WORKING WITH MIGMATITES

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PREFACE

Migmatites occur widely in cratons and orogenic belts throughout the world. Much of the published work on migmatites has concentrated on the petrological processes that have changed relatively homogeneous sedimentary, igneous and metamorphic protoliths into migmatites that are much more heterogeneous in appearance. From their location in metamorphic terrains between amphibolite-facies metamorphic rocks and bodies of granite, migmatites and the study of them have also played a significant part in the long-lived debate over the formation of granites and the related problem of how the continental crust differentiated into a more felsic upper part, and a more mafic lower part. Currently, interest in migmatites has expanded into geodynamics and the role that their partially melted precursors may play as very weak rocks or zones in the tectonic evolution of orogens and plateaus. This interest from the geodynamics community in the changes in rheology with melting and the effects of the transfer of mass and heat in orogens will surely increase in the coming years.

Most migmatites are striking-looking rocks, with very complex morphologies that result from the interplay of both petrological and structural processes. Unfortunately, these same characteristics which fascinate a few geologists enough to make a career out of studying migmatites have the opposite affect on the majority of geologists. One of the most common comments one hears on field trips is “migmatite are too complex, I don't know where to start”. Much of the background material that a geologist new to the study of migmatites requires to begin working in migmatites is not directly available in the current research literature. Principally, this is because this material is considered to be “common knowledge” by authors, reviewers and editors alike. Moreover, a geologist new to migmatites cannot go to textbooks to obtain this background information because there are none more recent Mehnert’s (1968) highly influential book or Ashworth’s (1985) volume, and much has changed in our understanding of processes in migmatites since these volumes were published.

This short course volume, therefore, is intended to fill the "information gap" that has developed between those who have a long term interest in migmatites and those wanting to begin working with migmatites. Most geological studies begin with the documentation and understanding of the small-scale relationships in rocks, commonly at the outcrop-scale, even if the overall scope of the work is regional in scale. This is especially true for migmatites. For this reason we emphasize the field, petrographic and petrological aspects of migmatites. This is the basic information a geologist needs to have a better understanding of how to describe the constituent parts of a migmatite to decide by what processes a migmatite formed and to learn what meaning may be ascribed to the migmatite terrain under investigation.

The volume starts (Sawyer chapter 1) with an outline of the terminology that is used to describe migmatites. This is followed by an outline of the constituent parts and the principal morphologies of migmatites which are defined using a genetic nomenclature based on the understanding that migmatites are produced by partial melting. A two-tier classification scheme for the morphologies of migmatites is proposed and the various types described.

Migmatites are heterogeneous rocks, therefore what can be depicted on a map depends largely on the scale of observation. In chapter 2 Sawyer proposes that mapping migmatites at the outcrop scale is concerned principally with the recognition of the various parts of the migmatites, and is a pre-requisite to sampling. However, for regional- and terrain-scale maps details of lithology, type of migmatite and the relationship between these different migmatites and other rocks, most notably the lower-grade non-melted rocks, are important considerations.

Most migmatites have cooled slowly and the microstructural relationships and mineral compositions in them have been modified with time. In chapter 3, Cesare examines the micro-structures and mineral relationships in melt-bearing pelitic rocks that were brought rapidly to the surface as enclaves in volcanic eruptions. These partially melted rocks have cooled so quickly that the melt in them quenched to glass, and the features that formed during partial melting are preserved without resetting. These rocks, therefore, provide a test for many of our ideas on partial melting.

The presence of glass is definitive evidence for the former presence of melt. However, most migmatites cooled slowly so that the melt has crystallized rather than quenched. Holness shows in chapter 4 that microstructures formed during partial melting and during crystallization of the anatectic melt are preserved in some migmatites. The microstructures in rocks adjusts to changes in the conditions that the rocks experience, and consequently understanding the microstructure in migmatites has the potential to reveal much new information. Holness describes how the microstructure and range of dihedral angles in the pockets of former melt can be used extract information, such as cooling rates, from migmatite terrains.

Petrogenetic modeling has become a wide-spread tool in the understanding of metamorphic rocks. In chapter 5, White demonstrates some of the applications of petrogenetic modeling to understanding processes in migmatites. Examples are given of how this approach can provide significant insights into understanding the evolution of mineral assemblages, mineral compositions and microstructures in migmatites.

The broad-scale implications of the movement of melt within the partially melted regions of the crust have been known for some time. In chapter 6, Brown outlines the outcrop-scale evidence for the segregation, extraction and ascent of melt from the source to the upper crust. This contribution makes clear the connection between the small-scale features, such as the networks of leucosomes, that can be mapped in an outcrop of migmatites, to medium-scale features, such as shear zones and dykes that transport melt longer distances. These connections may enable distinction among the mechanisms proposed for the large-scale movement of anatectic melt through the continental crust.

Most migmatites were forming at the same time as the rocks were deforming. Solar, in chapter 7, describes the effect that deformation has on the morphology of migmatites. He stresses that migmatites cannot be properly interpreted without understanding the structure and lithologies in the nearby unmelted rocks on the low-grade side of the “melt-in” isograd. Context is important in understanding tectonics and migmatites. Changes in the morphology of migmatites and the amount of melt it may have contained may indicate differences among structural domains and may allow the identification of regions of net gain of melt and net loss of melt, in migmatite terranes.

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