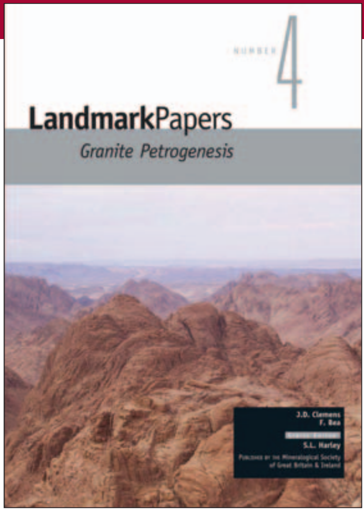
GRANITES AND GRANITES

*Granite Petrogenesis** is the fourth publication in the Mineralogical Society of Great Britain and Ireland's Landmark Papers series. The purpose of the series is "to allow students and others to read for themselves, in the original form, how some of the giants in the field set down their ideas." The 20 papers were selected by John Clemens, of the University of Stellenbosch, South Africa, and Fernando Bea, of the University of Granada, Spain, and appear as facsimile copies of the originals. Each paper, plus an introduction to the paper by Clemens and Bea (usually of one page or less), constitutes a chapter. The introductions put the chosen papers into a historical context, provide a summary, and justify the choice as a "landmark."

The papers are grouped into four sections: the origins of granitic magmas; field relations, magma transport and emplacement; typology and magmatic evolution; melt compositions, experimental petrology and economic potential. This scheme does not work well. The papers are often hard to classify, and a systematic reader will find concepts appearing before they have been introduced. For example, the I- and S-type classification of granites is introduced in chapter 11, although the terms are used in chapters 6, 7 and 10. Scientific landmarks are waypoints on a journey in time into an untravelled world. The high ground is recognized only when we see that it stands above the foothills. I would have preferred to read the papers by date of publication, and I've arranged my comments below in this way.



Sins of omission are easy to suggest, as I do below, but the literature on granite is vast and I'm sure most granite experts would find great difficulty in selecting their personal "landmarks." Simon Harley (the series editor) notes in his foreword that the first published evidence that granite formed from molten material intruded into pre-existing rocks is usually ascribed to James Hutton's (1794) *Observations on Granite*, but Clemens and Bea did not include any text from Hutton. Some extracts would have been my choice as a first landmark.

Chapter 1, by R. W. Bunsen (of burner fame) (1861), is reproduced in German with an English translation. Bunsen introduced the concept of eutectic crystallization and also the idea that silicate liquids were solutions. The next paper historically (chapter 15) is by R. W. Goranson (1932). Goranson heated a natural granite with variable amounts of water in sealed platinum capsules and concluded that "at 700 ± 50 °C and under a water vapor pressure of 1000 bars Stone Mountain granite will become, except for hematite, completely liquid. The melt will have 6.5% water in solution." Few works in experimental petrology have had so many ramifications across so many fields.

Cont'd on page 315

* Clemens JC, Bea F (eds) Granite Petrogenesis. Mineralogical Society Landmark Papers Volume 4, 343 pages, ISBN 978-0-903056-30-4, £32.00, member price: £18.00

A Life in Science *Cont'd from page 313*

Expected Results

To demonstrate competency, it is helpful to show preliminary results that indicate how your study will answer the question posed. If this is not possible, then you may consider showing the results of similar studies, indicating how your study will build on that previous work. It also increases the evaluator's confidence in your project if you can suggest strategies for overcoming potential problems with your approach (e.g. alternate experimental methods) that you can reasonably foresee.

Table 2 ANALOGIES BETWEEN WRITING A PROPOSAL AND RIDING A BIKE

Writing a proposal	Riding a bike
Make sure that you are eligible	Make sure that the bike works
Follow any guidelines	Follow the road rules
Good proposals take time to mature	Competent riding takes time to learn
Decide on a compelling reason to propose the study	Decide on your destination
Decide on your approach and write an outline	Decide on your route
Anticipate potential obstacles and address them	Take supplies and avoid problem areas
Start writing!	Leave on your trip!
Keep it simple, limit sidetracks	Just ride the bike, stay on the path
Take breaks	Take breaks
Include figures	Take photos of your trip
Hastily written proposals may get rejected	Hasty bike riders may crash

OTHER CONSIDERATIONS

Pay close attention to your writing, and make sure that you have checked for typographical, spelling, and grammar errors. Try to use mostly nouns and verbs, and avoid excessive superlatives, adjectives, and adverbs that produce complex, jargon-filled text that is difficult to read and understand. To see if you have done well, ask an educated person outside your field to read your proposal and then tell you what your proposal involves and why you are proposing the project. Figures and tables greatly help your reader to understand the material, so try to include them in your proposal. Follow standard rules for citing the literature and for listing the references. Finally, you might like to think about the analogies between writing a proposal and riding a bicycle (Table 2).

WHAT IS NEXT?

Remember that a proposal is just that: proposed or potential work. Science, by its very nature, rarely follows the progression envisaged initially. Don't forget to be flexible after the proposal, but if you have to make major changes to the research project, it is worth meeting with your evaluators again to discuss, adapt, and forge a new path.

Penny King
(Research School of Earth Sciences, Australian National University) and
Christopher Fulton
(Research School of Biology, Australian National University)

RESOURCES FOR WRITING PROPOSALS

Cryer P (2006) The Research Student's Guide to Success, 3rd edition. Open University Press, 269 pp

Day RA, Gastel B (2006) How to Write and Publish a Scientific Paper, 6th edition. Greenwood Press, 302 pp

Peters RL (1997) Getting What You Came For: The Smart Student's Guide to Earning an M.A. or a Ph.D. Noondolay, 399 pp

Granites and Granites *Cont'd from page 314*

Chapters 2 and 3 were the opening and closing addresses at a GSA meeting held in Ottawa in 1948 devoted to the "Granite Problem." The first, by H. H. Read, has the oft-used title that heads the present review; the response is by the great N. L. Bowen. Read's review gives serious consideration to large-scale granitization by aqueous fluids and even by "diffusion in the solid," processes which Bowen dismisses on energetic and kinetic grounds. The lectures mark the dawn of a new world in which phase equilibria and thermodynamics provide a secure basis for igneous petrology. However, although today the emplacement of granite bodies as magma is rarely questioned, the evidence for metasomatic replacement of country rocks at their margins and of pervasive subsolidus replacement reactions is irrefutable. *Dents de cheval* exist. I would have included P. M. Orville's classic 1963 experimental work on this topic.

The next landmark did not appear until 1973 (chapter 4, by W. S. Fyfe). Apparently, for 25 years after Read and Bowen locked horns, no landmarks arose. This is a major shortcoming of the volume. The systematic work done in the 1950s and 1960s, initially by Tuttle and Bowen, was the golden age of experimental work on granite petrogenesis. Units in innumerable composite plutons approximate to liquid lines of descent in the system albite–anorthite–orthoclase–quartz–water and head inexorably towards the "granite minimum." Although partial fusion is not the reverse of fractional crystallization, the same scaffolding is there, directing the changing composition of the liquids and, hence, their density, compressibility and viscosity, the factors that control the beginning of their ascent by melting deep in the crust, their ability to rise through the crust, and, should they become water saturated, their potential arrest by pressure release or eventual explosive eruption.

Fyfe's paper is a delight to read and shows how a simple model of gravitational instabilities in a partially molten lower-crustal layer of appropriate viscosity and density could lead to the detachment of periodically distributed, bubble-shaped diapirs that rise in the crust. It is followed by B. W. Chappell and A. J. R. White's 1974 paper (chapter 11) in which they introduce the much used I- and S-type classification, and then by an important experimental study by S. Malløe and P. J. Wyllie (1975; chapter 16) in which they deduce the water content of a granite magma by studying the order of crystallization of the minerals in a natural granite under water-undersaturated conditions. S. Ishihara's paper (1977) on the magnetite- and ilmenite-series of I-type granites follows (chapter 12), and then a paper by C. W. Burnham and H. Ohmoto (1980; chapter 20) which deals with second boiling, large-scale alteration and economic mineralization. The next two papers, the first by D. J. DePaolo (1981; chapter 5) on Nd isotopes and crust–mantle evolution and the second by I. H. Campbell and S. R. Taylor (1983; chapter 8), with the catchy title "No water, no granites – no oceans, no continents," appear only as abstracts. The first, published in *Nature*, could not be included for "financial reasons," and the second, from *Geophysical Research Letters*, could not be included because the AGU "does not allow reproduction of its content in publications such as this." Ambitious researchers, take note!

From 1983 on, there is a change of gear in the style of the papers, which become more focused and less broad-brush, perhaps reflecting the maturity of the field. Chapter 13 is E. B. Watson and T. M. Harrison's 1983 experimental paper on zircon stability in granitic liquids, in which they show that zircon's solubility is a function of temperature and the cation ratio (Na + K + Ca)/(Al + Si). There's that feldspar scaffolding again! P. C. England and A. B. Thompson (1986; chapter 6) make the theoretical connection between crustal thickening, heat flow, and the presence of water in continental collision zones. V. J. Wall, Clemens and D. B. Clarke (1987; chapter 14) provide a review of models of granitoid evolution, particularly the role of restite (residual material after partial melting). In chapter 7, H. E. Huppert and R. S. J. Sparks (1988) consider the generation of granitic magmas by intrusion of basalt into continental crust, using tank experiments and theoretical considerations. Chapter 9, by D. H. W. Hutton (1988), is a clear review of tectonic controls of granite emplacement. Chapter 10, by Clemens and C. K. Mawer (1992), is entitled "Granitic magma transport by fracture propagation." The authors make a case for dyking as a process in the lower crust, but to me the interesting part of granite petrogenesis is how magmas generated from heterogeneous sources arrive in their final resting place and produce composite intrusions that are structurally and chemically orderly.

Two further papers from 1988 are experimental and share the objective of understanding vapour-absent melting in the deep crust. Their authors used contrasting experimental strategies and starting materials, and the papers make an interesting pair. W. K. Conrad, I. A. Nicholls and V. J. Wall (chapter 17) used synthetic glasses (not crushed rocks as stated in the introduction) and studied the crystalline phases that grew over a range of temperatures, whereas D. Vielzeuf and J. R. Holloway (chapter 18) used a natural metapelite and studied the appearance of silicate liquid between 0.7 and 1.2 GPa under vapour-absent conditions. The most recent landmark (chapter 19; Bea 1996) is an interesting paper about REE, Y, Th and U in granites and their crustal protoliths. Clemens and Bea comment that they are not able to discern landmarks amongst more recent papers.

There are many interesting papers in this anthology, but for this reviewer the missing Himalayan range of experimental work from the 1950s to the early 1970s is a major shortcoming. For this reason I would not recommend the volume as an introduction for students. Overall it concentrates too much on the sources of granite magma, too little on its evolution and emplacement.

Ian Parsons
University of Edinburgh, UK