



Crisis of isotope geodynamics: Sm-Nd aspect

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Isotope geochemistry for many years contributes to improve our understanding of the Earth's interiors. There are a lot of models of the crust-mantle system evolution based on the isotope data. Indeed, identification of various types of the mantle material on the basis of isotope composition of its magmatic derivatives has opened perspective to fill geophysical models with the geochemical content. Study of the mantle material composition, changing in time and in space, with the same approach originated a new branch of geology, which was named chemical geodynamics or isotope geodynamics. Opportunities of the new approach have been unambiguously admitted more than 30 years ago after DePaolo & D.Wasserburg pioneer works, dedicated to development of Sm-Nd isotope systematics. This systematics became the most considerable component in the basement of isotope geodynamics as a whole. Since then nobody ever discussed the constrains of this systematics. At the same time there are many contradictions in it.

There are numerous mantle xenoliths depleted in main elements (Pearson et al., 2003), for which the whole variation curve normalized to chondrite is plotted below chondrite level. Paradox of the situation is that this mantle material has REE pattern which displays a continuous decrease of their concentration from La to Lu. Accordingly, Sm/Nd ratio in such material is lower than in chondrites. Through some time this material will be able to generate melts with $\text{ENd} < 0$, which is considered to be the characteristic of the enriched mantle. At the same time, the material producing such melts in terms of the total REE concentration and the main elements concentration is high depleted.

Another example, which demonstrates the independent variations of the main elements concentration, of the total REE contents, of Sm/Nd ratio and of Nd isotope composition in a source of the mantle magmatic derivatives, is connected with tholeiites of the middle ocean ridges and ocean islands. Tholeiites represent perhaps the most widespread terrestrial magmatic rocks. At the same time about 40 % of them are represented by rocks in which REE relative concentration continuously decreases from Eu to La while the total REE content exceeds the chondritic one ten times. Naturally in this case the Sm/Nd ratio in tholeiites is higher than the same ratio in chondritic. As for the concentration of the main and rare-earth elements in tholeiites these rocks are undoubtedly enriched material. They compose a considerable part of an oceanic crust and, apparently, are an essential component of lower crust as a result of underplating. However during melting of the tholeiites, in which Sm/Nd ratio is higher, than in PM, and which had enough time to change Nd isotope composition according to this ratio, the melts will be marked by values of $\text{ENd} > 0$. In common Sm-Nd isotope systematics these isotope characteristics correspond to derivatives of the depleted material. So, in terms of the Nd isotope analysis the derivatives of the enriched material of oceanic or even of lower continental crust will be referred to derivatives of the depleted mantle. The same situation is observed in Lu-Hf isotope systematics of tholeiites.

Isotope-petrochemical identification of xenoliths corresponding to the material of geochemically closed primitive mantle, has shown that MORB source is not depleted mantle as it was considered to be earlier, but a primitive mantle – PM (Pushkarev, 2006, 2007). It means that deficiency of Nd relative to Sm in PM in comparison with their concentrations in chondrites is caused not by crust formation. This peculiarity is either a primary feature of protoplanetary material, whose composition was different from chondritic one, or it reflects predominant capture of LREE by a component of segregating core, or it is a consequence of both reasons simultaneously. Identity of MORB source to primitive mantle and its discrepancy with the composition of chondrites in Sm-Nd isotope systematics was discovered earlier by J.A.Kostitsyn (2004) on the basis of the representative isotope-geochemical analysis of the mantle volcanic rocks. Recently this discrepancy with chondritic composition has been additionally confirmed (Caro et al., 2008) by studying of rocks of the Earth, the Moon and Mars from position of the coupled

^{146}Sm – ^{142}Nd , ^{143}Nd isotope systematics.

It is supposed, that the main cause of decoupled behaviour of the main elements and REE during the mantle material differentiation is the combination of effects of two independent processes: melting and mantle metasomatism. Thus the Nd isotope composition provides information only about final Sm/Nd ratio which has arisen in the mantle substratum as a result of combination of the processes that influenced distribution of these two elements. So, the classification of the mantle material into enriched and depleted one without mentioning the classification attribute (concentration of the main elements, total concentration of REE or Sm/Nd ratio) is meaningless. It means, that the main postulate of Sm-Nd isotope systematics, according to which Nd isotope composition and Sm/Nd ratio in the mantle source of magmatic melts are connected with its depletion or enrichment by the main and rare earth elements, is invalid. Respectively all isotope-geodynamical models based on the traditional isotope systematics of the mantle material, require serious revision.

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