

CARBON-BEARING COMPOUNDS IN INCLUSIONS FROM THE MINERALS IN THE KOVDOR MASSIF (KOLA PENINSULA, RUSSIA)

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Two large apatite-magnetite and phlogopite deposits are known within the Kovdor massif of alkaline-ultramafic rocks and carbonatites. Rock-forming minerals from the ores of both deposits contain abundant inclusions. In silicates only melt inclusions are present, whereas in apatite and in carbonates fluid (mainly gas-liquid) inclusions prevail, though melt inclusions are also present. PTX data on these inclusions have been obtained previously (Sokolov, 1986, 1994; Sokolov et al., 1999).

Using luminescence method, bitumens having various compositions have been discovered within inclusions in apatite from carbonatites and rocks of the phlogopite deposit at the Kovdor massif (Sokolov, 1978, and our new data). Investigations have been performed using both sides-polished sections under fluorescence microscopes ML-2 and IL-1 using blue- and ultra-violet light. The results obtained demonstrate prevailing oleaginous and oily-resinous bitumens showing yellowish-white, yellow or light-blue luminescence; rarely bitumens of the asphaltene series were detected showing pinkish-brown luminescence.

In accordance with numerous gas-chromatographic analyses (after literature and original data) for samples of different rocks from alkaline ultramafic massifs of the Kola region, including the Kovdor massif, volatile component of inclusions contains carbon in the forms of oxides, CO and CO₂, as well as methane CH₄ and its first homologues (ethane C₂H₆ and propane C₃H₈).

In the present communication results of investigations of carbon-bearing substances present in primary inclusions within rock-forming apatite, forsterite and diopside from the two above-mentioned deposits by means of the IR spectroscopy are given.

IR spectroscopic investigations of carbon-bearing components are facilitated by the fact that frequencies of stretching vibrations involving hydrogen (e. g. in the groups C-H, N-H, (CO)O-H, S-H) and frequencies of stretching vibrations of the multiple bonds, such as C=O, C=N, C≡N, C=C, lie in the ranges beyond that of characteristic vibrations of wide spread minerals – silicates, carbonates and phosphates. In most cases overlapping of the stretching vibrations bands of the above listed organic groups with overtones of a host mineral is also absent. For this reason, registration of the IR spectra of aliphatic and unsaturated hydrocarbons, aldehydes, amines, HCO₃⁻ ions, the molecules CO₂, CO, H₂S, HCN etc. is possible using relatively thick (up to 1 mm or even more) plates of minerals and rocks. The detection limit of the above-mentioned components can be of the order of 10⁻³ wt.% or less and depends on the thickness of the plate and absorption coefficients of carbon-bearing substances.

Samples containing most abundant accumulations of inclusions have been investigated by IR spectroscopy. In particular, apatite, diopside, forsterite from different ore body zones of the phlogopite deposit, and apatite and forsterite samples from apatite-forsterite and tetraferriphlogopite-amphibole-magnetite phoscorites were used. The silicate samples contain melt inclusions in which fluid phase is present together with microcrystalline aggregates. Inclusions in diopside contain more fluid phase than that in forsterite.

In apatites fluid inclusions with varying ratios of gas and liquid phases were studied. For each sample IR spectra were obtained also for the regions that contain no inclusions visible by an optical microscope. The spectra were obtained by a SPECORD 75 IR spectrophotometer with focusing of IR irradiation onto the area ranging from 4 to 25 mm².

Carbon-bearing compounds, mostly hydrocarbons and carbon dioxide, have been found as components of inclusions in all samples studied, though in different amounts. Contents of hydrocarbons, CO₂ and H₂O lower in the sequence apatite → diopside → forsterite, which is in agreement with lowering role of liquid phase in the entrapped inclusions. Aliphatic hydrocarbons showing the bands in the range 2850-2985 cm⁻¹ prevail essentially over amines (narrow bands in the range 3260-3305 cm⁻¹, aldehydes and/or ketones (bands in the range 1710-1730 cm⁻¹) and aromatic hydrocarbons (3050-3100 cm⁻¹).

A single band in the range 2315-2325 cm⁻¹ indicates that most CO₂ is dissolved in hydrocarbons; rarely poorly resolved splitting of this band is observed showing presence of minor amounts of gaseous CO₂.

In most samples acidic groups such as P-OH (2450-2520 cm⁻¹), Si-OH and/or HCO₃⁻ (2250 cm⁻¹) are present. N-H, C=O and C=C groups are usual species present in apatite (narrow bands at 3305, 1710-1730 and 1635 cm⁻¹, respectively).

In the regions of minerals where no inclusions were discovered by optical methods, intensities of most bands listed above are lowered; bands of amines and acidic groups are absent, and CO₂ is present as gaseous species showing doublet 2310 + 2340 cm⁻¹.

From the analysis of IR spectra the following conclusions can be drawn: (1) apatite from phoscorite is characterized by highest contents of hydrocarbons (aliphatic, as well as non-aliphatic, showing the band at 3017 cm⁻¹); (2) apatites from phoscorites are enriched with unsaturated hydrocarbons, but they contain no carbonyl compounds and are characterized by lower amounts of CO₂ than apatites from the phlogopite deposit; (3) on the phlogopite deposit, central zone of the ore body

contains lowered amounts of hydrocarbons and CO₂, but is enriched with H₂O, C=O and N-H groups as compared with intermediate zone.

Discovery of carbon-bearing substances in primary inclusions entrapped by rock-forming minerals shows that these substances are specific components of fluids that participated at the formation of the apatite-magnetite and phlogopite deposits in the Kovdor massif. Presence of hydrocarbons and (in accordance with the results of gas-chromatographic analyses) CO and H₂ (Krasnova, 2001; Potter et al., 1998; our unpublished data) indicate reducing character of these fluids. On the other hand, presence of CO₂ and acidic groups in inclusions is an indicator of enhanced acidity of the fluids. In the course of temperature lowering, components of fluids entrapped within inclusions could react with each other giving liquid and solid bitumen-type products.

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