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Ductile deformation of garnet in mylonitic gneisses from the Münchberg Massif (Germany)

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Abstract

Mylonitic gneisses from the Münchberg Massif contain single grains (type I) and polycrystalline aggregates (type II) of garnet displaying a distinct elongation parallel to a macroscopic lineation which is interpreted as the result of ductile deformation. Lattice-preferred orientations of quartz (textures) symmetrical to the macroscopic foliation and lineation and the lack of rotational microfabrics indicate that the bulk deformation was pure shear at least during the latest strain increments. Garnet textures measured by EBSD together with microprobe analyses demonstrate that these two structural types of garnet can be related to two different processes of ductile deformation: (1) For the single grains stretching can be attributed to diffusion creep along grain boundary zones (Coble creep). The related mass transfer is indicated by the fact that primary growth zones are cut off at the long faces of the grains while the related strain shadow domains do not show comparable chemical zoning. Pressure solution and precipitation suitable to produce similar structures can be largely ruled out because retrogressive reactions pointing to the presence of free hydrous fluids are missing. (2) For the polycrystalline garnet aggregates consisting of cores grading into fine-grained mantles, dislocation creep and associated rotation recrystallization can be assumed. Continuous lattice rotation from the core to the outer polycrystalline rim allow a determination of the related dominant slip systems which are {100}<010> and equivalent systems according to the cubic lattice symmetry. The same holds for garnets which appear to be completely recrystallized. For this type of fine-grained aggregates an alternative nucleation model is discussed. Due to penetrative dislocation glide in connection with short range diffusion and the resulting lattice rotation, primary growth zones are strongly disturbed.

Since for the considered rock unit of the Münchberg Massif peak metamorphic temperatures between 630 and 670 °C can be assumed, this study clearly demonstrates that the inferred processes of ductile garnet deformation can occur not only in HT regimes as often suggested in the literature even if embedded within a matrix of "low-strength" minerals like quartz, feldspars and micas.

Keywords: Garnet; Diffusion creep; Dynamic recrystallization; Texture; Münchberg Massif

1. Introduction

In contrast to other rock-forming minerals, comparatively few investigations have been carried out on the ductile deformation behaviour of garnet. The main reasons are: (1) in many mylonitic rocks, garnet grains are embedded in a matrix of more ductile minerals and hence are buffered from intracrystalline deformation; (2) deformation substructures cannot be observed by conventional microscopy because of the optical isotropy of garnet. For the same reason, simple texture measurements

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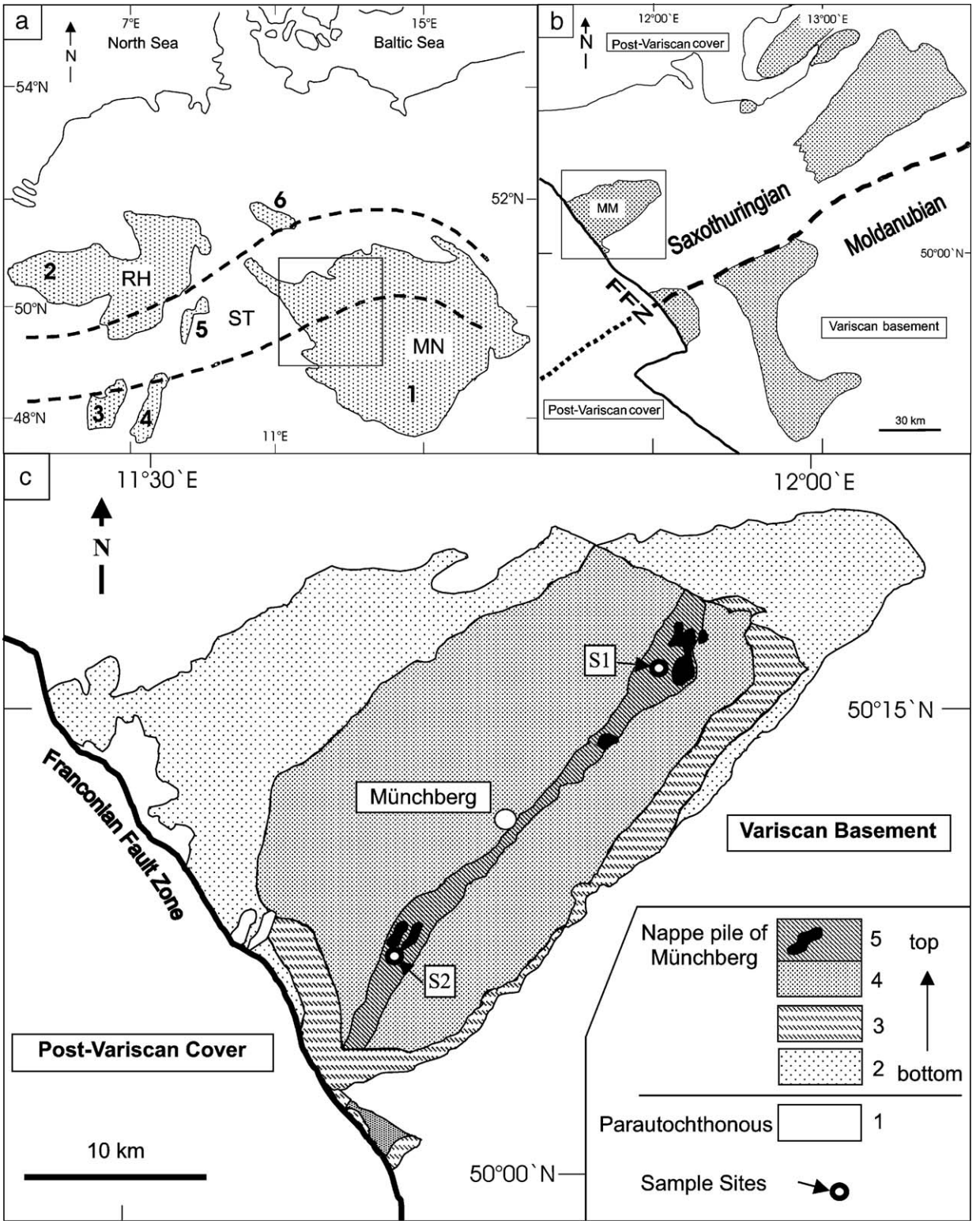
a
7°E
North Sea
15°E
Baltic Sea
N
54°N
52°N
50°N
48°N
11°E
RH
ST
MN
1
2
3
4
5
6
b
12°00`E
13°00`E
Post-Variscan cover
MM
Saxothuringian
Moldanubian
FFZ
50°00`N
Variscan basement
Post-Variscan cover
30 km
c
11°30`E
12°00`E
N
S1
S2
50°15`N
50°00`N
Münchberg
Franconian Fault Zone
Variscan Basement
Post-Variscan Cover
10 km
Nappe pile of Münchberg
5
4
3
2
top
bottom
Parautochthonous
1
Sample Sites