The aenigmatite-rhönite mineral group

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Abstract: The aenigmatite-rhönite mineral group consists of eight minerals: Aenigmatite, rhönite, serendibite, kri­

novite, welslibite, dorritle, wilkinsonite and högtuavite. The general chemical formula of the minerals in this group may

be written as \(\{X_2\} [Y_6] (Z_6) O_{20}\), with \(\{X\}\) eightfold coordinated Na\(^+\), Ca\(^{2+}\) and \([Y]\) sixfold coordinated Mg\(^{2+}\), Fe\(^{2+}\), Fe\(^{3+}\), Ti\(^{4+}\), Al\(^{3+}\), Mn\(^{2+}\), Cr\(^{3+}\), Ti\(^{3+}\), Ca\(^{2+}\), Sb\(^{5+}\), Nb\(^{5+}\) and As\(^{3+}\), and \((Z)\) fourfold coordinated Si\(^{4+}\), Al\(^{3+}\), Fe\(^{3+}\), Be\(^{2+}\) and 

B\(^{3+}\). There are two subgroups: a sodic group, including the minerals aenigmatite, krinovite and wilkinsonite, and a

calcic group with rhönite, serendibite, dorritle, welslibite and högtuavite. The general features of the crystal structure

are common to all the minerals of this group. These minerals occur in a wide range of rock types, e.g. alkaline lavas,
sodium-rich intrusives, granitic gneisses, skarns, limestone-basalt contacts and meteorites, but mostly as accessories.

Experimental data on stability are available only for aenigmatite and rhönite. Aenigmatite was synthesized at 700°C/

1000 bars and 750°C/500 bars by Thompson & Chisholm (1969) and Lindsley (1969). The oxygen fugacity is con­

strained be lower than the fayalite-quartz-magnetite = FQM buffer. Rhönite is stable from 850°-1000°C/1 bar to at

least 5 kbar, 900 to 1100°C (Kunzmann, 1989). There is no limit on oxygen fugacity. In alkali-basaltic rocks, the sta­

bility is restricted to pressures lower than 600 bars and temperatures from 840 to 1200°C (Kunzmann, 1989). The

chemistry of this group is complex, due to the flexibility of the structure. The structural formulae of 192 available

analyses can be described in terms of seven substitutions: 1: Si\(^{4+}\) + Na\(^{+1}\) \(\rightarrow\) Al\(^{3+}\) + Ca\(^{2+}\); 2: Si\(^{4+}\) + Mg\(^{2+}\) \(\rightarrow\) Al\(^{3+}\) + Al\(^{3+}\); 3: Ti\(^{4+}\) + Mg\(^{2+}\) \(\rightarrow\) 2Al\(^{3+}\); 4: Mg\(^{2+}\) \(\rightarrow\) Fe\(^{2+}\); 5: Al\(^{3+}\) \(\rightarrow\) Be\(^{2+}\); 6: Si\(^{4+}\) + Be\(^{2+}\) \(\rightarrow\) 2 Al\(^{3+}\); 7: Sb\(^{5+}\) + 2 Mg\(^{2+}\) \(\rightarrow\) 3 Fe\(^{3+}\). The theoretical number of end-members (and names) resulting from these seven substitutions is immense.

A simplified nomenclature is proposed here based on three substitutions. I: 2 Si\(^{4+}\) + 2 Na\(^{+1}\) \(\rightarrow\) 2 Al\(^{3+}\) + 2 Ca\(^{2+}\); II: 2 Si\(^{4+}\) + 2 (M\(^{2+}\)) \(\rightarrow\) 2 Al\(^{3+}\) + 2 (M\(^{3+}\)) + 2 (M\(^{3+}\)) \(\rightarrow\) 4 (M\(^{3+}\)). This results in a rectangular poly­

dhedron for the aenigmatite-rhönite group, in which ten sub-volumes can be assigned to ten end-members.

Key-words: aenigmatite, rhönite, stability, chemistry, nomenclature

Introduction

The aim of this paper is to present an overview

of the minerals of the aenigmatite-rhönite group,
based on published data as well as results obtained

by the author. The present knowledge of this min­
eral group is summarized in terms of history, prop­
erties, structure and occurrence. Further data on

the temperature and pressure stability of rhönite, as well as the occurrence of rhönite as a low-pres­

sure breakdown product of Ca-amphibole, are

based on the author’s own research. In the section

on chemistry and substitutions, 192 analyses are

presented which clearly demonstrate the mecha­
nisms of substitution and the great chemical vari­

ability within this mineral group.