"ORE ELEMENTS IN ARC LAVAS" by R. L. Stanton

FORTY YEARS OF UNDERSTANDING
THE GENESIS OF GREAT STRATIGRAPHIC OREBODIES
OF THE WORLD

Reviewed by John C. Grover O.B.E.

Well known internationally, the author of numerous major papers and the text-book ORE PETROLOGY (which sold some 18,000 copies), Richard L. Stanton, formerly Professor of Geology at New England University, New South Wales, has recently produced a unique volume of value to practical mineral exploration and to university teaching.

Of 403 pages, and traditional hard cover, ORE ELEMENTS IN ARC LAVAS is Oxford Science Publication Monograph on Geology and Geophysics, Number 29.

If ever there were a labour of love (of science) this is it: the finale after forty years of thoughtful field work and laboratory research laced with adventure -- if one reads between the lines.

Beginning in the late 1940s with studies of conformable mineral deposits in New South Wales (Stanton, 1955a and b), in December 1950 Stanton was co-opted at short notice to join Professor Charles E. Marshall's Sydney University Geological Expedition and flown to the then British Solomon Islands Protectorate. It was to prove one of the most productive ventures of its day, to study what was geologically one of the least known regions of the world (Umbgrove 1945, p. 209; Glaessner 1950, p. 870; Grover 1994, pp. 37-43).

Disappointed at having to cancel his arrangements for research during those summer holidays, Stanton was in no mood for the venture. He had no idea that he was about to see a grand picture in the rocks of those jungle-covered, roadless, volcanic mountains of islands rising from the Pacific -- where it rained heavily nearly every day and sometimes for days at a time. It did not halt his islanders, and the work continued on foot or by hired canoe, or launches whose engines too often failed to work. However, he was soon fired up with what he saw, taking the remoteness, the physical hardships and the administrative difficulties in his stride. Christmas Day he spent as an honoured guest in a small village of Santa Isabel watching the dancing prior to a feast of succulent pig cooked in a ground oven of hot stones.

Three months later he flew out to New Guinea and Australia. Stanton knew that his life had been changed by this visit (personal communication, 1951). Evidence stimulated his thoughts on stratiform metalliferous orebodies.

He later returned to the Solomon Islands with the support of the BSI Geological Survey Department. Visits by Stanton (and his colleague Dr P.J. Coleman, at different times) were to become annual events.

Welcomed at Honiara airport, after two nights as guest of the Geological Survey the visitor was then able to join the twin-screw 10.3 metre Geological Survey ship Noola, crewed, fuelled and supplied, with geological assistants and bearers ready to go -- all of them competent old hands quietly proud of their jobs. Shore work involved following and mapping many streams and rivers where outcrops were visible. Where the population was small and confined largely to the coast, inland areas were often trackless.

These expeditions considerably increased the knowledge of the Survey, for specimens and samples were air freighted to the university for study. Findings were published in due course. The contributions by Stanton and Coleman were on-going for years. In turn, Australian Universities developed a knowledge of island arc geology
which was previously lacking (Grover 1994, p. 42).

Stanton's further studies at Queens University in North America embraced deposits at New Brunswick and in Newfoundland, and brought him into touch with other lively minds of the day, who gave him further encouragement.

In 1959, in company with Dr J.D. Bell of the Solomons Geological Survey, Stanton began investigating the Pliocene-to-Recent lavas of the New Georgia Group in the Solomons -- a wide spectrum of volcanics ranging from highly olivine-rich picritic lavas to felsic andesites. Suspicion that exhalative ores might have genetic ties with with lava differentiation stages led to the study of traces of the metals copper, zinc, lead, etc. It began in 1963 with wet chemical and X-ray fluorescence methods, but the techniques then were inadequate and the project was postponed for another decade or so -- after atomic absorption work by his long-time research assistant, Mrs W.P.H. Roberts, had shown that trace metals in the Solomon lavas occurred systematically and were probably amenable to geochemical investigations. Field work continued.

Interest led to a crescendo of scientific activity in the 1960s by the Royal Society, by private companies and by George P. Woollard and American Universities -- resulting in much geophysical documentation of this once least-known region of the world.

By 1980 automated and highly accurate X-ray fluorescence became available, along with the electron-probe microanalyser. The large collection of specimens from the previous three decades could be thus subjected to study.

Some 12,000 electron-microprobe analyses of mineral grains and glass in situ were made by Stanton, assisted by N.G. Ware of the Research School of Earth Sciences, Australian National University. 900 X-ray fluorescence, neutron activation and ICP-MS (inductively coupled plasma emission spectrometry/mass spectrometry) analyses of whole rock and mineral and groundmass separations were made by Dr B. W. Chappell.

The results enshrined in this volume are set in the context of geochemistry from other island-arc lavas and mid-ocean ridges.

Previously little had been known of the behaviour of the principal ore minerals in lavas, and there was no systematic documentation of their incidence in the lavas of island arcs, the main locale of volcanic ores in ancient terrains. Yet the suggestion that some ores might have a volcanic origin had been made long ago (Beaumont, 1847; Bowen, 1933; Fenner, 1933). Their work had never been investigated. Clear statements of the theory began to emerge in the mid-1950s and this history of events is covered in the Introduction.

Chapters 2 to 4 give an outline of problems in volcanic ore petrology that led to the investigation and the historic connotations. Chapter 5 is more detailed, about the petrology and geochemistry of the Solomons lavas as a basis for the more detailed geochemical chapters.

Chapters 6 to 19 are concerned with the geochemistry and abundance behaviour of each of 14 elements in exhalative ores. The principal components, apart from iron and sulphur, are copper, zinc, lead, and barium. Strontium is next, though conspicuous by its absence from volcanic exhalative ores -- in spite of its close chemical relationship with barium, an eloquent clue to ore-forming processes. The remaining nine elements are dealt with in sequence of increasing atomic number.

Chapter 20 is about the behaviour of the hyperfusible elements sulphur, chlorine and fluorine, and minor metals silver, gold, molybdenum, cadmium and uranium; and the semi-metals arsenic, antimony and bismuth. It demonstrates some of the relationships between elements.

(a) abundances of potassium, rubidium, zirconium and strontium which indicate the melt process;

(b) minerals like barium, a trace constituent of lavas and also a major element of exhalative ores;

(c) ore elements, such as lead, which are important components of many ores associated with volcanic rocks, although their igneous systematics are not well known.

Data on the Solomons lavas have been given a frame of reference for the reader: early information from mid-ocean ridge
basalts is followed by island arc descriptions. Some arcs are fully oceanic, like Vanuatu, Tonga and the Solomons, which have no connection with continental crust. Other arcs do in part: like the Aleutians, the Lesser Antilles and the southern part of the Tonga-Kermadecs. Such information could have many uses as well as indicating areas needing more attention.

In Chapter 21 the information in the foregoing chapters is applied to examining the abundance patterns in a crystallising volcanic melt of Solomons island-arc type -- the Younger Volcanic suite.

Fractional crystallisation and loss of the volatile phase probably affected the enrichment and impoverishment of ore elements in melts. Leading from this, Chapter 22 is about volcanic sublimates, condensates, gases and plumes, Chapter 23 concerns the derivation and development of Solomons lavas, mainly the basalt-picrite and basalt-andesite-dacite lineages. Chapter 24 deals with the petrogenesis of exhalative ores in the light of all the features observed in the Solomon Islands Younger Volcanic Suite. This leads to relations between crystallisation, lava type, and reflections on the leaching hypothesis.

The account concludes with thoughts on ore-element geochemistry and the refining of mineral exploration methods in ancient island arc terrains, like those in Australia.

A purpose of the book has been to show how intimately and systematically some ore deposits are related to magmatic differentiation. It will serve to emphasise Crook's perceptiveness in 1914, and add substance to the past work of Lindgren, Fenner, Bower, Niggli and Buddington.

R. L. Stanton's *ORE ELEMENTS IN ARC LAVAS* is essential reading for university geology departments, geological surveys and for those engaged in major mineral search ventures.

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