BOOK REVIEWS

Pieters, C. M. and Englert, P. A., Eds. *Remote Geochemical Analysis; Elemental and Mineralogical Composition.* Cambridge (Cambridge University Press), 1993. xxiv + 594 pp., 22 colour plates. Price £60.00. ISBN 0-521-40281-6.

Remote sensing by and large does not have a good reputation amongst laboratory based Earth Scientists, who never seem to get beyond the idea of 'pretty pictures'. This may explain why the editors chose *Remote Geochemical Analysis* as the title for a book which is very largely about remote sensing.

This book should convince any doubters that remote sensing is a serious science, utilising a wide range of sophisticated sensors, and with a huge range of impressive achievements to its credit. Indeed, almost all that we have learned about our neighbours in the Solar System has been through remote sensing techniques of one sort or another. Remote sensing, of course, embraces measurements of many diverse phenomena, from gravity and magnetic fields to radiant thermal flux. Elemental and mineralogical compositions form only a small part of the range, but it is a particularly important part. It is only through remote sensing that we can learn what distant objects such as asteroids are made of, and begin to elucidate their histories.

Sixty authors have contributed to the 27 chapters in the book. Many of them are leading experts in their fields — to the extent that the author list reads like a 'Who's Who' in remote sensing. The book is therefore nothing if not authoritative. The editors have grouped the chapters into three sections. The first 11 chapters deal with the technical and scientific background to remote sensing, covering the origin of the electronic spectra of minerals, the theory of reflectance and emittance spectroscopy and techniques used in terrestrial and planetary remote sensing. For the most part, this section focuses on the 'conventional' visible to thermal infra-red part of the spectrum, but there are also chapters on X-ray, planetary neutron and alpha-particle spectrometry.

The second section of ten chapters covers applications and measurements. It starts with a couple of chapters on terrestrial problems, moves out to the Moon and Mars, and concludes with chapters on asteroids and icy planetary surfaces. Inevitably, rather a mixed bag of topics is included — it is a broad step from Landsat Thematic Mapper studies of mixed oak-hickory forests on Earth to gamma ray observations of cometary compositions, especially since the latter is concerned with an instrument planned to be sent to Comet Kopff, but which has been scrapped for budgetary reasons. This, and a chapter on neutron spectrometry, might have been better placed in the first section, if included at all.

Similar issues arise in the final section, which is concerned with active surface analyses. Here, six chapters range from studies of elemental analysis of extra-terrestrial surfaces using alpha particle sources to the interpretation of chemical concentration logs in oil wells from gamma rays. Because these techniques involve getting sensors very close to, or even in contact with, the surfaces under investigation, they are 'remote' only in the sense that the objects are distant from Earth. Thus, they form a very different group of techniques from those typically employed on spacecraft or aircraft. Alpha particle instruments planted on the surface of the Moon by the Surveyor spacecraft in 1967 and 1968 provided the first ever direct data on lunar surface compositions, and down-hole geophysical logging of oil wells has been of first importance to the petroleum industry, but the two chapters make odd bed-fellows. Although the failure of their recent missions to Mars has been discouraging, the work of Russian scientists in developing instruments for studying the surface properties of its tiny satellite Phobos has been exciting and visionary — they planned an instrument that would generate a signal for on-board mass spectrometry by laser-induced ionization of its surface materials from a range of about 30–70 m.

Overall, *Remote Geochemical Analysis* is an excellent compendium of studies for serious students of remote sensing. In trying to be too all-embracing, however, many readers will inevitably find much of it only marginally relevant to their own interests. Although terrestrial issues are addressed, the book really seems to be aimed at the planetary community. And trying to choreograph so many different contributions is equally inevitably a lengthy process. (Two of the authors are listed as deceased). Thus, the resulting book is less up-to date than it should be. Though some chapters include references up to 1992, most are based on the literature of the 1970s and 80s. There is also no mention of recent important missions, such as the spectacularly successful Clementine mission to the Moon, and the Galileo encounters with asteroids Gaspra and Ida. Both spacecraft obtained new multispectral data of the first importance for the planetary remote sensing community. It is particularly surprising that there is no mention at all of microwave studies of Venus, which have provided *some* data on its surface properties. While the book must be regarded as a major accomplishment, the editors might have been better advised to aim for a shorter, more focused book, which could have been more speedily delivered.

P. W. Francis

Peckett, A. *The Colour of Opaque Minerals* Chichester and New York (John Wiley and Sons), 1992. xxxix + 471pp., Price £95.00. ISBN 0 471 93347 3

Colour is often the first characteristic we use to describe an object, opaque minerals are no exception. However, in episcopy it is one of the most enigmatic properties of a mineral, apparently variable and dependent on 'outside' influences. The controls on mineral colour in reflected light are, of course, very complex but nonetheless controlled by well established parameters; the problem is the variability in the eyes' perception of colour. In this definitive text on the subject, Andrew Peckett documents the complex interactions between photons and electrons that govern a mineral's colour and gives detailed analysis of thc quantitative methods of colour characterization. He also dramatically reveals the limitations of the eye in colour estimation.

In the introduction and preface Dr Peckett acknowledges the debt owed to the late Norman Henry and Roy Philips for their contribution to this work. Reflected light microscopists do, indeed, owe much to these two researchers who did much to change a purely qualitative science into a quantitative one. Their work was unfinished and it is fortunate that Andrew Peckett has collated their unpublished work, merging it with his own knowledge of the subject to produce a book of great merit.

The book comprises three main explanatory chapters (2–4) and then a vast database of information on the properties of opaque minerals (chapters 5–13). Its coverage is immense, dealing not only with the controls on colour but also the wider aspects of optics and their theoretical and practical basis. Chapter 2 covers 'the nature of light and colours' and deals with a whole range of topics relevant to 'colour'. For instance, the mechanics of the eye are detailed and then the subjectivity of qualitative colour description is cruelly exposed using a series of illustrative plates — this section should be read by every ore microscopist before embarking on mineral description. Chromaticity and its quantification are covered in detail and this section benefits from someone with an extensive practical knowledge of the subject.

Chapter 3, entitled 'light and crystals' explains the theoretical basis of colour generation due to the interaction between light and solids. Light waves, photons and quantum mechanics are all explained, revealing their role in colour generation. Bonding models are outlined and their relative merits discussed. In all cases the discussion of each subject is much broader than that relevant to colour alone. Chapter 4 focuses on 'reflected light microscopy' treating the subject in great detail and dealing with both plane and crossed polarized light. The early sections explain the theoretical basis for optical properties. Tensors are used to explain the important parameters governing these properties, especially the permittivity tensor that is of relevance to reflectance. The calculation of reflectances using data obtained from the principal axes is documented and the relationship between wavelength, reflectance and colour is demonstrated.

Chapters 5–13 comprise a database of information on the opaque phases. Dominated by sulphides, it also includes data on metals, alloys and oxides. Included under each entry are data on the qualitative and quantitative colour of the phase, crystallographic and structural information, and source references. The latter often includes the most recent citation in *Mineralogical Abstracts* — a useful piece of information in its own right. Furthermore, the entries often include a summary discussion of the crystallographic and electronic structure of the mineral and its variants.

In dealing with the physico-chemical concepts, the author starts at an elementary level, building quickly to a level where useful discussion of their effect can be made. Thus, those with little background knowledge, as well as the expert can