Fluid inclusions of metamorphic rocks and a late-orogenic granitic intrusion

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The Ladoga region is considered a typical example of andalusite-sillimanite type of metamorphic zoning in the southern part of the Baltic shield. On the basis of mineral assemblages and compositions, as well as the amount of leucosome in metapelitic rocks, the Ladoga region is divided into five metamorphic zones. The PT-estimates of the Early Proterozoic Ladoga metamorphic complex range from 3-4 kbar and 400-500°C to 5-6 kbar and 800-900°C.

The Tervu granite massif (intrusion) is one of the late-collision granites that intruded a high–grade core of the Early Proterozoic Ladoga metamorphic complex. The Tervu massif consists mainly of two feldspar mica granites with rare veins of aplite and pegmatite. The U-Pb age of zircon of the Tervu massif is 1.86 Ga. The age of monazite from the latest veins of the Tervu massif is 1.85 Ga. Minerals of the Tervu granite massif consist of different types of fluid inclusions such as H_2O, H_2O+salt (up to 1-3 % NaCl, KCl, $CaCl_2$, $MgCl_2$), CO_2, CH_4, N_2. Original homogeneous allocation of a fluid phase is expected at the moment of crystallization of the massif. This is supported by the monotonic mineral composition of rocks of the massif, absence of significant bulks of facies and phase varieties. Fluid inclusions of the massif have more or less the same compositions, but there are also specific features of their allocation: 1) CO_2 inclusions occur only in the northern and central parts of the massif, 2) aqueous, mineralized by salts Ca, Mg (Cl_2) occur in the northern peripheral part, 3) methane - nitrogenous inclusions occur in the northern and central areas, 4) only aqueous occur in the south-east and northern areas of the massif, 5) aqueous inclusions with NaCl and KCl mineralization occur in the southern, central and northern parts, 6) aqueous inclusions with a low mineralization occur everywhere within the intrusion. Such variability of compositions of fluid implies that most likely the total contents of fluid in samples varied from the moment of crystallization because of new volatile phases, which have caused variations in composition of fluid inclusions in the most fluid-enriched rocks.

Comparison of compositions of fluid of the Tervu massif with composition of fluid of metamorphic rocks demonstrates mostly their similarity. However, the fluid inclusions enriched with salts $CaCl_2$ and $MgCl_2$ are not characteristic for the metamorphic rocks. It is possible to consider that genesis is primary magmatic for such fluid inclusions.

CO_2 inclusions are unusual for the Tervu intrusion but the surrounding migmatitic leucosomes have a lot carbonic inclusions. Thus, the Tervu massif is characterized by unequal fluid compositions, and strong variations in density and salt contents in different parts of the massif. The specified features of allocation of fluid may be a consequence of redistribution of the fluid phases within the massif during post-crystallization tectonic and thermal processes.

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^{30}Si isotopic signature of major terrestrial and aquatic pools

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Silica is the second most important element in the Earth crust. Weathering of minerals in soils as well as global Si fluxes have strong effects on the global cycling of many other elements including carbon. Despite the important role of Si in terrestrial and marine ecosystems and for living organisms, the knowledge about Si fluxes in biogeosystems is strongly limited. An important gap in the knowledge on global Si cycling is the absence of a clear explanation of the enrichment of marine ecosystems with ^{30}Si – the heavy stable Si isotope. Therefore, we aimed this review on 1) critical evaluation of the δ^{30}Si data existing for various pools of terrestrial and marine ecosystems, and 2) linking δ^{30}Si signatures in terrestrial and marine pools by considering isotopic fractionation of ^{30}Si by biological processes.

Table 1. Overview about published δ^{30}Si values for various pools in global biogeosystems (standard: NBS28)

Si pools	δ^{30}Si, ‰	References
Rivers	+0.4…+1.2	De La Rocha *et al.* 2000
Seas	+0.6…+1.7	De La Rocha *et al.* 2000
Rocks	-1.0…+0.3	Douthitt 1982; Ding *et al.* 1996
Primary quartz	-0.1…+0.7	Basile-Doelsch *et al.* 2005
Secondary quartz	-5.7…-1.6	Basile-Doelsch *et al.* 2005
Pedogenic kaolinite	-1.9…-1.0	Ding *et al.* 1996
Phytolites	-1.7…+2.8	Douthitt 1982
Phytolites of maize	-1.8…-0.8	Ziegler *et al.* 2000
Soils from basalt	-2.5…-0.5	Ziegler *et al.* 2005
Soil extracts	more posit. than soils	Ziegler *et al.* 2005

Based on the δ^{30}Si values, the following processes can be reconstructed: Si dissolved by weathering of primary minerals becomes a component of soil solution. The elements in the soil solution, including Si, are mainly subject of two mass flows: upward uptake by plants and downward transport by leaching. As light isotopes are preferred for uptake in biological processes, δ^{30}Si values in plants are negative: -1 to -2.5‰. The remaining soil solution will be enriched by ^{30}Si. The ^{30}Si depleted phytogenic Si remains in terrestrial biogeosystems, mainly in the upper soil horizons and will be reused by plants and microorganisms in further cycles. Therefore, at least a part of secondary minerals is ^{30}Si depleted, which was biologicaly recycled at least once. The ^{30}Si enriched soil solution discharge into rivers, seas and oceans. Further biological depletion by continental transport (limnic and fluvial systems) leads to additional accumulation of ^{30}Si up to +0.5…+1.4‰ in discharge systems and seas