Occurrence of thorite and radioactive zircon in syenite pegmatite, North of Ashwaraopet, Khammam district, Andhra Pradesh, India

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Abstract. This paper reports the occurrence of thorite and confirms the earlier find of radioactive zircon by Subbarao, Murali and others from syenite pegmatite in the Vinayakapuram-Kunavaram alkaline belt in the Khammam district of Andhra Pradesh, India. Thorite has also been found as residual concentrations in soil overlying the pegmatite.

Keywords. Thorite; zircon; syenite pegmatite; gamma-ray survey

1. Introduction

The belt of alkaline rocks between Vinayakapuram and Kunavaram was selected for a γ -ray spectrometric survey, which led to the identification of thorite and radioactive zircon from a syenite pegmatite south of the village of Nandipadu (figure 1). Extensive work on this belt has been reported earlier (Mahadevan and Satapati 1954; Krishnan 1968; Ramaswamy 1959; Subbarao 1964, 1967, 1971; (Rao and Murthy 1970, 1973; Sharma *et al* 1971; Murthy 1972; Murali *et al* 1983). The alkaline rocks are exposed in a chain of hills and ridges striking NE-SW. The belt is cut by Gondwana formations in the south, flanked by gneisses and alluvium in the east and amphibolites in the west. Paragneisses of the Eastern Ghats occur as conspicuous bands and patches in the syenites and amphibolites.

2. Gamma-ray survey

The area was surveyed with a Scintrex GIS-5 portable γ -ray spectrometer. The instrument was operated in the total count mode with an integration time of one second. The range of the normal background count in the area varied between 100 and 200 cps. The syenite pegmatite with its overlying residual concentration of thorite and zircon shows values between 300 and 1800 cps, with a point anomaly of 75,000 cps. Biotite-nepheline syenites north-west of Vinayakapuram show some smaller anomalies around 1200 cps.

3. Mineralization

The syenite pegmatite hosting thorite and radioactive zircons occurs in sheared quartz veins adjacent to the amphibole-nepheline syenites about 1 km south of the village

Figure 1. Location and geology of alkaline rocks of Vinayakapuram-Kunavaram belt (after Subbarao 1971).

Nandipadu. The pegmatite strikes NE-SW and cuts across the road to Nandipadu. It is highly weathered, and outcrops are few. The anomalous zone, as traced by γ -ray spectrometry can be followed over more than 500 m along strike, with a variable width of a few to more than 10 m. Thorite was also observed as residual concentrations

in soil above the pegmatite, where it forms a blanket of about 10 cm thickness below the top soil. The grain size ranges from 0.1 to 1.5 cm, and the larger grains were, in fact, handpicked from the soil. Zircons show a similar dispersion in the soil and similar grain size. The weathered pegmatite was exposed in shallow pits below the residual concentration zone. The feldspars in the pegmatite are highly weathered and the zircons stand out prominently. Another generation of pegmatites in this locality is characterized by black tourmaline and shows low radioactivity.

4. Mineralogical studies

Thorite is black, and detrital grains can easily be separated by panning on account of its high specific gravity. It responds to a simple chemical test, as it dissolves in concentrated hydrochloric acid; the solution gelatinizes on concentration by heating. The grains of thorite are altered by weathering to a greater extent than the zircons. These are yellowish to reddish brown and can easily be mistaken for garnet. They display an unusually short prismatic habit and some grains resemble garnet not only in colour but in crystal habit as well. They can easily be recognized by their yellow fluorescence under ultraviolet light.

The minerals were confirmed by X-ray powder diffraction studies using a Guinier camera (table 1). The diffraction lines were measured, and the *d*-values compared against a standard set compiled by JCPDS (1972).

Table 1. *d*-values for thorite and zircon from syenite pegmatite north of Ashwaraopet.

Thorite		Zircon	
<i>d</i> observed	<i>d</i> standard	<i>d</i> observed	<i>d</i> standard
4.728 (9)	4.72 (9)		
3.556 (10)	3.55 (10)	4.425 (5)	4.43 (5)
		3.305 (10)	3.30 (10)
2.838 (5)	2.84 (5)		
2.680 (8)	2.68 (8)		
—	2.52 (3)	2.523 (5)	2.52 (5)
		2.339 (3)	—
2.225 (2)	2.22 (3)		
2.019 (3)	—	2.070 (3)	2.07 (2)
		1.909 (2)	1.91 (1)
1.886 (2)	1.89 (3)		
1.840 (4)	1.83 (7)		
		1.749 (2)	1.75 (1)
		1.710 (5)	1.71 (4)
		1.649 (2)	1.65 (1)
		1.382 (2)	
		1.364 (2)	
		1.287 (1)	
		1.262 (1)	
		1.189 (1)	

Standard *d*-values from JCPDS (1972). Line intensities given in parantheses.

5. Discussion

Thorium occurs in nature exclusively in the tetravalent state and forms rather insoluble minerals. Significant amounts of Th^{4+} can substitute in accessory minerals like zircon and sphene. Such substitution is possible because the radius of Zr^{4+} (0.80 Å) is not too different from the radius of Th^{4+} (1.02 Å). In the secondary environment thorium is mobile only as clastic and detrital grains in heavy fractions of soils and sediments, where the relatively resistant Th-minerals may become concentrated. Favourable conditions can lead to their concentrations in placer deposits, e.g. the Th-rich monazite sands of India.

Thorite was reported as a rare accessory in pegmatites from the Jos Plateau, Nigeria, in veins associated with carbonatites (Mountain Pass, California, and Powder Horn District, Colorado) and in other veins (Heinrich 1958). Its occurrence in syenite pegmatites was reported from Larvik and Langesundfjord area, Norway (Brøgger 1890; Siggerud 1956), and from nepheline syenites in eastern Siberia (Portnov 1967). Eight occurrences from USA associated with alkaline rocks and/or carbonatites have been listed by Staatz (1974). Occurrences of pegmatites with Th-minerals are numerous and markedly variable in their mineralogical associations. As pointed out by Heinrich (1958), pegmatites can represent the most common type of radioactive mineral deposit in hard rock terrains.

Radioactive zircons are found in a wide variety of felsic to intermediate igneous rocks. Associations with thorite in syenite pegmatites have been reported from the Langesundfjord area of Norway by Siggerud (1956), and also from the Haliburton-Bancroft area of southern Ontario by Satterly and Hewitt (1955). Reddish brown zircons in association with thorite, and containing numerous inclusions of thorite occur in the Jos Plateau, Nigeria. These zircons are also characterized by a garnet-like crystal habit (Schuiling 1989).

6. Conclusions

Thorite, in association with radioactive zircons, has been discovered in the syenite pegmatite from the Vinayakapuram-Kunavaram belt of alkaline rocks. The area contains a large number of pegmatites as reported earlier and a more extensive exploration programme is perhaps warranted. Detailed γ -ray surveys combined with geochemical investigations may lead to the identification of some productive zones of radioactive minerals. The chance of finding residual concentrations should not be overlooked in future studies as the larger grains of thorite could be handpicked from the soils during the present investigations.

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