

OXIDATION-REDUCTION EFFECT OF THE FLUID ON MINERAL PARAGENESES OF BASIC ROCKS IN EXTERNAL BUFFERING CONDITIONS

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One of the main aspects of fluid/rock interaction is redox processes. This is of particular importance for external buffering environments when the fluid composition does not depend on processes proceeding in rock, and is controlled by an external source. In this case the fluid serves as the additional factor which operates equally with temperature and pressure for formation of equilibrium mineral associations.

Character and degree of oxidation-reduction effect of a fluid on rock were studied by method of physicochemical modeling using the "Selector" program [1]. The model represents two interacting reservoirs. The first of the two is a source of a fluid. Composition of a gas phase at certain PT values under carbon saturation conditions is computed for the source. The second reservoir is actually a basic rock which composition is given on the basis of average basalt composition (MORB). One-way interaction between reservoirs is assumed. The fluid of the certain composition comes in the rock in the amount, which corresponds to weighted fluid/rock ratio of 1/10. Then, in the second reservoir, the equilibrium mineral paragenesis is computed.

If one of the composition variables is given in addition, the composition of the fluid phase in equilibrium with graphite at fixed T-P values is unambiguously determined [2, 3]. For example, such variable can be either O/H ratio or $X_O = n(O)/(n(H)+n(O))$ value [4, 5]. With increase of X_O the composition of the fluid changes from methane through water to carbonic acid. At values of $X_O < 1/3$ the fluid represents a H_2O-CH_4 mixture, and at $X_O > 1/3$ – H_2O-CO_2 mixture. The increase of temperature leads to growth of amount of H_2 and CO in H_2O-CH_4 and H_2O-CO_2 fluids, respectively. The composition of the fluid is illustrated by the T- X_O diagrams, which represent carbon saturation unfolded surface at constant pressure.

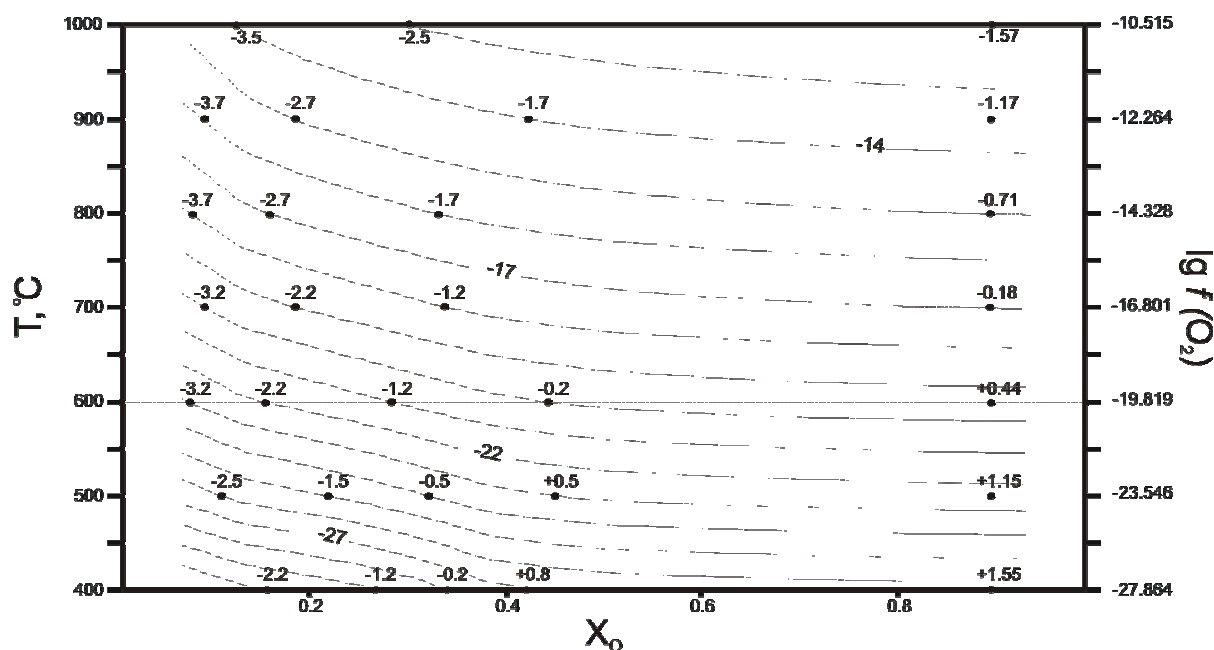


Fig.1. Comparison of oxygen fugacity in rock and fluid (P = 5 kbar)

Oxygen fugacity of the carbon saturated fluid calculated for pressure of 5 kbar and a temperature range of 400 - 1000 °C in comparison with oxygen fugacity of "dry" rock (before interaction with a fluid) is shown in fig. 1. The difference between the fugacities determines areas of oxidation or reduction fluid ability.

Calculated mineral parageneses are shown on fig. 2. Within the oxidative area, the phases containing atoms with high oxidation level (carbonate, magnetite) are present. Graphite enters into the parageneses within the reducing area, where practically all iron is in bivalent or native state.

Oxidation-reduction effect of a fluid has an effect on compositions of minerals as well. In epidote, the ferric iron content increases with growth of X_O . Chlorite has an opposite trend of decreasing ferrous content on transition to the oxidative area. The maximum content of actinolite is observed at values of X_O less than 1/3 and with its raise it is sweepingly reduced. Iron content of pyroxenes is decreasing both with raising and lowering of X_O . In the first case, oxidation of iron up to 3 valency is the reason. In second case, iron is recovered up to a native state. Annite end-member in biotite also is a subject of oxidative affect of the fluid and it is reduced with raise of X_O . In carbonate, besides it is presented only under oxidative conditions, magnesite grows with raise of X_O .

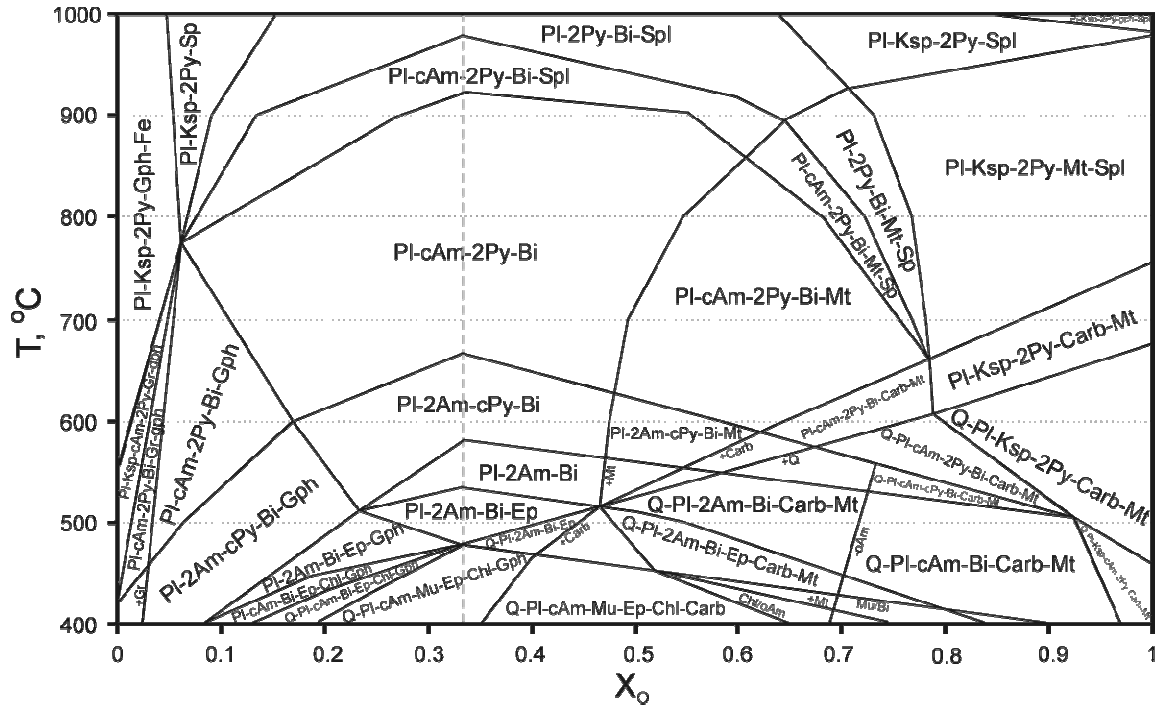
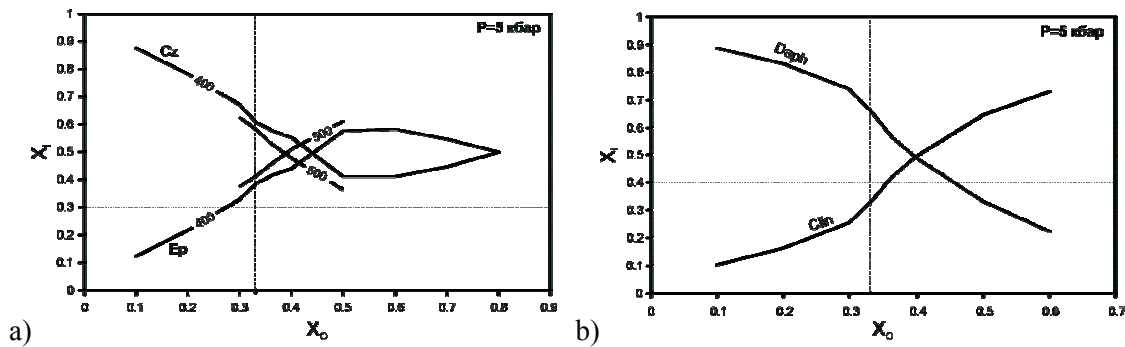


Fig.2. Mineral paragenesis, generated under the influence of a fluid of various composition ($P=5$ kbar)

Thus, oxidation-reduction fluid influence is reflected both in paragenesis and in mineral compositions. Under conditions of external buffering, the fluid determines directivity of redox reactions in a rock. Quantitative ratios of end-members, which contain elements of variable valency, are determined the oxidation-reduction potential level of a fluid. In oxidative environment, decrease of amount of end-members with ferrous iron is registered. Reduced fluids have opposite effect; bringing down oxidation level of atoms and decrease of amount of end-members with ferric iron is registered.



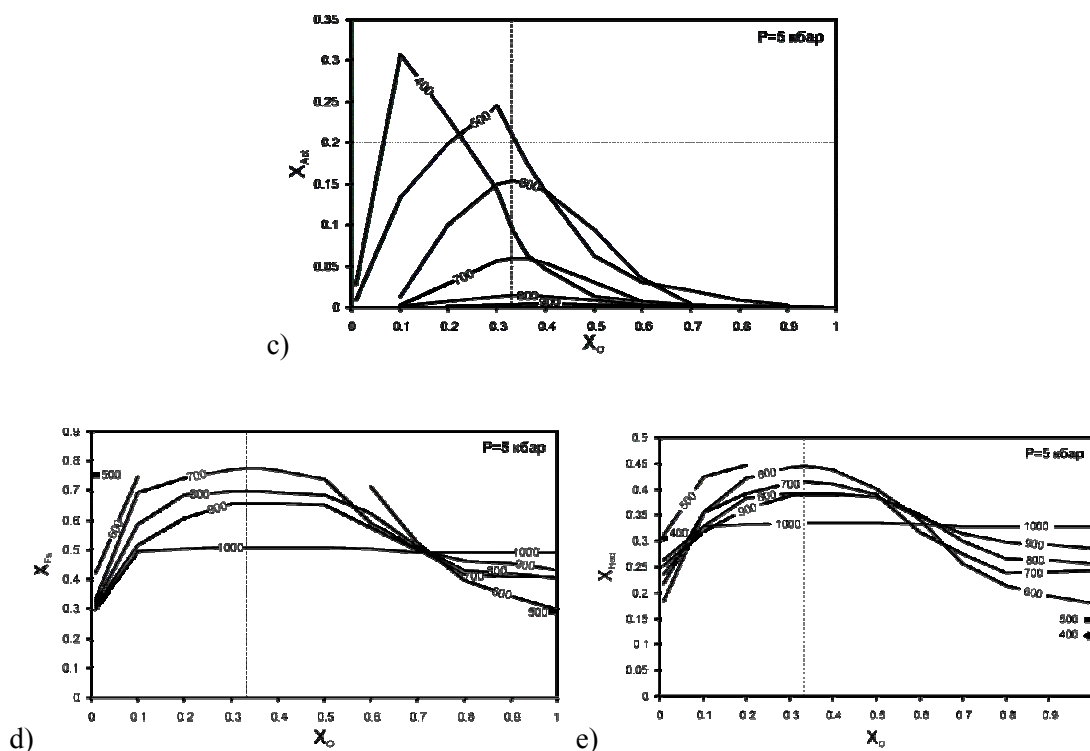


Fig.3. Variations in mineral composition: a) epidote, b) chlorite, c) clinoamphibole, d), e) orthopyroxene and clinopyroxene.

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