Book Review

TIMESCALES OF MAGMATIC PROCESSES: FROM CORE TO ATMOSPHERE: Edited by Antony Dosseto, Simon P. Turner, and James A. van Orman. (2011) Wiley-Blackwell, 264 pp. US $160.00 hardback; US $99.95 paperback, US $129.99 e-book. ISBN: 978-1-4443-3260-5.

One hundred years ago in June 1911 Arthur Holmes published the first determination of mineral ages on the basis of radioactive decay. It was known that uranium was radioactive, that helium and lead were produced as products of that radioactive decay, and that the age of a sample could be linked to its measured U/Pb ratio. The first ages ranged from 340 to 1640 Ma, providing critical evidence that the Earth was at least that old. These ages were obtained two years before the discovery of isotopes by Soddy in 1913.

The 100 years following those first determinations by Arthur Holmes have seen dramatic changes in mass spectrometry and in our ability to obtain high-precision ages on tiny volumes of material. The age of the Earth is well established, and there are hundreds of thousands of ages on the crystallization of zircons for most of the last 4.55 Ga. These are the basis for the temporal framework in which events recognized in the geological record took place. However, models for how natural processes occur are constrained by knowledge of the rates of change involved, and only recently has it been possible to obtain age information for relatively short periods to estimate rates of change from the geological record. This welcome volume provides an introduction to the different approaches that are currently used to study the timescales over which magmatic processes take place, and some of the constraints that can be derived.

The book consists of 11 chapters and an introduction. Much of the recent interest in the timescales of magmatic processes has been rekindled by the development of improved techniques for the measurement of isotope ratios within the short-lived U-series. These are used to constrain the timescales of magma degassing (Chapter 11, Berlo et al.), magma cooling and differentiation (Chapter 8, Dosseto and Turner), melt transport from the mantle to the crust (Chapter 5, Turner and Bourdon), and melt production in the mantle (Chapter 3, Bourdon and Elliott). The isotope systems used have half-lives of less than ~76,000 years, and consequently these studies have to be undertaken on geologically young magmatic systems. This limitation is highlighted by the observation that no silicic magma has reached the Earth's surface for more than 70,000 years. However, elements that diffuse significantly over the time periods of interest can be used to constrain rates of melt production of melt in the mantle (Chapter 2, van Orman and Saal), and to estimate timescales from much older minerals (Chapter 7, Costa and Morgan). These in turn can be linked with geological and experimental constraints to investigate the timescales associated with large silicic bodies (Chapter 10, Bachman), of melting processes within the crust (Chapter 9, Rushmer and Knesel), and of the rates of magma ascent constrained by the presence of mantle-derived xenoliths (Chapter 6, O'Reilly and Griffin). Formulations are being developed for simulating the multistage physics of magma ascent (Chapter 4, O'Neill and Spiegelman), and relatively short-lived isotope systems that are now extinct constrain the earliest differentiation of the Earth and the Moon (Chapter 1, Caro and Kleine).

The volume is well presented and clearly written by authors who are leading authorities in their different fields; it succeeds well in its stated objective of providing an accessible introduction to the subject and it should encourage others to get involved. As the authors are well aware, there is a temptation to feel that better constraints on timescales are a goal in themselves. Yet the underlying challenge is to ensure that different models are sufficiently developed that magmatic processes happening at different rates become a key test of the processes that might be involved. This remains a priority and this volume goes some way to highlighting this as a way forward. It remains striking, however, that the timescales for broadly similar processes can vary by several orders of magnitude, depending on the approach used. Thus, it appears that there is still much to be done in terms of understanding the implications of the data obtained, as well as in the development of improved models. This, therefore, remains a richly rewarding field.

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