Kontinentales Tiefbohrprogramm der Bundesrepublik Deutschland

SEM - Cathodoluminiscence Studies of Palaeoporosity in Metamorphic Rocks

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1. Problem

Generally, in all crystalline rocks relics of the solutions and gases of all prograde and retrograde genetic events or structural processes have been preserved as fluid inclusions. The sum of all these inclusions filled with palaeofluids is the sealed residual porosity (matrix porosity). The permeability is determined by secondary cracking, fracture, and solution porosity. In comparison to sediments the porosity and permeability values in crystalline rock are extremely low.

Are the porosity and permeability data determined by logging, laboratory analyses or theoretically also typical of geological crustal events?

Do they only represent the stage of post-crystalline/posttectonic uplift, of erosion and lessening of tension?

In order to answer these questions we must investigate the subsequently sealed palaeoporosity and palaeo-permeability.

2. Possible Solution

By cathodoluminescence, healed palaeoporosity/palaeo-permeability events can be made visible and can be classified, different genetic events can be distinguished and the volume of the accumulated palaeoporosities can be inferred. The main components quartz and feldspars are most suitable for this kind of investigation due to the high sensitivity of the CL characteristics in contrasting changes in the concentration of activator elements in the range of trace elements in the mineralizing fluids. The CL characteristics are also determined by lattice defects in the crystal lattice.

3. Methods

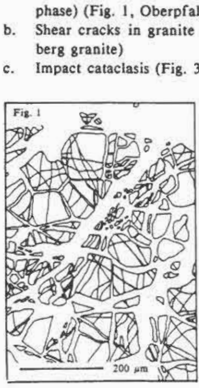
The CL investigations are carried out with a device based on an optical microscope (see poster Neuser, Behr) and a scanning electron microscope with a special CL detector (Cambridge Instruments S250 MK3, CL-Detektor S20 extended). The data are evaluated with an image analysis system (Viper).

4. CL Structures from Quartz Microstructures in Crystalline Rock

The palaeostructures distinguished by CL can be assigned to genetic processes and crustal stockworks. Examples are shown in the following:

Cataclasis

a. Internal microcataclasis in strike-slip zones (polyphase) (Fig. 1, Oberpfalz well)
b. Shear cracks in granite (monophase) (Fig. 2, Falkenberg granite)
c. Impact cataclasis (Fig. 3, Gravberg well, Lake Siljan)



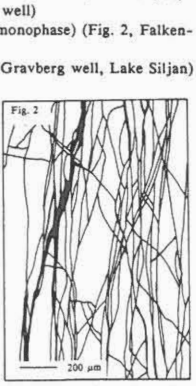


Fig. 1a Quartz, polyphase cataclastic, Oberpfalz well -
The clasts have been newly cemented by quartz.

Fig. 2 Quartz, monophase sheared, Falkenberg granite, Oberpfalz. The shear paths are healed with quartz (black).

Channelway Porosity

The channelway porosity is typical of the upper and middle crust.

a. Greenschist facies alteration in the course of uplift, shear and tension tectonics (Fig. 4, channelway in granite)
b. Thermal crackling in magmatites (Fig. 5, Triberg granite)

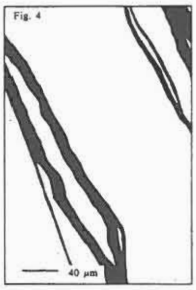
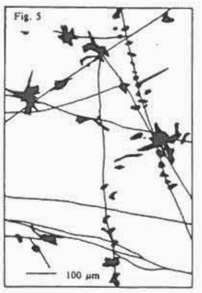


Fig. 3 Quartz, with impact-cataclasis, granite, Gravberg well, Lake Siljan, Sweden. The clasts have been newly cemented by young quartz (black).

Fig. 4 Quartz, with channelway fluid passage, episyenite, Honnersreuth, Oberpfalz. The channelways are healed with quartz (black).

Pervasive Porosity

It is typical of the middle crust and occurs in migmatite gneisses and at the end of an HT metamorphism. Besides, it is typical of tension tectonics and low-velocity channels, e.g., in the central Schwarzwald (Fig. 6, pervasive fluid systems).



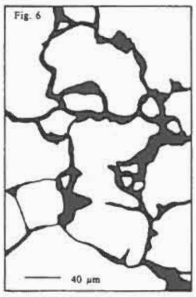
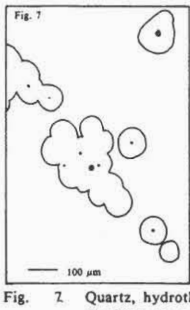


Fig. 5 Quartz, thermal crackling, Triberg granite, Schwarzwald. Pores and diffusion haloes appear black.

Fig. 6 Quartz, pervasive fluid passage, gneiss anatexite, Horbach, Schwarzwald. Quartz redeposited by pervasive fluids and pores appear black.

Diffusion Porosity

It forms at grain boundaries, dead-end microcracks, around fluid inclusions, at radiogenic lattice defects, around passages of radioactive solutions and around radioactive minerals such as uranium ores, zircon, monazite, etc. (Fig. 7, radiogenic haloes; Fig. 8, Kola well)



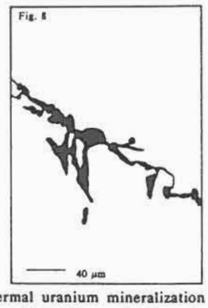


Fig. 7 Quartz, hydrothermal uranium mineralization Großschloppen, Oberpfalz. Radiogenic haloes, uranium ore (black).

Fig. 8 Quartz, tonalitic gneiss, Kola SG3 well, depth: 11,000 m. Diffusion porosity and diffusion haloes (black).

Grain Boundary Porosity

In lower crustal rock the grain boundary porosity predominates. Here, the CL phenomena are determined by the composition of the solution diffusing at the grain boundaries. (Fig. 9, grain boundary porosity in granulite)

5. Quantitative Analysis of the Palaeoporosity

From the analysed examples (ca. 400 analysed micrographs) it can be inferred that in metamorphites 10-50 vol% (Tab. 1) of the rock-forming quartz is redeposited after the climax of the metamorphism due to alteration processes, tectonic breaking-up and retrograde metamorphism. This high portion of palaeoporosity originates in accumulated volumes. The residual porosity concentrates in palaeoporosity structures providing evidence for their consisting of newly formed mineralizations due to fluid phases.

In this abstract volume it is not possible to present original micrographs as they will be shown on the original poster during the poster presentation of the conference.

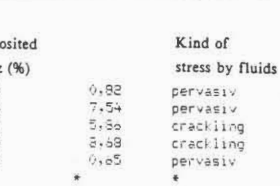


Fig. 9 Quartz, charnockite, Varberg, Sweden. Grain boundary porosity.

Tab. 1

sample	porosity in quartz (%)	redeposited quartz (%)	porosity of the redeposited quartz (%)	Kind of stress by fluids
13 Gneis.metatektisch SW	0,53	29,00	0,82	pervasiv
18 Paragneis, anatektisch SW	2,20	29,16	7,54	pervasiv
29 Pegmatoid OPF	0,54	9,21	5,66	crackling
31 Episyenit OPF	1,26	13,20	3,68	crackling
43 Orthogneis.granulitisch SW	0,31	47,52	0,65	pervasiv
49 Paragneis SW	0,95	*	*	*
52 Leptinit.lagig SW	0,51	*	*	*
54 Ky-Gneis SW	0,50	*	*	*
56 Orthogneis.granulitisch SW	0,73	14,00	5,91	Korngrenzdiffusion
57 Kerngranulit SW	0,42	*	*	*
61 Granit,Triberg SW	0,80	9,83	6,15	crackling
84 Granit,Falkenberg OPF	0,59	34,63	1,82	crackling
32 Graphitquarzit OPF	2,03	*	*	*
79 Kluftquarz OPF	5,44	*	*	*

* = no data obtained
OPF = Oberpfalz
SW = Schwarzwald