

Sweden: Lithotectonic Framework, Tectonic Evolution and Mineral Resources

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Sweden: Lithotectonic Framework, Tectonic Evolution and Mineral Resources

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Preface

This Memoir provides a coherent lithotectonic framework for the solid rock mass of Sweden and addresses the tectonic evolution of this part of Europe from the Neoproterozoic to the Neogene. Sweden is currently situated inside the Eurasian Plate, the capital city Stockholm lying more than 2000 km from the nearest plate boundaries to the south and west. Considerable focus is placed on the application of the plate tectonic paradigm to the Proterozoic evolution, nearly 80% of the solid rock mass on land in Sweden belonging to one of the planet's continental nuclei, the Fennoscandian Shield. A tectonic synthesis of the type presented here has previously been lacking for Sweden, and this Memoir complements earlier national compilations that have included a tectonic disposition, published 2005 for Finland and 2008 for Norway.

The need for a tectonic synthesis of Sweden arose after receiving requests from visiting mineral exploration geologists. Sweden has a long history of mining with metal deposits in operation for at least a thousand years. Deposits in the Bergslagen ore district, central Sweden, all had an immense economic importance for Sweden during the seventeenth and eighteenth centuries. Subsequently, the Kiirunavaara iron ore deposit and massive sulphide deposits in the Skellefte district, in combination with several deposits in Bergslagen, contributed to the industrial development during the nineteenth and twentieth centuries. Today, mining remains important for the net export value of Sweden with currently 15 metal deposits in production. Sweden provides more than 90% of the iron ore in Europe and is a major European producer of copper, zinc, lead, gold and silver. The mineral and bedrock resources of the country are addressed in this Memoir in the context of the lithotectonic framework and the tectonic evolution.

A desire to make use of extensive, publicly available geoscientific information arising from nationwide studies by the Geological Survey of Sweden (Sveriges geologiska undersökning) has provided a key inspiration to complete this Memoir. In the first instance we have aimed to produce an extensive compilation of previously published geoscientific literature

relevant for each lithotectonic unit. Secondly, we have aimed to compile and evaluate material stored in the databases at the Geological Survey, and to integrate this geological, geophysical, geochronological, lithogeochemical and mineral resource information with the published material for each unit. The integration of all this information has been carried out at a scale less detailed than that usually presented in the published literature. Thus, the volume does not only supply a review of previous work, but also an analysis of the tectonic aspects arising from the evaluation of the integrated datasets and, as a consequence, the arguments for or against particular hypotheses for the tectonic evolution. A third specific aim has been to identify aspects where knowledge is lacking or insufficient, and where further geoscientific research is required. Attention has focused here on a better understanding of the tectonic evolution.

Several aspects of the geology of Sweden are addressed either briefly or not at all. Brittle deformation in the solid rock mass is not discussed in any detail, but an understanding of the lithotectonic framework and the ductile deformation provides a basis for an understanding of the brittle deformational evolution. The Memoir does not address geological developments during the Quaternary period, when Sweden was affected by dramatic climate variation with glaciations and inter-glacial periods while drifting eastward away from the Mid-Atlantic Ridge. Landform characteristics and the morphology of the rock surface; palaeontological aspects of the younger sedimentary successions with implications for evolutionary processes; meteorite impact structures; and a focused study of physical rock properties also lie outside the scope of this volume.

The Memoir is designed to serve a professional audience, in particular geoscientists working at universities, exploration and mining companies, geological surveys and consulting companies. The selection of this audience unfortunately provides limitations on the aspiration to also reach a broader public. However, we believe that the book provides the necessary foundation for a more popular version aimed at reaching a more general audience.

Acknowledgements

The work involved with this Memoir began at the Geological Survey of Sweden (Sveriges geologiska undersökning) when both the editor and graphics editor were employed at this expert governmental agency. We wish to thank Lars Rodhe and Anna Åberg at the Geological Survey for their insight in supporting the initial execution of this work.

At an early stage in its development (2013–15), colleagues at the survey extracted and structured geoscientific data from various public databases at this agency. These colleagues also provided information on the databases, which is summarized in the presentation of sources of information to the Memoir in Appendix A1 in Chapter 1. We specifically wish to thank Ildikó Antal Lundin (geophysical databases), Stefan Bergman (geological and tectonic map databases), Torbjörn Bergman (mineral resources database), Anders Hallberg (litho-geochemical database) and Fredrik Hellström (geochronological database) for their help with these tasks. Ildikó also generated the magnetic, Bouguer gravity and radiometric anomaly maps presented in this Memoir. Reflection seismic profiles along various lines close to the eastern coast of Sweden were kindly provided by Christopher Juhlin (Uppsala University). More information on these seismic profiles is provided in Appendix A1.

Several people have contributed to the writing of this Memoir. These authors and the institutions who have supported their participation are identified in the heading to each chapter. Initial drafts of some chapters were produced during 2014–15, but the work with this volume advanced significantly after both the editor and graphics editor had left the Geological Survey and when an agreement with the Geological Society of London (GSL) to produce a GSL Memoir was established during July 2016. We are very grateful to Angharad Hills, formerly employed at the Geological Society of London, in her role as commissioning editor, and to Bethan Phillips, who took over after Angharad, and Jo Armstrong for their fantastic support over the last three years. Due to the role played by the editor (Stephens) as author in several chapters, there was a need for a corresponding editor in the peer-review process. The Society Books Editor, Randell Stephenson (University of Aberdeen), took on this role in an enthusiastic and efficient manner. We also wish to express our warm thanks for his important contribution.

Several colleagues have provided advice concerning the text and figures in some of the chapters. In particular, we wish to thank Jenny Andersson and Dick Claeson (Geological Survey of Sweden) for their help with Chapter 15 and the explanatory text to the Supplementary material, respectively; to Peter Hedin (Geological Survey of Sweden, formerly Uppsala University) for help with the figures in Chapter 20;

and to Graham Leslie (British Geological Survey Scotland) for helpful remarks on Chapter 23. We also wish to thank Nelly Aroka (formerly Geological Survey of Sweden) who generated the base figures illustrating litho-geochemical data in Chapters 3 to 7, as well as Chapters 11 and 15.

The following people, as well as two anonymous persons, provided the peer reviews: R. Allen, U.B. Andersson, L. Augland, S. Bergman, F. Beunk, B. Bingen, S. Claesson, S. Cuthbert, J.S. Daly, O. Eklund, R. Greiling, I.C. Henderson, K. Högdahl, P. Japsen, Å. Johansson, L. Johansson, I. Kleinhanns, R.A. Kumpulainen, S.Å. Larson, S. Lindström, S. Luth, C. Möller, Ø. Nordgulen, J.P. Nystuen, D. Roberts, A. Scherstén, L. Shumlyansky, H. Sjöström, G. Skridlaite, P. Skyttä, T. Slagstad, U. Söderlund, P. Sorjonen-Ward, M.B. Stephens, R. Stephenson, G. Viola, J. Waldron and D. Young. All these reviewers contributed significantly to improving the geoscientific standard of the Memoir and we want to express our warm thanks for their constructive reviews.

We are grateful to the Geological Survey of Sweden, in particular Anna Åberg and Kaj Lax, for providing permission to extract geodata stored in the various databases at the survey, thereby providing the basis for most of the tables and some of the figures. We also wish to acknowledge the permission provided by geoscientific journals, the Geological Survey of Sweden and the individual owners of photographs to reproduce some of the graphics. We warmly thank Boliden Mineral AB, LKAB, the Swedish Association of Professional Scientists (Geology), the Swedish Nuclear Fuel and Waste Management Company (Svensk Kärnbränslehantering AB), and the Universities of Gothenburg, Lund, Stockholm and Uppsala for contributing financially to the production of the graphics. The logos of these companies and institutions are included below.

Last, but not least, the editor (Stephens) wishes to thank his wife, Pia, for calmly enduring the many hours of writing and editing at home since 2016. He also wants to acknowledge the inspiration to focus on structural geology and tectonics, which was established while reading geology at undergraduate level at the University of Cambridge during the late 1960s. Inspiration came from the teacher, John Dewey, at a time when the plate tectonics paradigm had just started to emerge. This enthusiasm continued to blossom while completing a PhD at the University of Leicester under the supervision of Brian Windley and with support from David G. Gee who, at that time, was employed at the Geological Survey of Sweden. A truly exciting period!

M.B. STEPHENS (editor) and
J. BERGMAN WEIHED (graphics editor)



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