CHAPTER - 1

INTRODUCTION, GENERAL BACKGROUND AND SCOPE OF PRESENT STUDIES.

1.1. Introduction.

The name of the mineral zircon for zirconium silicate is very old and is believed to be derived from the Arabic ZARQUN, in turn obtained from the Persian ZAR for gold and GUN for colour, (Deer et al 1963). Well crystallized varieties, both clear and coloured have long been used as gem stones. The use of zircon sands for foundry purposes commenced only after the second world war.

Sands provide the refractory medium for making moulds to shape metals and alloys by founding. An analysis of the founding process reveals that the moulding sand affects the entire process in the production of a sound casting, even to the stage of machining. The optimum requirements of a sand at one stage, in the production of a casting, may be different from those required in some other stage. Good sand practice requires a judicious balance between such conflicting requirements. This in turn demands strict control over the sand characteristics.

In deciding on a moulding sand the most important consideration is the selection of the basic constituent. Silica is widely used as a basis for moulding sands. These sands give a satisfactory performance for most castings. However, with an increasing demand for quality castings which require more accurate dimensional control and a higher degree of surface finish, other base sands are being sought. Different materials with the required size classification and distribution such as, Olivine, Zircon, Chromite, Chamotte, Carbon, Ilmenite, Synthetic mullite etc. are being tried out by the foundry technologist.

A major difficulty in utilising a bulk material, such as, sands, particularly for critical applications, is their apparent lack of unformity, reproducibility and reliability. For purposes of evaluation, the methods and techniques adopted must be so chosen that the sources of variability in the material may be identified and its properties related to the desired performance. The variability of the material may be attributed to its intrinsic property, processing parameters and testing techniques.

Australia produces about 75 percent of the world's requirement of zircon, (Butler 1970). Other producers are India, U.S.A., South Africa, Malaysia and Egypt.

1.2. General Background.

1.2.1 Occurrence of Zircon Sands on the East Coast of Australia.

The coasts of New South Wales and South Eastern Queensland are the origin of large zircon and rutile deposits. These are mostly obtained from the beach deposits of heavy black sands which also contain a high concentration of ilmenite and minute traces of cassiterite, platinum, gold and osmiridium (Department of Mines, New South Wales 1967). The heavy black sands in the northern region of these beaches were initially mined for gold. The immense value of zircon and rutile was then unknown and these were discarded. Commercial exploitation of these deposits for zircon and rutile was made for the first time in 1933.

Typically, after severe cyclonic storms, with the pounding of fierce waves, heavy black sands are deposited on a beach at or near high water mark. Storms in these areas are accompanied by gale force winds from the south east, so that strong wave action takes place on the northern end of the beaches which

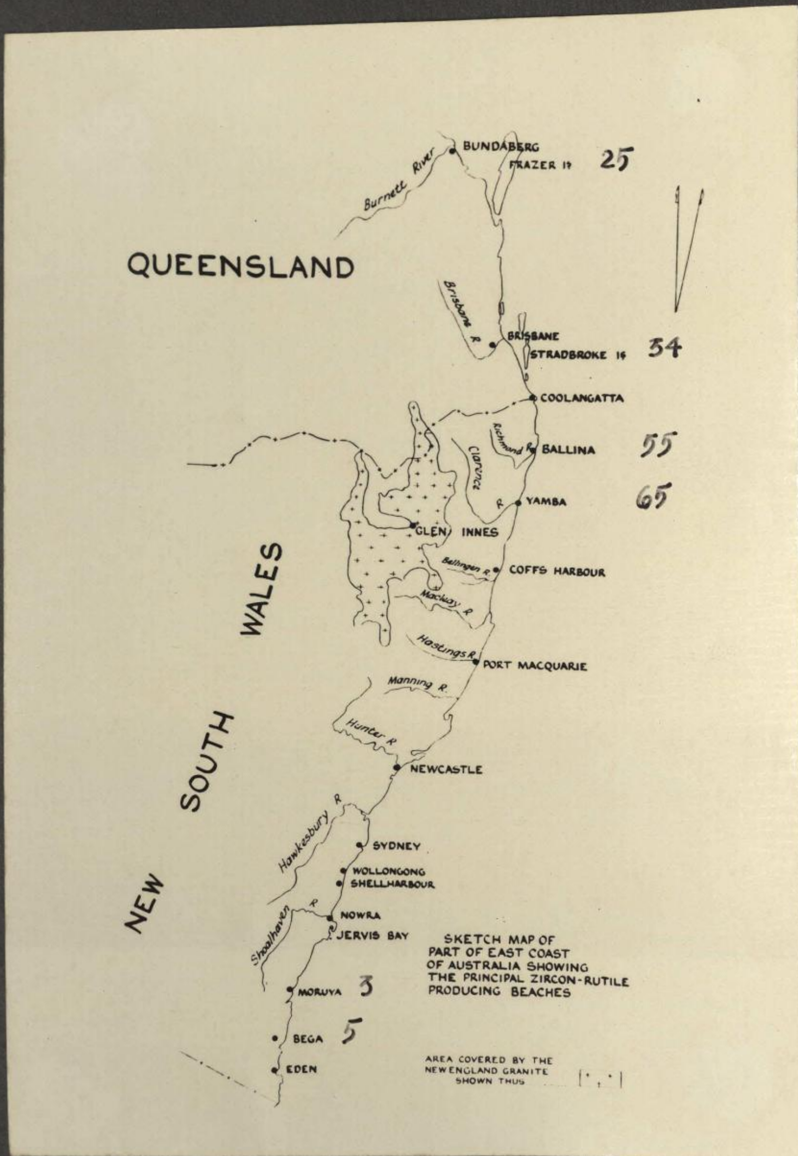

Fig. 1.1 The Distribution of Zircon bearing Sands on the East Coast of Australia (Whitworth). Figures represent average zircon content in the heavy minerals at corresponding areas.

receive heavy pounding by waves. The southern end, however, is somewhat sheltered by the headland. Deposits, in exceptional cases, may be as much as six feet in thickness, upto three hundred feet wide and a mile or more in length, weighing five to ten thousand tons. This is a continuous process and older deposits may form hard, rock like aggregates, the grains being bonded by organic matter through long periods of time. On the contrary, a deposit formed by wave on a beach may even be withdrawn into the sea by subsequent wave action and tide.

Large scale selective mining of rich seams of 'black sands' from beaches have quite depleted the deposits of concentrates and most mining operations have now receded landwards in swamps and dunes to work the still older deposits.

1.2.2 Origin of Zircon Sands.

It was earlier thought that the origin of the heavy minerals in the beach sand deposits was the 'New England Granite'. However, the mesozoic sedimentary rocks of the Clarence River Basin were found to contain rutile, zircon and ilmenite as their chief minerals, (Whitworth 1956). These are also present in the Permain sediments of the main coal basin of New South Wales and in the overlying Triassic sand stones. During succeeding geological ages, in many parts of the world, discharges by land drainage systems were common and major oscillations of sea level took place. Thus the formation of ice and snow during the cold phases of the Ice Age Cycles, held a large portion of the earth's water, causing a world wide lowering of sea level. In the last glacial stage, 20,000 to 30,000 years ago, the oceans may have been 300 to 450 feet lower than at present. Off the New England coast, the 120-foot isobath occurs about 10 miles offshore, whilst the 600-foot isobath is located 25 miles from the coast. The mouths of the Tweed, Richmond, Clarence and Macleay rivers and others in Pleistocene times may have been located 15 miles further out to sea than at present. At the end of the last glacial phase, large volumes of water were progressively and rapidly released from the ice and returned to the ocean basins, raising the sea to its present level, (Anderson & Chakraborty 1970). This phenomenon was not uniform and in the process the mouths of the eastern Australian rivers retreated from the edge of the continental shelf. Since the land was higher than at present, the eroding power of the rivers was much greater and large amounts of sediments must have been transported by relatively fast flowing streams.

Eventually when they reached the continental shelf, the river valleys may have been filled with their own sediments. The prevailing climatic conditions on the eastern Australian sea board have also played a major role in this respect. On Frazer Island, successive cyclonic storms are known to have deposited or removed upto four feet depth of sandy beach in 24 hours.

In the case of some material occurring to the north of the Clarence river at Yamba, zircon is generally the most abundant mineral in the heavy fraction comprising, upto 80 percent of the total heavy mineral content and this was the chief mineral sought in commercial exploitation after gold.

1.2.3 Mining and Concentration.

In present mining operations, mostly in the coastal swamps and dunes, bulldozers are used to clear the vegetation and the top soil. The top soil is kept aside and mining completed, followed by revegetation on the mined site. Sands containing as little as 0.5 to 0.6 percent heavy mineral is dredged. After primary concentration which could produce a concentrate of upto 90 percent heavy mineral the remaining light sands, gravel etc., which form the bulk of the dredged material are returned to the dredged areas which are recovered with the top soil. Revegetation is undertaken for soil conservation, re-afforestation and beach restoration.

The dredge is a mobile, barge mounted, primary concentrating plant, fed by a large suction pipe. The sand is sucked up in the form of a sand-water-slurry and is passed through rotary screens to remove any coarse material, such as, gravel, shells and wood. The sand is then treated by cone concentrators and spiral concentrators. The material used in construction of the concentrators is fibre glass since the weight of the concentration unit is an important consideration. Separation is based on the higher specific gravity of the heavies as opposed to that of the lighter ones, mostly quartz. The capacity of a dredge, used for primary concentration, is of the order of 900 tons of dredged material per hour.

Rutile, Ilmenite and Zircon form the bulk of the concentrate. This material is conveyed from several primary concentration units to a central dry separation plant. Here the concentrate is passed over vibrating tables to remove any remaining quartz. It is then dried in a rotary kiln. Ilmenite and some of the traces of magnetite, monazite, garnet, epidote, chromite and chrome - spinel are removed by electromagnetic separators. Ultimately zircon is separated from rutile by electrostatic separators, the product having a zircon content of more than 98%.

1.3 Scope of Present Studies.

Out of the eight samples studied in the present investigations, the Harrington and Belmont Zircons were obtained from the concentrating plant at Tomago of M/s. Rutile & Zircon Development Association, Sydney, Australia, the Southport Zircon from M/s. Associated Minerals Consolidated Ltd., Southport, Australia, the Egyptian, Malaysian and South African Zircons from the Steel Castings Research and Trades Association, U.K., the Florida Zircon from M/s. American Colloid Company, U.S.A., and the West Australian Zircon from the School of Applied Geology, University of New South Wales, Australia.

The aims of the present studies are -

1) Characterization of the eight samples of zircon sands from different sources, in terms of physical, chemical, structural, thermal and mineralogical features, to identify the possible sources of variability in performance as a base sand;

2) development of an improved test piece for the study of compacted moulding sand; and

3) to determine the mould forming characteristics of zircon sands as indicated by green strength, permeability, bulk density and thermal expansion.