and electrostatic plate separators to produce zircon concentrates. Figure 4 is a simplified flowsheet of the zircon separation plant.

The magnetic discards serve as a feed to the monazite plant.

ILMENITE UPGRADING PLANT

Historically, ilmenite deposits on Australia's eastern seaboard have had chemical specifications, particularly in regard to chromium, outside those acceptable to the titanium pigment industry. Hence, until 1985 the market for ilmenite was limited to the steelmaking and abrasives industries, and by 1984 some 1.5 Mt of high chrome ilmenite had been stockpiled on North Stradbroke Island.

A tightening supply situation in world markets in 1984/85 brought about metallurgical testwork and a pilot plant capable of producing 50 000 t/yr of upgraded ilmenite with a minimum of 50% TiO_2 and a maximum of 0.40% Cr_2O_3 was operated.

Successful evaluation of test shipments from this plant led to the design of a 175 000 t/yr plant at Pinkenba, which was subsequently upgraded to 256 000 t/yr.

Processing involves

1. initial screening and washing,
2. drying and magnetic separation of the product, and
3. scalping of the tailing and recovery of suitable tailing material.

Feed for the ilmenite plant is a mixture of magnetic tailing and stockpiled ilmenite. The ilmenite feed is ferried to the Pinkenba dry mill together with final rutile/zircon concentrates in a 3-hold 1800 t barge. A common clam-shell grab crane, hopper, and conveyor system is used for unloading.

QUALITY CONTROL

Quality control of the rutile, zircon, and ilmenite concentrates is monitored on site using mainly physical techniques. Grain counting, magnetic separation, and heavy liquid separation are used to determine the grade and recovery of each mineral.

Samples are taken hourly by the operators and these are used to control the processing in both the dry mill and ilmenite plant. Automatic samples are collected and tested daily. These form the basis of two metallurgical balances which summarise the weekly production. Automatic samples are also taken as ships are loaded at the bulk mineral terminal.

Weekly composite samples are sent to an independent NATA registered laboratory for routine XRF analysis. The same laboratory is used for all shipment assays required by contract.

Dry mineral sands separation plant of Mineral Deposits Ltd at Hawks Nest, NSW

Staff of Mineral Deposits Ltd[1]

INTRODUCTION

Mineral Deposits Limited's dry mill is located at Hawks Nest, north of Port Stephens, NSW. The Hawks Nest dry mill produces up to 30 000 t/yr of rutile and a similar quantity of zircon. Small quantities of monazite are also produced. The concentrate produced by the wet plants contains 25–35 per cent rutile, 20–40 per cent zircon, 15–20 per cent ilmenite, 10–15 per cent quartz, with some garnet, tourmaline, a small quantity of monazite, and other heavy minerals.

HAWKS NEST MILL

The dry mill process technology of Mineral Deposits involves two main phases.

The first phase comprises feed preparation by the wet gravity rejection of quartz and the lighter heavy minerals and the removal of surface coatings on the mineral grains, particularly organic matter as humic acid, using caustic soda.

The second phase of separation is the dry mill separation proper. The high grade concentrate from the feed preparation circuit is dried and then separated in high tension separation machines into conductor and non-conductor streams. Both these streams are subjected to magnetic separation — the conductor stream for the rejection of ilmenite and the non-conductor stream for the rejection of garnets and other non-conducting magnetic minerals, including monazite. A finishing stage of electrostatic cleaning produces final rutile and zircon concentrates.

A general view of the Hawks Nest dry mill is shown in Fig. 1. The feed preparation circuit is shown in Fig. 2 and the dry separation circuit is shown in Fig. 3.

The feed to the Hawks Nest dry mill comprises approximately 70 000 t/yr of wet plant concentrates. These concentrates are drawn from three wet plants, and vary considerably in their rutile/zircon contents, size distribution, degree of surface contamination, and quartz content. For this reason, the dry mill feed is carefully blended from concentrate stockpiles ahead of the dry mill.

WET PLANT

Blended concentrates from the mining plants are tipped at a rate of 20 t/h onto a concrete slab and washed by hydraulic monitor into a pump which delivers to a cyclone. The cyclone underflow passes to four Warman attritioning cells in series. Caustic soda is added to disperse clay slimes and to remove humate coatings where present. After attritioning, the material is pumped to a spiral and table circuit for the removal of quartz and "light-heavy" minerals (Fig. 2).

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Fig. 1 — General view of Hawks Nest dry plant of Mineral Deposits Ltd.

The concentrate from the primary stage of spirals is recleaned to produce a final concentrate, the middlings from the primary spirals and the tailings from the cleaner spirals are scavenged to produce an intermediate concentrate which is further cleaned on a bank of six Scott tables.

Middlings from the scavenging unit are recirculated while tailings join the primary spiral tailings to form a rejectable tailing.

Spirals are very effective in this duty, but suffer from the defect that they are somewhat difficult to control visually to produce the best metallurgical performance. For this reason, the final and most critical separation is made by a small number of shaking tables. The introduction of this spiral circuit has been extremely effective, and has reduced the quartz content of the feed to the dry mill to less than 0.5 per cent. In addition, it has enabled a significant amount of the lighter heavy minerals (eg. tourmalines) to be rejected with consequent improvement in grade of feed to the dry mill, but without significant increases in loss of valuable minerals.

The final concentrate from the spirals and tables is mixed with fresh water and pumped to a wet drum magnetic separator for magnetite removal. The non-magnetic fraction is pumped again with fresh water, to dewatering cones situated over a drying floor. The use of fresh water at this point removes liberated slimes and traces of caustic soda which would be deleterious to high tension separation. Residence time on the drying floor is at least 1 wk, giving a consistent 4 per cent moisture feed to the dry mill. A low moisture content minimises fuel oil consumption, and temperature fluctuations in the dry mill.

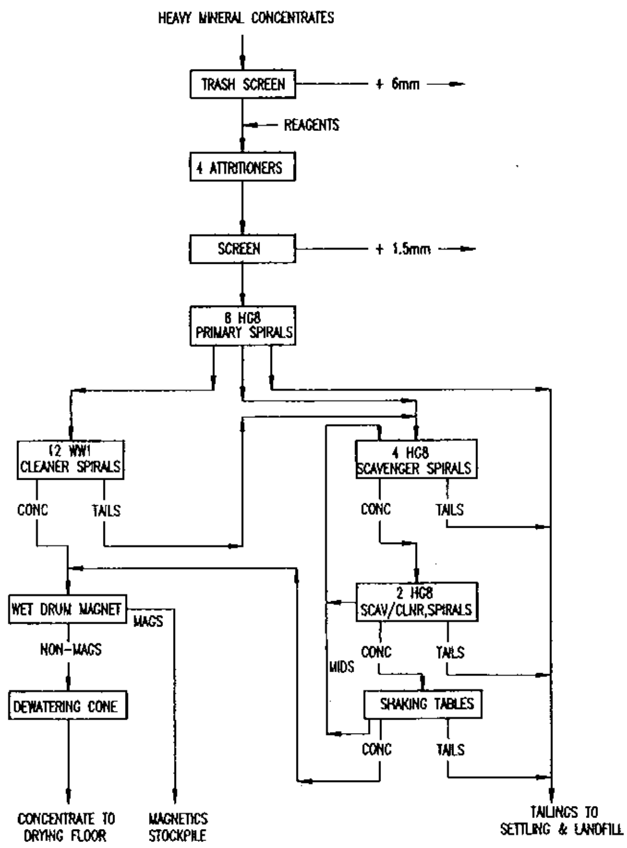

Fig. 2 — Flowsheet of feed preparation circuit at Hawks Nest dry plant of Mineral Deposits Ltd.

RUTILE PRODUCTION

The concentrate from the drying floor is fed with a front end loader through a conveyor system to a 100 t bin. From the bin it is metered at about 13 t/h by a disc feeder into a stainless steel dryer, which uses either diesel or coal fuel. The burner is controlled to give a discharge temperature from the dryer at approximately 150°C. The dryer discharge falls to a vibrating screen (3 mm apertures) where coarse trash is eliminated. The screen undersize passes to a bucket elevator feeding five Reichert Crossover and one 240 mm MDL Mk. IV high tension roll separators in parallel. These separators have four 150 mm diameter rolls and produce a conductor and a non-conductor product, and a middling recirculated to new feed. The recirculation of middling reduces fluctuations in feed rate and temperature from the dryer. The rougher conductors are fed via a bucket elevator to three Reichert conductor cleaner high tension separators which produce a clean conductor product containing essentially rutile and ilmenite, a non-conductor product which is recirculated back to rougher feed, and a middling which is recirculated on the conductor cleaners themselves (Fig. 3).

The conductor fraction which contains less than 0.5 per cent zircon, passes to two stages of high intensity dry magnetic separation to remove ilmenite. The first stage comprises six Reichert four roll semi-lift magnetic separators which remove the highly susceptible magnetic fraction. The non-magnetics pass to two Exelon and two Reichert four-roll high intensity magnetic separators which remove the poorly susceptible magnetics to produce a rutile product basically free of ilmenite. The ilmenite produced by the high intensity magnetic separator contains about 2 per cent rutile. This product is passed through a Readings cross-belt separator, which selectively removes the bulk of the ilmenite as a product containing less than 0.5 per cent rutile. The crossbelt non-magnetics are repassed to a Reichert high intensity magnetic separator which is lightly loaded to produce a final ilmenite and a non-magnetic rutile product.

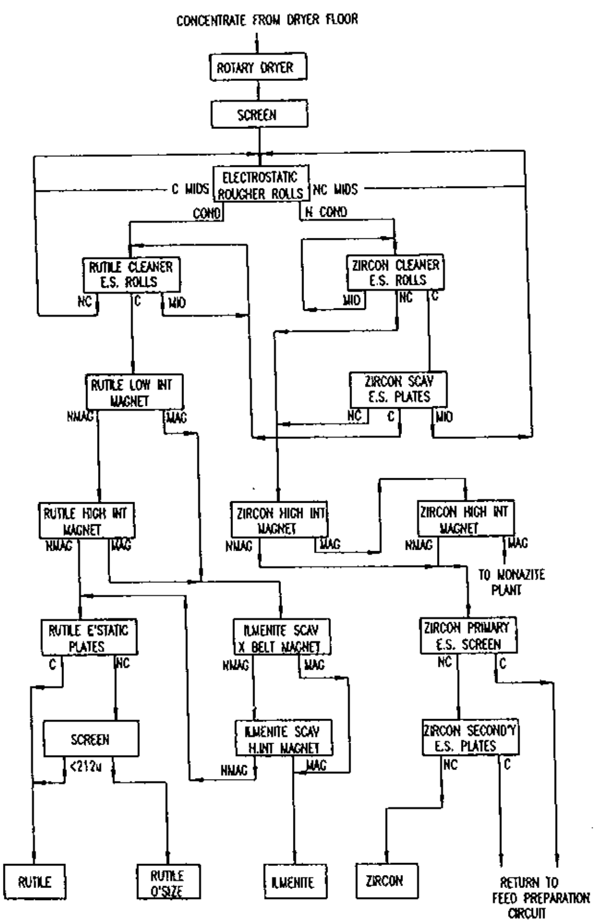

Fig. 3 — Flowsheet of dry separation circuit at Hawks Nest dry plant of Mineral Deposits Ltd.

The non-magnetics from the rutile magnetic separator pass to a stage of plate electrostatic separation using three single-sided Reichert five-plate electrostatic separators. These separators produce a clean rutile product and a non-conductor fraction which gravitates onto a vibrating screen. The screen, with approximately 220 µm apertures, rejects very coarse round zircon grains which tend to be thrown on the high tension separators into the conductor fraction. The conductors from the plate separators and the screen undersize join together and are delivered to storage by a conveyor belt. The rutile product can either be bagged or delivered to a bulk store for road haulage to Newcastle.

ZIRCON PRODUCTION

The non-conductors from the roughing high tension stage pass to five Reichert non-conductor cleaner high tension separators (Fig. 3). These produce a clean non-conductor product which contains less than 1 per cent rutile and leucoxene and a conductor product which is recycled back to two plate separators. The non-conductor product passes to a group of six Reichert four-roll high intensity dry magnetic separators which remove a magnetic product comprising garnets, magnetic zircon, and monazite, with some other magnetic silicate grains. This "zircon magnetics" product is later retreated for recovery of residual non-magnetic zircon and monazite. The non-magnetics from the zircon magnetic separator pass to two stages of electrostatic separation.

The first stage consists of three Reichert screen electrostatic separators, and the non-conductors from this stage pass onto a bank of two Reichert plate separators. Each of these separators has five stages of separation to produce a final zircon product that is less than 0.10 per cent TiO_2.

The electrostatic conductor product, which is rich in poorly conductive leucoxene, is returned to the wet gravity separation mill to be processed with incoming mine concentrates.

Air tables are currently used at Hawks Nest to remove residual quartz levels in the feed, particularly when producing ceramic grade zircon.

ZIRCON MAGNETIC SCAVENGING

Two high intensity induced roll magnetic separators were installed in 1988 for the purpose of scavenging magnetic zircon for the production of foundry grade zircon for the refractory industry.

ZIRCON MAGNETICS RETREATMENT

Current production "zircon magnetics" and recovered material from old dumps are currently being reprocessed. The dump material is fed by a front end loader and a field bin at the rate of 3 t/h to wet tables.

A top cut from the tables gives a monazite-rich fraction. An upper middlings fraction from the tables is retabled to produce a similar top cut rich in monazite. A zircon-rich product from all tables is stockpiled for reprocessing through the dry mill for zircon recovery. The magnetic zircon tends to be somewhat coarser than the non-magnetic zircon, and reports lower down the tables, together with the other non-conductor magnetic minerals of lower specific gravity, such as garnet, which are rejected as a final tailings. The monazite-rich top cut fractions are dewatered, then dried in a small dryer on day shift, and after a screening are processed through four stages of Reichert high intensity magnetic separators to produce a monazite concentrate containing at least 92 per cent acid solubles. Reject magnetic and non-magnetic fractions are recycled through the tabling circuit as the recovery of monazite in one pass is only 50 per cent. Overall recovery of monazite after recycle is in excess of 90 per cent.

ILMENITE RETREATMENT

Before the introduction of the Readings crossbelt magnetic separator, the ilmenite being stockpiled contained approximately 2 per cent rutile.

During 1989/90 a 200 000 t stockpile was reprocessed to recover 3380 t of rutile, utilising a Readings wide rotor wet high intensity magnetic separator at the rate of 30–50 t/h.

The ilmenite product produced contained less than 0.5 per cent rutile, while the non-magnetic fraction contained 22 per cent rutile and 16 per cent quartz.

Further processing in the wet gravity separation mill reduced quartz levels to approximately 1 per cent. This concentrate was then batch processed through the dry mill to produce a rutile product which was later blended with the high grade rutile product.

DRY MILL CONTROL

The grade of product from the dry mill is controlled by grain counting. Samples are taken every hour in the dry mill and counted by the operator to give an indication of final product grade. In addition, automatic samples are taken of final products and composited to shift samples. These are grain counted on day shift by the laboratory personnel. Also, weekly composite samples are grain counted and duplicates sent to the company's laboratory in Bundall, Queensland, for chemical or XRF analysis which closely checks with the grain count analysis.

The main operating variable control used in the dry mill is the voltage on the high tension machines. This is controlled by altering the voltage on the rectifiers to control the voltage on the electrode on the high tension separators, which determines the degree of lifting. Shift operators are not permitted to make other adjustments in the ordinary course of events.

The magnetic separators require little or no adjustment on a shift basis, but samples of the products are checked on a daily basis in the control laboratory.

Table 1

Guaranteed grades of rutile and zircon concentrates produced by Mineral Deposits Ltd

Rutile		Zircon			
		Ceramic grade		Premium grade	
TiO_2	95%	ZrO_2	66% min	ZrO_2	66% min
Fe_2O_3	1% max	Fe_2O_3	0.05% max	Fe_2O_3	0.05% max
ZrO_2	1% max	TiO_2	0.1% max	TiO_2	0.15% max

Table 2

Sizings of rutile and zircon from the Hawks Nest plant of Mineral Deposits Ltd

Size (μm)	Rutile (% wt)	Zircon (% wt)
+ 250	1.2	1.2
−250 +212	2.9	5.7
−121 +180	10.6	12.4
−180 +150	46.3	37.4
−150 +125	24.2	25.4
−125 +106	11.6	13.5
−106	3.2	4.4

PRODUCTS

The Hawks Nest dry mill produces rutile and zircon products of guaranteed grades as shown in Table 1. Typical sizings are shown in Table 2.