APPLICATION OF QUARTZ THERMOLUMINESCENCE TO THE UNDERSTANDING OF SOIL PROCESSES*

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In recent years the luminescence of minerals has found ever growing use in solving several geological problems, such as the diagnostics of minerals and the dating of the physical age of one or another geological complex. We have attempted to evaluate the influence of soil processes on the intensity of the thermoluminescence of quartz, the essential mineral of Estonian soil-forming rocks. It was assumed that as the result of weathering in the soil, even in grains of such a resistant mineral as quartz, the diffusion of impurities along structural channels becomes easier, and may lead to a change in the intensity of the TL of a mineral, as the latter is rather sensitive to structural changes.

For these purposes five Estonian soil sections in fluvioglacial sands were studied. In 4 cases the soil was podzol, and in one case it was brown soil. Samples were collected from all genetic horizons. For the quartz separation we used our own technique (Hütt et al., 1977): a fraction 0.1-0.16 mm was obtained by sieving and from this fraction minerals with density 2.61-2.62 g/cm^3 (light fraction) and 2.63-2.67 g/cm^3 (heavy fraction) were separated by heavy liquids. In order to get a monomineral quartz sample and to remove the contaminated surface layer the grains were etched in HCl and HF. The above treatment eliminated the influence of the surface layer and the TL was thus associated with internal processes due to the defects in the quartz lattice.

We studied the heavy and light fractions of quartz in order to explain the occurrence of the great amount (up to 40% from the bulk sample) of light quartz, although according to the literature quartz with a density below 2.63 forms only 0.1-4% of the quartz in magmatic rocks and Phanerozoic sandstones (Katz and Simanovich, 1974).

The results obtained permit the following conclusion to be made. Light and heavy fractions are indistinguishable according to their TL properties. It does not show that they are of the same origin, however, it eliminates the possibility that the light quartz might be of soil origin.

In soils the intensity of the TL of quartz is subjected to regular changes - in the upper part of the section it is usually much weaker than in the lower part (see fig.). An abrupt change is observed at the upper boundary of the BC horizon. The BC horizon serves as a transitional area between the part of the section where the soil-forming rocks have undergone great changes due to soil processes, and the part of the section where no changes have taken place in the soil (C horizon, curves 32, 33, 81). This change is distinct in better developed soils whereas in less differentiated soils (curve 31) it is almost unnoticable. The 6th section serves as an exception, where the TL intensity shows an abrupt increase in the upper part of the A2 horizon.

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*[Editor's note: this article is a translation of the Russian paper originally appearing in Esti NSV Teaduste Akeemia Toimetised. 31. Koide Geoloogia (1982, Nr3, 117-118). Special thanks are extended to Helle Kukk for translation and D. J. Huntley for editing.]

The 1m homogeneous layer of soil-forming sediments is practically of the same age. In the control-section comprising 1m layer of fluvioglacial deposits untouched by soil processes no changes in TL intensity were found.

The content of radioactive elements is constant throughout the whole section: γ-spectrometric studies by A. Molodkov (Inst Geol Acad Sci ESSR) showed the constancy of U, Th and K content in the samples. Such factors as cosmic radiation etc. may cause some increase of TL in the near-surface part of the sediments.

Thus, the decrease in TL intensity of quartz in the near-surface part of soil-forming rocks may be ascribed to soil processes, taking place in the soils studied in an acid medium with pH 3.4-4.4., and resulting in various degrees of weathering of the quartz.

The data obtained show that the TL intensity of quartz associated with specific quartz lattic defects may serve as an additional criteria for the evaluation of the intensity of the effect of soil processes on minerals. Microscopic methods which have been used so far for the study of the changes in the grain surface do not always reflect the actual degree of weathering of minerals.

The author wishes to thank G. Hütt for scientific discussions and E. Sheremet for conducting the TL measurements.

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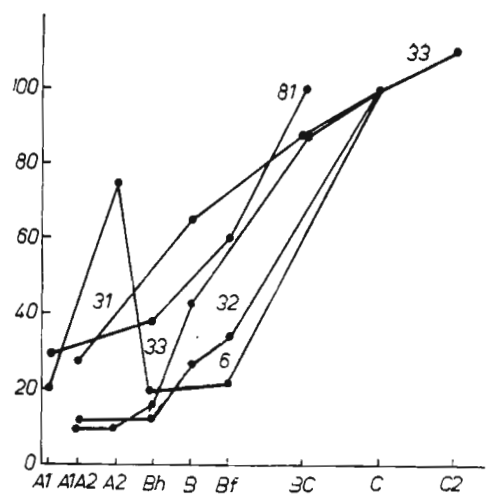

Figure: Change in the intensity of quartz thermoluminescence (I) in sandy soils from fluvioglacial sediments. from Estonia. 6, 31, 32 and 33 - podzols, 81 - brown soil.