The effect of mineralogical variation in the UG2 chromitite on recovery of platinum-group elements

by

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Platinum-group elements (PGEs) are recovered from UG2 chromitite by milling and flotation. The mechanisms involved during beneficiation of this type of ore are still poorly understood, partly because of its complex nature. Image-analysis techniques were used to characterise the mineralogy of UG2 chromitite from diverse geological environments, as well as the milling and flotation products derived from each of these ores.

Postmagmatic alteration of UG2 chromitite has a profound effect on the mineralogy, chemistry and recovery characteristics of the UG2 chromitite. Relatively unaltered UG2 chromitite consists predominantly of chromite and primary silicates, mostly bronzite and plagioclase with minor phlogopite, and small amounts of secondary silicates such as talc and chlorite. Trace quantities of base-metal sulphides, predominantly pentlandite, pyrrhotite and chalcopyrite ± pyrite, generally occur at chromite-silicate grain boundaries. PGEs are present both as discrete PGE minerals, and, to a lesser extent, sub-microscopically in other phases, mostly palladium and rhodium in pentlandite.

The PGE mineral assemblage is characterised by sulphide minerals, mostly braggite, cooperite, nickeloan malanite and laurite, and is closely associated with the base-metal sulphides. Recovery of PGE minerals is strongly dependent on the degree of liberation, with liberated PGE minerals and PGE minerals associated with liberated

base-metal sulphides, the fastest-floating particles. PGE minerals report to flotation tailings predominantly as fine-grained inclusions in coarse silicate particles.

In places, the footwall rocks have been replaced by iron-rich ultrabasic pegmatoid. As a result of interaction with Fe- and Ti-rich fluids, the chromite grains in the UG2 chromitite have been enlarged due to sintering, and the PGE mineral assemblage replaced by one consisting predominantly of laurite, Pt-Fe alloy and other non-sulphide PGE minerals. The non-sulphide PGE mineral grains appear to be slower-floating than sulphide PGE minerals.

Low temperature hydrothermal alteration appears to have caused relatively widespread alteration of the UG2 chromitite in some areas, resulting in corrosion and redistribution of sulphide minerals, as well as the replacement of primary magmatic silicates by secondary silicates such as pumpellyite, epidote, prehnite, albite, talc, chlorite and quartz. Ore from such areas are characterised by a base-metal sulphide assemblage consisting predominantly of millerite, chalcopyrite, and pyrite. Base-metal sulphide and PGE minerals occur in fine-grained intergrowths with silicates, resulting in poor liberation. In the samples investigated, composite particles were often faster-floating than expected, at least partly due to the presence of naturally floatable talc.

The effect of faulting on the mineralogy of the UG2 chromitite probably depends on distance from the fault zone, and possibly also timing of faulting, and can cause cataclasis of the ore. Where cataclasis occurred, broken mineral grains are cemented by secondary, hydrous silicates. Liberation of base-metal sulphides and PGE minerals are poor, and recoveries consequently very low.

It was demonstrated that reasonable estimates of total PGE+Au recovery can be made from the mineralogical characteristics of UG2 chromitite ore. Based on the mineralogy of ore from a specific area, provision can be made for appropriate adjustments to metallurgical flowsheets.

Die effek van mineralogiese variasie in die UG2 chromitiet op herwinning van platinum-groep elemente

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Platinum-group elemente (PGE) word herwin uit die UG2 chromitiet deur middel van maling en flottasie. Die meganismes betrokke tydens opgradering van hierdie tipe erts word nog nie goed verstaan nie, deels as gevolg van die komplekse aard van die erts. Beeldanalise-tegnieke is ingespan om UG2 chromitiet vanaf verskillende geologiese omgewings te karakteriseer, asook die maal- en flottasieprodukte afkomstig uit elkeen van hierdie ertse.

Na-magmatiese verandering het dikwels 'n ingrypende effek op die chemie, mineralogie en herwinningseienskappe van die UG2 chromitiet. Relatief onveranderde UG2 chromitiet bestaan hoofsaaklik uit chromiet en primêre silikate, hoofsaaklik bronsiet en plagioklaas, met min flogopiet, en klein hoeveelhede sekondêre silikate soos talk en chloriet. Spoorhoeveelhede onedelmetaal-sulfiede, hoofsaaklik pentlandiet, pirrotiet en chalkopiriet ±piriet, kom oor die algemeen gewoonlik voor langs chromiet-silikaat korrelgrense. PGE is teenwoordig beide as diskrete PGE mineraalkorrels, en, tot 'n mindere mate, submikroskopies, hoofsaaklik palladium en rhodium in pentlandiet.

Die PGE mineraal versameling bestaan sulfiedminerale, hoofsaaklik braggiet, cooperiet, nikkeldraende malaniet, en lauriet, en kom nou geassosïeer met die onedelmetaal-sulfiede voor. Herwinning van PGE minerale hang grotendeels af van graad van bevryding, met bevryde PGE mineraalkorrels, en PGE minerale geassosieer met bevryde onedelmetaal-sulfiede die mees vinnigsfloterende partikels. PGE

minerale in die flottasie uitskotte kom hoofsaaklik voor as fynkorrelrige insluitsels in groot silikaatpartikels.

In sekere areas, is die vloergesteentes vervang deur ysterryke ultrabasiese pegmatoïed. As gevolg van die interaksie met Fe- en Ti-ryke vloeistowwe, is die chromietkorrels in die UG2 chromitiet vergroot deur 'n sinteringsproses, en die PGE mineraalversameling vervang deur een wat grootliks bestaan uit lauriet, Pt-Fe allooi, en ander nie-sulfied PGE minerale. Dit wil voorkom asof die nie-sulfied PGE minerale stadiger flotteer as PGE sulfiedminerale.

Lae temperatuur hidrotermale verandering het in sekere gebiede relatief wydverspreide verandering van die UG2 chromitiet veroorsaak. Die resultaat is korrosie en herverspreiding van sulfiedminerale, asook die vervanging van primêre magmatiese silikaatminerale deur sekondêre silikaatminerale soos pumpelliet, epidoot, prehniet, talk, chloriet, kwarts en albiet. Hierdie monsters work gekenmerk deur onedelmetaal-sulfiedversamelings wat bestaan hoofsaaklik uit milleriet, chalkopiriet en piriet. Onedelmetaal-sulfiede en PGE minerale kom fynvergroeid met silikate voor. Dit lei tot swak bevryding. In die monsters wat ondersoek is, is egter gevind dat saamgestelde partikels in hierdie monsters beter flotteer as wat verwag is, deels as gevolg van die teenwoordigheid van natuurlik flotterende talk.

Die uitwerking van verskuiwings op die mineralogie van die UG2 chromitiet, hang waarskynlik af van die afstand vanaf die verskuiwingsssone, en moontlik ook die stadium waarop die verskuiwing plaasgevind het, en kan kataklastiese teksture in die erts veroorsaak. Waar dit voorkom, is gebreekte mineraalpartikels deur sekondêre silikate gesementeer. Bevryding van onedelmetaal sulfiede en PGE minerale is gevolglik swak, en herwinning laag.

Totale PGE+Au herwinning kan redelik goed voorspel word uit die mineralogiese eienskappe van die UG2 chromitiet. Op grond van die mineralogie van erts afkomstig vanaf 'n spesifieke area, kan voorsiening gemaak word vir geskikte aanpassings aan metallurgiese vloeikaarte.

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LIST OF ABBREVIATIONS

SEM – scanning-electron microscopy

EDS – energy-dispersive X-ray spectroscopy

IA – image analysis

XRD – X-ray diffraction

PGE – platinum-group element

PGEM – platinum-group mineral. This abbreviation was used rather than the more commonly accepted PGM to avoid confusion, as PGM is also used to indicate platinum-group metal.

BMS – base-metal sulphide

ECD – equivalent circle diameter

GB – grain boundary

Mintek – Council for Mineral Technology