Rock porosity and element distribution in an extremely acid-sulphate altered Tertiary Latite, Styria, Austria: A comparison

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Introduction

The Tertiary Latite of the Gleichenberg Volcanic Area, Styria, Austria is part of a volcanic province named Transdanubian Volcanic Region (Embey-Isztin, 1990; Kurat et al., 1991). The latite has in places been completely altered by hydrothermal acid sulphate solutions. The alteration processes result in the area of the Gosendorf open-pit mine in alteration products which consist of various associations of the secondary minerals opal-C/-CT, alunite, kaolinite and montmorillonite. These alteration products occur in a zonal arrangement: Samples of the innermost zone consisting of opal-C/-CT are followed by opal-C/-CT + alunite and opal-C/-CT + alunite + kaolinite (middle zone I) and opal-C/-CT + alunite + kaolinite + montmorillonite (middle zone II). In the outermost zone montmorillonite is the main alteration product. Altered samples consisting almost exclusively of opal-C/-CT (inner zone) typically contain no parent rock but have retained the original latite structure (Barth-Wirsching et al., 1990). Moreover, they are characterized by uniform SiO₂ contents of about 90.0 wt.% but by different values of TiO₂ (1.2–3.5 wt.%) and of porosity (1.4–55.0 vol.%). All the other major, minor and common trace elements are extremely discharged. The purpose of this study is to investigate if in altered samples consisting of opal-C/-CT only, the chemical data (SiO₂/TiO₂ distribution) correlate with physical rock properties (porosity).

Analytical methods

Qualitative as well as quantitative mineralogical compositions were analyzed by X-ray powder diffraction (Philips PW 1800/00/01) and Guinier method (Guinier double chamber after Jagodzinski). The chemistry of the alteration products was determined by X-ray fluorescence spectroscopy (Philips PW 1410/10). Porosity and pore-radii distribution were analyzed by Hg-porosimetry (Quantachrom Autoscan-33 porosimeter).

Results

Chemical data of altered samples, except of those which consist of opal-C/-CT only, show a high scatter not only between different but also within individual zones. The high data scattering within the individual zones is in relation with the extremely different quantities of the secondary minerals especially in the middle zone. The major, minor and common trace elements, except of SiO₂, are extremely discharged in altered samples consisting of opal-C/-CT only. In contrast, TiO₂ is increased in respect to the 'unaltered' latite. Critical tests with binary plots for immobility of elements, using the correlation coefficients as a gauge of mobility, show, that only TiO₂ might be immobile during these extremely acid-sulphate alteration processes. The frequent occurrence of the Ti-phase anatase confirms this assumption.

Mass change calculations of SiO₂ with TiO₂ as the immobile monitor reveal quite different reactions. Samples show both SiO₂ gains and

![Figure 1. SiO₂-TiO₂ distribution of samples consisting of opal-C/-CT.](image-url)
losses. The high scatter of gains and losses refers to the extreme mobility of SiO$_2$ under these conditions although samples consist of a microcrystalline SiO$_2$-phase (opal-C/-CT) only. Exclusively mass losses were calculated for all the other elements investigated. The high TiO$_2$ content of these samples, however, indicates that they are altered rock and not a deposit of siliceous sinter. The SiO$_2$-TiO$_2$ distribution shows a very good correlation between Ti and Si, whereby an increase of TiO$_2$ refers to a drastic decrease of SiO$_2$.

The material changes of SiO$_2$ correspond also with the porosity investigated (Klammer, 1991). Plots of SiO$_2$/TiO$_2$ ratios versus porosity (1.4–55 vol.% ) show for low ratios high porosity and vice versa. High porosities refer to net losses of SiO$_2$, net gains, however, are observed in altered samples with a porosity below 5 vol.%, exclusively.

Volume change calculations show generally volume decreases up to a maximum of about −70 vol.%. In contrast to these observations Schoen et al. (1974) found, referring to the porosity of most altered andesite, only a stable behaviour of SiO$_2$ in the silica cap at Steamboat Springs, Nevada.

Conclusions
Major, minor and common trace elements were investigated from a hydrothermally acid-sulphate altered latitic rock in the Gleichenberg Volcanic Area, Styria, Austria. The most altered rocks are mined in a open-pit near Gossendorf and are arranged in a zonal distribution. Samples of the innermost zone consist of opal-C/-CT only and are characterized by: a) Extreme mobility of all elements investigated except of TiO$_2$; b) Extreme net mass losses of all elements except of SiO$_2$ which shows mass gains also; c) A good correlation between TiO$_2$ and SiO$_2$. The increase of TiO$_2$ refers to the drastic decrease of SiO$_2$; d) A correspondence between SiO$_2$/TiO$_2$ ratios and the rock porosities; high ratios show high porosities and vice versa; e) A good correlation between porosity and mass change of SiO$_2$: net mass losses correlate with high porosities, net mass gains with low porosities. These SiO$_2$ gains are caused by diffusion of the SiO$_2$ content available in the latite from places of SiO$_2$ losses and do not come from outwards of the geothermal system; f) A correspondence between the calculated volume decreases up to −70 vol.% which refer to high SiO$_2$ losses and high porosities.

References