Geochemical properties of natural systems

Yu.G. Shcherbakov

Institute of Geology, Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia

Introduction

A number of regularities of trace-elements distribution in minerals and rocks are widely known but they are mainly of empirical character. In our paper we made an attempt to formulate and quantitatively express the concept of geochemical properties of elements, minerals and rocks and thus to pass to their systematical analysis.

Common characteristic of the problem

The ratios of the element contents between two principal connected natural systems I named here as elementary geochemical properties. The calculation of the stable modules of geochemical properties is based on the average element contents in nondifferentiated chondrites - Ch, the main meteoritic mineral phases: iron - i, throilites - t, stones - (lytos) - l, so as in basalt - v and clay shales - c. The geochemical properties of the elements to be considered next are modules of: oxyphility - v/Ch; siality c/v, centrifugality - c/Ch, siderophility - i/Ch, chalcophility - t/Ch, and litophility - l/Ch. Each of the mentioned modules illustrates some tendencies in elements behaviour (notion introduced by V.M. Goldschmidt) during particular geochemical processes and show regular periodicity of properties similar to physical and chemical ones, because all of them are equally dependent on the atomic structure [1].

The sequence of mineral formation, the series of geochemical zoning, the degree of elements concentration and dispersion in minerals, rocks, ores, plutons and other natural systems governed by the conditions of their formation, vary proportionally to particular geochemical properties of the elements. That is why, each of the discussed properties can be used as a base for quantitative multigrade geochemic classification of the elements [2].

The geochemical zoning of rare elements in magmatic plutons (from bottom to top) is controlled by the increase in fractioning and content of more oxiphile elements, i.e. higher values of v/Ch ratios. The increase in modules of siality c/v determines the evolution of the continental crust composition and the origin of epigenetic ore deposits. The degree of geochemical evolution of both ore provinces and separate systems correlates mainly with the module of centrifugality c/Ch.

The modules i/Ch, t/Ch and l/Ch define the degree of predominance and subordination of various mineral types during the geologic history of elements, as well as the variety of their isomorphism, especially at low Eh.

The sequence of mineral formation in ultrabasite-basite systems corresponds to the series of elevated specific oxophility of minerals.

The second derivatives of the pairs of geochemically related especially trace elements, which differ from each other in the c/v or v/Ch characteristics, reflect the siality and oxiphylity levels of rocks and ores. Their comparison reveals a direct dependence of the degree of geochemical development of natural systems on the corresponding modules of elements, their acting masses and total energy of transformation.

The ratios of the pairs of trace elements in rocks and ores, plotted in the coordinates c/v and v/Ch, reflect the original and high degree independent from major elements tendencies, sequence and common level of their geochemical development (Fig. 1). This dependence allows us to select the most informative indicative pair of elements for genetic reconstruction. The possibility of the quantitative analysis of the complicated natural systems was predetermined by V.M. Goldschmidt, who introduced the idea of the geochemical properties of elements into the science.

Conclusion

The concepts of chalco-, sidero-, lithophility and other geochemical properties of elements are formulated as a quantitative basis of their classification and reconstruction of geological history. Thus, distribution of rare elements in igneous rocks gives us possibility to discriminate both types of the magmatic sources and the facies level of the geochemical development of magmatic systems.

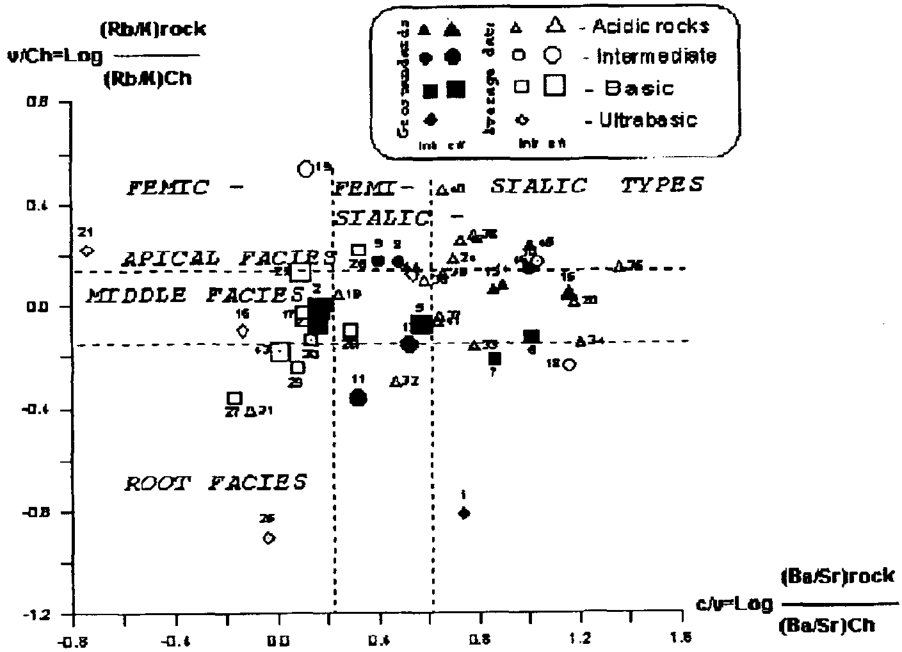

FIG. 1. Plots of geochemical properties of magmatic rocks: v/Ch versus c/v. Geostandards: 1-15 [3]. USGS: 1 - PCC-1; 3 - W-1; 4 - SYN-1; 5 - BCR-1; 7 - QLO-1; 10 - GSP-1; 12 - AGV-1; 13 - G-2; 14 - G-1; 15 - RGH-1; CORMP: 8 - SY-2; 9 - SY-3; 2 - BR, CRPG; 6 - SGD-1A, IGI; 11 - JA-I, GSJ; Data 16-20 [4]; 21-24 [5]; 25-42 [6] 25-42; 25 - anorthosite; 26 - comatiite; 27 - basalt tholeitic-oceanic; 28 - basalt tholeitic-continental; 29 - basalt-Na; 30 - basalt-K; 31 - granite tholeitic; 32 - enderbite; 33 - charnokite; 34 - granite ultrametamorphic; 35 - granite-rapakivi; 36 - granite-andesite; 37 - granite-latite; 38 - granite agpaitic; 39 - granite Ca; 40 - granite rare-metalic; 41 - granite Ca-alcalic; 42 - granite rare-metalic; data of this study: 43 - basalts; 44 - andesites; 45 - granites; 46 - syenites.

References

1. Shcherbakov, Yu.G. (1979) The Distribution of Elements in the Geochemical Provinces and Ore Deposits. In *Origin and Distribution of the Elements*. Pergamon Press Oxford and New York, 689–95.
2. Shcherbakov, Yu.G. (1963) Classification Geochemique des Elements. *BRGM Paris. Trad.* 4909, 16.
3. Govindarajn K. Editor-in-Chief: *Geostandards Newsletter. vol. VIII, Special Issue, July - 1984,* Vandoeuvre-les-Nancy, France.
4. Turekian K.K. and Wedepohl K.H. (1961) *Bull. Geol. Soc. Amer.*, **72** N2, 175.
5. Vinogradov A.P. (1962) *Geokhimiya,* N7 (in Russ.).
6. Tauson L.V. (1979) Magmatism and Ore formation. Moscow, 'Nauka', 36 p. (in Russ).