Phosphate deposits of the world

VOLUME 2

Phosphate rock resources

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EDITED BY
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Preface

Project 156, Phosphorites, was established in 1977 as a research programme on Proterozoic–Cambrian Phosphorites of Asia and Australia, sponsored and led by Peter J. Cook and John H. Shergold of the Bureau of Mineral Resources, Geology and Geophysics, Canberra. As such, it is one of a number of long-term, interdisciplinary geological research projects being supported by the International Geological Correlation Programme (IGCP) under the aegis of the International Union of Geological Sciences and UNESCO.

However, such has been the interest shown in Project 156 that it has of necessity been extended to cover a much wider range of topics. There are now four Working Groups within Project 156, the work of each of these being co-ordinated by two Chairmen: Working Group 1 – Proterozoic–Cambrian Phosphorites (Co-Chairmen: P.J. Cook and J.H. Shergold); Working Group 2 – International Phosphate Resource Data Base (Co-Chairmen: R.P. Sheldon and A.J.G. Notholt); Working Group 3 – Young Phosphogenic Systems (Co-Chairmen: W.C. Burnett and S.R. Riggs); and Working Group 4 – Cretaceous-Eocene Phosphorites (Co-Chairmen: K. Al-Bassam, S. Sassi, and J. Lucas). In addition, other groups have been formed as Project 156 progressed. The Committee on Rock Phosphate Standards was convened by Z.S. Altschuler, L. Prévôt and Y. Zanin, and also one on igneous Phosphates by A.J.G. Notholt and S.M. Punukollu. National working groups also formed to promote interchange between phosphate geologists in various countries and, where appropriate, to arrange international meetings. Contacts with national working groups have been made formally through National Representatives nominated by National IGCP Committees, or informally through National Correspondents. Links with all these Working Groups and, notably, with the more than 700 scientists participating in Project 156 have been maintained primarily through the publication, bi-annually, of the Project Newsletter.

One of the aims of Project 156 has been that the results of each of the four Working Groups, as well as the wealth of data accumulated during its existence, should be made available through publication. With this objective in mind, a series of multi-author volumes was planned under the general title *Phosphate Deposits of the World* to be published by the Cambridge

University Press in its Earth Science Series. The first in the series, devoted to *Proterozoic and Cambrian Phosphorites* and edited by P.J. Cook and J.H. Shergold, was published in 1986. The present volume on *World Phosphate Rock Resources* is thus the second in the series and reflects the systematic and comprehensive efforts of Working Group 2 to organise geological data on all major world deposits and phosphate fields.

Phosphorus is an element widely distributed in nature and occurs, together with nitrogen and potassium, as primary constituents of plant and animal life. It is also a mineral-forming element in a large variety of crustal rocks. As a commercial source of phosphorus, phosphate rock is an essential raw material in the manufacture of fertilisers and certain industrial chemicals: there is little opportunity for substitution or recycling, unlike other vital mineral commodities such as iron ore, copper and sulphur. Phosphate rock for direct application to the soil has been invaluable for many years for use on predominantly acid soils which are usually markedly deficient in phosphorus.

However, phosphate rock itself is an imprecise term for a wide variety of rocks of diverse origin, character, and mode of occurrence, the chemical and physical characteristics of which may render them acceptable for use in the minerals industry. Most of the world's marketable production of around 134 million tonnes per annum is derived from deposits of sedimentary marine origin (phosphorites), notably those of Miocene–Pliocene, Upper Cretaceous–Eocene, and Permian age in the USA and of Cambrian age in the USSR and China, but a significant quantity, representing about 18% of the total output, is derived from igneous rocks and their weathering derivatives. The USSR is by far the most important producer of phosphate rock. The remainder is obtained largely from residual sedimentary deposits developed from weakly phosphatic Ordovician limestones in Tennessee, USA, and from the supposedly guano-derived deposits worked in the western Pacific on Nauru and on Christmas Island in the Indian Ocean. In spite of the very wide variety of phosphate rock types, the phosphate mineral in sedimentary deposits is invariably carbonate-apatite or francolite. Fluorapatite predominates in crustal rocks and represents the principal phosphate mineral in deposits of igneous origin. In igneous deposits, francolite occurs only as a secondary mineral, being important in the supergene phases and residual enrichments. Thus, of the several species or varieties of the apatite group, only two are of commercial importance at present, although calcium-aluminium phosphate minerals predominate in residual (lateritic) deposits.

The phosphate content or grade of phosphate rock, as mined, is commonly reported as phosphorus pentoxide (P_2O_5), and in commercial deposits this may average as little as 3.8%. The phosphate content may also be expressed as tricalcium phosphate ($Ca_3(PO_4)_2$) traditionally referred to as bone phosphate of lime (BPL), reminiscent of the time when bones represented the principal source of phosphate in fertiliser manufacture ($P_2O_5 \times 2.1853 = \text{BPL}$). A minimum of around 28% P_2O_5 is normally stipulated by manufacturers of phosphoric acid and phosphatic fertilisers, the principal end-uses; most marketed grades of phosphate rock contain more than 30% P_2O_5 (65% BPL). To meet this requirement most phosphate ores undergo beneficiation; many techniques are available, including washing and sceening, de-sliming, magnetic separation, flotation and calcination.

As is evident from the present volume, *World Phosphate Rock Resources*, phosphate rock is widely distributed throughout the world, both geographically and geologically, and there are very large resources capable of meeting anticipated demand for many years. Estimates of world resources vary considerably, but on the basis of the information collated in this volume we estimate that total world resources are of the order of at least 163 000 million tonnes of all grades and types of phosphate rock: Africa contains about 41% (mostly in the Tethyan phosphogenic province); the USA has 21%; the USSR 13%; the Middle East 10%; Asia 8%; South America 3%; and Australia, New Zealand and Oceania have 2%. Resources in Europe account for less than 1% of total known resources. World igneous phosphate rock resources total about 5500 million tonnes, equivalent to roughly 4% of the world total. It must be stressed, however, that much of the total world resources includes deposits whose commercial exploitation depends on either greatly improved or new technology or more favourable economic circumstances. For example, perhaps as much as two-thirds of the known resources are composed of carbonate-rich phosphate rock for which satisfactory beneficiation technology has yet to be developed on a commercial scale. In addition, resource estimates for many countries and deposits often ignore the essential technical distinction between reserves and resources and offer insufficient data about the technical and economic feasibility of producing marketable grades of phosphate rock.

Throughout the life of Project 156, the scientific aim of all participants has been to develop a better understanding of the distribution, nature and origin of phosphate deposits. With that objective in mind, we judge that this volume will be of interest to both the specialist and general reader alike and, in this context, will prove to be a valuable source of reference on the subject. We hope that *World Phosphate Rock Resources* will make an important contribution not only to basic scientific knowledge but also in the search for phosphate deposits in many parts of the world and, ultimately, to the successful development of the world's resources of this vital raw material.

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