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Dados preliminares de geoquímica isotópica Rb-Sr e Sm-Nd de sedimentos do Ediacariano e Cambrico Inferior da Zona de Ossa-Morena (Portugal)

Preliminary Rb-Sr and Sm-Nd isotope geochemistry on Ediacaran and Early Cambrian sediments from the Ossa-Morena Zone (Portugal)

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SUMÁRIO

Neste trabalho são apresentados dados preliminares de geoquímica isotópica Rb-Sr e Sm-Nd em amostras de rochas detríticas das bacias do Ediacariano-Câmbrico Inferior da Zona de Ossa-Morena. As amostras analisadas mostram valores baixos da razão $^{147}Sm/^{144}Nd$ (0.105-0.119) e negativos de $\varepsilon Nd_{(T)}$ (-3.9 to -12.4), sugerindo uma proveniência típica da crusta continental. Estes resultados obtidos para as rochas do Ediacariano-Câmbrico Inferior da Zona de Ossa-Morena são similares aos registados para rochas correlacionáveis da Zona Saxo-Thuringia (Alemanha).

Palavras-chave: Rb-Sr; Sm-Nd, Ediacariano-Câmbrico Inferior, TIMS, Gondwana

SUMMARY

This work presents preliminary Rb-Sr and Sm-Nd isotope geochemistry results from samples of detrital rocks from the Ossa-Morena Zone Ediacaran-Early Cambrian basins. The analysed samples present low $^{147}Sm/^{144}Nd$ values (0.105-0.119) and negative $\varepsilon Nd_{(T)}$ values (-3.9 to -12.4), which suggest a typical upper continental crust provenance. These results of Ediacaran-Early Cambrian Ossa-Morena Zone rocks are close to those obtained for the Saxo-Thuringian Zone (Germany) correlatives.

Key-words: Rb-Sr; Sm-Nd, Ediacaran-Early Cambrian, TIMS, Gondwana

Introduction

Isotope geochemistry has been used to identify the different isotopic reservoirs in the crust and the mantle and to characterize the sources of igneous and sedimentary rocks [1]. In this radiogenic isotope study we used two different systems: Rb-Sr, and Sm-Nd, to characterize detrital sedimentary rocks.

Sr reflects fairly close the original bulk composition of rocks, although Rb is more mobile. Sr and Rb are strongly fractionated from one another between crust and the mantle leading to the accelerated Sr isotope evolution of continental crust relative to the mantle. Sm and Nd isotopes are not significantly fractionated within continental crust by sedimentary processes and thus preserve the characteristics of their source (e.g. [2]).

The Rb-Sr and Sm-Nd isotopic characterization has been applied to test correlations between old sediments from basins separated in nowdays by several kilometers due to post-Variscan tectonics [3].

Geological setting and sample selection

In the northern domains of the Ossa-Morena Zone (OMZ) close to the Central-Iberian Zone (CIZ)

boundary (Northeast Alentejo, Portugal) outcrops the Serie Negra Cadomian succession [4-5], which is composed by Ediacaran metapelites, metagreywackes, black metacherts and metabasalts (Mosteiros Formation). Early Cambrian calc-alkaline volcanic-sedimentary and detritic-carbonate complexes unconformably overlie the Serie Negra. They represent a sequence of reworked felsic tuffs, andesites, rhyodacites and rhyolites (Nave de Grou-Azeiteiros volcanic-sedimentary complex) that passes to the top to arkosic sandstones and pelites and then to limestones (Assumar detritic-carbonate complex) [6-7].
The selected sample from Ediacaran was taken from a Serie Negra outcrop at North of Alter do Chão (CTO-200). The Early Cambrian rocks were sampled from the felsic-dominated volcanic-sedimentary complex of Nave de Grou-Azeiteiros at North of Ouguela (OGL-1) and the detritic-carbonate complex of Assumar in the same cross-section where was taken the Serie Negra sample (CTO-2).
[6], have studied the geochemistry of such rocks recently. There are no main differences in major elements between these detrital rocks, but there is an increasing tendency for the Al_2O_3/SiO_2 values from the metagrywacke (CTO-200: 0.19), the pelite/reworked andesitic tuff (CTO-2: 0.29) and the arkose (OGL-1: 0.41). The chondrite-normalized REE distribution patterns are similar with a characteristic negative Eu-anomaly, a clear enrichment of the LREE relative to HREE (CTO-200: La_n/Yb_n= 21.3; CTO-2: La_n/Yb_n= 10.46; OGL-1: La_n/Yb_n= 16.8). The chondrite-normalized incompatible trace element patterns show negative anomalies of Nb, Sr and Sm and enrichments of Th, La, Ce, Nd and Zr. The REE abundance distributions normalized with respect to PAAS are unfractionated with nearly flat patterns characterized by a slightly positive Eu-anomaly.
Their calc-alkaline signature and felsic provenance indicate that the source of these rocks was a recycled Cadomian continental magmatic arc [7].

Analytical procedures

Three samples (CTO-2, OGL-1 and CTO-200) were selected for the study of Sr and Nd isotopes.
The samples were dissolved with HF/HNO_3 solution in Teflon Parr acid digestion bombs at 180°C of temperature. After evaporation of the final solution, the samples were dissolved with HCl (6N) and dry. The elements to analyse were purified using conventional ion chromatography technique in two stages: 1) separation of Sr and REE elements in ion exchange column with AG8 50W Bio-Rad cation exchange resin; 2) purification of Nd from others lanthanides elements in columns with Ln Resin (ElChroM Technologies) cation exchange resin.
All the intervenient reagents in the preparation of the samples were distillate two times, and the water produced by a Milli-Q Element (Millipore) apparatus.
The isotopic analysis were carried out at the Laboratório de Geologia Isotópica da Universidade de Aveiro (LGI-UA), Portugal. Sr was loaded on a single Ta filament with H_3PO_4 (1N), whereas Nd was loaded on a Ta outer side filament, with HCl (2,5N), in a Ta-Re-Ta triple arrangement with Re as the ionizing central filament. Both elements were determined using a Multi-Collector Thermal Ionisation Mass Spectrometer (TIMS) VG Sector 54, with 7 Faraday cups. Data were acquired at multidynamic mode with peak measurements at 1-2V to ^{88}Sr and 0,8-1,5V to ^{144}Nd. The measurements of Sr were corrected for possible interference by ^{87}Rb and were normalized to $^{88}Sr/^{86}Sr$=0.1194. The measurements of Nd were corrected for interference by ^{142}Ce and ^{144}Sm and normalized to $^{146}Nd/^{144}Nd$=0.7219. During this study, the NBS-987 standard gave an average value for $^{87}Sr/^{86}Sr$=0.710263±10 (N=8; conf. lim.=95%) and $^{143}Nd/^{144}Nd$=0.512114±2 (N=27; conf. lim.=95%) to JNdi-1 standard ($^{143}Nd/^{144}Nd$ data are normalized to La Jolla standard). The error on εNd calculations is ±0.3.

Rb-Sr and Sm-Nd results

Rb-Sr and Sm-Nd results are reported in Table 1.

Tab. 1: Rb-Sr and Sm-Nd analytical data together with εNd (T for three clastic sedimentary rocks from OMZ.

Sample	CTO-2	OGL-1	CTO-200
$^{87}Rb/^{86}Sr$	3.419	11.651	0.789
$^{87}Sr/^{86}Sr$	0.731820	0.776305	0,714828
$^{147}Sm/^{144}Nd$	0.119	0.118	0.105
$^{143}Nd/^{144}Nd$	0.512163	0.511859	0.511662
εNd (0)	-9.3	-15.2	-19.0
εNd (540)	-3.9	-9.7	
εNd (560)			-12.4

The $^{87}Sr/^{86}Sr$ values obtained from the three clasti sedimentary rocks range from 0.714828 (CTO-200 to 0.731820 (CTO-2) and 0.776305 (OGL-1). Th 2σ error range from 0.000035 to 0.000042.
The obtained $^{143}Nd/^{144}Nd$ values show an increasin tendency from 0.511662 (CTO-200), to 0.51185 (OGL-1) and 0.512163 (CTO-2). The 2σ error rang from 0.000012 to 0.000018.
This trend is followed by the $^{147}Sm/^{144}Nd$ value which range from 0.105 (CTO-200), to 0.118 (OGI 1) and 0.119 (CTO-2).
The three samples display negative εNd values:
For 560 Ma –Ediacaran deposition age – CTO-20 metagreywacke, $\varepsilon Nd_{(0)}$= -19.0 and $\varepsilon Nd_{(560)}$= -12.4;
For 540 Ma –Lower Cambrian deposition age OGL-1, reworked felsic tuff/pelite, $\varepsilon Nd_{(0)}$= -15 and $\varepsilon Nd_{(540)}$= -9.2.
And for 540 Ma –Lower Cambrian deposition age CTO-2, arkose, $\varepsilon Nd_{(0)}$= -9.3 and $\varepsilon Nd_{(540)}$= -3.9.

Discussion

These three samples present low $^{147}Sm/^{144}Nd$ values (0.105-0.119), which suggest a typical upper continental crust provenance. The obtained results fit well with the Sr and Nd compositional ranges of Precambrian upper continental crust ($^{87}Sr/^{86}Sr$= 0.71463-0.78662 and $^{143}Nd/^{144}Nd$= 0.511843-0.512261) and detrital rocks ($^{87}Sr/^{86}Sr$= 0.711440-0.78919 and $^{143}Nd/^{144}Nd$= 0.511816-0.512259) from Southern Britain (e.g.[2, Table 6.6, pp.235-236]).

The obtained $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ values are in agreement with previous studies made by for detrital and volcanic Ediacaran-Early Cambrian rocks of the Ossa-Morena and Central-Iberian zones:

- [8] on Early Cambrian OMZ arkoses ($^{87}Sr/^{86}Sr$= 0.754677 and $^{143}Nd/^{144}Nd$= 0.512149) and Ediacaran CIZ greywackes and pelites ($^{87}Sr/^{86}Sr$= 0.735193; $^{143}Nd/^{144}Nd$= 0.512131-0.512172);
- [9] on Ediacaran OMZ metapelites ($^{87}Sr/^{86}Sr$= 0.742721-0.743536; $^{143}Nd/^{144}Nd$= 0.511976-0.512008) and Ediacaran-Early Cambrian CIZ metapelites and metagreywackes ($^{87}Sr/^{86}Sr$= 0.736217-0.812759; $^{143}Nd/^{144}Nd$= 0.512217-0.512288);
- [10] on Ediacaran-Early Cambrian CIZ pelites ($^{87}Sr/^{86}Sr$= 0.72747-0.77767; $^{143}Nd/^{144}Nd$= 0.511971-0.512272);
- [11] on Early Cambrian OMZ pelites ($^{143}Nd/^{144}Nd$= 0.512055-0.512129) and Early Cambrian OMZ andesites ($^{143}Nd/^{144}Nd$= 0.512555-0.512745);
- [12] on Ediacaran-Early Cambrian CIZ andesitic basalts ($^{87}Sr/^{86}Sr$=0.721888; $^{143}Nd/^{144}Nd$= 0.511993) and Ediacaran-Early Cambrian CIZ dacitic volcaniclastic rocks ($^{87}Sr/^{86}Sr$= 0.712356-0.716902; $^{143}Nd/^{144}Nd$= 0.512361-0.512310).
- [13] on Neoproterozoic CIZ metasedimentary rocks (pelites) ($^{87}Sr/^{86}Sr$=0.73495-0.79150; $^{143}Nd/^{144}Nd$= 0.51213-0.51227)

The same similarity seems to be expressed on the equivalent age detrital rocks from the Saxo-Thuringian Zone (STZ, Germany; $^{87}Sr/^{86}Sr$= 0.716690-0.786917; $^{143}Nd/^{144}Nd$=0.511786-0.52248) (e.g. [14]).

This similarity is also expressed by the fact that the OMZ samples show negative $\varepsilon Nd_{(T)}$ values (-3.9 to -12.4) are equivalent to the obtained results for the Ediacaran-Early Cambrian STZ correlatives with $\varepsilon Nd_{(T)}$ values ranging from -2.6 to -10.4 ([14]; table 4).

The presented Rb-Sr and Sm-Nd isotope geochemistry data represent one more clue to suggest a close relationship between the OMZ and STZ Ediacaran-Early Cambrian Gondwana basins.

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