Book news

1. Book review

● The geology of some northern Nigerian anorogenic ring complexes, by J.N. Bennet, D.C. Turner, E.C. Ike, and P. Bowden. *The British Geological Survey: Overseas Geology and Mineral Resources,* no. 61. London, HMSO, 1984. 66 pp.

Reviewer: R.H. Ingram

The ring complexes of Nigeria and Niger constitute some of the best examples of mid-plate 'hot spot' magnetism in the world. The ring complexes consist of high-level, sub-volcanic, anorogenic intrusions spread over a north–south axis of 1250 km between the 8th and 10th meridians, and mark the transit of the continental plate over a nearly stationery mantle plume during the period 487 to 144 M.a. b.p.

The detailed descriptions of the mineralogy and petrology of these unusual rocks will be of interest to academic as well as economic geologists, since these ring complexes are host to tin and tungsten mineralization at Jos, among other sites. There are detailed descriptions of the styles of volcanism that took place during the emplacement of these ring complexes. This is possibly best demonstrated by the Ningi Burra Complex, where six discrete ring structures have been identified occupying an area 70 by 15 km. Early stage 'pre-caldera' basalt, trachybasalt, trachyte, rhyolitic ashfall tuffs, and ignimbrites preceded a 'caldera forming stage', when substantial crystal-rich intra-caldera rhyolitic ignimbrites were deposited and granite porphyry ring-dykes were emplaced. During the post-caldera stage, syenite, peralkaline, and biotite granites were emplaced. Another late-stage event was the development of greisens, which do not carry mineralization.

The style of mineralization associated with the ring complexes is exemplified by the Banke complex, where tin and tungsten mineralization is found within greisenized basement, the erosion of which has given rise to significant alluvial deposits.

The petrogenesis of these rocks is explained, and comparisons are made with other ring complexes. The role of fractional crystallization in the formation of gabbros, anorthosites, and peralkaline volcanics is discussed, as is partial fusion of the crust in the formation of biotite and hornblende granites. It is also noted that a tensional regime may be associated with the emplacement of ring complexes, and may be related to tectonic rifting and the opening of the proto-South Atlantic.

This is a well-written paper, and will be read with interest by South African geologists.

2. Mintek reports

● **Report M226**

The separation of tungsten and molybdenum by the formation of sulphide complexes and extraction into a weak-base resin.

The separation of molybdenum from tungsten can be achieved if a solution containing molybdate and tungstate ions is reacted with sulphide ions, and the molybdenum sulphide is extracted with an anion-exchange resin. The separation between molybdenum and tungsten is influenced by factors such as the pH value of the solution, the concentrations of sulphide and resin in the solution, and the period of contact between the resin and the metal ions in solution.

A fundamental study of the interaction between sulphide ions and molybdate or tungstate ions confirmed a mechanism proposed recently in the literature:

$$MeO_4^{2-} + nHS^- + nH^+ \rightleftarrows MeO_{4-n}S_n^{2-} + nH_2O,$$

where Me = molybdenum or tungsten and n = 1, 2, 3, or 4. In these reaction sequences, each successive step in the reaction (sulphur being substituted for oxygen) is slower than the preceding one, and the molybdate reactions with sulphide are several orders of magnitude faster than the analogous tungsten reactions. As a result, the extent of the complexing of tungsten with sulphide is minimal compared with that of molybdenum in the time span of the extraction experiments.

However, the current investigation shows that this is not the cause of the selectivity of anion-exchange resins for molybdenum in this system, and that the separation factor between molybdenum and tungsten is much the same for the precursor tungstate anion as it is for the various tungsten sulphide anions. The selectivity of the resin for molybdenum apparently originates from a thermodynamic preference of the amine functional group on the resin for molybdenum sulphide anions over tungstate or tungsten sulphide anions.

It is shown that, under optimum conditions, a separation factor of about 30 between molybdenum and tungsten can be achieved in this system.

● **Report M228**

The solvent extraction of zinc, iron, and indium from chloride solutions by neutral organophosphorus compounds.

The preparation of several neutral organophosphorus compounds and their evaluation as selective extractants for zinc in chloride media are described. The compounds belong to the series trialkyl phosphates $(RO)_3PO$, dialkyl alkylphosphonates $R'PO(OR)_2$ alkyl dialkylphosphinates $R'_2PO(OR)$, and trialkylphosphine oxides R'_3PO. They were characterized by measurement of their physical properties (melting and boiling points, refractive indices, and densities), and their purities were confirmed by osmometric determination of their molecular masses; by carbon and hydrogen microanalysis; by the titrimetric determination of acidic impurities; and, for liquid products, by comparison of their experimental molar refractivities with empirical values.

Metal-distribution equilibria were determined for solutions of the extractants in xylene and aqueous phases containing 0,5 to 5,0 M sodium chloride. Moderately good selectivities were shown for zinc(II) over iron(III), and excellent selectivities were shown for zinc(II) over iron(II), copper(II), and cadmium(II). The extraction of indium(III) was similar to that of zinc(II). The extraction of zinc(II), iron(III), and indium(III) increased markedly through the series

$$(RO)_3PO < R'PO(OR)_2 < R'_2PO(OR) < R'_3PO.$$

However, no marked effect on extraction or selectivity characteristics was shown when substituent alkyl groups were varied, except when phenyl groups were incorporated into the compounds, which led to much weaker extraction. These results appear to reflect the importance of electron-inductive effects rather than of steric effects. The extracted complexes of zinc(II), iron(III), and indium(III) have the stoichiometries $ZnCl_2L_2$, $FeCl_3L_2(H_2O)$, and $InCl_3L_2(H_2O)$ respectively, where L represents the neutral organophosphorus compound.

● **Report M230**

Shear flocculation of fines for improved flotation.

A shear vessel consisting of two concentric cylinders, one of which rotates within the other, produced uniform shear forces on fine particles of sulphide minerals. With increased shear force and higher concentrations of potassium amyl xanthate, fine galena particles (1,5 to 5 μm) were flocculated to form, via hydrophobic bonding, intermediate flocs (10 to 14 μm) and, ultimately, very large flocs (larger than 40 μm). Improved response to flotation after shear flocculation was observed for fine particles of galena and chalcocite. Although the results were often irreproducible, particles of gangue that are not capable of hydrophobic bonding did not interfere with the shear flocculation or subsequent flotation of fine valuable minerals.

Attempts to apply shear flocculation to cleaner tailings from a pyrite flotation plant were not successful.

● **Report M239**

A mineralogical study of residue from the column leaching of a low-grade nickel–copper sulphide ore.

An examination was made of solid residue from a column experiment that was designed to simulate the heap leaching of a low-grade nickel sulphide ore.

The precipitation of secondary minerals was shown to play an important role in the mechanical disintegration of coarse fragments of ore. Three distinct types of solid accumulation were identified as responsible for the gradual reduction in the permeability of the column as a whole as leaching progressed: the accumulation of fine chemical precipitates, the precipitation of secondary minerals, and the formation of agglomerates composed of denuded ore fragments. Jarosite, gypsum, and elemental sulphur were the principal secondary minerals formed.

3. Recent publication

● *Dräger Review*, special edition, Oct. 1985. 48 pp. (Copies obtainable from Roly Nyman, HAMPO PMIE Division, P.O. Box 170, Johannesburg 2000.)

Covering the history of Dräger's self-contained oxygen breathing apparatus and self rescuers, which goes back to the 19th century, this edition gives details of the development of the South African Oxyboks range of self rescuers. Fully illustrated, it includes the test results on Oxyboks K (chemical oxygen) units, which are now on field trial in selected South African mines, and the development to date on the Oxyboks D (compressed oxygen) units.

Black Mountain's achievement

The 13 689 t consignment of metal concentrate that was loaded aboard the bulk carrier 'George' and shipped out of Saldanha Bay early in December brought the number of tons exported from Black Mountain via the Sishen–Saldanha railway and harbour system to one million. The shipment was the 111th since production started in the latter part of 1979 at Aggeneys in the north-western area of the Cape Province. The first shipment of two consignments left Saldanha Bay on 29th February, 1980, and since then most of the products have been exported to Europe and Japan.

Black Mountain Mineral Development Company (Pty) Limited, which produces lead, zinc, copper, and silver from the mine at Aggeneys, is a joint venture between Gold Fields of South Africa Limited and Phelps Dodge Corporation of the U.S.A. Phelps Dodge started exploration in the north-western Cape in 1970, when the first shaft was sunk on Swartberg—the Black Mountain of the company's name. In 1976, Phelps Dodge sought a partner for the venture. Negotiations with Gold Fields followed, and in October 1977 an agreement was reached by which Gold Fields and its associates subscribed for a 51 per cent interest in Black Mountain. After that, Gold Fields took over the management of the project and brought the mine to production within two years.

Prior to the development of the mine, the Aggeneys region had practically no infrastructure. The South African government authorities agreed to provide a road link between the mine at Aggeneys and Halfweg (better known as Loop 10) on the Sishen–Saldanha railway line. Tractor–tridem rigs, each with a payload of 60 t, transport the concentrate on a gravel road over a distance of approximately 166 km to the mine's storage and rail-loading facilities at Loop 10. From Loop 10, the concentrates are railed to Saldanha, where the South African Transport Services have provided storage and shiploading facilities.

At present, more than 1500 people are employed by Black Mountain, and the townships on the mine have all modern facilities. The company reduced its debts from R111,5 million (December 1979) to R40 million (30th September, 1985) and, at the end of December 1984, showed a net profit of R22,7 million. Increased sales and the decline in the value of the rand were major contributors to the company's recent performance.

During an official function at the Langebaan Hotel in Saldanha on 9th December, the management of Black Mountain made presentations to the South African Stevedores, South African Transport Services, Freightmarine Shipping, and Refreight Forwarding in appreciation of their support and co-operation in the export operation.