6 Lead and Zinc

6.1 Introduction

Past zinc and lead production in Zambia has come almost exclusively from the Kabwe Mine (formerly known as Broken Hill), 110km north of Lusaka. First discovered in 1902, the mine went into production in 1906, before the Copperbelt deposits, and produced continuously until closure in 1992. Almost 11Mt of ore have been produced from the mine and the overall grade averaged about 25% Zn and 15% Pb (Watts, Griffis and McOuat, 1991). This grade and tonnage makes the Kabwe deposit one of the richest orebodies of its class in the world. Silver, vanadium and cadmium have also been produced in relatively small quantities. Kabwe and a number of smaller deposits occur within Roan Group sediments and can be regarded loosely as "carbonate-hosted" deposits. They fall more readily into the Mississippi Valley type (MVT) rather than the synsedimentary carbonate-hosted class, because of their pipe-like, breccia and vein styles, but depositional temperatures of 250–370°C (Kamona, 1997) are significantly higher than most MVT deposits. There has also been a considerable amount of secondary alteration and some of the orebodies could be classified as "karst-type" because of their relationship to the current topography and complex oxide and silicate mineralogy.

The potential for additional sulphide and oxide-silicate deposits in the immediate vicinity of Kabwe and northwards along the Lower Roan–Upper Roan contact is considerable. Key targets are areas where the Lower Roan–Upper Roan contact units have undergone shearing and/or tight folding. Focusing of fluid migration along unconformities might also have contributed to the genesis of such deposits and as a consequence the Mwashia–Lower Kundelungu break should be targeted.

New metallurgical methods of processing secondary zinc carbonate deposits by electrowinning have increased exploration interest in this type of deposit and the Kabwe area and its associated occurrences (Figure 18) offers promise for the discovery of small but relatively high grade secondary $ZnCO_3$ deposits. Much of the previous exploration has been directed at the discovery of disseminated and breccia-type sulphide deposits rather than the near surface secondary ores.

A second potentially significant group of deposits yet to be fully explored or worked are the polymetallic volcano-sedimentary deposits of the Nyimba area extending westwards to the Lukusashi Valley in the southern part of Eastern Province (Figure 26). These are believed to be in rocks of Muva age and open up a further extensive area for exploration in the Irumide terrain.

6.2 Carbonate-hosted Lead-Zinc Deposits

6.2.1 Kabwe

The most important lead-zinc deposits in Zambia (Figure 18) are the pipe-like and vein lodes comprising the Kabwe main orebodies and the nearby deposits of the Foundry Area, 5km south of the main orebodies. In January, 1902, T Davey discovered lead and zinc in iron-rich carbonate hillocks (kopjes) representing the outcrops of the pipe-like bodies of Broken Hill, which were named after similar deposits in New South Wales, Australia. The kopjes were numbered 1 to 4 and the other outcrops were 5, 6, E and F. These bodies were developed and became the number 1, 2, 3/4, 5/6 and E orebodies. Mining began in 1904, and the first concentrates were shipped to Europe in 1906.

The orebodies generally comprise a core of massive sphalerite + galena + pyrite surrounded by a breccia envelope of oxide-silicate mineralisation containing willemite, smithsonite and minor cerussite (Kamona, 1993; Watts, Griffis and McOuat, 1991). Also present are minor contents of silver, copper, cadmium and vanadium. Additionally, discrete oxide-silicate orebodies are also present – No. 2 and Mine Club/Speak's, which are tabular Zn-Pb (+Cu) deposits that appear to be secondary, discontinuous extensions of the sulphide deposits. The mineralisation is hosted by dolomites and dolomitic limestones of the Broken Hill Group, which is believed to be the equivalent of the Upper Roan (Bancroft) Formation on the Copperbelt (Cairney and Kerr, 1973; Kortman, 1972). A model lead age of 680 ± 13Ma (Kamona, 1997) indicates that the mineralisation was introduced during mid-Lufilian times during the Monwezi phase of deformation (see Table 6).

Prospects in the immediate Kabwe Mine area are not very encouraging. The oxidised nature of the ore at surface and the pipe-like nature of the orebodies make them difficult to locate by surface geophysical methods and geochemistry likewise suffers because of rich residual pockets of secondary ore overlying minor or no sulphides. Drilling and underground development was the best way to explore for the plunging, pipe-like bodies, when the mine was operational. The No. 2 orebody was the only remaining one underground and this had problems due to the sheared and unstable hanging wall. The other silicate deposits (including Mine Club and Speak's), which could have been used to supplement the feed from No. 2, were probably too refractory. A low-grade resource, the Airfield deposit, has been identified 1–2km north of the main orebodies where the estimated resource is 4.5Mt grading 3.6% Zn+Pb (approximately 2Zn:1Pb). Reopening of the Kabwe Mine is unlikely unless new metallurgical methods can be developed for treating the refractory oxide-silicate ores.

6.2.2 Kabwe to Kapiri Mposhi Area

The northward continuation of the mineralised Kabwe horizon has been traced almost as far as Kapiri Mposhi before it swings westward paralleling the Mufukushi River (Smith, 1966). A number of prospects have been discovered along this strike length (Figure 18) and are described below.

Chiwanda

The Chiwanda deposit is located 5 km west of Kabwe Mine and was initially discovered by Loangwa Concession Ltd in 1930, but geochemical soil sampling in 1955-6 identified a surface anomaly due to residual lead secondaries and willemite. From 1970 to 1972, further work was conducted by Zamanglo, consisting of stream and grid soil sampling (at 30m intervals along lines 300m or 600m apart) that located four base metal anomalies. These anomalies were investigated by pitting, trenching and various geophysical surveys (including geomagnetic, I.P., gravity and EM). The initial pitting located high Pb values in soil horizons, ranging up to 2.0% in one area, and more widely distributed Zn values up to 0.7% (extending for about 300m NE from the main Pb anomaly). Follow-up work included the excavation of 10 trenches. One trench returned a peak of 7.4% Pb over 1.5m, where galena was located. Zinc values were normally several times above background where lead values were high, however, zinc minerals were only visible in trenches 4 and 5. Trench 5 returned assays of 5.6% Zn over 8.0m, with a peak of 15.4% Zn over 3m. Two gravimetric and geochemical anomalies were followed up by 14 diamond drill holes but no economic values were intersected. Extensive exploration has defined a small (less than 100,000t) podiform deposit of sporadic disseminated galena and sphalerite hosted by the same dolomite unit as the Kabwe mineralisation (Watts, Griffis and McOuat, 1991).

Sebembere Copper and Kabwe West

A further 11km to the north-west, the Sebembere or Kabwe West area was trialled by T Davey, the discoverer of Kabwe, in 1902, but no further work was done until 1955 when Mineral Search of Africa (Rio Tinto) carried out a geochemical soil survey. They followed up the Cu and Zn soil geochemical anomalies by resistivity and gravity surveys, limited pitting/trenching and 10,000m of drilling in 27 boreholes, covering about 6,400m of strike. Of these holes, only 9 intersected values of >1% Cu varying from 100–400 m below surface. In 1970, a shaft was sunk (to 37 m) by the Romanian company, Geomin, but encountered water problems close to surface and the shaft was abandoned. From 1970-72, Geomin drilled 9 holes into the Cu prospect. One hole, R3, was collared in the Kabwe West area, however, no information is available on the hole. Rio Tinto drilled many holes into Sebembere, and one hole (SB20) that was drilled on the other side of the Sebembere "syncline" intersected almost 10 m of 6.16% Zn (from 96.08–105.23 m). Disseminated Zn was also intersected in massive dolomite over 55 m in hole SB21 (no assays).

In 1976, a soil sampling program for Zn was conducted by Minex and resulted in the granting of the Kabwe West PL. This survey identified three anomalous Zn areas, which was followed by pitting (abandoned, due to thick overburden – up to 15 m) and auger drilling of 403 holes to test the Zn content in the overburden and at the bedrock contact. Up to 30% Zn was found in the overburden but work on the Kabwe West lead-zinc prospect was suspended in 1978 due to lack of funding.

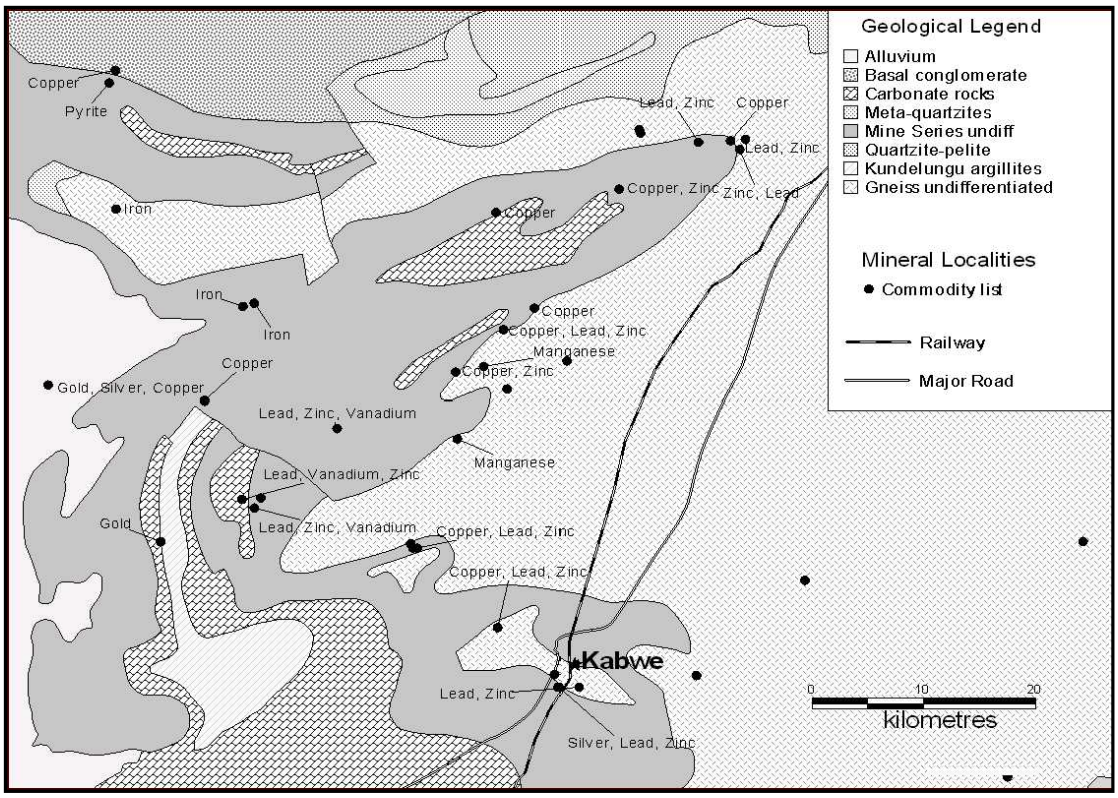

Figure 18 Location of mineral deposits and occurrences in the Kabwe area

As a follow-up of this earlier work, Minex entered a technical co-operation agreement in June, 1989 with two Japanese Government agencies; Japan International Co-Operation Agency (JICA) And Metal Mining Agency of Japan (MMAJ), which provided for an exploration drilling program to assess the potential for any mineralisation in the Kabwe West area (JICA, 1991). The program consisted of magnetic and EM geophysics and the drilling of 20 holes on a 100 m grid pattern. The zinc occurrences are promising (Samama et al., 1991; Watts, Griffis and McOuat, 1991), and may prove to be a better target than the pipe-like structures previous sought at Kabwe because the disseminated Zn deposits appear to be simple, both geologically and mineralogically.

A number of other geochemical anomalies and prospects have been identified along the strike of the Upper Roan dolomites and upper part of the Lower Roan sequence (Figure 18), emphasising the considerable importance of this horizon in terms of zinc-lead mineralisation and future exploration.

Camarnor

This zinc prospect, 35km north west of Kabwe, was located following the discovery of descloisite mineralisation (lead-zinc vanadate) in laterite in 1925 and 200t of vanadium ore grading 18–19% V_2O_5 produced between 1925 and 1927. An arcuate belt of Pb-Zn anomalies were found by subsequent soil sampling but the best values intersected in pits were 1.26% Zn and 26.4% Pb over 1.5m and 22.5% Zn and 5.27% Pb over 1.4m. Values of 1.29% Pb and 14.8% Zn over 2.1m and 0.29% Pb over 2.6m were intersected in boreholes.

Millberg and Mufukushi

The northerly continuation of the mineralised Kabwe horizon swings back westwards paralleling the Mufukushi River (Figure 18). Evaluation of the strike extension does not appear to have been intensive but two prospects have been identified - Mufukushi and Millberg. Mufukushi is actually a copper deposit containing an estimated 6Mt at 1.23% Cu and 1.4Mt at 0.70% Zn, the zinc occurring in the hangingwall of the copper mineralisation (Watts, Griffis and McOuat, 1991). A similar copper zonation is also evident in other deposits including Sebembere, Kabwe West and the Mine Club area at Kabwe. A resource of 300,000t at 3.7% Zn and 1.7% Pb has been estimated for the small lensoid deposit at

Millberg, which occurs as small pockets and lenticular bodies in a tremolite-rich rock. The structural position of this and other prospects such as Lukali, Kabwe west and the Kabwe Mine, are in the noses of west-plunging synclines of Lower Roan quartzites and the mineralisation appears to be concentrated in the Upper Roan carbonates lying immediately above. Further exploration along the whole of this zone should take place with special attention to these westerly plunging synclines.

6.2.3 Lunga Basin

Extensive stream sediment and soil geochemistry surveys in the area, together with some airborne EM, have identified a number of copper anomalies and two zinc anomalies – Kaungashi and Wambo.

The Kaungashi copper-zinc anomaly is 2.7km in length and consisted of soil values up to 1500ppm Cu and 5000ppm Zn. Follow-up pitting, cross-cutting, trenching and wagon drilling of 13 holes (from 21–33m) was conducted from 1959–61. This work showed that the anomaly was related to steeply dipping phyllitic rocks and values up to 2.97% Cu over 11m and 3.27% Zn over 9m were located in trenches. The wagon drilling indicated that surface enrichment was present, as the values were lower than in the trenches and pits. No further work was done until 1968, when additional pitting and trenching were completed. This was followed by more trenching, the drilling of 6 boreholes and a geomagnetic survey in 1970. Best results of core drilling were 1.14% Cu over 8m and 2.3% Zn over 9m. The Kaungashi mineralisation is associated with breccias adjacent to one of a number of syenite bodies that have intruded a sandstone-phyllite-limestone sequence of Upper Roan to Kundelungu age. Quartz veining and silicification are common, the bulk of the mineralisation occurring in brecciated and limonitic phyllite.

The Wambo prospect covers an area of anomalous zinc in soils, some 600m in diameter, and the Pb-Zn concentrations occur in clay and in the lower part of the C-horizon in solution hollows between pinnacles of dolomitic limestone. The limestone is brecciated with the interstices filled with haematite, and contains up to 1% Zn in brecciated bedrock. The circular nature of the soil anomaly, and the brecciation of the limestone suggest that this occurrence is possibly metasomatic, related genetically to nearby syenitic intrusives.

6.2.4 Mumbwa Area

Two prospects have been identified, in the South Lunga basin 50–60km NNW of Mumbwa, Bob and Katanga, both originally pegged for copper (Watts, Griffis and McOuat, 1991).

Bob Zinc was discovered by Mineral Search of Africa (Rio Tinto) in 1957, while drilling for water. Five holes were drilled by Mindeco/Noranda followed the initial discovery hole, and these confirmed the mineralisation. A geochemical survey outlined an anomalous area of over 1000ppm Zn. A small open pit excavation exists on the original outcrop, which may have been mined for manganese. A total of 12 surface holes were drilled in 1957 and 1964. Five of these holes intersected zinc-silver mineralisation within this anomalous area. The results ranged as high as 15.7% Zn and 177ppm Ag over 115m (drilled predominantly down the pipe). A total of 8 holes penetrated the ore body, 6 in high-grade, and 2 in low-grade mineralisation. Additional surface work was conducted by other companies in 1975, 1977 and by JICA/MMAJ in 1985–86. In 1986, JICA confirmed the original soil data (up to 1800ppm Zn) and also drilled six more holes over this area, but failed to locate any other significant mineralisation. The mineralisation of the Bob prospect comprises willemite and silver in brecciated and veined dolomite of inferred Lower Kundelungu age. The brecciation is presumed to relate to a prominent northerly trending fault zone, some 2.5km to the east. Subsequent drilling, however, indicated that the orebody was of limited size and a resource of 280,000t averaging 11.6% Zn and about 150g/t Ag was estimated.

The Katanga Copper prospect, 10km north of Bob, consisted of gossan containing malachite and chalcocite in dolomite. Ancient workings were located in Chief Kaindu's area and the Katanga claims were pegged in 1928. A pothole, right beside the old workings, was excavated in gossan down to 3 m and sampled at a depth of 2.42 m. The sample (no. 1) assayed 8.24% Cu, 5.37% Zn, 1150ppm Ag and about 3% Mn. Sample no. 2, taken from limestone outcrop near the pothole, assayed 1.3% Cu (with all other elements returning nil). Other small native workings are located about 30m east and 60m south-east of the pothole. No further work appears to have been done on the prospect.

6.2.5 Copperbelt

At Itawa, north of Ndola, galena was first noted in Ryeland's quarry, about 1.5 km east of Ndola railway station, in 1956, and, around the same time, an old copper occurrence was re-located in a road cutting to the east of Ndola. Subsequently, coarsely disseminated sphalerite and galena in dolomite was noted in five boreholes in the old quarry area with assay values from traces to 7.63% Zn over 3.3m. As well, galena was seen to occur in narrow veins. Holes were also drilled north of the quarry area. A resource of 3Mt of disseminated and vein mineralisation at 3.5% Pb + Zn has been identified and one drillhole by Rio Tinto at Munkulungwe, south of Ndola, averaged 0.5% Zn over 100m, with restricted zones up to 2.66% Zn (Watts, Griffis and McOuat, 1991).

6.3 Volcano-sedimentary Deposits

6.3.1 Introduction

Volcano-sedimentary deposits are located in a sequence of folded and faulted clastic metasediments, schists, gneisses, mafic and intermediate volcanic rocks and carbonate units of Muva age in southeastern Zambia (Figure 26). One prospect, Mpongo, is located in the Lukusashi Valley and the remainder occur in the area around Nyimba (Keppie, 1974).

The potential for large volcano-sedimentary deposits in southeastern Zambia is difficult to assess. The bimodal volcanism would suggest some potential for VMS deposits in the Chipirinyuma – Umba River area and several additional base metal occurrences have been recorded – Ng'ambwa, Kazizi, Nyazi, Fundo, Chambeshi, Ndake and Lutala Hills, all within 20km of Chipirinyuma. Sediment-hosted deposits of Sullivan type cannot be ruled out in the sediment-dominated sequences elsewhere in the Nyimba area.

6.3.2 Mpongo prospect

The initial discovery was made in the 1930s by Loangwa Concession Company. and was followed up by one large, and several smaller, trenches at the west end of the prospect. Chartered Exploration Limited explored by mapping, resampling old trenches, digging new trenches along the ironstone, carrying out a geomagnetic survey and, from 1964-66, drilling 11 surface boreholes (total of 1,000+m), over a strike length of 1,500m. These holes were spaced from 50 to 400m apart and from 50 to 150m in depth. The mineralisation has only been tested over "the best" (identified so far) 760 m strike and from depths of 30 to 150m. Not enough is known about the oxide mineralisation to calculate tonnages and grades. Only 10 holes have been used in the calculations, and the zones appear to be open down-dip and along strike to the west, under the Karoo sediments (which may be up to 100m deep near the river). Core recovery in the diamond drill holes was poor, and varied from as low as 10% for some lithologies, averaging <75% for the entire hole.

The deposit ranges in thickness from 1.8m to 36m and has been traced along strike for more than 5km (Watts, Griffis and McOuat, 1991). Copper-rich and zinc-rich zones have been defined by drilling along only about 1000m of strike. Estimated resources below the zone of oxidation are:

Cu-rich zone: 733,000t at 1.47% Cu, 1.55% Zn, 0.62% Pb, 39.4g/t Ag

Zn-rich zone: 158,000t at 0.15% Cu, 6.4% Zn, 0.98% Pb, 19.4g/t Ag.

6.3.3 Nyimba area

The two most interesting prospects in this area are Chipirinyuma and Umba River but a number of other targets at Lutala Hills, Ndake and Ng'ambwa, were identified by Minex during regional stream sediment geochemistry in 1975 and earlier airborne geophysics. Minex drilled nine holes at Chipirinyuma and its extension, and eight at Lutala Hills.

Chipirinyuma

Gossanous outcrops at the contacts between cyclically repetitive units of mafic and felsic gneisses define zones of massive pyrite and pyrrhotite containing sphalerite and minor molybdenite,

chalcopyrite, galena and gold (Watts, Griffis and McOuat, 1991). The host rocks consist of amphibolite, pink magnetic quartz-feldspar schist, magnetite-amphibole rock, pyrite-quartz schist and a tourmaline-quartz rock. Many of these probably represent exhalative sediments deposited around a hydrothermal vent system. A resource of 1.3Mt at 4.0% Zn and 0.8Mt at 3.79% Zn was estimated in 1989 but the deposit has been the subject of an evaluation more recently by Rio Tinto, the results of which remain confidential. Gold contents reportedly range up to c.0.5g/t.

Umba River

This is a zinc-lead-copper prospect located about 25km north-west of Chipirinyuma. Limited pitting and trenching yielded values of up to 4.8% Cu, 6.0% Pb, 0.44% Zn, 130g/t Ag and 33.3g/t Au (Watts, Griffis and McOuat, 1991).

The prospect was discovered as a result of an aeromagnetic survey of part of the eastern province, which was published in 1971. This showed the presence of a series of magnetic anomalies coinciding approximately with the Umba River prospect and extending along strike to the north-east and south-west. In May, 1973, the GSD followed up a galena find brought in by a prospector with a field program of soil sampling (cut short because it was thought that the mineralised zone was narrow and the sampling interval of 25 m was too large to outline such a small deposit) and stream sediment sampling. A number of lead, zinc and copper anomalies (up to 1.1% Zn and 0.3% Pb) were outlined and further work was recommended. Fieldwork in 1975 consisted of mapping and detailed geochemical sampling in the area of the old workings (trenches), excavating two new trenches, reconnaissance sampling over the magnetic anomalies and ground follow-up using a proton magnetometer.

The mineralisation appears to be confined to a narrow zone of 0.5m maximum width, (but reports are not well documented) close to the sheared contact between an 'upper' marble unit and the schist-pegmatite series. The magnetic anomalies do not seem to be related to the mineralisation, but appear to represent the gneisses and epidote-garnet amphibolite horizon. The Kawuyu prospect, south west of Umba River, was found by a geochemical Zn soil anomaly and appears to lie on the continuation of the Umba structure. It consists of disseminations in amphibolite with traces of gold. Not enough work has been done to assess the precious metal potential of the area and there does not seem to have been a full structural interpretation or an attempt to correlate the mineralisation between the prospects.

Lutala Hills

From mid-1975 to 1982 geophysical work over the area was conducted using magnetic, self-potential and induced potential methods. A coherent set of anomalies was discovered that mirror the known, 2.9km long, geological structure (the IP anomaly continued for 1.8 km). Analysis of gossan samples showed very promising base metal contents during the rock geochemistry survey (Zn up to 3,500ppm, Cu to 1,700ppm and Mo to 160ppm). Pitting was carried out, and the soil geochemistry for Zn, Cu, Pb and Mo contoured. Both the geochemical and geophysical anomalies were drilled (total of 927 m). Overall the results were disappointing, with a 6m thick sulphide-rich band, mostly pyrite and magnetite, being intersected over about 1,000m length and down to about 100m. The best results were borehole LT8 – 0.74% Zn and 0.04% Cu over 8.35m and borehole LT4a – 0.22% Zn and 0.13% Cu over 3.8m.

Ndake

Good geophysical (magnetic and EM) anomalies accompanied by stream sediment geochemical anomalies were found by Minex in the 1975 survey. The well defined Zn stream sediment anomalies (accompanied by lesser Cu and Mo) was followed by a detailed soil survey consisted of 3,135 samples with Zn from 100–3,000ppm and coincident lower values for copper and molybdenum. Chip sampling included 12 pits and 6 trenches, with many values ranging from 2,500–5,000ppm Zn, 300–1250ppm Pb. Two follow-up drill holes were put down in 1983 over the previously identified anomalies, but only 0.4m of massive sulphide was intersected, assaying 2% Zn and 0.07% Cu in drillhole NDK-1.

Ng'ambwa

This prospect and Kazizi, which is a continuation of Ngambwa West, exhibited good magnetic and EM anomalies discovered during first phase of exploration. The prospects were drilled in May, 1978, with three drillholes into a Zn anomaly (west) and one hole into a Cu anomaly. The results were

disappointing with the highest values being 0.49% Zn over 0.5m, and 320ppm Cu and 156ppm Mo over less than 0.5m.

7 Ferrous Metals Fe, Mn, Ti, V

7.1 Introduction

Zambia possesses an abundance of iron deposits of various types and attention has been directed to them on a number of occasions as a basis for a domestic iron and steel industry. In addition to fairly extensive investigations by larger companies including Anglo-American and Rio Tinto in the 1940s to 1960s, the skarn-type deposits south of Mumbwa were investigated by Yugoslav parastatal Geozavod in 1966–1967, and a joint UNDP-Mindeco programme focused on iron deposits during 1969–1973. Reports on all these studies are available at the Geological Survey Department and are listed in the bibliography.

Considerable discussion in recent years has revolved around whether domestic consumption in Zambia could support a limited iron and steel industry, particularly in view of the fact that the distance to any port largely rules out any export potential outside Africa. Consumption was estimated to be 150,000 tonnes of iron in 1999 (ECL, 1999), up from 70,000 tonnes of iron per year in 1965 (Watts, Griffis and McOuat, 1991), but the latter authors concluded that this requirement could be met by the established ZISCO plant in Zimbabwe and imports from the Republic of South Africa.

Despite these earlier negative prognostications, a number of developments since 1991 have placed the concept of domestic iron production in a more favourable light. The privatisation of the copper industry has seen major external investment into Zambia, and an increasing demand for iron and steel in the mining sector, across the construction and manufacturing industries, and in other areas of domestic activity. At the present time this demand has been met by imports from South Africa and Zimbabwe, and there are plans to create an iron and steel industry in neighbouring Mozambique. Zambia possesses an abundance of iron ore deposits and sufficient resources of limestone and energy are available to create its own iron and steel industry. Given its enviable political stability and position in Central Africa the country could meet its own domestic requirements and supply its neighbours with products from the iron and steel industry. However, the distance to ports is too great to allow the development of a large export-based industry and future prospects must depend on the continuation of economic growth and stability.

Three types of iron occurrence can be recognized in Zambia: sedimentary ironstone, skarn and replacement deposits and laterite. With only one exception (the Kampumba deposit), the larger deposits are confined to Katanga Supergroup rocks and commonly to units equivalent to the Mine Series Group (Lower Roan) (Figure 27). Key features of the more important deposits are presented in Table 23 taken from Watts, Griffis and McOuat (1991).

7.2 Sedimentary Ironstone Deposits

This group includes the massive and locally brecciated haematitic deposit of Nambala, a 300m-high ridge located approximately 20km south of Mumbwa, which is part of a discontinuous curvilinear line of ironstone ridges that extends for a distance of 24km (Phillips, 1955 and 1957; Dawson, 1974). Variations in the types of sedimentary deposits include the massive haematite beds intercalated with conglomerate and arkose at the Kasumbalesa deposit north of Chingola (Stohl, 1980) to the magnetite-quartzites of Mutombe and Pamba, 45km west of Lusaka (Stohl, 1977).