

Nepheline As a Source of Amorphous Phases in Supergene Processes

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In order to specify the effect of technogenic factors on the composition of natural waters, the behavior of nepheline particles <0.002 mm in size at a temperature of 18–20°C and pH 7.4–8.6 has been studied. The results obtained show that finely ground nepheline passes into an amorphous phase over a few days or months. The study is based on the data on natural and technogenic water in the area of the Khibiny alkaline pluton.

The natural surface water in the Khibinskaya Tundra area located far from industrial enterprises is characterized by the following upper limits of concentrations (mg/l): 6.4 Na, 1.4 K, and 0.054 Al at pH = 6.9–7.4 [1–3]. In subsurface water, these concentrations are slightly higher: 9.0 Na and 0.087 Al [3] (Table 1). At the same time, analyses of particular samples of river water taken far from dressing plants demonstrate anomalously high concentrations (16 Na, 3.8 K, and 0.092 Al mg/l) [3]. On the basis of computer-aided physicochemical modeling [4], it has been shown that the present-day weathering in the Khibiny Mountains develops slowly and is unable to provide such high concentrations. An abrupt single increase in the concentration of rock-forming elements in natural water may be caused by opening of local porous reservoirs with easily dissolved salts [6]. However, Na, K, and Al concentrations close to the natural anomalous values are permanently recorded in the lakes affected by discharges from dressing plants of the Apatite Open Joint-Stock Company ([1], Table 1).

The apatite–nepheline deposits of the Khibiny pluton are the major suppliers of phosphorus ore. The apatite concentrate is produced by flotation with grinding of rocks to 0.3 mm. As a result, a huge mass of mineral particles less than a micrometer in size is transported to the environment. In this regard, a question arises about possible phase transitions of fine mineral particles of the Khibiny apatite–nepheline rocks, and above else, of nepheline.

The dissolution of nepheline in acids is considered in its mineralogy [7]. Fast dissolution of fine particles of some minerals, for example, feldspars, in water has long been known. To examine the possible slow modification of fine particles of apatite–nepheline ore, we took a sample consisting of the following components (wt %): 42 nepheline, 38 apatite, 12 pyroxene, 3 titanite, 1 titanomagnetite, and 2 feldspar.

The chemical composition of this ore is as follows (wt %): 25.50 SiO₂, 0.52 TiO₂, 18.90 Al₂O₃, 2.29 Fe₂O₃, 19.00 CaO, 10.82 Na₂O, 3.12 K₂O, and 16.63 P₂O₅. Small portions of the sample were ground in agate mortar. The yield of fraction +0.002 μm amounted to 20%. Distilled water was poured over the charges of ground material, which preliminarily settled in an open vessel up to saturation in atmospheric components. The solid/liquid ratio was 1/50, and the duration of contact of the powder with water in the process of periodic stirring varied from one day to three days and three months.

The water composition was determined after its settling for a day and filtration under a vacuum pump through a Fladipore membrane filter with a hole diameter equal to 0.45 μm (analyst L.P. Kudryavtseva, Institute of Problems of Industrial Ecology of the North). In general, the water composition after pumping was close to the composition of technological water of dressing plants [10] except for low SO₄ and Cl contents (Tables 1, 2).

The material collected from filters after the runs turned out to be X-ray amorphous. The presence of the

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Table 1. Chemical composition of lake, river, and subsurface waters in the area of the Khibiny alkaline pluton and in the zone affected by dressing plants of the Apatity Open Joint-Stock Company, mg/l

Component	1	2	3	4	5	6	7	8
pH	7.2	7.08	7.16	7.08	6.9	8.1	7.7	7.43
Ca	4.0	3.30	0.63	0.44	1.2	0.5	3.65	4.01
Mg	1.3	1.02	0.07	0.11	0.24	0.16	1.03	1.03
Na	7.5	5.52	4.5	4.36	6.44	9.43	16.2	17.0
K		1.17	1.17	0.76	–	–	2.54	2.54
SO ₄	3	9.41	2.05	2.8	2.88	3.25	26.9	26.9
Cl	1.8	2.28	0.52	1.4	1.07	1.35	5.29	5.03
P _{tot}	0.008	0.002	–	–	–	–	0.001	0.001
Si (NO ₃ + NO ₂)	0.6	1.46	1.3	1.44	1.75	1.75	0.14	0.23
Al	–	0.022	0.03	0.054	0.087	0.074	0.085	0.009
Fe	–	0.022	0.02	0.028	–	–	0.034	0.055
Cu	<0.005	0.004	–	–	–	–	0.004	0.004
Zn	<0.005	0.007	–	–	–	–	0.001	0.015
Mn	–	0.022	0.003	0.002	–	–	0.009	0.014
Sr	–	0.042	0.005	0.056	–	–	0.063	0.070

Note: (1) Limited initial natural composition of water in Lake Imandra [1]; (2) water composition of Lake Imandra in the control zone [1]; (3) maximum and (4) minimum concentrations of mineral components in surface water away from industrial discharges [10]; (5, 6) the same in subsurface water [10]; (7) composition of water in Lake Imandra in the zone affected by discharges of dressing plants near the surface and (8) at the bottom (author's data; analyst L.P. Kudryavtseva, Institute of Problems of Industrial Ecology of the North, Apatity).

dispersed phase along with visible depletion in nepheline is established from X-ray powder patterns of the ore after its residence in a constant water volume (Fig. 1). This change was corroborated by IR spectra (analyst O.A. Zalkind, IKHTREMS, Kola Scientific Center, Russian Academy of Sciences). The reconnaissance analyses of powders on an MS-46 microprobe (analyst Ya.A. Pakhomovskii, Geological Institute, Kola Scientific Center) checked and confirmed the depletion in crystalline nepheline relative to apatite with enrich-

Table 2. Water composition, mg/l, after dissolution of finely ground apatite ore: (1) over 3 days and (2) over 3 months

Component			Component		
	1	2		1	2
pH	7.94	8.61	P	1.94	3.20
K	4.4	2.91	Al	0.59	0.76
Na	2.63	10.1	Sr	0.28	0.19
Ca	2.87	3.05	Fe	0.058	0.11
Mg	0.19	0.04	Mn	0.002	0.001
SO ₄	0.43	<0.2	Zn	0.003	0.001
Cl	0.39	0.30	Pb	0.003	0.001
HCO ₃	39.0	32.3	Ni	0.008	0.002

ment in the dispersed phase (Fig. 2). The determinations were carried out after partial removal of the finest suspension.

The transition of fine nepheline particles into the amorphous state in water at high pH values may play a substantial role in variation of the natural water composition. Colloids may accumulate in natural and technogenic stagnant reservoir rocks of the Khibiny pluton as a result of this effect. When these reservoirs are opened and the water contained therein mixes with meteoric water, the colloids, which readily pass into solution with a decrease in pH, can induce transient anomalies of major elements contained in the apatite–nepheline ore. The washout of colloidal silica into lake water cannot be excluded as well. The white, X-ray amorphous, foamy coatings mainly consisting of silica occur on banks of brooks in the Khibiny Mountains. This effect may be the cause of the permanently elevated Si content in the water of Lake Imandra [1], which is contaminated with large volumes of technological water delivered from dressing plants.

The plant sludge with the finest fraction left after the grinding of ores is transported to the apatite tailings dump, and their technical effluents enter Lake Imandra. The transition of fine nepheline particles of the tailings dump into the colloidal phase may control the permanently high Na, K, and Al concentrations in the lake

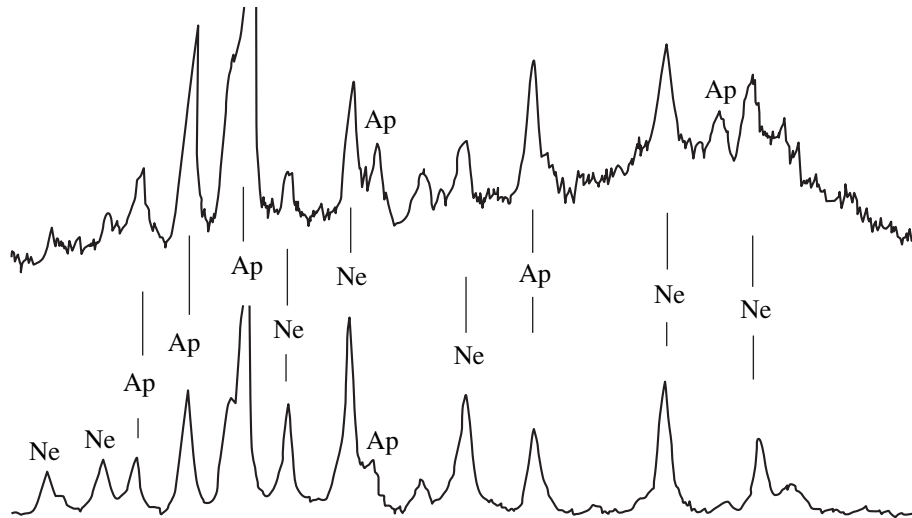


Fig. 1. X-ray powder patterns of the ground apatite–nepheline ore (below) and after its residence in water for 3 months (above). (Ap) apatite, (Ne) nepheline.

water in the zone affected by apatite production. The effect of quicksand, which is locally observable in stagnant areas of the tailings dump, may also be related to the concentration of the colloidal phase.

To consolidate the sand in the tailings dump, it was proposed to impart cementing properties to the fine wastes of apatite flotation [5]. The data obtained may increase interest in the interpretation of the origin of natrolite veins that are abundant in ijolite and urtite of the Khibiny pluton. The principal possibility to produce artificial adsorbents from the amorphous nepheline

phase without any additional physicochemical complications attracts interest as well.

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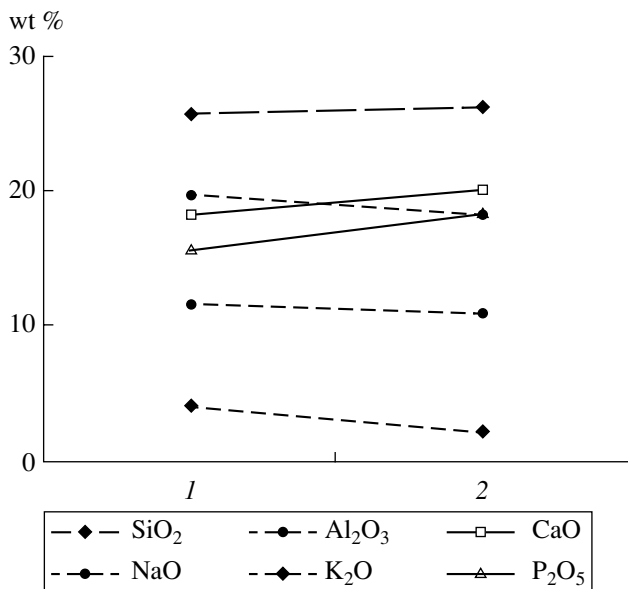


Fig. 2. Compositional variations of the sample (1) after its residence in water for 3 months (2). The finest suspensions were partially removed along with the water. Analyst Ya.A. Pakhomovskii, Geological Institute, Apatity.