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ADVANCES IN THE STUDY OF PLATINUM-GROUP ELEMENTS

PREFACE

This volume developed from a special session on "Advances in the Study of Platinum-Group Elements", which took place as part of the annual GAC - MAC meeting held in Montreal, in May 1989. Twelve of the papers in this volume were presented at that session. However, we are pleased to report that owing to the popularity of the subject, and the attraction of publishing in *The Canadian Mineralogist,* as rumors spread concerning the proposal of a special volume on the platinum-group elements (*PGE*), we received a number of other manuscripts for consideration. Happily, the inclusion of these papers, expanded our coverage of the field and allowed us to produce a volume that truly reflects the diversity of topics covered by the study of the *PGE.*

The articles in the volume have been divided into four broad categories: 1) showings of platinum-group minerals (*PGM*) and *PGE* deposits, 2) the distribution of *PGE* in ophiolites, 3) the mobility of the *PGE,* and 4) mineralogy of the *PGE.* In the first paper, which derives from his 1990 MAC Presidential Address, Duke reviews the implications of magmatic segregation process models for Kambalda-type nickel sulfide deposits and draws attention to an apparent inconsistency between the relatively low concentrations of the *PGE* in the ores and the undepleted levels in spiniflex-textured peridotites.

The article by Naldrett, Brügmann and Wilson deals with the most important type of *PGE* deposit. These are the *PGE*-dominated deposits, such as the Merensky Reef and UG-2 reef of the Bushveld Intrusion, the Main Sulfide Zones of the Great Dyke, and the Robie Zone of the Lac des Iles Intrusion. Naldrett *et al.* provide models for the igneous processes that led to mineralization, involving the collection of the *PGE* by sulfide. In Canada, some of the highest-grade *PGE* deposits are found in the Ni–Cu sulfides associated with komatiites of the Labrador Trough and the Cape Smith Fold Belt. The articles by Beaudoin, Laurent & Ohnenstetter, Brace & Wilton, and Barnes & Giovenazzo describe examples of this type of mineralization. In all three cases, the sulfides are believed to have segregated from a komatiitic magma, but the composition of the sulfides has been modified by postmagmatic effects, resulting in the redistribution of Pt, Pd, Au and Cu. Barrie, Naldrett and Davis describe an example of a Ni–Cu sulfide deposit, Montcalm, that is depleted in the *PGE*, possibly owing to an earlier episode of sulfide segregation. Paktunc, Hulbert & Harris report that chalcopyrite and pyrrhotite from mafic intrusions contain less than detection levels of Pd, Rh and Ru, whereas pentlandite contains these elements at the ppm level. Mulja & Mitchell describe the *PGM* from the showing found in the Geordie Lake Intrusion; this showing is unusual because it is associated with alkaline rocks. The final article on *PGE* showings and deposits, by Nixon, Cabri & Laflamme, discusses the enigmatic *PGE* concentrations found in the Alaskan-type Tulameen complex, and suggests that Pt–Fe–Cu alloys and Os–Ir–Ru *PGM* crystallized directly from a silicate magma.

Interestingly, the Tulameen article leads into the section on the distribution of the *PGE* in ophiolites, for although it is often argued on theoretical and experimental grounds that Os–Ir–Ru *PGM* and Pt alloys cannot have crystallized directly from a silicate magma (*e.g.,* Peach *et al.* 1989), a number of authors in this volume (Nixon *et al.*, Edwards, Peck & Keays, and Corrivaux & Laflamme) argue, on the basis of mineralogical and geochemical studies, that if the magma is undersaturated with sulfur, crystallization of *PGM* is possible. Thus the important question of whether the *PGM* can crystallize directly from a silicate magma remains open. Tanguay, Hébert & Bergeron, and Prichard & Lord point out that in spite of the *PGE*-depleted nature of mid-ocean-ridge basalts (MORB), the cumulate portions of ophiolites do contain zones of *PGE* enrichment. Whether these zones represent the complementary *PGE*-enriched cumulates that correspond to the *PGE*-depleted MORB or are the product of boninitite crystallization, as suggested by Edwards and by Peck & Keays, remains a subject for future investigation.

The third group of papers deals specifically with *PGE* mobility and begins with two examples from layered intrusions, by Harney & Merkle and by Nyman, Sheets & Bodnar. In both cases, the authors argue for redistribution of the *PGE* by hydrothermal fluids at intermediate temperatures. Crocket has examined the distribution of Au, Pd and Ir in the most unusual setting, namely hydrothermal sulfides from the Juan de Fuca and Mid-Atlantic ridges. The concentrations of all three elements is highest in the sulfides formed from the highest-temperature hydrothermal fluids. This study clearly indicates the difference in the mobility of these three elements. Au concentrations reach the ppm range, Pd concentrations reach the 100 ppb level, whereas Ir concentrations never exceed 1 ppb. Wood & Vlassopoulos document the distribution of Au, Pt and Pd around three *PGE* showings and deduce that Pd is mobile at surface conditions. In a separate experimental study also relevant to the mobility of *PGE* at surface conditions, Wood considers the ability of fulvic acid to maintain Pt in a hydromorphically transportable form. Many of the papers in the first two sections also document examples of *PGE* mobility (*e.g.*, Beaudoin *et al.*, Brace & Wilton, Barnes & Giovenazzo, Corrivaux & Laflamme, Tanguay *et al.*).

The final section consists of two papers relevant to the mineralogy of the *PGE*. Kim and Chao present the phase relations in the system Pt–Sb–Te at 600, 800 and 1000°C. Atanasov describes a new Pd mineral, vasilite, discovered in clastic sediments in Bulgaria.

This volume would not have been possible without the help and cooperation of numerous people. Firstly, we thank all authors for their contributions. Secondly, we acknowledge the input of the reviewers, and their efforts in helping the authors to think and express themselves more clearly. Thirdly, we thank the Geological Survey of Canada, for its grant in aid of publication of this thematic issue. Finally, thanks go to the editor-in-chief, Robert Martin, who edited the papers and kept the volume on schedule, and to Sandra Doig, who coordinated the production of the issue.

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