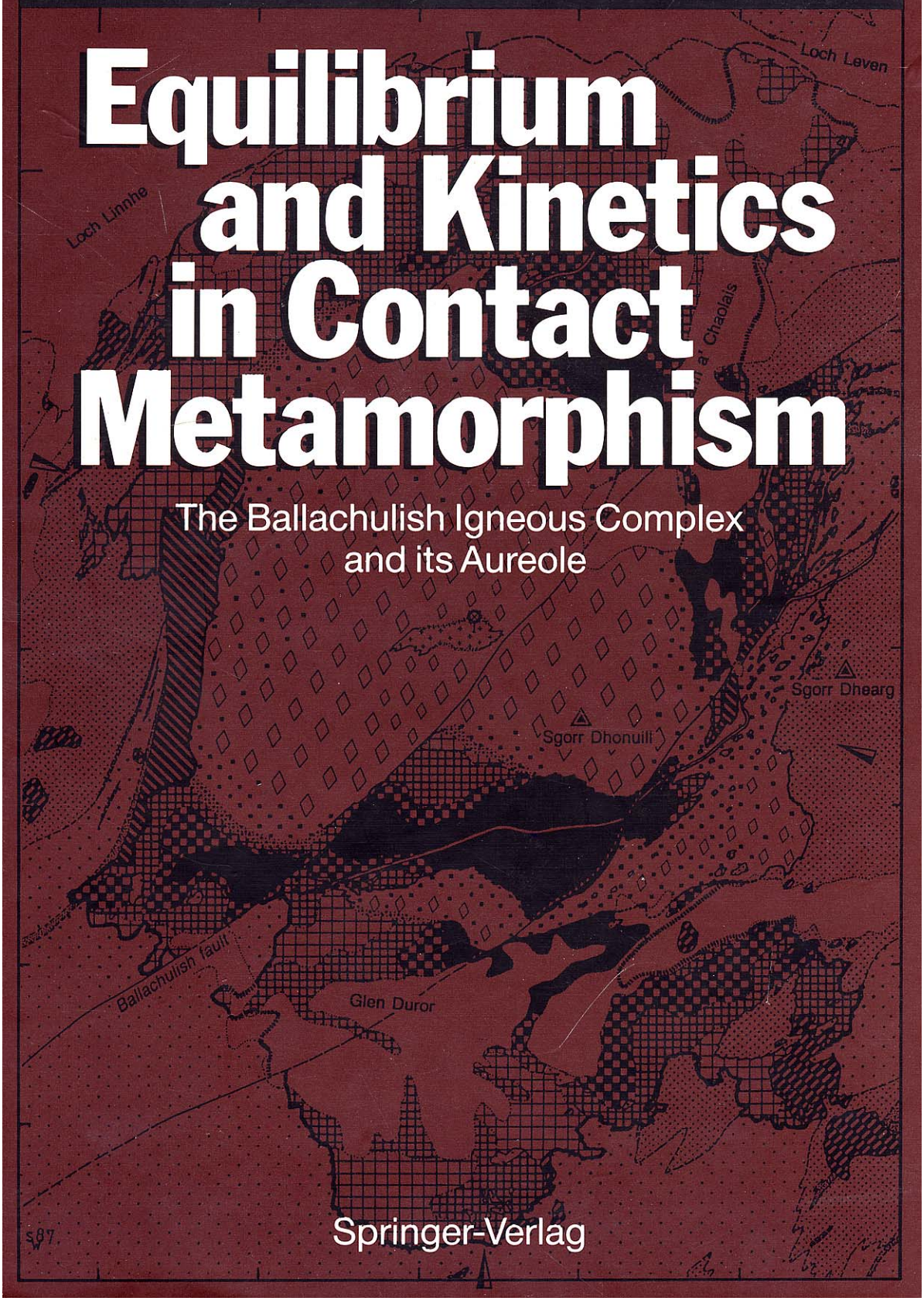
G. Voll · J. Töpel · D. R. M. Pattison · F. Seifert
Editors

Equilibrium and Kinetics in Contact Metamorphism

The Ballachulish Igneous Complex and its Aureole



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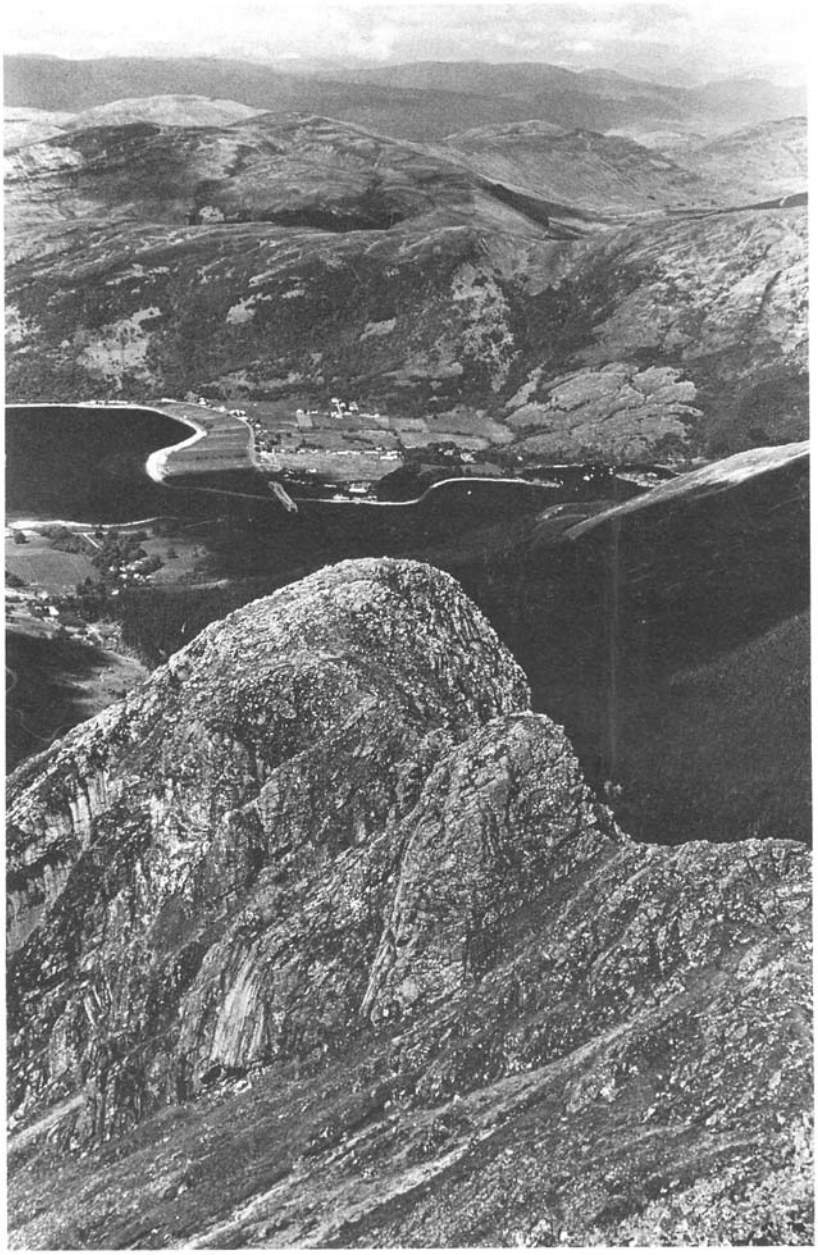

View from just east of the summit of Sgorr Dhonuill, looking north. In the foreground are prominent cliffs of resistant porphyritic granite, occupying the centre of the Ballachulish Igneous Complex. Below the cliffs are the forested slopes of Gleann a' Chaolais, underlain by diorite of the igneous complex. Across Loch Leven, spanned by the Ballachulish Bridge, lie North Ballachulish and the hills of Nether Lorn, underlain by Dalradian metasediments. The small tidal island forming a promontory on the west side of the small anchorage east of North Ballachulish contains incipiently cordierite-spotted phyllites of the Leven Schist, and marks the outer margin of the thermal aureole in this area

Preface

With the new global tectonics approach in the Earth Sciences, the quantitative aspects of the dynamics of rock-forming processes came into focus: geologists are no longer satisfied knowing the pressure-temperature conditions of the formation of a metamorphic rock or of the emplacement of a magmatic body, but instead would like to learn the time history of these rocks as well, i.e., derive the temperature-pressure-time path and relate it to a tectonic process. To achieve this goal, a knowledge of both pressure-temperature-dependent equilibria and the time scales at which these equilibria may be attained are essential. However, the latter kinetic information is much more difficult to retrieve than that on equilibria: whereas equilibria are controlled by state variables, and proper laboratory experiments may be directly applied to equilibrium natural assemblages, kinetics also depends on factors other than state variables, such as grain size, dislocation density, and especially time (rate of heating, duration of annealing, rate of cooling). Extrapolation of kinetic data obtained at high temperatures on laboratory time scales to more realistic lower temperatures and geological time scales are dangerous because, for example, of possible changes from an intrinsically controlled defect regime to an extrinsic one as temperature is lowered, or from an interface-controlled to a diffusion-controlled reaction mechanism.

Progress in our understanding of the kinetics of rock-forming processes can, therefore, only be expected by a careful comparison of laboratory and field data. With the time history of the evolution of a natural rock being in general poorly known and the factors controlling the kinetics difficult to reconstruct, it is essential to use as many data and techniques as possible, but at the same time keep the number of complicating factors low.

In this book, such a multilateral approach is attempted for *one* contact aureole, that of the Ballachulish Igneous Complex in the Scottish Highlands. It has been selected because of the large variety of different rock types contained and the relatively simple cylindrical geometry. Also, because of its size, the time scale of contact metamorphism in this aureole (in contrast to that of regional metamorphism) is closer to that of laboratory studies than in regional metamorphism, and a chance might exist for a linkage of results. It is probably not an exaggeration to say that

this is the most comprehensive study of a single igneous complex-contact aureole system yet published.

The work on the Ballachulish igneous body and its aureole presented here started independently in two places: at the Grant Institute of Geology of Edinburgh University, and in a priority program run by the Deutsche Forschungsgemeinschaft, entitled "Kinetics of rock- and mineral-forming processes" in which a number of groups in geophysics, petrology, mineralogy and geochemistry from different German universities participated. It was only by a combination of activities that the complex problem could be tackled.

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