

# Chromium ore at Implats

Implats Mineral Resource and Mineral Reserve Statement 2018 | 108

**THE WORLD CHROMIUM ORE PRODUCTION ORIGINATES FROM THE MINERAL CHROMITE (A CHROMIUM-IRON OXIDE) IN THE ROCK OR ORE CALLED CHROMITITE. THE MAJORITY OF THE CHROMIUM MINERAL RESOURCES OF THE WORLD ARE TO BE FOUND IN THE BUSHVELD COMPLEX OF SOUTH AFRICA AND THE GREAT DYKE OF ZIMBABWE, WHERE IT OCCURS AS NUMEROUS THIN AND LATERALLY CONTINUOUS STRATIFORM CHROMITITE LAYERS, INTERLAYERED WITH MAFIC AND ULTRAMAFIC ROCKS.**

Up to 11 chromitite layers are known in the Great Dyke, named from the top down as Seams 1 to 11. Thirteen chromitite layers are known in the Bushveld Complex, which are further clustered into three groups, ie, the lower, middle and upper groups of chromitite layers. Named from the bottom up, these are termed LG1 to LG7, MG1 to MG4 and the UG1 and UG2. In places, individual chromitite layers may comprise multiple layers of subsidiary chromitite units, separated by intercalated silicate units.

Although some of the chromitite layers have been known since 1865, limited mining only commenced in 1916 in the Bushveld Complex and in 1919 on the Great Dyke. The use and mining of chromium escalated after the conclusion of the Second World War, with approximately half of the total world chromium ore production being mined from the Bushveld Complex.

In the Bushveld Complex, only the LG6, MG1 and UG2 chromitite layers are amenable to underground mining.

The uppermost chromitite layer (UG2) occurs at a depth range of 50m and 400m below the Merensky Reef and hosts economically exploitable quantities of PGMs within the chromitite. The UG2 chromitite layer is therefore mined at all Implats' operations, principally for the PGMs. Chromium can therefore be seen as a by-product of the UG2 Reef in South Africa. The LG6 and MG1, with an average  $\text{Cr}_2\text{O}_3$  grade of between 40% and 50%, occurs more than 250m below the UG2 Reef. These units can therefore not be mined from the existing infrastructure at the Implats' operations and are mined by other operators close to surface in opencast and underground mining operations for the chromium content only.

The UG2 Reef at **Impala** has an average *in situ*  $\text{Cr}_2\text{O}_3$  grade of approximately 33%, and a mined grade of about 16%. The mined ore from the UG2 Reef is milled and processed to recover the PGMs at the mine's two PGM concentrator plants. The tailings from the central concentrator are pumped directly to the tailings dams, as they are predominantly Merensky Reef tailings. Some of the tailings generated by the UG2 PGM recovery plant is reprocessed at two metallurgical plants to recover the chromite. Impala has an off-take agreement with Merafe Resources and annually sells approximately 220kt of chromite concentrate recovered at one of the chromite recovery plants. The second chromite recovery plant, which is owned by Impala Chrome, was commissioned in 2010 and is operated by Chrome Traders (Pty) Ltd. Currently some 200kt of chromite is reprocessed per annum by Chrome Traders and the remainder is pumped to the tailings dams. The retrieved chromite from the UG2 tailings has an average  $\text{Cr}_2\text{O}_3$  grade of approximately 41.5%. The number 3 and number 4 tailings dams at

Impala currently contain some 500Mt of milled and processed ore, with an average  $\text{Cr}_2\text{O}_3$  grade of less than 8%.

At the **Marula Mine**, ore from the UG2 Reef is milled and processed to retrieve the PGMs at the PGM recovery plant of the mine. The Makgomo chrome recovery plant subsequently reprocesses the UG2 tailings generated by the PGM recovery plant to extract the chromitite. The plant has been operating since 2010. Owned by Makgomo Chrome (Pty) Ltd, the plant is operated by Chrome Traders that has an off-take agreement whereby all of the chromite concentrate produced is purchased on a free carrier basis from the plant. Makgomo Chrome is 50% owned by the Marula Community Chrome (Pty) Ltd, 30% by Implats and 20% by Marula Platinum Mine. In recent years some 150kt of chromite concentrate is produced per annum and the remainder is pumped to the tailings dams. The *in situ* grade of the UG2 chromitite layer at Marula has not been determined, but the chromite concentrate has an average  $\text{Cr}_2\text{O}_3$  grade of approximately 42%. The tailings dam at Marula currently contains some 15.7 million tonnes of milled and processed UG2 ore at an average  $\text{Cr}_2\text{O}_3$  grade of approximately 12%.

At the **Two Rivers Platinum Mine**, ore from the UG2 Reef is milled and processed to recover the PGMs at the mine's MF2 PGM concentrator. The chromite recovery plant then reprocesses the UG2 tailings generated by the concentrator to recover the chromite. The chromite recovery plant was commissioned in 2013 and is owned and operated by Two Rivers, which also has an off-take agreement with Chrome Traders whereby all of the concentrate produced is purchased on a free carrier basis from Two Rivers. Currently some 240kt per annum of chromite is produced at a  $\text{Cr}_2\text{O}_3$  grade of 41.5% and a silica content of less than 3%, with the remainder being pumped to the tailings dams. The UG2 tailings at Two Rivers that have been reprocessed at an average  $\text{Cr}_2\text{O}_3$  grade of 15%. The tailings dams at Two Rivers currently contain some 24 million tonnes of milled and processed ore, at an average  $\text{Cr}_2\text{O}_3$  grade of 17%.

No mining has taken place at **Afplats**. The UG2 Reef in this area has an average *in situ*  $\text{Cr}_2\text{O}_3$  grade of about 31%.

At **Zimplats**, the uppermost chromitite layer (Seam 1) occurs 220m below the MSZ. It can therefore not be mined from the existing infrastructure and is mined by other operators and artisanal miners close to the surface outcrop for its chromium content only. This is also the case at **Mimosa**.

The available information is currently not sufficient to support a comprehensive Mineral Resource or Mineral Reserve Statement for the chromium ore production by Implats.

# Areas excluded from Mineral Resource estimates

Implats Mineral Resource and Mineral Reserve Statement 2018 | 109

## IMPLATS INTRODUCED A DEPTH CUT-OFF IN 2010 WHEREBY MINERALISATION BELOW A CERTAIN DEPTH IS EXCLUDED FROM THE MINERAL RESOURCE ESTIMATE.

This depth cut-off is applicable to the Bushveld Complex setting and is reviewed annually considering a range of assumptions, specifically the virgin rock temperature (VRT), cooling requirements, available technology, support design and other cost, prices and mining depth limits presently in the platinum industry. It is recognised that while the actual depth cut-off could vary from area to area and over time as conditions vary, a constant depth is assumed for all operations at present. The depth cut-off of 2 350m was applied during the 2013 Implats Mineral Resource estimates and equated approximately to a VRT of 73°C. The depth cut-off was effectively set at 2 000m below surface in 2014. Additional to the depth cut-off areas, various Mineral Resource blocks are considered on a case-by-case basis. Effectively all mineralisation deeper than 2 000m below surface has now been excluded from the Mineral Resource Statements, as well as other areas where the eventual economic extraction is in doubt.

In order to avoid confusion, these areas are not reported with the Mineral Resources but separately in this section. For further clarity, note that these are excluded from the summation of total Mineral Resources per area and the attributable Mineral Resources. These areas are also indicated as excluded areas on the Mineral Resource maps per operation.

The indicative quantum of such excluded areas is as follows:

- > At Impala the estimate for the areas underlain by the Merensky and UG2 Reefs that are excluded in the Mineral Resource estimates is in the order of some 19.5Moz Pt. More than 60% of these areas occur at depths greater than 2 350m below surface
- > At Afplats all of the Merensky Reef is excluded from the Mineral Resource estimates given the unlikely eventual economic extraction. In addition, there are areas where the UG2 Reef occurs at depths deeper than 2 000m and these are excluded in the Mineral Resource estimates listed in the Afplats section. The indicative quantum of such excluded areas is in the order of some 16Moz Pt for the UG2 Reef and Merensky Reef
- > At Two Rivers, an area west of the major fault on the farms Kalkfontein and Buffelshoek is excluded from the Mineral Resource estimate. The indicative quantum of such excluded areas is in the order of some 9Moz Pt in total for the Merensky and UG2 Reefs
- > At Zimplats, areas which are excluded from the Mineral Resource estimates are indicated on the Mineral Resource maps. These are mostly low grade areas and the quantum of these is not material in comparison with the total estimate for Zimplats.



Underground borehole core, 11C Shaft, Impala

# Glossary of terms

<b>4E (equivalent to 3PGE+Au)</b>	Refers to the sum of platinum, palladium, rhodium and gold content as determined by a nickel sulphide collection fire assay procedure; this is considered to be the most accurate assay procedure, and results can usually be compared between laboratories.
<b>6E (equivalent to 5PGE+Au)</b>	Refers to the sum of platinum, palladium, rhodium, ruthenium, iridium and gold content as determined by a nickel sulphide collection fire assay procedure; this is considered to be the most accurate assay procedure, and results can usually be compared between laboratories.
<b>AA</b>	Atomic absorption spectroscopy is an analytical technique which uses the absorption of light to measure the concentration of elements.
<b>Afplats</b>	Afplats (Pty) Ltd.
<b>Anorthosite</b>	Igneous rock composed almost entirely of plagioclase feldspar.
<b>ARM</b>	African Rainbow Minerals Limited of which ARM Platinum is a subsidiary.
<b>ASX</b>	Australian Securities Exchange.
<b>AusIMM</b>	Australasian Institute of Mining and Metallurgy.
<b>BEE</b>	Black economic empowerment.
<b>Bord and pillar</b>	Underground mining method where ore is extracted from rectangular shaped rooms, leaving parts of the ore as pillars to support the roof. Pillars are usually rectangular and arranged in a regular pattern.
<b>Bronzite</b>	Igneous rock composed mainly of orthopyroxene.
<b>Concentrating</b>	A process of splitting the milled ore in two fractions, the smaller fraction containing the valuable minerals, the rest waste.
<b>Chromitite</b>	A rock composed mainly of the mineral chromite.
<b>CIMA</b>	Chartered Institute of Management Accountants.
<b>Decline</b>	A shallow dipping mining excavation used to access the orebody.
<b>Development</b>	Underground excavations for the purpose of accessing Mineral Reserves.
<b>DMR</b>	Department of Mineral Resources, formerly known as the Department of Minerals and Energy (DME).
<b>Diorite</b>	Igneous rock composed of amphibole, plagioclase feldspar, pyroxene and small amounts of quartz.
<b>Dunite</b>	Igneous rock consisting mainly of olivine.
<b>Dyke</b>	A wall-like body of igneous rock that intruded (usually vertically) into the surrounding rock in such a way that it cuts across the stratification (layering) of this rock.
<b>ECSA</b>	Engineering Council of South Africa: The Engineering Profession Act, 2000 (Act No 46 of 2000), was promulgated in 2000; the Act became effective in 2011. In terms of Section 18(1), the Act empowers ECSA to register persons in certain prescribed Categories of Registration. Paragraph 9 of the SAMREC Code refers to ECSA: A 'Competent Person' is a person who is registered with SACNASP, ECSA or SAGC, or is a Member or Fellow of the SAIMM, the GSSA or a Recognised Overseas Professional Organisation (ROPO).
<b>EPO</b>	Exclusive prospecting order (Zimbabwe).
<b>Felsic rock</b>	An igneous rock composed mainly of a light-coloured mineral, like feldspar (or plagioclase) and usually quartz, which are more than 60% by volume.
<b>Gabbro</b>	Igneous rock composed mainly and approximately equally of plagioclase feldspar and clinopyroxene.
<b>g/t</b>	Grams per metric tonne. The unit of measurement of metal content or grade, equivalent to parts per million.
<b>GSSA</b>	Geological Society of South Africa.
<b>ha</b>	Abbreviation for hectare, unit of area measured equal to 10 000 square metres.

# Glossary of terms

<b>Harzburgite</b>	Igneous rock composed mainly of olivine and pyroxene.
<b>ICP-MS</b>	Inductively coupled plasma mass spectrometry is a type of mass spectrometry which is capable of detecting metals at low levels. This is achieved by ionizing the sample with inductively coupled plasma and then using a mass spectrometer to separate and quantify those ions.
<b>IMSSA</b>	Institute of Mine Surveyors of Southern Africa.
<b>In situ</b>	In its natural position or place.
<b>JORC Code</b>	The 2004 Australasian Code for Reporting of Mineral Resources and Ore Reserves. This was updated and reissued as the JORC Code 2012.
<b>JSE</b>	JSE Limited, the South African securities exchange based in Johannesburg. Formerly the JSE Securities Exchange and prior to that the Johannesburg Stock Exchange.
<b>JV</b>	Joint venture.
<b>Kriging</b>	A geostatistical estimation method that gives the best unbiased linear estimates of point values or of block averages.
<b>LoM</b>	Life-of-mine.
<b>Mafic</b>	An igneous rock composed mainly of dark ferromagnesium minerals, which are less than 90% by volume.
<b>Merensky Reef</b>	A horizon in the Critical Zone of the Bushveld Complex often containing economic grades of PGM and associated base metals. The 'Merensky Reef', as it is generally used, refers to that part of the Merensky unit that is economically exploitable, regardless of the rock type.
<b>Mill grade</b>	The value, usually expressed in parts per million or gram per tonne, of the contained material delivered to the mill.
<b>Moz</b>	Million ounces. All references to ounces are troy ounces with the factor being 31.10348 metric grams per ounce.
<b>MPRDA</b>	Minerals and Petroleum Resources Development Act of South Africa.
<b>MSZ</b>	The Main Sulphide Zone (MSZ) is the PGM-bearing horizon hosted by the Great Dyke. In addition to the economically exploitable PGMs there is associated base metal mineralisation. The MSZ is located 10m to 50m below the ultramafic/mafic contact in the P1 pyroxenite.
<b>Mt</b>	Abbreviation for million metric tonnes.
<b>Norite</b>	Igneous rock composed mainly of plagioclase feldspar and orthopyroxenes in approximately equal proportions.
<b>Pegmatoid</b>	An igneous rock that has the coarse-crystalline texture of a pegmatite but lacks graphic intergrowths.
<b>PGE</b>	Platinum group elements comprising the six elemental metals of the platinum group. The metals are platinum, palladium, rhodium, ruthenium, iridium and osmium.
<b>PGM</b>	Platinum group metals being the metals derived from PGE.
<b>Pyroxenite</b>	Igneous rock composed mainly of pyroxene and minor feldspar.
<b>QAQC</b>	Quality Assurance and Quality Control.
<b>RBR</b>	Royal Bafokeng Resources.
<b>Reef</b>	A local term for a tabular metalliferous mineral deposit.

# Glossary of terms

<b>RPO</b>	Recognised Professional Organisation.
<b>SACNASP</b>	South African Council for Natural Scientific Professions: The Natural Sciences Profession Act, 2003 (Act No 27 of 2003), was approved in 2003. The Act empowers SACNASP to register persons in certain prescribed categories of registration. Paragraph 9 of the SAMREC Code refers to SACNASP: A 'Competent Person' is a person who is registered with SACNASP, ECSA or SAGC, or is a Member or Fellow of the SAIMM, the GSSA or a Recognised Overseas Professional Organisation (ROPO).
<b>SAICA</b>	South African Institute of Chartered Accountants.
<b>SAGC</b>	South African Geomatics Council.
<b>SAIMM</b>	Southern African Institute of Mining and Metallurgy.
<b>SAMREC</b>	The South African Mineral Resource Committee.
<b>SAMREC Code</b>	The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves.
<b>SAMVAL Code</b>	The South African Code for the reporting of Mineral Asset Valuation.
<b>Section 11</b>	Section 11 of the MPRDA provides that the Minister's written consent is required for the cession, transfer or sale of a right, or an interest in such right, as well as the sale of a controlling interest in an unlisted company or close corporation.
<b>Section 52</b>	Section 52 of the MPRDA provides that the holder of a mining right must, after consultation with applicable trade unions, inform the Minerals and Mining Development Board if any mining operation are to be curtailed or to cease with the likely consequence being that 10% or more of the workforce or more than 500 employees, are likely to be retrenched in any 12-month period.
<b>Section 102</b>	Section 102 of the MPRDA provides that a right may not be amended or varied without the written consent of the Minister. This includes the mining work programme, environmental management programme, extension of the area or addition of minerals or seams.
<b>Seismic surveys</b>	A geophysical exploration method whereby rock layers can be mapped based on the time taken for wave energy reflected from these layers to return to surface.
<b>Smelting</b>	A pyrometallurgical process to further upgrade the fraction containing valuable minerals.
<b>SSC</b>	SAMREC/SAMVAL Committee.
<b>Stoping</b>	Underground excavations to effect the removal of ore.
<b>UG2 Reef</b>	A distinct chromitite horizon in the Upper Critical Zone of the Bushveld Complex usually containing economic grades of PGE and limited associated base metals.
<b>Ultramafic rock</b>	An igneous rock composed mainly of dark ferromagnesium minerals, which are more than 90% by volume.
<b>Websterite</b>	Igneous rock composed almost entirely of clino- and orthopyroxene.

# Mineral Resource and Mineral Reserve definitions

**SAMREC Code** – The Code sets out a required minimum standard for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves. References in the Code to Public Report or Public Reporting pertain to those reports detailing exploration results, Mineral Resources and Mineral Reserves and which are prepared as information for investors or potential investors and their advisers. SAMREC was established in 1998 and is modelled on the Australasian Code for reporting of Mineral Resources and Ore Reserves (JORC Code). The first version of the SAMREC Code was issued in March 2000 and adopted by the JSE in its Listings Requirements later that same year. The Code has been adopted by the SAIMM, GSSA, SACNASP, ECSA, IMSSA and SAGC, and it is binding on members of these organisations. For background information and the history of the development of the Code, please refer to the SAMREC Code, March 2000. A second edition of the SAMREC Code was issued in 2007 with an amendment being issued in 2009 and the latest edition was released in May 2016, this supersedes the previous editions of the Code.

A **‘Competent Person’** (CP) is a person who is registered with SACNASP, ECSA or SAGC, or is a Member or Fellow of the SAIMM, the GSSA, IMSSA or a Recognised Professional Organisation (RPO). These organisations have enforceable disciplinary processes including the powers to suspend or expel a member. A complete list of recognised organisations will be promulgated by the SAMREC/SAMVAL Committee (SSC) from time to time. The Competent Person must comply with the provisions of the relevant promulgated Acts. A Competent Person must have a minimum of five years’ relevant experience in the style of mineralisation or type of deposit under consideration and in the activity which that person is undertaking. If the Competent Person is estimating or supervising the estimation of Mineral Resources, the relevant experience must be in the estimation, assessment and evaluation of Mineral Resources. If the Competent Person is estimating, or supervising the estimation of Mineral Reserves, the relevant experience must be in the estimation, assessment, evaluation and assessment of the economic extraction of Mineral Reserves. Persons being called upon to sign as a Competent Person must be clearly satisfied in their own minds that they are able to face their peers and demonstrate competence in the commodity, type of deposit and situation under consideration.

A **‘Mineral Resource’** is a concentration or occurrence of solid material of economic interest in or on the earth’s crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling. Mineral Resources are subdivided, and must be so reported, in order of increasing confidence in respect of geoscientific evidence, into Inferred, Indicated or Measured categories. Geological evidence and knowledge required for the estimation of Mineral Resources must include sampling data of a type, and at spacings, appropriate to the geological, chemical, physical, and mineralogical complexity of the mineral occurrence, for all classifications of Inferred, Indicated and Measured Mineral Resources.

An **‘Inferred Mineral Resource’** is that part of a Mineral Resource for which quantity and grade or quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade or quality continuity. An Inferred Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to a Mineral Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration.

An **‘Indicated Mineral Resource’** is that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit. Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation. An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Mineral Reserve. An Indicated Mineral Resource has a higher level of confidence than that applying to an Inferred Mineral Resource.