O_2 evolution in the Paleoproterozoic: Experimental simulation of the relationships between Fe in paleosols and PO_2

HIROKAZU SUGIMORI AND TAKASHI MURAKAMI*

Department of Earth and Planetary Science, the University of Tokyo, Tokyo 113-0033, Japan
(*correspondence: murakami@eps.s.u-tokyo.ac.jp, sugimori.hirokazu@iri-tokyo.jp)

Ferrous iron is supplied by mineral dissolution for water in a weathering profile. Because Fe^{2+} is soluble and Fe^{3+} is insoluble, Fe remaining in the profile as Fe^{3+} is related to PO_2 according to Fe^{2+} oxidation kinetics,

$-[Fe^{2+}]/dt = k[Fe^{2+}][OH^-]^2[PO_2]^x$ (1)

where k is the rate constant and x the variable ($0 \leq x \leq 1$). On the other hand, the mineral dissolution rates and Fe behavior during weathering under low O_2 conditions are poorly known. We have simulated weathering under low O_2 conditions in the laboratory, examined the Fe redistribution, and established the relationships between Fe in the dissolution system and PO_2 levels.

Olivine, $Mg_{1.82}Fe_{0.18}SiO_4$, was dissolved in a glove box at 0.2, 8.9×10^{-3}, 9.4×10^{-4} and 8.6×10^{-5} atm of PO_2 in a flow-through system. To model the Fe behavior during weathering, olivine was also dissolved in the ambient atmosphere changing pH and temperature. To discuss the effects of PO_2 on the Fe behavior during dissolution or weathering, we define a ratio of the total amount of precipitated Fe^{3+} (remaining in a profile) (Fe_{prec}) to that of Fe^{2+} dissolved from mineral (Fe_{diss}) as $\Phi = Fe_{prec}/Fe_{diss}$. Fig. 1 shows the relationships between Φ and PO_2 (diamonds, observed values; dashed curves, calculated variations with different x values in equation (1)). The Φ value increases with increase in PO_2 (solid curve). Furthermore, the x value decreases with decrease in PO_2. The O_2 level is considered to have increased from 10^{-6} to 10^{-3} atm in the Paleopreterozoic. Therefore, our results under low O_2 conditions indicate that Φ is a good indicator of the oxidation state of paleosols, and more importantly, we can quantitatively estimate PO_2 levels at the time of weathering based on the Fe^{2+} and Fe^{3+} concentrations in paleosols.

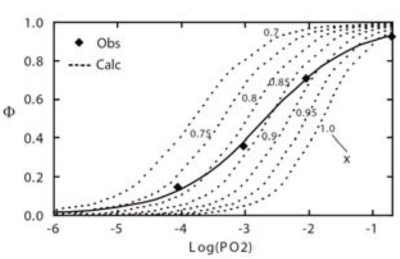

Figure 1: Relationships between Φ and PO_2.

An alternative interpretation of U-Th isochron and estimation of magma residence time

JIANLI SUI, QICHENG FAN, YONGWEI ZHAO, XINGXING DU AND BIN HAN

Institute of Geology, Chinese Earthquake Administration, Beijing 10029 (suijianli@ies.ac.cn)

Mineral U-Th isochron systematics is designed to date the eruption age of young (<350 ka) volcane, but reseaches provide alternative interetation of timescales of magma residence and crrystallization.

In one case of Tianchi Volcano [1], a rilable mineral U-Th isochron reveals a calculated age of ca. 23ka. Since the eruption age of the voclano is ~1000 aBP, the difference is ragard to reflect the magma residence time. After that, more cases prove that the mineral U-Th isochron provide an approach to estimate the timescale of magma residence and crystallization. However, numerical modelling and thoeretical interpretation on this alternative interpretation is still poorly known now, here we report a numeracal model on U-Th dacay in a prolonged magma crystallization process.

Crystallization in magma chamber can be described by a zoning growth model ($^{230}Th/^{232}Th)_t$, and the average isotopic ratio is an integral

(1) $$\left(\frac{^{230}Th}{^{232}Th}\right) = \int_0^T \left(\frac{^{230}Th}{^{232}Th}\right)_t dvdt$$

is the istopic ratio in a crystall zoning belt, and it varation can be described by the normal dacay equation,

$$\left(\frac{^{230}Th}{^{232}Th}\right)_t = \left(\frac{^{230}Th}{^{232}Th}\right)_0 \cdot e^{-\lambda t} + \left(\frac{^{238}U}{^{232}Th}\right)_0 \cdot (1 - e^{-\lambda t})$$

Surppose the magma $V = kt^2$ crystallization occur in a square order of

$$dv = kt \cdot dt$$

we can calculate the equation (1), and get still a linear equation of U-Th isotopes. The linear slope is a function of crystallization time and eruption age

$$m = \frac{1}{\lambda T_m} \cdot (e^{-\lambda(T_2 + T_m)} - e^{-\lambda T_2})$$

According to the model, crystallization time of Tianchi Volcano is about 100 ka. This model can also be used on other volcanoes, and can provide more precise estimation on magma crystallization time.

[1] Dunlap CE. 1996. PhD thesis. University of California Santa Cruz. 1-215.