On a skarn monazite occurrence from the Namib desert near Usakos, South-West Africa.

By O. VON KNORRING, Ph.D., and T. N. CLIFFORD, Ph.D.

Research Institute of African Geology, University of Leeds.

[Read 3 November 1960.]

Summary. An unusual monazite deposit of metasomatic origin is described. The monazite occurs as randomly oriented crystals in a dolomitic marble. The chemical composition and optical data of the monazite are given.

DURING 1959, in the course of a geological investigation in the Karibib–Swakopmund area of South-West Africa, a unique monazite deposit was examined at a locality some 21 miles west-south-west of the town of Usakos. The monazite occurs as large, randomly oriented, reddish-brown, platy crystals or aggregates up to 5 in. in length, embedded in a coarse, iron-stained dolomitic marble. This remarkable rock has been exposed in a number of prospectors' pits that lie approximately 4 miles north 15° west of the Ebony railway stop on the Usakos–Swakopmund line. At this locality large pebbles of residual monazite are seen scattered over a considerable area in the desert.

Geological environment.

The general geological configuration of this sector of South-West Africa has been described by Gevers (1934 *a*, *b*, and *c*). In the main, the area consists of high-grade regionally metamorphosed sediments of the Damara 'System' folded along regional axes trending east-north-east, and characterized by synkinematic granites and post-orogenic quartz veins, together with uranium, lithium–beryllium, copper–zinc, and tin–tungsten pegmatites. One of the most important structural marker-horizons within the Damara 'System' is the Marble Series (Gevers, 1934*a*, pp. 313–319) consisting of up to 3 000 feet of marble with inter-bedded biotite-schist, para-amphibolite, amphibolitic biotite-schist, and, in the basal portions of the series, thin quartzite horizons. Typical bedded grey metamorphosed limestones of this series crop out near the monazite locality described in this communication, but the intervening ground is covered with superficial deposits.

Petrography.

The brown dolomitic host rock (excluding the monazite) consists of about 90 % of dolomite, 5 % of calcite, and 5 % of the following accessories: magnetite, graphite, and pseudomorphs after earlier skarn silicates. The dolomite grains are mostly rounded and embayed, and are from 1 to 3 mm. in diameter. The calcite forms irregular grains, which are partly interstitial, and is also observed in small veinlets often associated with the larger monazite crystals. The accessory minerals, including the smaller monazite grains, are typical of many minerals found in skarn deposits in that they exhibit rounded, corroded margins. Dominant amongst the accessory constituents are pseudomorphs after possible original skarn silicates. Individually these now consist of rosettes of a serpentine-like mineral and secondary carbonates enclosed within a framework of goethite. Magnetite is found in small distorted crystals, which are mostly fresh and highly magnetic. Graphite is common and consists of small, rounded flakes. The monazite found in the marble varies in size from minute rounded grains to hand-size, platy crystals weighing up to some 2 kg. The smaller crystals are golden yellow in colour, whilst the larger ones are reddish brown owing to inclusions of red iron oxide along the cleavage planes. In general appearance, the monazite closely resembles certain varieties of chalybite. For the most part, however, the monazite is free from intergrown inclusions and secondary alteration products. Some crystals, nevertheless, do contain inclusions of calcite, dolomite, and the other accessories, suggesting a rather late period of formation of the monazite.

Geochemical considerations.

The rare-earth elements are normally concentrated in both the granitic and syenitic suites of rocks. Monazite, one of the most abundant rare-earth minerals, is a characteristic accessory in granitic rocks and is also found in large crystals and aggregates in pegmatites. Amongst alkaline rock associations, monazite has been recorded from many carbonatite complexes, particularly from African localities (Garson, 1959).

Although much work has been done on the distribution of rare-earths in the granitic (pegmatite) monazites, comparatively few analyses are available of monazites from alkaline complexes. Murata *et al.* (1957, 1959), and Heinrich *et al.* (1958), have found that in pegmatitic monazites the sum of the atomic percentages of the more basic rare-earth elements La, Ce, and Pr, with respect to total rare-earth elements, varies between some 50 % and 80 %. In monazites from alkaline environments, however, this quantity appears to exceed 80 %. Moreover, in pegmatitic monazites the distribution of the three dominant rare-earth elements is generally: Ce > La > Nd or Ce > Nd > La. In contrast, in monazites from alkaline rocks the tendency seems to be Ce > La > Nd with the percentage of La approaching that of Ce. Another significant feature regarding monazites from these two suites lies in the thoria content. Granitic monazites are always thorium-bearing and their thoria content varies from some 3 to 18 wt. %. In contrast, in monazites from carbonatites the thoria appears to be low and is generally well below 1 %.

TABLE I. Chemical analysis and optical data of monazite from the Namib desert. Analyst: O. von Knorring.

SiO_2	0·13	Sp. gr.	5·15 (Berman balance)
ThO_2	0·70	α	1·787 (±0·002)
Ce_2O_3	33·65	β	1·789 (±0·002)
La_2O_3*	23·0	γ	1·842 (±0·002)
Nd_2O_3*	10·0	$2V_\gamma$	14°±1°
R_2O_3†	2·18		
P_2O_5	30·10		
	99·76		

* Semi-quantitative spectrographic determinations by Miss J. M. Rooke.
† Approx. amount of other rare-earths by difference.

The chemical analysis of the Namib Desert monazite is given in table I. In addition, spectrographic determinations have shown traces of Na, Mg, Al, Ca, Mn, Y, Zr, Pr, and Pb; Sm, Eu, Dy, Ho, and Yb were not detected. The high values of Ce and La, and the low thoria, are typical features of monazites associated with carbonatites as outlined above. It is interesting to note that this monazite, developed in a carbonate rock, should show the same chemical characteristics. The close areal association of the monazite occurrence with other bedded skarns (wollastonite, diopside, sphene, &c.) suggests that the distinctive dark-brown marble host rock is part of the metasedimentary Marble Series of the Damara 'System' that has acted as a reservoir for migrating liquors bearing rare-earths and phosphorus and related to the regional phase of pegmatite emplacement. This suggested mechanism of fixation of monazite is comparable with that envisaged by Gevers (1929) to explain the presence of cassiterite in the coarse-grained meta-limestones of the Marble Series at Arandis some 18 miles to the west-south-west. Although other rare-earth minerals are known from many skarn deposits, monazite has rarely been observed in large amounts. Heinrich (1958, p. 249) records monazite-bearing carbonate layers in schists and gneisses from Lemhi County in Idaho. The carbonate rock there consists of calcite with locally associated typical skarn assemblages of actinolite, baryte, chalybite, pyrite, magnetite, ilmenorutile, garnet, zoisite, apatite, and monazite. Microscopically the thorium-low monazite appears as subhedral to euhedral crystals replacing calcite and actinolite, and was apparently one of the latest minerals to crystallize.

There is no doubt about the economic potentialities of the present occurrence, and detailed investigation may reveal other deposits connected with the Marble Series of this area.

References.

Garson (M. S.), 1959. Rept. No. MSG/38, Geol. Survey of Nyasaland.
Gevers (T. W.), 1929. Trans. Geol. Soc. South Africa, vol. 32, p. 165.
—— 1934*a*. Neues Jahrb. Min., Beil.-Bd. 72, Abt. B., p. 283.
—— *b*. Ibid., p. 399.
—— *c*. Ibid., Beil.-Bd. 73, Abt. B., p. 27.
Heinrich (E. Wm.), 1958. Mineralogy and Geology of Radioactive Raw Materials. McGraw-Hill Book Company, Inc., New York.
—— Borup (R. A.), and Levinson (A. A.), 1958. Bull. Geol. Soc. America, vol. 69, p. 1580.
Murata (K. J.), Rose (H. J., Jr.), Carron (M. K.), and Glass (J. J.), 1957. Geochimica Acta, vol. 11, p. 141.
—— Dutra (C. V.), Teixeira da Costa (M.), and Branco (J. J. R.), 1959. Ibid., vol. 16, p. 1.