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Geochemical Characterization and Provenance Study of Ilmenites from Fluvial Sediments of River Cauvery in Parts of Tamil Nadu, Southern India

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***Abstract*: The Cauvery river is the third longest flowing river in South India. This river flows through three Southern Indian states (Karnataka, Tamil-Nadu, and Puducherry). The river Cauvery takes its birth at a place called Talacauvery in the state of Karnataka, and after a long journey of 800Kms from the Western-Ghats finally forms a delta and joins the Bay of Bengal in the east. This river traverses high grade metamorphic rocks. Ilmenites are good indicators of provenance and several researchers throughout the globe have contributed on this aspect. The present study is focused on chemical characterization of the detrital ilmenite from the fluvial sediments of downstream of the river Cauvery. The TiO2 content of ilmenites varies from 46.42 to 51.28 wt%, whereas iron oxide values range between 46.35-50.68 wt. %. The detrital ilmenite grains are primary in nature and not subject to any alteration. Bychemistry we can conclude that basic suites are source for the ilmenites in fluvial sediments of river Cauvery.**

Keywords:- Ilmenite, Cauvery, provenance, Precambrian rocks, Southern granulite terrain, fluvial sediments.

INTRODUCTION

Heavy minerals are path finders for provenance. Various heavy minerals such as garnet, zircon, and amphibole are found along the upper reaches of the river Cauvery and its tributary river Kabini (Prakashnarasimha etal., 2018). Ilmenite generally occurs in a wide variety of igneous rocks, both intrusive and extrusive, as well as pegmatite and other vein rocks, and even some metamorphic rocks, especially gneiss (Ramdohr., 1980). Previous studies of detrital ilmenite also suggest that the variation in its element content is sufficient to provide an unmistakable signature to determine sediment source (Darby et al., 1985). Detrital ilmenite is commonly present as a large part of sand particles (Pettijohn et al. 1987). Several researchers worked on the ilmenites across the global level to understand the source from the geochemistry of ilmenites (Hegde et.al., 2006; Sukumaran et.al., 1994; Grigsby., 1992). The present study is aimed at chemical characterization and provenance of the detrital ilmenite from the fluvial sediments from downstream of the river Cauvery.

STUDY AREA

Cauvery river is an easterly flowing river of the Peninsular India that runs across three of the southern Indian states (Karnataka, Tamil-Nadu, Puducherry). The third largest river of southern region, begins its 800 km long journey from the Western Ghats; traverses through Mysore plateau and finally forms a delta on the eastern coastline of the subcontinent (Poompuhar) before falling into the Bay of Bengal. The Cauvery river basin lies between latitude 10°09'N to 13°30'N and longitude 75°27'E and 79°54'E. The lithological units along the course of river Cauvery comprises of Precambrian rocks, principally the gneiss, granulite, laterite, and tertiary sediments (Pichamuthu., 1978). In the upper and middle part, the river drains through granitoids-gneisses, granulite, and ancient supra-crustal belts composed of meta-igneous, meta-sedimentary rocks, and carbonate rocks (Ramakrishna and Swaminath., 1981; Prakash Narasimha et.al., 2009, Pichamuthu., 1976). The lower part of the river basin is underlined by cretaceous sediments (Sundaram and Rao 1981; Subramanian and Selvan 2001).

METHODOLOGY

The sediment samples were collected from the river from eight locations at an interval of 60kms along the course of Tamil-Nadu part of river Cauvery. Cone and quartering method (pouring the sediment sample so that it takes on conical shape, and then flattering it into plane cake. The cake dividing into quarter; the two quarter which sit opposite one another are discarded, while the other two are combined and constitute the reduced sample) were employed to collect sediment samples. About 500 g of sediment sample was collected at 8 locations along the course of the river in parts of Tamil-Nadu at an interval of around 60 Kms (Figure 1).

Collected samples were dried and then subjected to the sieving in the sieve sizes of 60, 120, and 180-micron mesh. The 120 microns mesh sized sample was selected for heavy mineral separation by gravity method using heavy liquids. Ilmenites were separated with the help of stereo binocular microscope. These minerals were mounted on the slide with the help of epoxy and slightly polished and then subjected for the EPMA analysis at PPOD lab, Geological survey of India, Bangalore, India using Camera SX 100 EPMA instrument.

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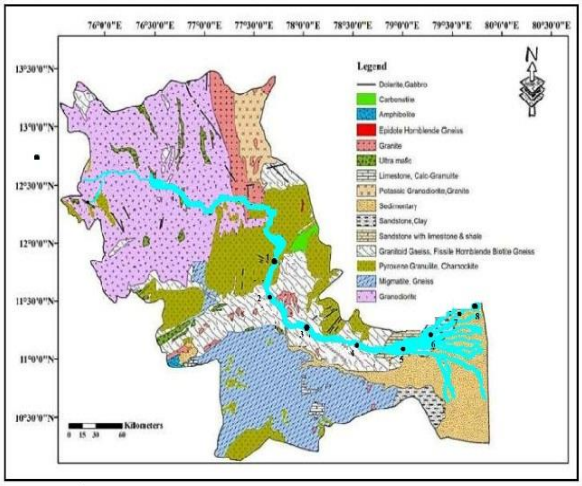

Fig.1Geology of the area with sampling locations

RESULTS AND DISCUSSION

The chemistry of the ilmenite grain which were determined are shown in Table 1 and based on two oxygen atom structure, has been calculated. The TiO2 and FeO concentration of ilmenite ranges from 46.42 to 52.18 wt%. and 46.35 to 50.68 wt% respectively. Primary ilmenite refers to unaltered grains, with composition close to the stoichiometry defined by the formula FeTiO3, where TiO2 content varies in between 48 and 53 wt. %. The trilinear plot of FeO-Fe2O3-TiO2 (Fig.3), and Scatter plot (Figure.4a) can be inferred to show that ilmenites along the course are unaltered to slightly altered (Figure.2). The Manganese concentration is higher in grains containing 45 to 50 wt. % TiO2 (Fig.4b). The MnO content of ilmenite ranges from 0.8% to 1.91%, and the MgO concentration varies from 0.07 to 0.85%. Magnesium is showing higher concentration when TiO2 concentration ranges between 50-55 wt. % except in sample C5. This is due to the presence of magnesium rich rocks in the sampling site (Fig. 4c). The scatter plot (Fig. 4d) of MnO vs. MgO represents the trend in such a way that there is an increase in MgO along with decrease in MnO in ilmenites. This indicates that the the source might be basic rocks present in the drainage basin. End-member compositions plotted on FeTiO3-MnTiO3-MgTiO3-Fe2O3 system (modified by Nayak and Mohapatra., 1998) fall towards the ilmenite apex of the basic suites (Fig.5). The amounts of Al2O3 (0.01 to 0.04%), Cr2O3 (0.02 to 0.1%) are recorded along the course of the river. The TiO2 concentration of ilmenite indicates that the sources of ilmenites are high grade metamorphic rocks. An ilmenite grain with TiO2 content between 50-60% indicates their metamorphic origin for the ilmenites (Basu and Molinaroli, 1991).

Table-1 showing chemical composition of Ilmenite grains

Sample.no	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	Avg
MgO	0.72	0.28	0.07	0.22	0.14	0.85	0.48	0.75	0.43
Al2O3	0.01	0.02	0.02	0.03	0.05	0.03	0.01	0.04	0.02
Cr2O3	0.08	0.02	0.02	0.02	0.03	0.03	0.1	0.02	0.04
FeO	46.35	49.31	49.01	50.68	47.4	48.29	48.08	46.77	48.23
TiO2	52.18	48.15	49.08	46.42	51.28	49.48	50.36	51.58	49.81
MnO	0.14	0.71	1.91	1.55	0.25	0.29	0.35	0.8	0.75
FeO©	45.514	42.096	42.091	39.796	45.627	42.702	44.092	44.252	43.27
Fe2O3©	0.929	8.017	7.689	12.09	1.97	6.21	4.43	2.7	5.50
TOTAL	99.46	98.45	100.07	98.92	99.05	98.91	99.38	99.96	-
ON THE BASIS OF 2 OXYGEN CATIONS									
Mg	0.018	0.007	0.002	0.006	0.004	0.022	0.012	0.019	0.01
Fe	7.850	8.631	8.442	8.929	8.113	8.327	8.245	7.917	8.30
Mn	0.002	0.010	0.028	0.023	0.004	0.004	0.005	0.011	0.01
Fe2+	0.6	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.61
Fe3+	0	0.1	0.1	0.2	0	0.1	0.1	0	0.07

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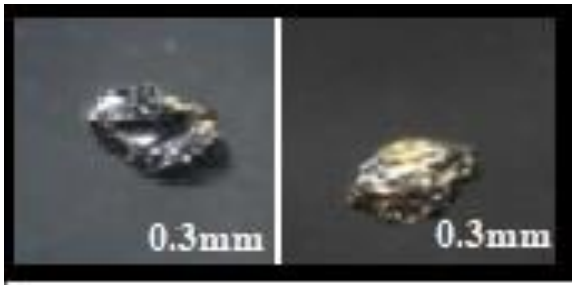

Fig. 2 Microphotograph of ilmenite grains

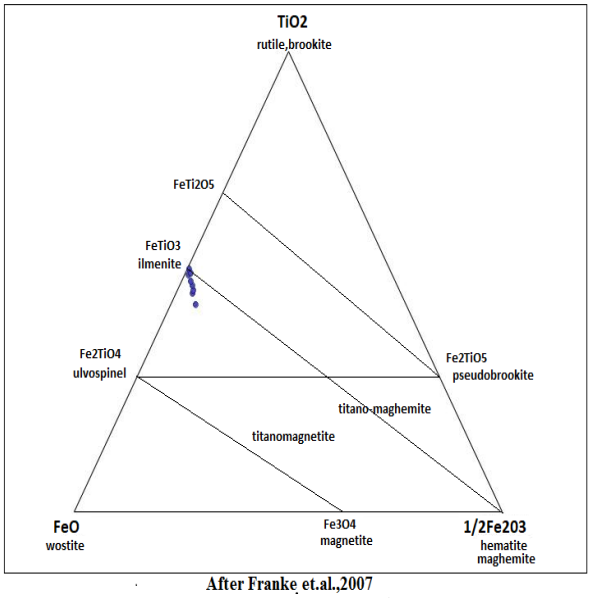

Fig. 3 Ternary diagram FeO-TiO2-Fe2O3 of coexisting phases and solidus-solutions between end members under low to high temperature conditions.

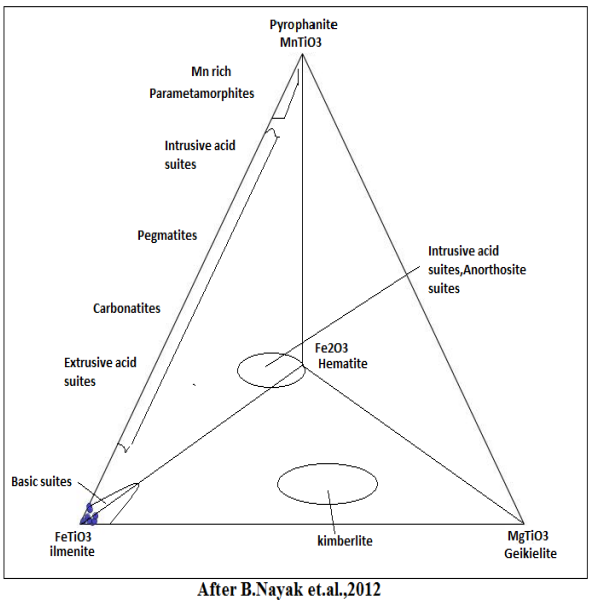

Fig. 5 Quaternary system FeTiO3-Mn-TiO3-MgTiO3-Fe2O3 (after Nayak and Mohapatra, 1998)

CONCLUSION

The chemistry of ilmenite grains indicates that rocks like metabasic suites are the major source for the ilmenites in the fluvial sediments of river Cauvery.

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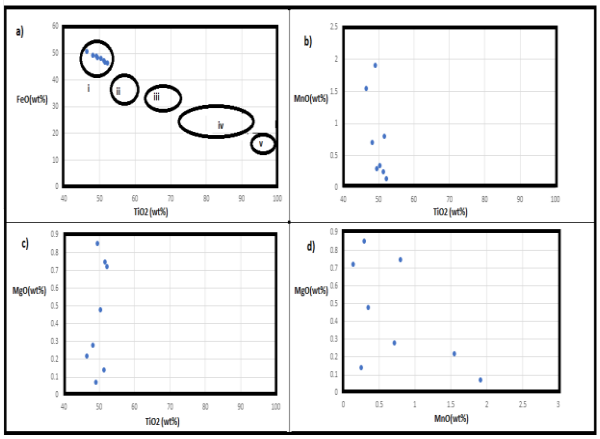

Fig. 4 X-Y scatter plots. a, b) Distinct ilmenite alteration product grouped in 4 classes: unaltered ilmenite (i), hydrated ilmenite (ii), pseudorutile (iii) and leucoxene (iv). c, d, e) Mn and Mg deportment with TiO2 increase.

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