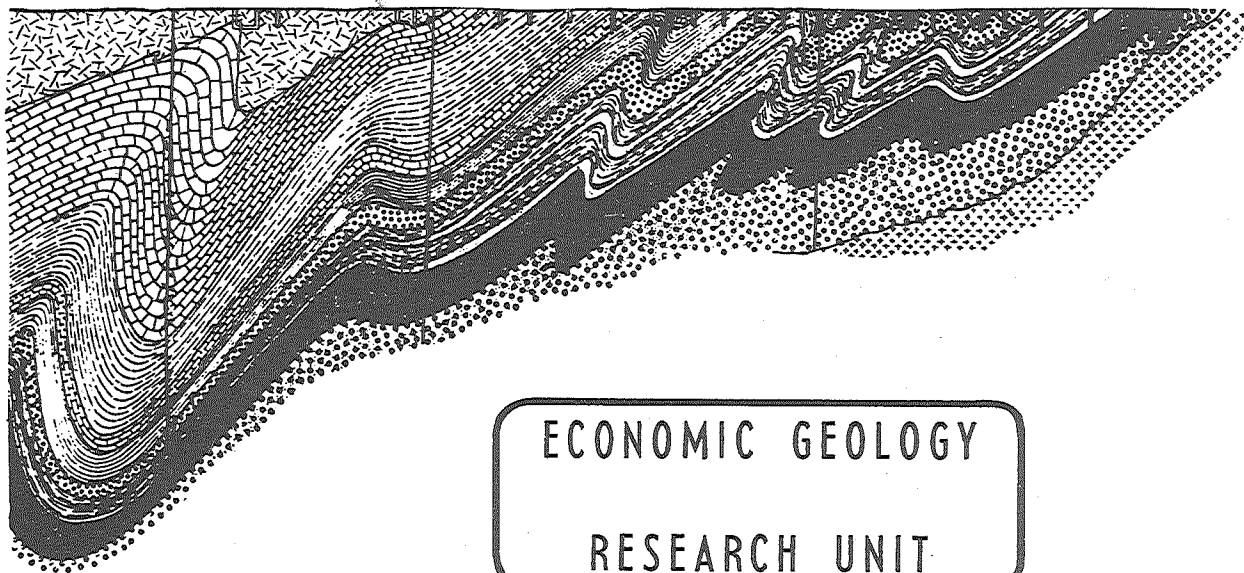




UNIVERSITY OF THE WITWATERSRAND  
JOHANNESBURG



ECONOMIC GEOLOGY  
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INFORMATION CIRCULAR No. 43

CHROMITE GRAINS SHOWING ALTERED  
BORDERS FROM THE BASAL REEF,  
WITWATERSRAND SYSTEM

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ABSTRACT

Chromite grains possessing different reflectivities and higher reflecting borders have been observed in the Basal Reef of the Witwatersrand System. Investigation with the electron-microprobe revealed the increase in reflectivity to be caused by an increase in the iron and, possibly, the chromium content, and a decrease in the magnesium and aluminium content of the chromite. It is suggested that this alteration took place to a great extent in situ, and has been intensified by radioactive emanation, which facilitated the destruction of the crystal lattice and thus promoted subsequent replacement.

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INTRODUCTION

The existence of chromite grains that exhibit rims of higher reflectivity has been known for some considerable time and described, among others, by Horninger (1941), Spangenberg (1943), de Wijkerslooth (1943), Augustithis (1960), Panagos and Ottemann (1966), and in great detail by Weiser (1967).

An ore-microscopic study of sediments belonging to the Basal Reef of the Witwatersrand System in the locality of Welkom, in the Orange Free State Goldfield, showed a large proportion of the chromite grains, which form a common constituent of the heavy mineral suite, to be rimmed by such a marginal area showing higher reflectivity.

Horninger (1941) describes the alteration product forming these high reflecting marginal areas as 'grey magnetite'. He suggests that the alteration takes place by substitution of material with the country rock, i.e., by either the removal of Al and Mg from, or the addition of Fe to, the chromite.

Spangenberg (1943) considers the high reflecting margins to be the result of serpentinization and chloritization of the country rock. He suggests an exchange between the  $MgAl_2O_4$  component of the chromite and the  $Fe_3O_4$  component of the country rock. During the process the  $Cr_2O_3$  content of the chromite is supposed to remain constant.

De Wijkerslooth (1943) believes that the formation of the marginal zones takes place at a later hydrothermal-metamorphic period that leads to a distinct selective resorption, during which certain components ( $FeO-Fe_3O_4$ ,  $Cr_2O_3$ ) are more slowly removed than others ( $Al_2O_3$ ,  $MgO$ ). The higher reflecting margins therefore represent areas which contain relatively higher concentrations of Fe and Cr. De Wijkerslooth does not agree with the addition of Fe as postulated by Spangenberg and Horninger.

Ramdohr (1950), discussing chromites in general, mentions weathering and hydrothermal decomposition as causative processes of higher reflecting borders, these having the composition of pure magnetite in extreme cases.

The composition of the marginal area in chromites from the Belledonne Massif has been surmised by Den Tex (1955) to be enriched in the magnetite phase. Qualitative determinations with an electron-microprobe carried out by Panagos and Ottemann (1966) on the marginal phase of chromites from Rodiani, Greece, showed not only an increase in the iron and chromium content, but also a decrease in the magnesium and aluminium content. The exact chemical compositions of the marginal phases of chromite grains from various localities have been determined by Weiser (1967). He found no uniform composition of the marginal areas, but always a displacement from the 'typical' chromite towards a more iron-rich spinel. He found that the boundary between altered and unaltered areas was sharp. However, he believes in a gradational chemical change that takes place over a submicroscopic width, which could not be recorded even with the electron-microprobe.

Weiser (1967) distinguishes two groups of marginal higher reflecting areas. In the one group, an increase in the Fe and Cr concentration is formed at the cost of a decrease in Al and Mg. This leads to solid solutions that are rich in ferrochromite. In the other group, considerably higher contents of Fe and lower concentrations of Al, Mg, and Cr occur and a magnetite-rich solid solution is formed. Weiser concludes that the

composition of the marginal rims can vary within an ore province, but generally not within one particular ore deposit.

On the composition of the marginal phase, the present authors have not much new to offer. However, they noted some unusual environmental relationship in some of the chromite grains present in the Witwatersrand sediments that may throw some light on the genesis of the marginal zones exhibited by the grains.

## METHODS OF INVESTIGATION

### A. OPTICAL INVESTIGATION OF POLISHED SECTIONS

An optical investigation of chromite grains in more than two hundred polished sections revealed a slight variation in the reflectivity of the grains, which, however, was not easily noticeable unless such grains were close enough to each other to be directly comparable (Plate 1, Figure 1). In addition to the variation in reflectivity of the grains, a large proportion contained borders showing higher reflectivity, this being especially noticeable when oil immersion objectives were used (Plate 3, Figure 1). These marginal areas were generally fairly narrow, following the outline of the grains and also bordering cracks and fractures. Where the chromite grain was in juxtaposition with a grain of uraninite or other radioactive mineral, the side of the chromite adjoining it had a noticeable widening of the marginal area (Plate 2, Figure 1). Similar features have been noted by Ramdohr and Schidrowski (1965) in connection with radioactive corrosion of chromite. This juxtaposition of chromite and a radioactive mineral is naturally rare. Among the limited amount of such grains observed, a few exceptions to the rule of marginal widening were noticed and these are puzzling phenomena.

### B. REFLECTIVITY DETERMINATIONS

Reflectivity determinations, with a Leitz Dialux-Pol microscope, fitted with an MPE Leitz-photometer and photomultiplier tube (type VFS9A, Fernseh GMBH; for its spectral sensitivity see Saager and Mihálik (1967), Figure 3), carried out on the grains pictured in Plates 1, 2, and 3, gave the results shown in Table 1.

TABLE 1  
RESULTS OF REFLECTIVITY AND HARDNESS  
MEASUREMENTS ON CHROMITES FROM THE  
BASAL REEF

Chromite Phase	Reflectivity Value %	Hardness Value HV
Darker grain, Plate 1, Figure 1	9.3	1226
Lighter grain, Plate 1, Figure 1	11.0	1206
Marginal phase, Plate 2, Figure 1	11.5	1206
Core of grain, Plate 2, Figure 1	10.3	1192
Marginal phase, Plate 3, Figure 1	13.2	1183
Core of grain, Plate 3, Figure 1	11.8	1183

Each of the reflectivity values given is the mean of 6 measurements and is related to the (111) plane of pyrite from Río Marina, Elba, which was standardized at 54.6 per cent at a wavelength of 590 nm, according to the value obtained by Singh (1965) on pyrite from the same locality.

The results obtained show the considerable variation in the reflectivity of both the cores and the rims of various chromite grains.

#### C. MICROHARDNESS MEASUREMENTS

The microhardness determinations were carried out on a Leitz Durimet Vickers Hardness Tester with a load of 200 grams and a contact time of 25 seconds. The results obtained on the grains shown in Plates 1, 2, and 3 are also given in Table 1. It seems that the differences obtained on the various types of chromite lie within the margin of error of measurement.

#### D. ELECTRON-MICROPROBE DETERMINATIONS

The qualitative determinations were carried out with an Applied Research Laboratories Model EMX electron-microprobe. Plate 1, Figure 1 shows two chromite grains, one moulded against the other, and each possessing different reflectivities. Figure 2 shows the electron-backscatter image indicating the grain of higher reflectivity to have a higher mean atomic weight. Figures 3 to 6 show the X-ray-distribution images of Al, Mg, Cr, and Fe K $\alpha$  radiations, respectively. The higher Mg and Al content of the darker chromite grain is apparent.

Plate 2, Figure 1 shows the optical photomicrograph of a chromite grain adjoining a grain of uraninite containing numerous inclusions of radiogenic galena. Figure 2 shows the electron-backscatter image. Note the clearly higher mean atomic weight of the marginal area, which is noticeably wider in the neighbourhood of the uraninite. Figures 3 to 6 show the X-ray-distribution images of Al, Mg, Cr, and Fe K $\alpha$  radiations, respectively. The markedly lower Mg and higher Fe content of the marginal area is illustrated. Here it seems that MgO has been replaced by FeO, whereas Al and Cr are little affected.

Plate 3, Figure 1 shows the optical photomicrograph of a chromite grain traversed by two younger pyrite veins and possessing a higher reflecting rim. Figure 2 is the electron-backscatter image, which shows again the higher mean atomic weight of the marginal area. Figures 3 to 6 show the X-ray-distribution images of Al, Mg, Cr, and Fe K $\alpha$  radiation, respectively. The Al and Mg are present in lower concentrations, in the marginal area, whereas again Fe is higher and in this instance possibly also chromium.

The higher iron and chromium content and the lower magnesium and aluminium content of the more intensely reflecting chromite phase is clearly demonstrated. It appears that, in the samples investigated, the intensity of the reflectivity of chromite is a measure of the degree of leaching of the magnesium and aluminium from the lattice.

#### CONCLUSIONS

The rounded form of Witwatersrand chromites and the lack of chats with the source-rock material suggested to Davidson and Bowie (1951) that the chromite grains

have been transported over a considerable distance. Ramdohr (1955), however, points out that chromite, even in primary deposits occurs mostly as rounded grains and that even after limited distance of transport the chromite is separated from its source-rock and that any serpentine attachments could be dissolved by pseudohydrothermal solutions circulating during the consolidation and metamorphism of the conglomerates. Ramdohr (1955) further considered the higher reflecting rims of many Witwatersrand chromite grains as prominent indications of a short transport, as such borders are present in chromites in their primary environment and would be abraded during long transport. This seems to the present authors to be contradictory to Ramdohr's earlier statement (Ramdohr, 1950), where weathering and decomposition are made responsible for the formation of the higher reflecting borders.

As mentioned earlier, the present investigation revealed that at least part of the higher reflecting borders in Witwatersrand chromites were formed in situ and, therefore, cannot be used as a criterion indicating a short distance of transport.

The two groups of marginal areas as described by Weiser (1967) were not observed in this investigation, and this may be due to chemical changes during the transport of the grains and during their incorporation into the Witwatersrand sediments. Subsequent alteration is further borne out by the presence of a marginal phase adjoining open cracks and fissures, and by the widening of the marginal areas where chromite grains were lying in juxtaposition with grains of uraninite. Both these phenomena were undoubtedly formed in situ.

The proximity of a radioactive mineral to certain of the chromite grains is believed to have been responsible for a certain amount of lattice destruction, which in turn facilitated the leaching of MgO from the lattice and its replacement by FeO. There is no apparent change in the Cr and Al content in this particular instance. In other cases, however, a decrease of Mg and Al, together with a marked increase in Fe and a possible increase of Cr, has been found. The physical damage caused to surrounding minerals by radioactive grains is not unknown, and has been described among others by Liebenberg (1955).

The presence of chromites, lying in juxtaposition, the cores of which differ in composition, points to considerable primary differences that must have existed between various chromite grains during the time of deposition.

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### KEY TO PLATES

#### Plate 1

- Figure 1 : Optical photomicrograph showing two chromite grains differing in reflectivity. Basal Reef. Oil immersion, 250X.

Figure 2 : Electron-backscatter image.

Figures 3  
to 6 : X-ray-distribution images of Al, Mg, Cr, and Fe K $\alpha$  radiations respectively.

Plate 2

Figure 1 : Optical photomicrograph showing a grain of uraninite lying in juxtaposition with a chromite grain. Basal Reef. Oil immersion, 500X.

Figure 2 : Electron-backscatter image.

Figures 3  
to 6 : X-ray-distribution images of Al, Mg, Cr, and Fe K $\alpha$  radiations, respectively.

Plate 3

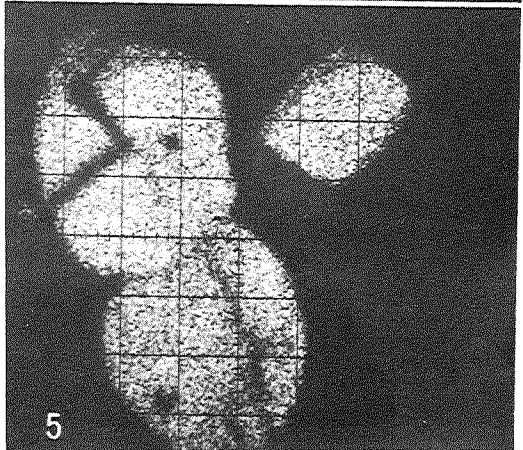
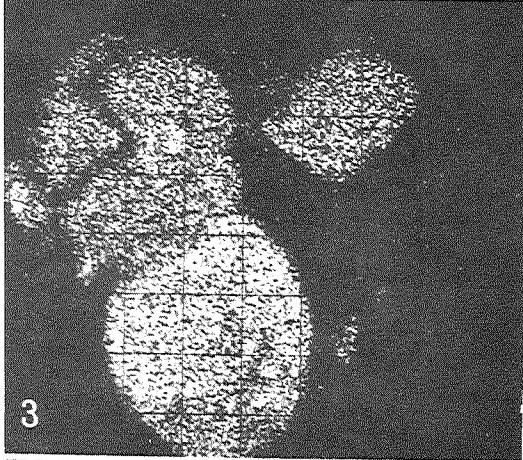
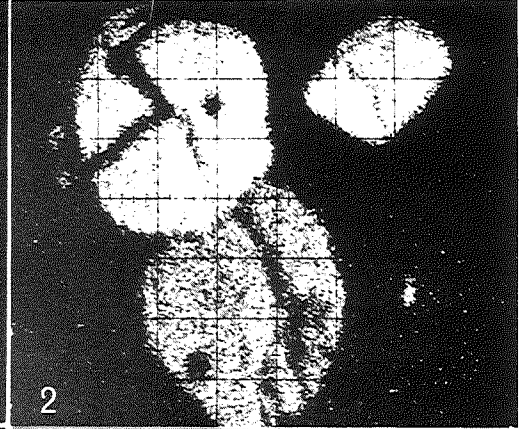
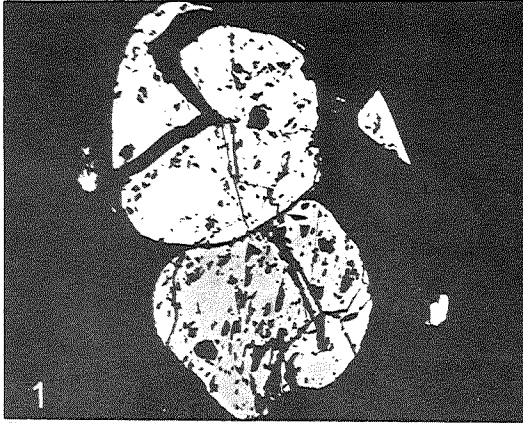
Figure 1 : Optical photomicrograph showing a chromite grain with a higher reflecting border. Basal Reef. Oil immersion, 250X.

Figure 2 : Electron-backscatter image.

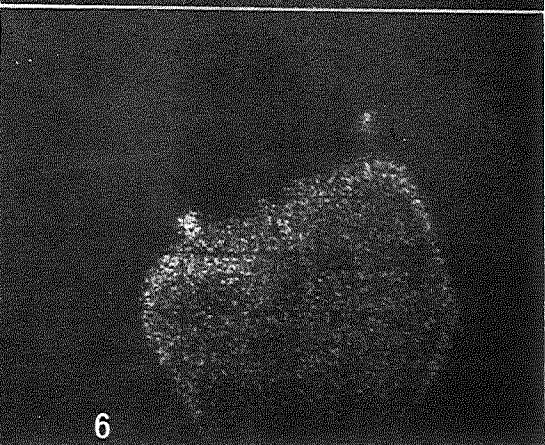
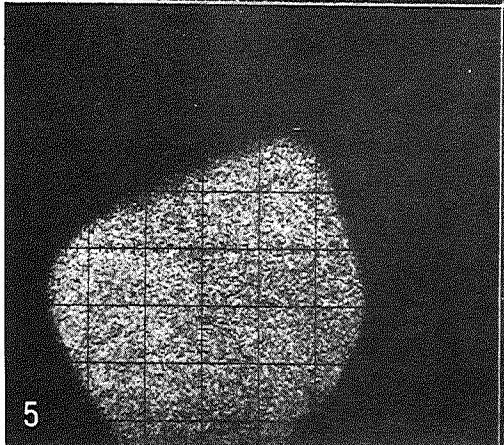
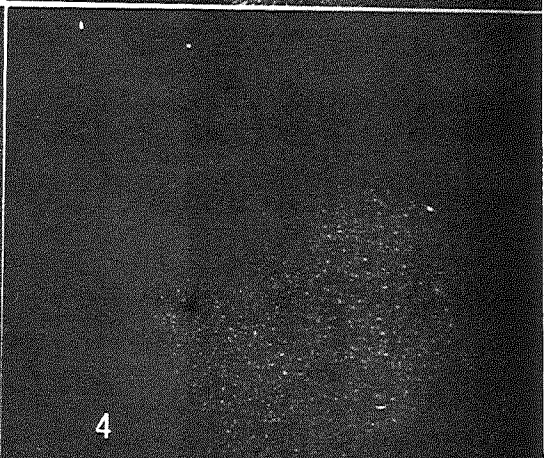
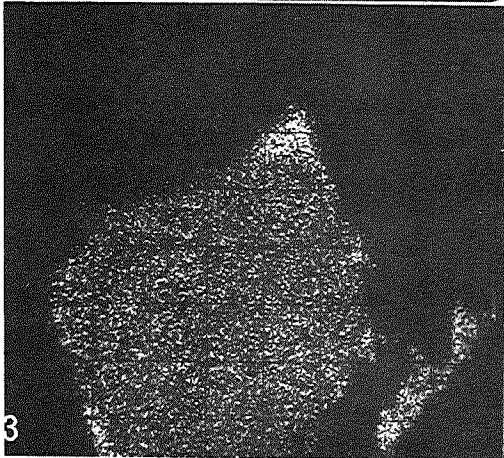
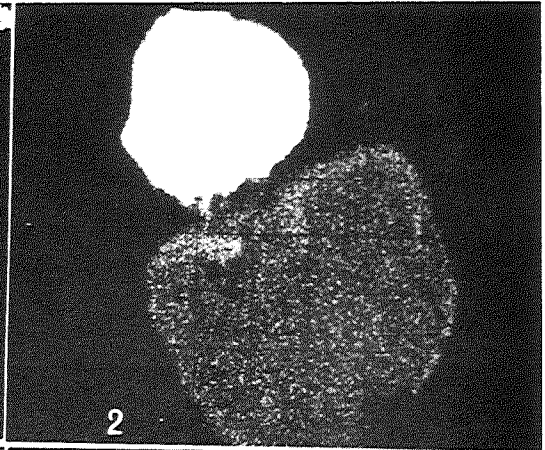
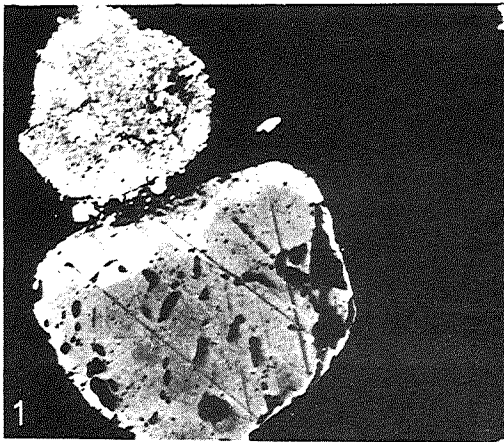
Figures 3  
to 6 : X-ray-distribution images of Al, Mg, Cr, and Fe K $\alpha$  radiations, respectively.

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# PLATE 1



# PLATE 2



# PLATE 3

