

## Landmark papers in Precambrian geology

**Granulites of South India**, B. P. Radhakrishna, M. Ramakrishnan, B. Mahabaleswar, eds. Geological Society of India, Memoir 17, Bangalore. 1990. 502 pp.

Thankfully, C. S. Pichamuthu lived to receive the presentation of this book commemorating his 90th birthday. His contributions to the knowledge of the South Indian Precambrian Shield, and to knowledge of the remote geological past in general are immeasurable, as readers of this memoir will be often reminded.

Memoir 17, the Pichamuthu Volume, is a collection of excerpted papers published since the beginning of this century. The papers are arranged historically and topically to show the development of thought on the classical deep-crustal (granulite) terrain of southern India. The first section highlights the historical aspect, starting with skillfully edited excerpts from Thomas Holland's Geological Survey of India memoir defining the Charnockite Series. Holland's discovery that a strange form of granite (charnockite) containing the dense minerals pyroxene and garnet is the most characteristic and widespread basement rock of southern India stimulated a surge of interest in ancient crystalline terrains the world over, which accelerates even today. Extensive excerpts from this and other landmark papers by such giants of Indian geology as W. F. Smeeth, L. L. Fermor, B. Rama Rao and C. S. Pichamuthu add up to a magnificent compendium. Their pioneering descriptions and insights outline the essential attributes of a three-billion-year-old protocontinent. The evolution of the earth's early crust is perhaps nowhere else as compactly, though comprehensively, revealed as in southern India. This section is a valuable contribution to the history of science.

C. S. Pichamuthu formulated the 'Charnockite Problem' with his great memoir of 1953 (Mysore Geologists Association), excerpted at length in Memoir 17. In this book he focused world attention on the possible relations

of the charnockitic terrains to other cratonal elements (the Peninsular Gneiss, Closepet Granite, Dharwar volcanic greenstones, metasedimentary khondalites, etc.) and to possible modes of origin of charnockite. This subject remains an unsolved problem today, one increasingly pertinent to the evolution of continents. Are the charnockitic rocks simply Peninsular Gneiss and Dharwar greenstones reconstituted under dry, deep-crustal conditions, as suggested by Fermor, or are they more fundamentally intrusive igneous rocks, crystallized magmas of some deep origin, as originally postulated by Holland and espoused brilliantly by R. A. Howie and A. P. Subramaniam on the basis of petrography and geochemistry? This reviewer believes that a 1969 paper by P. G. Cooray (*Am. J. Sci.*, **267**, 969-982) could have been excerpted profitably in this regard. He showed from his experience in the correlative Precambrian terrain of Sri Lanka that the South Indian charnockites could be regarded as products of profound deep-crustal metamorphism, with convergence of igneous, sedimentary and previously metamorphic precursors to a common charnockitic end-product.

There has been accumulation of much knowledge in recent years on the South Indian granulites by several Indian research groups and their international collaborators. Modern techniques of geochemistry, including the mass spectrometer and the electron-beam microanalyser, have contributed an impressive data base which reveals many intriguing features about granulites and deep-crustal processes. Many of these important discoveries are highlighted in the excerpted papers of succeeding sections of Memoir 17. The incredible range of length-scales of chemical interaction, from millimetre-scale isolation to kilometre-scale homogenization of isotopes and trace elements, is an important finding which testifies to the diversity of ancient deep-crustal processes. Deduction of the temperatures and pressures of granulite formation is one of the triumphs of this effort. Granulites of the Nilgiri Hills, for instance, were recrystallized at pressures of 10 kbar,

corresponding to 30+ km depth, and temperatures up to 800°C. Just how whole terrains of rocks, many of which manifestly originated at the surface of the earth (the metasediments), were later subjected to such profound conditions is one of the greatest mysteries of the granulite (and the charnockite) problem. Many workers believe that the process has to do with ancient continental collision and the formation of Himalayan mountain ranges.

One of the most exciting lines of investigation concerns the possible role of fluids in the origin of charnockite. Pichamuthu's classic 1960 paper in *Nature*, 'Charnockite in the making', is reprinted in its entirety in Memoir 17. He discovered a curious dark, patchy or vein-like alteration in the floor of a rock quarry at Kabbal village, Karnataka, which proved to be incipient charnockite, arrested 2.5 billion years ago in the act of replacing lower-grade rocks. Many similar examples of arrested 'charnockitization' have been found in southern India and Sri Lanka, and a few in other ancient terrains. A number of workers consider that Pichamuthu's phenomenon represents arrested infiltration into host rocks of copious fluids, necessarily low in H<sub>2</sub>O, therefore almost certainly rich in CO<sub>2</sub>. Fluid-rock interactions and charnockitization are topics that dominate later sections of Memoir 17. The questions arise: Whence the fluids? Were they fundamental agents of crust-shaping or were they minor and local in scope? Why are their apparent effects concentrated in the older terrains? The discussion in the Memoir 17 excerpts is diverse and somewhat conflicting (this is natural, since we know so little yet about the postulated fluids). A valuable aspect of the Memoir is that a newcomer to the study of granulites can quickly get 'up to speed' on the literature of fluid action in the deep crust (most of it stems from work in India).

A defect of the book is the poor quality of photograph reproduction. Photocopying at its present level cannot reproduce the subtleties of 'charnockite in the making' textures. Indeed, the only fully successful photography of this phenomenon yet published is the splen-

did colour plates in the Geological Society of India paper by C. Srikantappa *et al.* (26, 849–872, 1985). Unfortunately, although this important paper is reprinted nearly in its entirety in the Memoir, the colour plates were not

retained.

Thoughtful commentaries by the editors, a moving tribute to C. S. Pichamuthu by B. P. Radhakrishna, and a beautiful full-page colour portrait of Pichamuthu embellish an important

and timely collection.

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## PERSONAL NEWS

### Transition in Precambrian geology

#### *An obituary of C. S. Pichamuthu*

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It has been the lot of very few among the earth scientists in our country to have had the benefit of a good education and training in India and abroad, to have occupied positions of eminence both in the professional and academic hierarchies, to have substantially aided the growth and development of the subject by their own distinct contribution, and to have been the recipients of awards and honours from a grateful generation of students, scholars, colleagues, admirers and administrators. Professor Charles Solomon Pichamuthu, who passed away on the 18 August 1990, was one of the very few earth scientists of our country who belonged to this category (see *Curr. Sci.*, 1990, 59, 289 for a tribute on the occasion of his ninetieth birthday).

Born on 10 March 1900 and educated at the Central College, Bangalore, Pichamuthu served with distinction at Central College and the Mysore Geological Department. His stay at the University of Glasgow (1934–1936) for his doctorate and close association with the stalwarts there was to be one of the

most fruitful times of his career, laying a firm foundation for his abiding interest in the oldest rocks of our planet—the Precambrians.

A voracious reader, and a scientist



with a penchant for critical observation, logical analysis and clear exposition, his papers on any subject are sources of synthesized information for the student, scholar and professional alike. Through-

out his career, spanning over five decades, as a professional geologist and academician, he was to delve deep into the mysteries of Precambrian geology of South India in general and charnockites in particular. Two recent publications of the Geological Society of India [*J. Geol. Soc. India*, 1990, 35, 329; Memoir No. 17, 1990, on the granulites of South India (see page 942, this issue, for a review)], are a fitting tribute to this great scientist.

He was a soft-spoken gentleman, who, while maintaining the dignity of his occupation, whether in India or abroad, was a source of inspiration to all those who came into close contact with him by his example of diligent pursuit of science for its own sake.

In Pichamuthu's demise the earth science community in India has lost a savant and a kind soul. The only tribute that can be paid to him by any one is to try to live up to the high standards he had set for himself during his career as a scientist.

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