

Preface

My interest in pyrometamorphosed rocks began in 1981–1982 as a Humboldt Fellow at the Institute for Mineralogy, Ruhr University, Bochum, Germany, with Professor Werner Schreyer, where I began a study of basement xenoliths erupted from the Wehr Volcano, east Eifel. The xenoliths, mainly mica schists, had all undergone various stages of reaction and fusion. Because the high temperature reaction products and textures were fine grained they were difficult to study petrographically and for me they presented an entirely new group of rocks that I had had almost no experience with. However, by extensive use of the backscattered electron image technique of the electron microprobe the “wonderful world” of mineral reaction/melting textures arrested in various stages of up-temperature transformation by quenching was revealed. Almost every image showed something new. I had entered the seemingly complex and at times contradictory realm of disequilibrium where metastable nucleation and crystal growth is the norm.

Pyrometamorphism is a type of thermal metamorphism involving very high temperatures often to the point of causing fusion in suitable lithologies at very low pressures. The high temperatures are provided by flow of mafic magma through conduits, by way of spontaneous combustion of coal, carbonaceous sediments, oil and gas, and through the action of lightning strikes. These conditions characterise the sanidinite facies of contact metamorphism. Although pyrometamorphic effects related to igneous activity are usually restricted to very narrow aureoles and xenoliths and to the point of impact in lightning strikes, pyrometamorphic rocks may be exposed over a surface area of hundreds to thousands of square kilometres in the case of combustion of gently dipping coal seams. In all these instances, temperature gradients are extreme, varying by several hundred degrees over a few metres or even centimetres. Relatively short periods of heating create an environment dominated by metastable melting and rapid mineral reaction rates driven by significant temperature overstepping of equilibrium conditions. This results in the formation of a large variety of high temperature minerals, many of which are metastable, are only found in pyrometamorphic rocks, and are analogous to those crystallising from dry melts in laboratory quenching experiments at atmospheric pressure.

Compared with other types of metamorphic rocks, pyrometamorphic rocks are comparatively rare and volumetrically insignificant. This is probably the main reason why pyrometamorphism and sanidinite facies mineral assemblages have

received scant attention in many modern petrology text books despite the fact that there is a considerable literature on the subject dating back to 1873 when the first buchite was described and named. Since publication of the 1st edition of this book in 2006, some 28 papers have appeared in international earth science, technology and archaeological journals detailing processes, field relations, microtextures, mineralogy and geochemistry of pyrometamorphic rocks, and related phenomena such as biomass pyrometamorphism. Information from these articles is reviewed and synthesized in this 2nd edition which remains as a compendium of available data relating to some 94 terrestrial occurrences of igneous, combustion and lightning strike pyrometamorphism of quartzofeldspathic, calc-silicate, evaporate, mafic rock/sediment compositions (Chaps. 3, 4, and 5), together with examples of anthropogenic and biomass pyrometamorphism, such as brick manufacture, coal metamorphism, slag production, surface biomass burning, waste incineration and drilling (Chap. 6). The last chapter deals with aspects of high temperature disequilibrium reactions and melting of some common silicate, carbonate and sulphide minerals. My hope is that the book will stimulate further research into these fascinating rocks and vitrified substances to help explain the many unanswered questions relating to processes and products of recrystallization and melting/crystallization under high temperature/low pressure conditions.

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