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Elemental concentrations of Beach sand deposits between Visakhapatnam to Itchhapuram, India by PIXE method

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ABSTRACT

The chemical constituents of ilmenite, monazite and sillimanite of Bhimunipatnam – Visakhapatnam were analyzed by using PIXE technique. The mean values of 32.7% Fe and 66.33% titanium were determined in ilmenite. Monazite recorded 137.6 ppm Ce, 1.5 ppm Dy, 116 ppm Mn and 60.73% Ca, 7.2% Co and 15.8% Zr. Sillimanite recorded 108 ppm Mn and 3.33 ppm Nb. The above said mean values are found within the acceptable ranges prescribed with reference to the beach minerals.

Keywords: PIXE, Beach sands, ilmenite (ILM), monazite (MON) and sillimanite (SIL).

INTRODUCTION

Heavy minerals like monazite, zircon, garnet, sillimanite, ilmenite, leucoxene, kyanite, magnetite and rutile are found to occur in sand size fractions along the coastal tracts of Eastern Ghats region covering Orissa and Andhra Pradesh. They occur with more or less of same size and fractions and their separation from one to the other has been practiced as per their physical characteristics.

PIXE is a unique technique for performing non-destructive analysis of trace elements using characteristic X- rays induced by a proton beam of few MeV directed on to the surface of the specimen[1-4]. PIXE offers a good sensitivity even at lower atomic numbers due to the fact that bremsstrahlung caused by protons is low compared to electron excitation. The technique effectively employed to find out the chemical concentrations. Multi-elemental analysis of samples is of great importance in mineral prospecting[5,6]. The knowledge of the major and trace elements and correlations between them in chemical samples is very important[7-10] since they provide a key to the history of the minerals. The present Study area is shown in figure 1.

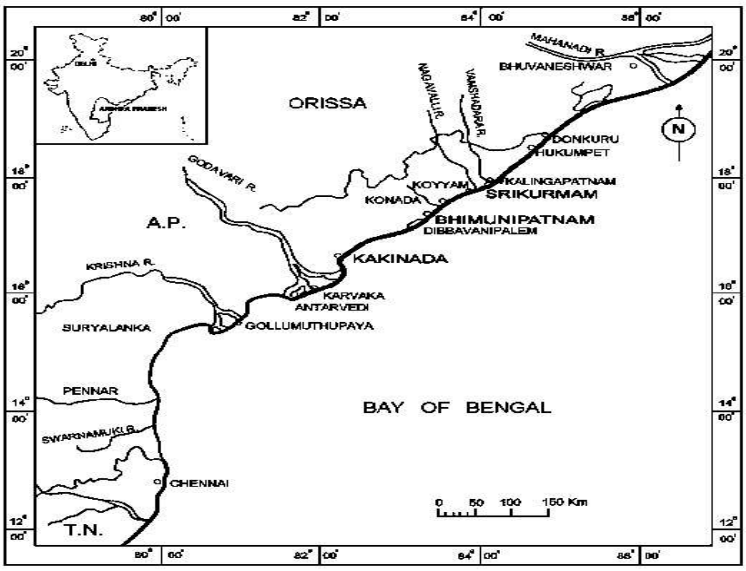

Fig.1 Location of the Present study area

MATERIALS AND METHODS

Sample collection and preparation: The beach sand samples were collected from the different parts between Visakhapatnam and Bhimunipatnam beach placer deposit by the grab sampling method at an interval of ~ half km. About 1 kg of sand sample was collected from each location. In the laboratory the samples were cleaned with warm water, dried and subjected to heavy mineral separation by gravimetric method using bromoform (tribromo methane, $\rho = 2.89$). A sample was fed to Wilfrey's table in order to separate heavier and lighter constituents; Quartz was separated as light sands. The heavier constituents present are ilmenite, magnetite, rutile, zircon, monazite, garnet and sillimanite. The heavy mineral concentrates were then separated into different individual mineral fractions with a hand magnet and Frantz Isodynamic Separator. Ilmenite and magnetite were separated by magnetic separation method. Sillimanite and monazite were nonconductive and these two fractions were separated from the heavier through Iso-dynamic separation and confirming the nature by a binocular microscope. To avoid contamination from other mineral sands, 0.5–0.7 A^o current setting was used and the sample splitting was done repeatedly to get the maximum purity. Approximately 10 grams of ilmenite, monazite and sillimanite sands were recovered from each sample. After coning and quartering two grams of each sand samples were taken for making the pellet of 13 mm diameter and about 1.5mm thickness. The pellets were then used as targets. The prepared targets were placed over the target ladder, which can withstand weight up to 25 Kg. Now the collimated beam was made to fall on the samples and the emitted respective characteristic X-rays were collected using Si (Li) detector.

Equipment: The 3MeV Proton beam obtained from tandem type pelletron accelerator at IOP (Institute of Physics), Bhubaneswar, India.

RESULTS AND DISCUSSION

Beach sand group of minerals have been studied in detail by several investigators and correlation of the physical and optical properties with the chemical composition has been established. East coast concluded that the TiO_2 content varies from 47.14 to 50.74% and mineral proportion of ilmenite intergrowth and chemical analysis, amounts to 23.73 kg (100kg L^{-1}) bulk sample of the black sands. The elemental concentrations in the set of three-ilmenite samples are given in table.1. Whereas the results of the other two sets containing three-Monazite and three-sillimanite samples are presented in table.2 and table.3

respectively. A total of 9 elements in ilmenite, 15 elements in monazite and 16 elements in sillimanite were measured. The elemental concentrations given in the above mentioned tables are in ppm otherwise % is specified. In the above mentioned Tables, the experimental errors in each of measured concentrations are also given along with the concentrations. Errors in PIXE results are based on number of counts and on the least-square fitting of the peak areas, which includes the uncertainties in the background subscription. It can be seen from tables 1, 2 & 3 that the results are consistent within the tolerable range of errors.
The mean concentration profiles for major elements K, Ca and Fe are shown in fig.2. The key elements K, Ca, Ti, V, Fe and Zn are measured in all the three beach sands.

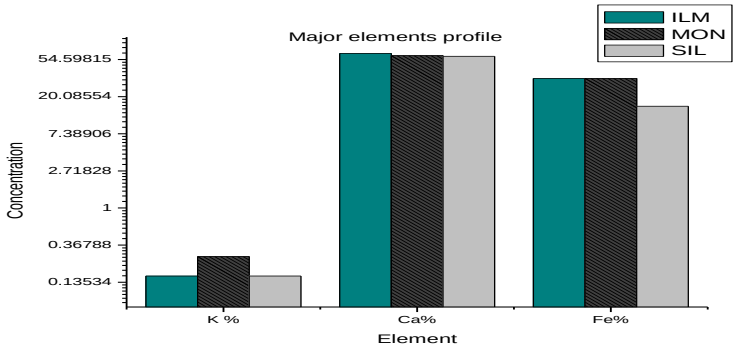

Fig.2 Major elemental concentration profile in ilmenite, monazite and sillimanite beach sand samples.

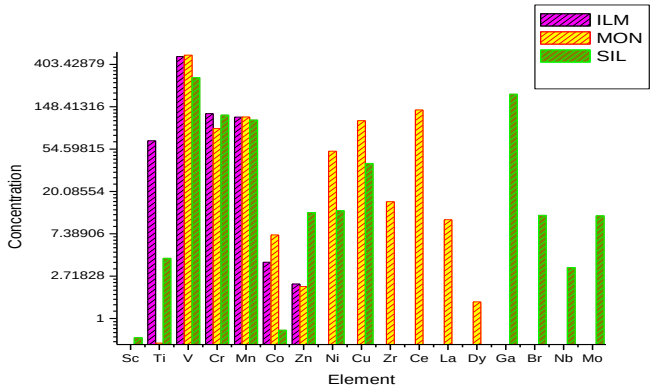

Fig.3 Mean minor elemental concentration in ilmenite, monazite and sillimanite type of beach sand samples

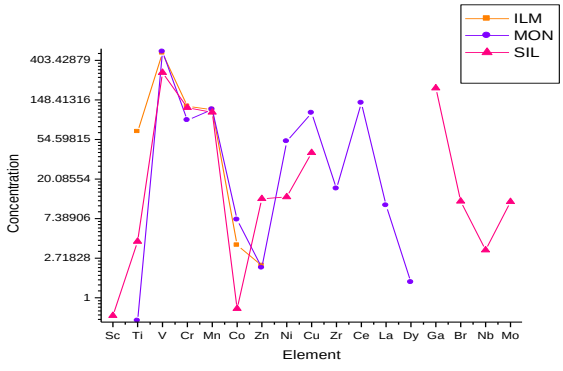

Fig.4 Mean elemental concentrations of all minor and trace elements in ilmenite,monazite and sillimanite type of beach sand samples**.**

Table.1 Elemental concentration mean values and ranges in ilmenite, monazite and sillimanite beach sand samples

	ILM		MON		SIL	
	Mean	Range	Mean	Range	Mean	Range
K	845.33	753-971	2776	2253-3211	1647.6	1342-1810
Ca %	64.33	58-71	60.73	60-61.2	59.66	56.1-62
Sc	---	---	---	---	0.633	0.32-0.86
Ti %	66.33	59.9- 69.5	0.56	0.5-0.6	4.156	3.65-4.8
V	485.4	438-534.2	501	478-543.2	296	180-406
Cr	126.3	89-189	122	79-163	122	72-183
Mn	116.3	85- 169	116.33	85-169	108.3	68-159
Fe %	32.7	29.6- 39.1	32.93	32.4-33.4	15.5	13.5-18.9
Co %	3.77	2.81- 5.1	7.2	6.3-8.2	0.76	0.4-1.1
Ni	---	---	52	34-64	13.03	11.2-14.1
Cu	---	---	107	81-124	39.06	36.4-42.2
Zn	2.26	1.68–2.81	2.13	1.8-2.5	12.2	10.8-14.5
Ga	---	---	---	---	200	150-270
Br %	---	---	---	---	11.46	10.1-12.5
Zr %	---	---	15.8 %	15.1-16.5	---	---
Nb	---	---	---	---	3.33	1-6
Mo	---	---	---	---	11.33	8-14
La	---	---	10.3	8.3-12.6	---	---
Ce	---	---	137.6	113-169.8	---	---
Dy	---	----	1.484	0.75-2.1	---	---

The K concentration in ILM and SIL is same but the difference between MON and the remaining two is quite noticeable and it can be observed clearly from the fig.2. It can also be noticed From the Figure3. that the mean concentrations of Ca in the three classes of beach sands are almost same. The concentrations of Ca in all three classes are found to be about 52%. Similarly, the observation on Fe concentration from figure.2 reveals that its value is high in ilmenite and is almost same in monazite and slightly lesser in sillimanite. The mean minor and trace elemental concentrations of the three beach sand samples are summarized in figures 3 and 4. The minor element concentrations were found to be very similar between the three beach sands.

Table 2. Concentrations of elements in ilmenite**.**

Element	ILM1	ILM2	ILM3
K	971 ± 11.4	753 ± 8.29	812 ± 9.16
Ca	58%	71%	64%
Ti	69.3%	59.9%	69.5%
V	534.2 ± 20.83	438 ± 17.08	484 ± 18.87
Cr	101 ± 5.03	189 ± 8.98	89 ± 3.73
Mn	95 ± 4.62	85 ± 3.64	169 ± 7.98

Fe	29.6%	39.1%	29.4%
Co	3.41 ± 0.303	2.81 ± 0.25	5.1 ± 0.453
Zn	2.3±0.2	1.68±0.14	2.81±0.23

Table 3 Concentrations of elements in monazite

Element	MON1	MON2	MON3
K	2253 ± 72.09	2864 ± 91.64	3211 ± 102.75
Ca	61%	60%	61.2%
Ti	0.6%	0.6%	0.5%
V	543.2 ± 21.83	478 ± 19.08	482 ± 18.83
Cr	124 ± 5.65	79 ± 3.72	163 ± 8.46
Mn	85 ± 3.64	169 ± 7.98	95 ± 4.62
Fe	33%	33.4%	32.4%
Co	8.2006 ± 0.713	6.3 ± 0.548	7.1 ± 0.61
Ni	58 ± 3.30	34 ± 1.93	64 ± 3.64
Cu	116 ± 5.91	81 ± 4.13	124 ± 6.32
Zn	2.5 ± 0.21	1.8 ± 0.15	2.1 ± 0.18
Zr	15.1%	16.5%	15.8%
Ce	169.8 ± 6.96	130 ± 5.33	113 ± 4.63
La	12.6 ± 0.80	8.3 ± 0.53	10 ± 0.64
Dy	0.754 ± 0.062	1.6 ± 0.13	2.1 ± 0.17

The results from the tables 1, 2 & 3 shows consistency in the concentrations of the measured elements in Monazite and its varieties from different locations. The finger printings of these elements may be used to differentiate beach sand from different locations.

Table.4: Concentrations of elements in sillimanite.

Element	SIL1	SIL2	SIL3
K	1791 ± 59.1	1342 ± 44.28	1810 ± 59.73
Ca	62%	61%	56.1%
Sc	0.8611 ±0.076	0.3250 ± 0.0289	0.7264 ± 0.046
Ti	4.8%	4.02%	3.65%
V	304 ± 14.89	180 ± 8.82	406 ± 19.89
Cr	111 ± 5.43	72 ± 3.52	183 ± 8.96
Mn	159 ± 7.79	68 ± 3.33	98 ± 4.80
Fe	13.5%	14.1%	18.9%
Co	1.1 ± 0.91	0.8 ± 0.06	0.4 ± 0.03
Ni	13.8 ± 0.86	11.2 ± 0.70	14.1 ± 0.88
Cu	42.2 ± 2.65	38.6 ± 2.43	36.4 ± 2.29

Zn	14.5 ± 1.02	11.3 ± 0.83	10.8 ± 0.73
Ga	270 ± 13.23	180 ± 8.82	150 ± 7.35
Br	10.1%	12.5%	11.8%
Nb	1 ± 0.83	6 ± 0.49	3 ± 0.24
Mo	8 ± 0.56	12 ± 0.85	14 ± 0.99

To compare the elemental concentration profile among the three classes of beach sands: ilmenite (ILM), monazite (MON) and sillimanite (SIL), the ranges and the mean elemental concentrations have been determined from each set of these samples and the results were furnished in table 4.

APPLICATIONS

The complementary accelerator-based technique of PIXE analyses was used for characterization of some natural minerals mainly used for scientific and technological applications especially for Beach sand samples.

CONCLUSIONS

The complementary accelerator-based technique of PIXE analyses was used for characterization of some natural minerals mainly used for scientific and technological applications. Several elements and their concentrations were determined from these samples. The heavy beach minerals of sillimanite, ilmenite and monazite from parts of Visakhapatnam – Itchhapuram coast, Andhra Pradesh were studied by the same PIXE technique. The mean values of 32.7% Fe and 66.33% titanium were determined in ilmenite. Monazite recorded 137.6 ppm Ce, 1.5 ppm Dy, 116 ppm Mn and 60.73% Ca, 7.2% Co and 15.8% Zr. Sillimanite recorded 108 ppm Mn and 3.33 ppm Nb. The above said mean values are found within the acceptable ranges prescribed with reference to the beach minerals.

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