0.60
Yb	6.42	3.23	2.93	6.78	3.93	6.03
Lu	2.24	1.21	0.84	1.85	1.57	2.13
Y	107.00	65.00	48.60	96.90	50.30	64.20
Total REE	759.03	267.18	264.85	536.36	304.36	326.02
LREE	693.97	234.16	238.86	480.81	274.44	293.45
HREE	65.06	33.02	25.99	55.55	29.92	32.57
LREE/HREE	10.67	7.09	9.19	8.66	9.17	9.01

TABLE –5.7

MAJOR OXIDE COMPOSITION OF AMPHIBOLITES FROM TIRUCHIRAPALLI AND OTHER AREAS

Oxides	R-13	R-14	R-15	A	B	C
SiO_2	59.42	68.41	59.89	50.06	50.85	50.00
TiO_2	2.17	2.07	2.14	1.48	1.16	0.69
Al_2O_3	10.28	9.91	8.00	14.03	14.82	15.30
Fe_2O_3	1.50	3.75	2.08	1.91	12.36	12.20
FeO	4.01	2.70	1.04	9.88	**	**
MnO	Nil	Nil	Nil	0.23	0.16	0.18
MgO	7.83	6.80	7.05	7.25	7.24	8.10
CaO	9.10	7.65	15.99	12.04	11.35	11.50
Na_2O	3.02	0.35	2.98	2.37	2.00	2.10
K_2O	3.55	0.66	3.55	0.28	0.07	0.05
P_2O_5	0.04	Nil	0.01	0.10	Nil	Nil
Total	100.92	102.30	100.73	99.63	100.01	100.12

R-13, R-14 &R-15; Analyses of Tiruchirapalli Amphibolite.

A: Analysis of Manapparai Amphibolite.

B: Amphibolite from Kolar (Rajamani et al., 1985)

C: Amphibolite from Holenarasipur (Drury, 1983)

** Calculated as total Fe_2O_3

TABLE-5.8

TRACE ELEMENT COMPOSITIONS OF AMPHIBOLITES FROM TIRUCHIRAPALLI AND OTHER AREAS (VALUES IN PPM)

Elements	R-14	R-15	A
Scandium	45.60	98.90	ND
Vanadium	421.00	229.00	ND
Chromium	242.70	232.20	324.00
Cobalt	26.30	59.40	69.00
Nickel	133.70	146.40	195.00
Copper	86.27	85.77	116.00
Zinc	114.00	85.80	ND
Gallium	45.30	12.30	ND
Rubidium	118.00	15.70	ND
Strontium	330.00	232.00	75.00
Zirconium	309.00	388.00	ND
Niobium	4.75	0.76	ND
Cesium	0.52	Nil	ND
Barium	1007.00	148.00	ND
Hafnium	4.04	4.90	ND
Tantalum	1.26	0.49	ND
Lead	34.00	17.00	ND

R-14 &R-15; Analyses of Tiruchirapalli Amphibolite.

A: Analysis of Manapparai Amphibolite.

ND; Not determined

TABLE-5.9

REE DATA OF AMPHIBOLITES
FROM TIRUCHIRAPALLI AND OTHER AREAS

REE	R-14	R-15	VS8
La	52.50	10.10	58.18
Ce	104.00	19.10	125.30
Pr	13.60	2.94	15.88
Nd	61.60	12.90	60.96
Sm	10.50	3.52	13.07
Eu	2.42	0.99	3.61
Gd	9.62	3.79	12.01
Tb	1.96	0.64	1.76
Dy	15.20	5.50	8.76
Ho	1.93	0.82	1.74
Er	10.70	4.03	3.46
Tm	0.80	0.31	0.60
Yb	8.05	3.11	3.46
Lu	2.14	1.53	0.70
Y	103.00	52.30	Nil
Total REE	295.02	69.28	277.00
LREE	244.62	49.55	3.14
HREE	50.40	19.73	8.36
LREE/HREE	4.85	2.51	310.14

R-14 & R-15; Analyses of Tiruchirapalli Amphibolite.

A: Analysis of Manapparai Amphibolite.

TABLE –5.10

MAJOR OXIDE COMPOSITION OF
GNEISSES FROM TIRUCHIRAPALLI

Oxides	R-16	R-17	R-18	R-19	R-20	R-21
SiO_2	68.20	74.23	72.36	76.15	70.79	73.63
TiO_2	Nil	Nil	Nil	0.05	Nil	0.03
Al_2O_3	12.07	8.38	13.03	9.60	10.51	10.23
Fe_2O_3	0.85	0.98	1.01	0.99	2.10	0.61
FeO	0.57	0.98	0.84	0.93	2.03	0.55
MnO	Bdl.	Bdl.	Bdl.	Bdl.	Bdl.	Bdl.
MgO	4.69	4.09	0.94	3.84	5.73	4.55
CaO	7.71	7.31	2.08	5.37	4.65	6.38
Na_2O	3.49	2.14	4.62	1.56	2.32	1.99
K_2O	2.55	2.55	4.07	2.51	2.50	2.10
P_2O_5	0.03	0.03	Nil	Nil	0.07	Nil
Total	100.16	100.69	98.95	101.00	100.70	100.07

R-16, R-17 & R-18: Hornblende – Biotite gneiss

R-19, R-20 & R-21: Migmatitic granitic gneiss

Bdl.; Below detectable limits

TABLE-5.11

TRACE ELEMENT COMPOSITIONS OF GNEISS FROM TIRUCHIRAPALLI (VALUES IN PPM)

Elements	**R-17**	**R-18**	**R-19**	**R-21**
Scandium	5.70	0.77	2.31	6.30
Vanadium	95.90	25.60	11.20	21.00
Chromium	40.20	3.26	2.51	3.74
Cobalt	27.00	1.71	1.92	2.99
Nickel	11.00	2.70	4.14	4.97
Copper	3.66	3.09	3.38	10.60
Zinc	92.00	46.50	49.70	61.90
Gallium	24.50	19.40	23.30	19.70
Rubidium	143.00	191.00	91.50	98.10
Strontium	215.00	350.00	936.00	831.00
Zirconium	531.00	406.00	405.00	1214.00
Niobium	2.13	0.78	1.55	1.93
Cesium	0.14	1.03	0.03	0.16
Barium	1187.00	1002.00	2419.00	1772.00
Hafnium	8.49	6.46	4.65	2.54
Tantalum	0.32	0.86	0.56	0.16
Lead	49.20	66.70	33.20	41.00

R-17& R-18: Hornblende – Biotite gneiss

R-19& R-21: Migmatitic granitic gneiss

TABLE-5.12

REE DATA OF GENISSES FROM
TIRUCHIRAPALLI (VALUES IN PPM)

REE	R-17	R-18	R-19	R-21
La	201.00	10.80	10.30	28.50
Ce	376.00	17.50	18.90	52.80
Pr	35.80	1.86	2.11	5.35
Nd	172.00	6.09	7.36	20.20
Sm	23.50	0.91	1.46	3.90
Eu	1.20	0.88	0.82	1.03
Gd	20.60	0.76	1.61	3.16
Tb	2.38	0.15	0.22	0.46
Dy	14.80	0.91	1.51	2.67
Ho	1.80	0.13	0.14	0.36
Er	8.59	0.47	0.58	2.32
Tm	0.28	0.02	0.05	0.12
Yb	4.36	0.33	0.90	1.20
Lu	1.83	0.43	0.09	0.31
Y	74.00	6.44	13.00	19.70
Total REE	864.14	41.24	46.05	122.38
LREE	809.50	38.04	40.95	111.78
HREE	54.64	3.20	5.10	10.60
LREE/HREE	14.82	11.89	8.03	10.55

R-17&R-18; Hornblende – Biotite gneiss

R-19 &R-21; Migmatitic granitic gneiss

TABLE-5.13

MAJOR OXIDES, TRACE ELEMENTS & REE COMPOSITION OF CALC-GRANULITES FROM TIRUCHIRAPALLI

Oxides	R-22	R-23	Elements	R-22	R-23	REE	R-22	R-23
SiO_2	58.59	29.15	Scandium	7.58	4.40	La	4.50	0.06
TiO_2	Nil	0.03	Vanadium	44.00	20.60	Ce	2669.00	502.40
Al_2O_3	8.36	1.07	Chromium	57.30	73.30	Pr	30.70	12.60
Fe_2O_3	0.89	0.19	Cobalt	10.80	10.60	Nd	49.90	9.60
FeO	4.05	0.17	Nickel	17.20	21.70	Sm	7.36	2.23
MnO	Nil	Nil	Copper	22.10	12.30	Eu	6.87	2.10
MgO	9.40	4.85	Zinc	76.30	45.70	Gd	1.92	0.67
CaO	12.56	40.62	Gallium	35.30	7.24	Tb	6.06	1.68
Na_2O	1.93	0.31	Rubidium	1.07	0.32	Dy	7.33	1.98
K_2O	5.09	0.50	Strontium	1.31	0.33	Ho	1.17	0.39
P_2O_5	0.09	Nil	Zirconium	278.00	334.00	ER	6.42	1.48
CO_2	ND	23.11	Niobium	72.10	6.93	Tm	0.98	0.27
Total	100.96	100.00	Cesium	64.70	9.71	Yb	4.13	0.73
			Barium	7.76	1.36	Lu	1.78	0.39
			Hafnium	0.46	0.09	Y	146.00	4.04
			Tantalum	6.10	0.19	Σ REE	2798.12	536.58
			Lead	3.17	0.61	LREE	2768.33	528.99
						HREE	29.79	7.59
						LREE/HREE	92.93	69.69

(The values of oxides are in percent and for Trace elements and REE in ppm)

TABLE-5.14

MAJOR OXIDES, TRACE ELEMENTS & REE COMPOSITION

OF QUARTZITE FROM TIRUCHIRAPALLI

Oxides	R-24	Elements	R-24	REE	R-24
SiO_2	70.50	Scandium	1.08	La	56.80
TiO_2	Nil	Vanadium	24.60	Ce	110.00
Al_2O_3	7.72	Chromium	5.07	Pr	13.70
Fe_2O_3	2.02	Cobalt	1.49	Nd	45.10
FeO	0.95	Nickel	3.14	Sm	9.51
MnO	Nil	Copper	3.64	Eu	0.11
MgO	2.07	Zinc	67.40	Gd	8.55
CaO	14.36	Gallium	15.50	Tb	1.59
Na_2O	0.40	Rubidium	147.00	Dy	9.97
K_2O	2.30	Strontium	33.20	Ho	1.37
P_2O_5	Nil	Zirconium	703.00	Er	5.83
Total	100.32	Niobium	4.97	Tm	0.36
		Cesium	Nil	Yb	4.46
		Barium	125.00	Lu	1.59
		Hafnium	12.90	Y	65.50
		Tantalum	1.32	Total REE	268.94
		Lead	44.00	LREE	235.22
				HREE	33.72
				LREE/HREE	6.98