The Formation of Chromite and Titanomagnetite Deposits Within the Bushveld Igneous Complex

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During the famous international Bushveld excursion in 1929 some geologists put up a sign: "Here was the Bushveld Complex, before Paul Ramdohr sampled it away". As you may find in the following paper Paul Ramdohr left something for further research.

Abstract

A brief analysis of the early tectonic history of southern Africa reveals that the intrusion of the Bushveld Complex is situated at the intersection of several lineaments. Based on gravity measurements, the Bushveld can be divided into five subcomplexes.

The differentiation of the Bushveld magma can be explained by two model systems: MgO – SiO_2 – Fe_3O_4 – Cr_2O_3 and MgO – SiO_2 – FeO – Fe_2O_3. However, these model systems can neither explain the formation of the chromitite seams of the Critical Zone nor the massive titanomagnetite layers of the Upper Zone.

f_{O_2}-Measurements on chromites indicate that the formation of chromitite seams is caused by periodical fluctuations of the f_{O_2}. A similar mechanism has been postulated before by various authors for the accumulation of massive titanomagnetite layers.

Detailed geochemical analyses of host rock magnetites are interpreted. Several field evidences indicate the existence of local, but enormous volatile activity and the formation of anomalous magnetite layers by an increase of the f_{O_2}, caused by contamination of the magma with sedimentary fragments.

A new model is presented, which explains the formation of massive chromite and titanomagnetite seams as a function of the f_{O_2}, as well as their extreme lateral consistency within the Bushveld Complex.

1 Introduction

The Bushveld Complex in South Africa is the largest intrusive complex of the earth. Its economic importance regarding the mineral resources of the earth is enormous. Concerning the reserves of chromium, platinum, vanadium and titanium, the Bushveld ranges first in the list of all known mineral resources. Besides this, the production of nickel and copper is also considerable. Abnormal concentrations of apatite in the diorites of the uppermost sequence are not yet sufficiently known in their quantities.

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Therefore, the importance of the Bushveld Complex as a possible reserve of phosphorus in the future is still unknown. Considering these facts, it seems highly justified to concentrate on this extraordinary geological feature and its genetic history.

2 Tectonic Evolution

An intrusion of the dimension of the Bushveld Complex must be the consequence of large-scale tectonic events. Therefore, we draw attention to the main tectonic structures of southern Africa between 2.5 and 1.8 b.y. Already during the formation of the Archean Greenstone belts, at least 3 ENE- and WSW-striking lineaments existed (Fig. 1). These main structures, the Barberton-, the Murchison- and the Soutpansberg-Lineament, date back to about 3.8 b.y. The minimum age of the Limpopo Belt, which connected the Kapvaal and Rhodesian-Craton, is 2.7 b.y. The Limpopo Belt is in fact the oldest mobile belt known. There is evidence in the belt of a significant thermal event at 2.0 b.y., an event which clearly postdates the phases of metamorphism and folding

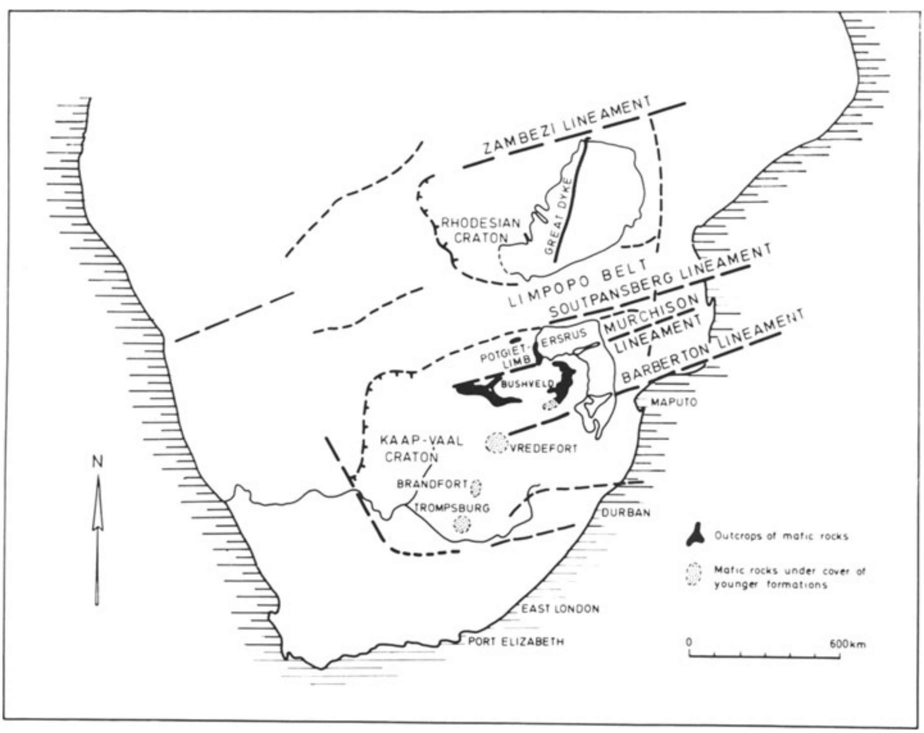

Fig. 1. Generalized tectonical map of Southern Africa (after van Biljon 1976). Several ENE-WSW striking lineaments control the geological evolution from the Precambrian up to now. Basic intrusions are lined up in a NNE-SSW striking direction. The ages of these intrusions (Great Dyke 2200 m.y., Bushveld Complex 2000 m.y., Vredefort Dome 1950 m.y., Brandfort Intrusion unknown, Trompsburg Igneous Complex 1400 m.y.) decrease significantly towards the south