I.1. CHEMISTRY OF MONAZITE

I.1.1. Chemical Composition and Characteristics

Monazite is essentially a phosphate of cerium (Ce) and lanthanum (La), in which Th and minor yttrium (Y) earths substitute for Ce, etc. The usual accepted chemical formula for monazite is (Ce, La, Y, Th)PO_4. In addition, most analyses reveal the presence of small to moderate amounts of ferric iron, aluminum, calcium, magnesium, silicon, titanium and zirconium (Cuthbert)[1]. Uranium is frequently reported in at least trace amounts, probably in substitution for thorium. Typical analyses for monazite obtained from different sources are given in Table (1)[2].

Table (1): Comparative Analyses of some World Monazite Sand Concentrates.

Constituent	Brazil %	India %	Florida, USA* %
ThO_2	6.80	9.90	3.40
Ce_2O_3	25.90	27.50	19.50
P_2O_5	25.50	29.50	20.50
SiO_2	2.51	1.50	8.50
Zr	3.50	1.0-3.0	0.1-1.0
TiO_2	1.10	0.40	2.10
Fe_2O_3	0.50	0.90	4.50
Al_2O_3	—	—	12.50
RE_2O_3**	60.50	59.80	40.10
U_3O_8	0.017	0.29	0.47
MoO_2	0.01	0.01	—

*Containing about 70% monazite

**Including Ce_2O_3

Monazite is a brittle mineral and it fractures unevenly and is sufficiently magnetic to be electromagnetically concentrated in a strong field. It occurs typically as small but distinctive round, glassy grains of various colors ranging from brown, reddish-brown to yellowish-brown, yellow, honey-yellow or green. Yellowish-brown to honey-yellow is the most characteristic color. On a streak plate, monazite shows a colorless to pale brown or

yellowish streak. Monazite has a resinous luster, a hardness of 5 to 5.5, refraction index of 1.786 to 1.837 and a specific gravity of 4.6 to 5.3.

I.1.2. Identification

Probably the most rapid and accurate way to identify monazite is with a petrographic microscope. Its optical properties-high refraction index, strong birefringence, and small axial angle-make it easily recognizable. In the laboratory "blowpipe" test, the mineral usually turns gray but is infusible. When heated with sulfuric acid and transferred on a platinum wire to the flame, it has enough phosphorus present to turn the color of the flame into bluish green.

Another rapid way to identify monazite is the micro chemical method in which the sand is warmed in concentrated H_2SO_4 followed by decanting a few drops. Evaporating the latter to a small volume and transferring the remaining product to a microscopic slide, monazite can be identified by the appearance of minute ovals of sodium cerium acetate when adding a drop of concentrated sodium acetate.

I.2. MODE OF MONAZITE OCCURRENCE AND DISTRIBUTION

Monazite is actually found in many geological environments. Thus, it occurs as a very minor accessory constituent in acidic igneous rocks such as granites, aplites and pegmatites or in alkaline syenites as well as in metamorphic rocks like gneisses beside vein deposits. Due to its physical and chemical stability, it also develops into a detrital mineral in beach placers and associated sand dune deposits. In the latter, monazite (Sp.gr. 4.6 to 5.3) occurs in association with some other heavy minerals, e.g., rutile, zircon, uraninite, thorite, fergusonite, samarskite, magnetite, apatite and ilmenite. These minerals might also occur in geologically old placer deposits (consolidated and cemented conglomerates). Its amount in the host rock seldom exceeds 0.1 percent (Farag)[3] although in India, host rocks from certain areas yield up to 46% (Gupta and Krishnamurthy)[4]

From its deposits, monazite is always obtained in conjunction with one or more of the other mentioned valuable minerals by proper physical dressing techniques. These mainly include gravimetric, magnetic, electrostatic and rarely flotation techniques.

I.2.1. World Distribution of Monazite Deposits in the World

Primary monazite deposits have commercial importance in a few instances. Notable examples are found in South Africa at Van Rhynsdorp and Naboomspruit, in the USA in Colorado, and in China at Bayan Obo[4]. However, the most important commercial sources of monazite are the secondary monazite deposits which are found in the beach placers and associated sand deposits. Due to high concentration of ilmenite and magnetite in these deposits, they are sometimes referred to as black sands. As a matter of fact, monazite-containing heavy mineral sand deposits are mainly found in large quantities in Australia, Brazil, India, China, Malaysia, South Africa, USA and Egypt. These locations and many other deposits are given in Fig. (1)[4].

I.2.2. Distribution of Egyptian Monazite Deposits

In Egypt, beach deposits (lenticalar strips of very dark black sands) are indeed distributed along the Mediterranean coast from Abu-Quir in the west to Rafah city in the extreme east. Particular local concentrations of high grade deposits are indeed found near the mouth of the Rosetta branch of the Nile (east and west), at Damietta as well as in Baltim and northern Sinai. Black sands have also been noticed in the Mediterranean Sea bottom close to the coast between Rosetta and Damietta.

It is well known that the River Nile has actually carried the mineral content of these black sand deposits after weathering of the source rocks in Ethiopia then they were laid down in the Mediterranean Sea. Later on, these minerals were re-transported to the Mediterranean shores by water currents, winds, waves and other agents. In general the placer deposits of the Egyptian monazite-containing black sand deposits can be classified into three major categories (Hammoud)[5]; namely,

i- Beach sands and sand bars between the lagoonal lakes and the Mediterranean shore.

ii- Sediments composing the bottom of the lagoonal lakes (submerged sediments).

iii- Sandy pouches intercalating with mud and clay all over the Delta and valley deposits.

I.2.2.1. Beach Sands and Sand Bars

These formations, building the Mediterranean shoreline, north of the Delta, extend from Rafah at the east to Abu Quir at the west. In places along shore and particularly beside the mouths of Damietta and Rosetta and the outlets of the lagoonal lakes, some erratic natural

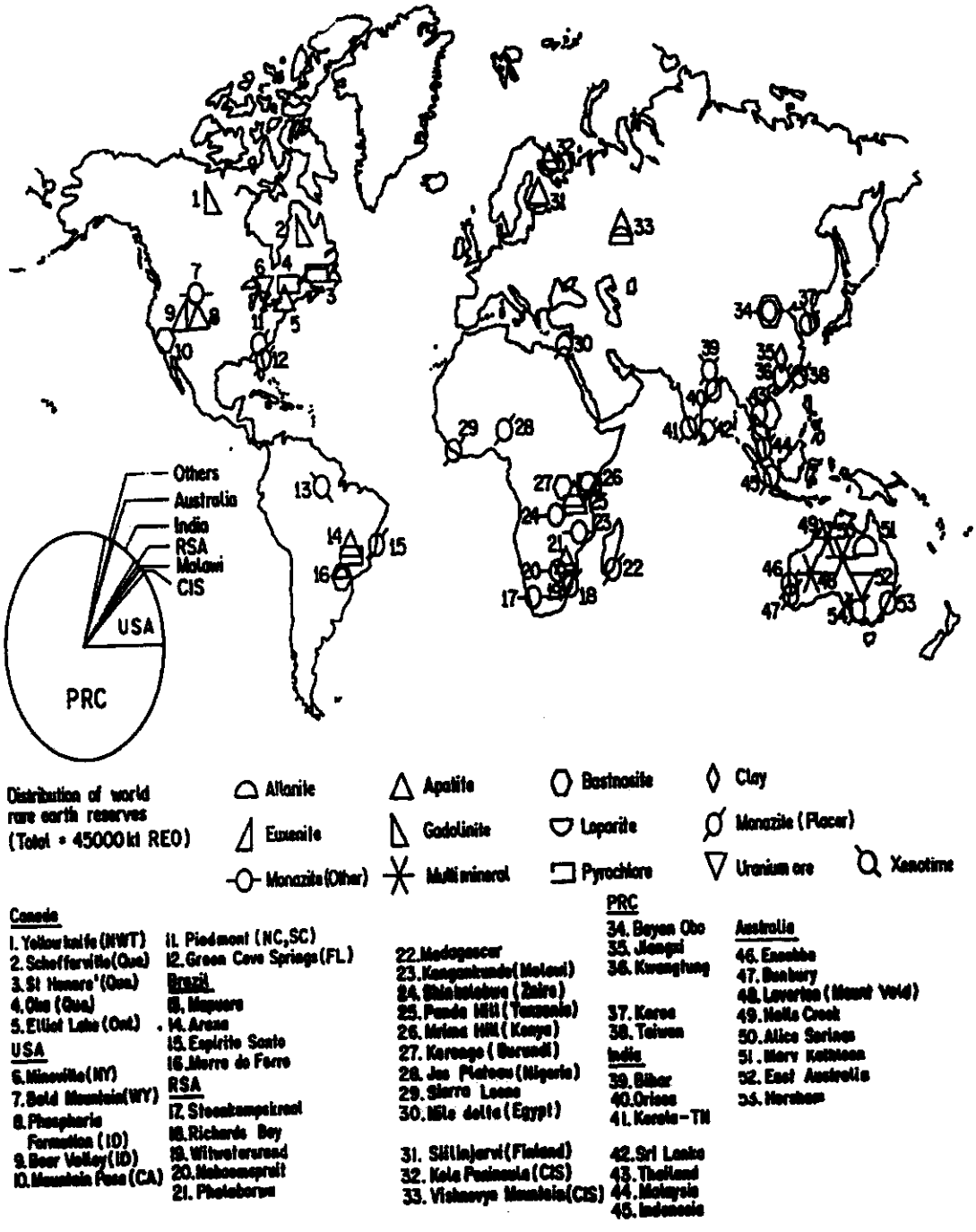

Fig. (1): World distribution of monazite deposits (after Gupta and Krishnamurthy, 1992)[4].