HEALING OF CRACKS IN QUARTZ

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Introduction

The formation of fluid inclusions is connected with healing of cracks. Besides elastic and other physical properties of breeds, opportunity mass transport, are connected to geometry of porous space, both common porosity and permeability. The processes causing change of morphology of cracks, can have an effect and for size of these characteristics. Experimentally studying a course healing of cracks in crystals of salt, Lemmlein [1] has shown, that cracks healing occurs by dissolution and precipitation of substance of cracks walls, if in a crack gets fluid and that the solution is sated concerning walls and supersaturated concerning sides growing across a crack. Smith & Evans, [2], Kotelnikova, [3] have shown, that healing depends on temperature, fluid nature and orientation of a crack.

Cracks healing can occur by a way diffusion through a lattice and transport of a material of a matrix along a surface firm - fluid or directly through fluid and to not require involving of a new matrix material. Thus the morphology of a crack changes. There is a difference of chemical potential between the moving end of a crack and its walls owing to roughness of a surface of cracks [2]:

$$\Delta\mu=\gamma(C_e-C_m)\Omega ,$$

where γ- superficial energy; Ω- molecular volume; C_e, C_m - curvature of a surface at excesses and in an average part accordingly.

The analysis of the equation shows, that the carry of substance occurs from convex or concave sites to the large curvature of a surface to convex parts with low curvature.

Different density of dislocations on walls also is the reason of a difference of chemical potential (Geguzin et al, [4]). Geguzin [4] has shown, that the size of narrowed pore in thermogradient field decreases up to critical meaning:

$$Y^*_D \sim (\nabla T)^{-1/2}$$

In a case healing ($\Delta\mu$) this dependence is display a limit in relation to dissolution of lateral walls of a crack. Practically from this dependence follows, that the more roughnesses in a crack, the finer formed inclusions.

If density of dislocations is low (10^5-10^6 cm^{-2}), they practically do not influence moving of a step of dissolution. In a case of a crystal with the high density of dislocations it is possible to consider, that dislocations are distributed along a surface in regular intervals. The steps of dissolution (growth) then are formed by outputs of dislocations and to move these steps can, if distance between dislocations is not less a diameter of a critical germ.

Nichols & Mullins [5] have shown, that at healing of cracks with formation of inclusions under the relation of distance between inclusions to their radius λ/R one can conclude to prevalence of the form of mass transport: at λ/R=12.96 has a place diffusion through a crystal lattice, if the relation is equal 9.02 - diffusion is through pore solution, at λ/R= =8.89 the exchange a surface - fluid prevails.

Technique of experiment

The prisms cut from a monocrystal of quartzes and subjected thermoshock for reception a network of cracks, placed in a platinum ampoule together with fluid mix and were maintained at high temperature and pressure within 2-900 hours. Length of the healed site determined on distance from minimal on the size of inclusions up to an open part of a crack. Measured also diameter of the least inclusions and distance between them. The mistake of calculation of average length of healing makes not less 50%. The average size λ/R for 600°C has made 9.0, that answers mass transport through fluid.

Results

The gaugings of lengths of healing have shown, that the velocity of healing is directly connected to temperature. For convenience the results are counted on time necessary for reduce of a crack in length 100 mcm at run with 1Ì the solution NaCl. At 500°C for this purpose it is required about 28 day. At 700°C - about 2 hours. As the mass transport went through pore fluid, for the description of this phenomena it is possible to take advantage of the modified circuit offered Geguzin et al., [4] for an estimation of velocity of movement of inclusions in thermogradient conditions, and complemented by the equations of Smith & Evans [2] for definition of time of formation of the first inclusions at crack healing. Length of the healed site L can be determined:

$$L=\Lambda[(t \exp(-Q/kT))/T],$$

where Λ and ω- constants dependent on initial geometry of a crack, Q- the energy of activation, for quartzes by estimations Smith & Evans, [2] is equal 50kJ/mole; T - absolute temperature, k - Boltsmann constant, t - time. Then speed of moving of short circuit of a crack (v):

$$v= \Lambda[(Q/kT)/T] = \beta\omega(Y-Y^*)(\partial c/\partial T)\Delta T,$$

where β - factor determined experimentally on a corner of an inclination on the diagram v-R. The analysis of these dependencies speaks: the speed of moving of short circuit of a crack (actually velocity of healing) linearly depends on width of a crack. Geguzin et al. [4] have shown, that factor (directly depends on density dislocations in a crystal. Healing in crystals with high density of dislocations occurs faster. The velocity of healing is function of temperature, time and concentration of a solution.

Conclusions

(1) In natural objects at raised temperatures (more 400°C) the velocity of cracks healing at presence of fluid is very large. Apparently, for maintenance of porosity and permeability of breeds it is necessary to assume return process occurrence of new cracks (for example, owing to different factor of expansion of minerals and pressure.

(2) Mass transport is carried out through fluid phase prousses, basically.

(3) Crack healing occurs the faster, than above temperature, concentration of sal in pore solution andcrystal density of dislocations.

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