Paramagnetic defects of quartz in KTB and a drilling profile from Eldzhurtinskiy granite, Russia

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Electron paramagnetic resonance (EPR) of natural and experimentally irradiated polycrystalline quartz samples from KTB (Table 1) and a drilling profile in the Eldzhurtinskiy Granite (Table 1), Caucasus, Russia, were measured in the frequency range of 9.5 GHz. The paramagnetic defect centers $[AlO_4]^0$ and $[TiO_4/M^+](M = H, Li)$ were studied (Figure 5). The intensities of those centers depend primarily on the intensity increase per unit γ dose, γ radiation intensity of the rock, time since the threshold temperature T_C, and the attenuation factor f which is a function of T. The time since passing T_c may be determined using model calculations for f (Agel, 1992).

The center intensities exhibit a quasi-proportional decrease with increasing *in situ* temperature T_S which is characteristic for the profile (Figures 1 and 3). The EPR data may be used to determine uplift rates and cooling rates for each sample. In the KTB the general decrease of the center intensity with increasing temperature is interpreted in terms of uplift rates as the predominant contribution. However, the data obtained for the Eldhurtinskiy Granite show a more complex relationship. Here, a rather high heat production of the granite is indicated. Models for a quantitative interpretation are being considered.

For the nearest future additional investigations of other profiles are necessary for a more quantitative interpretation of the relationship of spin concentration, temperature, and time. Also important is the study of the principles of the f factor and irradiation experiments with different radiation energies and doses. These investigations are in preparation.

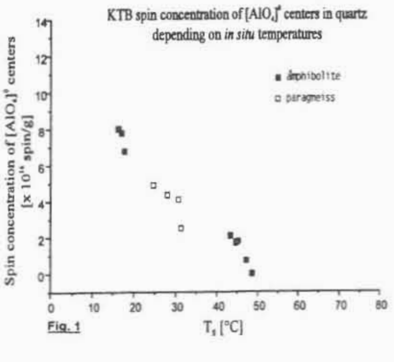

Fig. 1

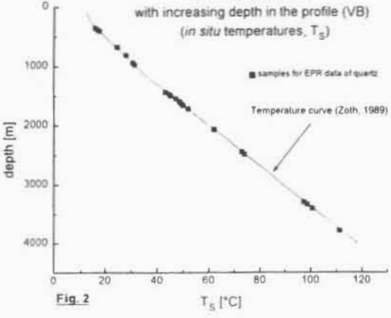

Fig. 2

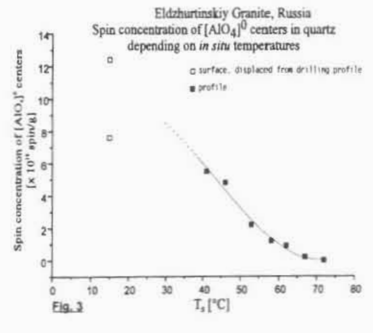

Fig. 3

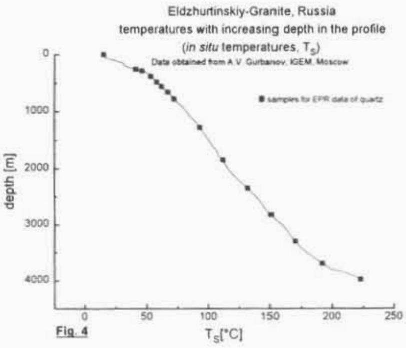

Fig. 4

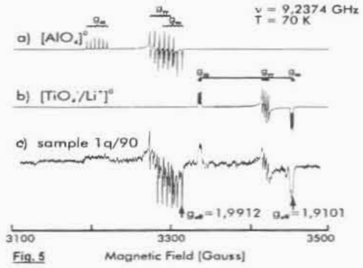

Fig. 5

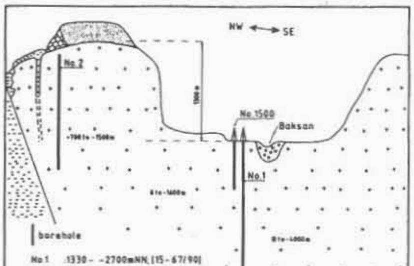

Fig.6: Geological sketch of the Eldzhurtinskiy Granite.(communicated by G. Witt-Eickschen, Köln)

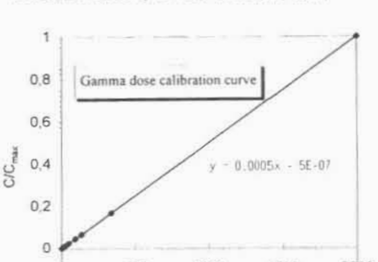

Fig.7: Calibration curve for determination of the natural dose which produced the observed center intensity.

Sample	Rock[a]	d [m]	T_S[b] [°C]	$[AlO_4]^0$ [x 10^{16} spin/g][c] nat.	$[AlO_4]^0$ irr.	$[TiO_4/M^+]^0$ [abitrary units] nat.	$[TiO_4/M^+]^0$ irr.
Continental Deep Drilling					[1x10^6 Gy]		[2x10^3 Gy]
K51B3	A	358	16	7.99	39.79	0.00	0.67
K56C19cT	A	386	17	7.66	nd	nd	nd
K60B1b	A	404	18	6.77	38.88	0.00	nd
K134A1bT	P	679	25	4.98	nd	nd	nd
K174A1x	P	815	28	4.34	nd	nd	nd
K234C1u	P	943	31	4.10	nd	nd	nd
K246B2d	P	978	31	2.52	nd	nd	nd
K299A1cT	A	1440	43	2.09	nd	nd	nd
K308C1g	A	1476	45	1.73	33.43	0.86	2.15
K308C1f	A	1476	45	1.71	nd	nd	nd
K313	A	1500	46	1.80	38.39	1.30	1.34
K324E11	A	1549	47	0.73	38.65	0.50	nd
K333E1v	A	1600	49	0.0	nd	nd	nd
K472C2d	P	2065	62	0.0	58.19	0.70	1.11
K596A1b	P	2441	73	0.0	67.08	0.00	nd
K606A1f	P	2483	74	0.0	29.63	0.00	0.69
K831B3h	P	3407	101	0.0	29.21	0.00	nd
K923D1ok	P	3784	111	0.0	27.59	0.00	nd

a A amphibolite, P paragneiss (Röhr et al., 1989), G granite (data from A.G. Gurbanov)

b *in situ* temperature at the location of the sample when collected (KTB: Zoth, 1989; Eldzhurtinskiy Granite: data from A.G. Gurbanov)

c calibrated according to Moiseev (1985)

d surface samples

nd not determined

bld below detection limit

Sample	Rock[a]	d [m]	T_S[b] [°C]	$[AlO_4]^0$ [x 10^{16} spin/g][c] nat.	$[AlO_4]^0$ irr.	$[TiO_4/M^+]^0$ [abitrary units] nat.	$[TiO_4/M^+]^0$ irr.
Eldzhurtinskiy Granite					[2x10^3 Gy]		[2x10^3 Gy]
4b/90[d]	G	0	15	7.6	166.7	8.2	55.0
34-2/90[d]	G	0	15	12.4	187.0	11.3	39.2
27-1/90[d]	G	0	15	14.9	89.3	9.0	36.2
1/90	G	258	41	5.5	nd	4.2	nd
1-2/90	G	285	46	4.8	205.6	4.4	56.0
2/90	G	385	53	2.2	nd	2.4	nd
2-7/90	G	484	58	1.2	117.3	2.3	56.3
3/90	G	561	62	0.9	127.7	2.2	43.3
4/90	G	660	67	0.2	105.8	1.2	23.6
5-2/90	G	792	73	bld	36.0	1.5	25.1
10-4/90	G	1334	94	bld	24.3	0.5	15.7
17-1/90	G	1835	111	bld	32.9	bld	18.5
26-1/90	G	2317	130	bld	30.9	bld	20.7
37/90	G	2802	150	bld	31.6	bld	20.1
49/90	G	3300	170	bld	34.3	bld	21.5
59/90	G	3700	192	bld	34.7	bld	24.0
67/90	G	3980	223	bld	35.7	bld	16.5

Table 1: Documentation of samples studied.

Sample	Th[a] [ppm]	Th[b] [ppm]	U[a] [ppm]	U[b] [ppm]	K[a] [%]	K[b] [%]	γ dose[c] [mGy/a]
5-2/90	29.5	5.7	6.5	3.4	3.6	0.06	3.13075
10-4/90	35.1	8.5	5.9	4.3	3.6	0.06	3.34965
17-1/90	36.5	9.1	7.2	3.2	3.1	0.06	3.45048
26-1/90	25.8	8.5	6.0	4.3	2.9	0.05	2.71442
37/90	27.1	7.1	7.1	3.6	3.1	0.03	2.95583
49/90	30.7	6.9	6.7	3.2	3.8	0.03	3.26361
59/90	28.4	5.5	7.5	1.7	3.3	0.02	3.11681
67/90	30.2	5.0	6.4	4.0	3.7	0.03	3.17934

(Th, U, K data from Dr.A.G. Gurbanov, IGEM, Moscow)

a Element concentration of the rock

b Element concentration of quartz

c Dose rates calculated after *Aitken, M.I. (1985)*

Table 2: Geochemical data of elements responsible for gamma radiation of the rock. The granite seems to be relatively homogenous for K, Th, and U.

References

Agel, A. (1992): Dissertation Universität Marburg, and references therein.

Agel, A., Scherer, T., S.S. Hafner (1993): 6. Kolloquium des DFG-Schwerpunktprogramms KTB, Gießen, 1.04.-2.04.1993, Abstracts, 116-119.

Aitken, M.I. (1985): Thermoluminescence dating, London, Academic Press.

Gurbanov, A.G.: personal communication.

Scherer, T., Agel, A., S.S. Hafner (1993): KTB Report *93-2*, 121-124.

Witt-Eickschen, G.: personal communication.

Zoth, G. (1989): KTB-Report *89-1*, 65-71.