Proceedings of Plumes, Plates and Mineralisation Symposium — An Introduction

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Background

The idea of a symposium on plumes, plates, and mineralization arose from a Students' Geocongress field excursion to the Bushveld Complex in July 1995. After Chris Hatton and Jochen Schweitzer described features of the complex explicable by a mantle plume, Sybrand de Waal suggested that this theory be discussed in a local symposium. Because the plume concept is of global interest, and is applicable in exploration, mining houses lent their support and from 14 to 18 April 1997 the Plumes, Plates and Mineralisation (PPM '97) symposium was held at the Conference Centre of the University of Pretoria.

Fourteen experts were invited to present papers on plume-genesis and their crustal expression. Over 200 delegates, 50 from overseas, attended. One day of the symposium was dedicated to workshops, where geophysical constraints on the Witwatersrand Basin, the Bushveld Complex, and the Kaapvaal Craton, exploration models for Africa, and computer-aided plate reconstruction were considered. A pre-symposium excursion examined intrusive and extrusive rocks and deposits of the Bushveld Complex, and was followed by two post-symposium excursions to the Ventersdorp/Witwatersrand sequences, and the Karoo Supergroup.

PPM '97 brought the plume concept closer to South African geoscientists. Reviews by the guest speakers of the current understanding on mantle plumes, their origin, life-cycle, and influence on crustal development provided a basis for much discussion. Progress towards a better understanding of local, plume-related deposits received a major boost.

Proceedings of the PPM '97 Symposium

The papers in this special issue consider possible South African plume-related deposits, such as the Ventersdorp and Karoo volcanic rocks, and the Bushveld and Uitkomst Complexes. These magmatic provinces are described and interpreted in the context of plume-theory. Mechanisms of magma formation are identified and plume positions and distances to their surface expression considered. Mantle plumes are considered as a heat and fluid source for the Witwatersrand gold deposits.

The first paper summarizes developments in plume hypothesis which may apply to the Bushveld Complex. White argues that plumes feed magma laterally into the crust, and the extrusive rocks may be hundreds of kilometres from the plume head. There is therefore no reason to assume that a plume was directly beneath the Bushveld Complex. Locating this plume may be a topic of future research.

Storey synthesizes data from the Karoo, Ferrar, and Chon Aike provinces showing that they are contemporaneous. The vast outpouring of magma over a very short time supports the idea that plumes played a major role in the generation of these provinces. The production of large volumes of magma in a short time is addressed by Leitch, Cordery, Davies, and Campbell. They demonstrate that peridotite mantle is unlikely to produce large volumes of melt. Much larger volumes can be produced if there is a significant component of eclogite in the plume.

A mechanism for driving the plates is outlined by Pavoni, who reviews hypothesis of bicellular mantle convection. Hatton proposes that plumes are preferentially associated with convective upwells, and suggests that upwells may be very long-lived.

In a review of the relation of layered intrusions to mantle plumes, Ernst emphasizes that the mafic intrusions may be located great distances (up to 2500 km!) from the plume centre. Uken and Watkeys consider the relationship between feeder dykes and layered intrusions of the Kaapvaal Craton. They recognize three trends which they associate with rifting during deposition of the Pongola and Ventersdorp packages, and with compression during emplacement of the Bushveld Complex. De Waal and Gauert identify mixing trends between primitive magmas of the Bushveld Complex, and show that one of these magmas underwent fractionation at a deeper level, perhaps during lateral movement. Remnants of a large igneous province in the Soutpansberg are described by Barton and Pretorius. Copper mineralization at Messina is linked to this sequence.

Gold mineralization, particularly in the Witwatersrand, is the focus of the last four papers in the volume. Phillips, Law and Stevenson review hypotheses proposed for the origin of the Witwatersrand gold in the 111 years since mining of this deposit began. The resurgence of the hydrothermal theory has stimulated the search for a source of heat and fluid. Phillips, Zhou, and Powell show that temperatures of 300 to 400 °C were reached during metamorphism in the Witwatersrand Basin. The highest temperatures occurred in the vicinity of Krugersdorp, in the northwest corner of the basin. Stevens, Boer, and Gibson consider the fluid flow that could have followed the Bushveld thermal event and propose that outward moving fluids could have generated gold deposits outside the Witwatersrand Basin.

In the final paper, Klemd and Hirdes suggest that high-density CO_2–N_2 fluid inclusions may be associated with gold mineralizations and apply this hypothesis to gold exploration in West Africa.

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The contributors who presented and submitted papers, and the efforts of the referees, are greatly appreciated. The list of referees appears elsewhere in this volume.