Reconstruction of the Cooling History of the Damara Orogen by Correlation of Radiometric Ages with Geography and Altitude

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Abstract

Rb/Sr, K/Ar and fission track ages were used to reconstruct the cooling history. Large and fast uptilt of the Southern relative to the Central Zone of the orogen must have occurred immediately after the peak of metamorphism between 530 and 520 Ma ago. Cooling proceeded fast and steadily in the Southern Zone whereas in the Central Zone the process came to a halt at 300 - 270 °C between 500 and 370 Ma ago. The fission track ages north of the Okahandja Lineament are low whereas they are high south of it; the lateral age gradient is very steep. The low ages, the plateau in the cooling curve and the steepness of the age gradient are best explained by a long lasting heat source in the uppermost crust which is lacking in the Southern Zone. The most probable heat source is radioactivity.

The K/Ar biotite and garnet fission track ages are strongly dependent on altitude. 1000m difference in altitude corresponds to age differences of 40 and 80 Ma, respectively. This correlation implies a greater thermal uniformity of the Central Zone than is suggested by the coincidence of the areas of high metamorphic grade, high radiogenic heat production and low ages. The inference is that a great part of the differences in ages and metamorphic grade seen at the present surface is simply a consequence of different depths of erosion.

1. Introduction

One of the least understood phenomena of an orogeny is how the temperature changes with time. Therefore, it is important to learn more about the temperature history of mountain belts. One section of this history can be reconstructed by the analysis of those mineral parageneses which were formed at the peak of regional metamorphism. This aspect commonly dominates the investigations. However, the cooling history of an orogen can also contribute valuable information about the distribution and magnitude of heat sources, especially the long lived ones. This report deals with the cooling history of the Damara orogen. It was hoped that the results would help to better understand the high temperature history (see contributions by Hoffer and by Puhan) of the orogen and vice versa. In addition the data were used for geophysical modelling (Hartmann et al., this volume) and also compared with the radioactivity of the rocks (Haack et al., 1983).

2. Geological situation of the Damara Orogen

Here only those aspects can be mentioned which have some bearing on the cooling history. The Damara Orogen in Namibia which is part of the Pan-African orogeny (Clifford, 1967) consists of three branches, two of which run parallel the present coast and one strikes SW - NE into the continent. It is this branch which is the subject of this report. A description of the orogen has been given by Martin (1965) and a model for a possible origin was proposed by Martin and Porada (1977a, b) who also give additional references (see also Martin, this volume). The intracontinental branch of the Damara Orogen may be roughly divided into...
three major units parallel to its trend: a Northern, a Central and a Southern Zone (Martin and Porada, 1977; Miller, 1979). This paper deals with the Central and Southern Zones. They contrast in their style of deformation (Porada and Wittig, 1975; Sawyer, 1978; Hälbich, 1977) and type of metamorphism (Hoffer, 1977; Puhan, 1979). Typical for the Southern Zone are remarkably linear, tight to isoclinal, often south facing folds and nappe emplacement at its southern margin. There, regional metamorphism took place under high pressure of up to 6 - 9 kb but low temperatures of not more than about 450°C with geothermal gradients of less than 20°/km (Hoffer, this volume; Puhan, 1979; Kasch, 1980). The central zone by contrast, is characterized by a pattern of north-east trending dome and basin structures, widespread granite intrusions and a very different type of metamorphism. There, high temperatures caused anatexis at low pressures of only 2.5 kb (Hoffer, 1977; Puhan, 1979) in an area close to the coast. There the geothermal gradients probably reached 70°C/km. The isograds for the pelites are shown in Hoffer's (1983) contribution on the metamorphism of pelites. The isograds cut all tectonic structures. Therefore the peak of metamorphism must have been reached after the last regional penetrative deformation (Hoffer, 1977).

The two zones are divided by the Okahandja Lineament Zone, a zone of 25-40 km width trending parallel to the strike of the orogen for at least 530 km. It is believed to have been a fundamental line of weakness in the crust throughout the history of the Damara Orogen (Miller, 1979). An impression of the importance of the lineament is provided by Fig. 1. It shows the presently exposed surface in relation to the temperature distribution during the time of metamorphism on a profile perpendicular to the strike. The 500°C and 600°C isotherms delineate a high thermal plateau north of the lineament with a rapidly falling flank south of it (based on data by Hoffer, 1977).