1238622

III SSAGI

CHILE 2001
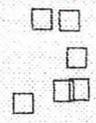
Rb/Sr establishes an age of 61 to 67 Ma for Colombian Emeralds.

Pucón, Chile
21-24 de Octubre de 2001
October 21-24, 2001

Koji, K.
Schultz-gutller, R

EXTENDED ABSTRACTS VOLUME

Organized by : Servicio Nacional de Geología y Minería de Chile and
Departamento de Geología de la Universidad de Chile,
with the sponsorship of the Sociedad Geológica de Chile

CONTENTS OF DISK

Copyright

Citation of this volume

The following is the recommended form for citing works from this volume:

Authors, 2001, title of abstract, III South American Symposium on Isotope
        Geology, Extended Abstracts Volume (CD), page number, Sociedad
        Geológica de Chile, Santiago, Chile.

Rb/Sr Establishes an age of 61 to 67 Ma for Colombian Emeralds

Romero Ordóñez, F.*; **Kawashita Koji ; ***Schultz-Güttler, R.

* Geociencias. UN. Bogotá, Colombia. fromero@ciencias.ciencias.unal.edu.co
** Geociencias. UFRGS. Portoalegre, Brazil. rubidio@ufrgs.com.br
*** Geociencias. USP. São Paulo, Brazil. rainersg@usp.br

Key Words: Colombia, Emeralds, Rb/Sr, Muzo, Chivor.

The age of emeralds is related to the environment within which they form and can be dated by geochronological methods of which the rubidium-strontium (Rb-Sr) method (Faure, 1986) is the best to date the emeralds and its host rocks (Vidal et al., 1992). Isotopic studies done by Vidal et al. (1992) established two different geochronological environments for dating emeralds depending on their ages: emeralds from Precambrian rocks in Brazil, Madagascar and Zambia with high radiogenic strontium enrichment due to the older ages and high Rb contents and emeralds hosted by younger rocks in Colombia, Paquistan and Afganistan generally, with low $^{87}Rb/^{86}Sr$ range and low radiogenic Sr enrichment, and low content of Rb (Table 1).

Origin	Weight (mg)	Rb µg/g	Primary Sr(1)(µg/g)	$^{87}Rb/^{86}Sr$ (2)	$^{87}Sr/^{86}Sr$	Model age with initial $^{87}Sr/^{86}Sr=0.705.$ (Ma)
Brazil:						
Santa Teresinha-1	169.7	11.8	162.8	0.210	0.72036	n.d
Santa Teresinha–2	92.8	21.9	3.48	18.49	0.8357	496
Socotó–1	234.4	51.3	1.24	119.4	2.717	1180
Itaberaí-1	76.4	14.3	1.02	38.64	0.98805	514
Itaberaí-2	46.9	17.0	1.77	26.33	0.88830	489
Madagascar-1	179.7	76.0	2.26	96.9	1.5578	618
Madagascar-2	142.9	93.7	2.85	94.9	1.3744	497
Zambia-1	91.4	28.1	0.029	1627.0	12.309	500
Zambia-2	94.1	94.4	0.005	10934.0	65.65	598
Colombia:						
Peñas Blancas-1	195.3	1.0	0.45	6.29	0.7197	61±5
Peñas Blancas-2	161.6	2.26	0.28	22.6	0.7324	61±5
Peñas Blancas-3	108.1	1.42	0.20	18.61	0.7316	61±5
Peñas Blancas-4	114.1	1.80	0.17	27.43	0.7380	61±5
Paquistan-1	130.7	5.0	0.85	16.83	0.71599	n.d
Afganistan-1	151.1	16.5	7.15	6.69	0.71388	n.d

Table 1. Rb/Sr analyses of emeralds from different localities around the world. (1) Primary strontium contents obtained by the subtraction of strontium blank from the laboratory (1.8 ng) from the strontium in the analyzed sample. (2) 86Sr = 86Sr primary + 86Sr from the blank. n.d = not determinated (from Vidal et al. 1992).

1- METHODS

Semi quantitative x-ray fluorescence analyses was first used to estimate the Rb and Sr concentrations to select favorable samples and to estimate the magnitude of the ^{87}Rb and ^{84}Sr spike to be diluted for precise isotopic determinations of ^{87}Rb/^{86}Sr ratios. Teen samples which have the best ratios in the Rb/Sr ratio (Table 2) were selected to get an isochron.

Origin	Material	Rb-DI (ppm)	Sr-DI (ppm)	^{87}Rb/^{86}Sr (calculado)	Error	^{87}Sr/^{86}Sr (calculado)	Error
Coscuez1	Lixiviado	0.10	0.93	0.3221	0.0010	0.71379	0.00009
Chivor-1	Total	7.91	2.13	10.770	0.1000	0.75176	0.00030
Chivor-1	Lixiviado	1.82	1.09	4.860	0.0300	0.75207	0.00010
Chivor-1	Residuo	6.28	1.17	15.590	0.1500	0.76179	0.00035
Muzo-2	Total	2.14	5.28	1.1760	0.0090	0.71557	0.00065
Muzo-3	Lixiviado	0.33	4.76	0.1981	0.0008	0.70843	0.00009
Muzo-3	Resíduo	2.94	0.37	23.650	0.9400	0.737460	0.00088
Muzo-4	Total	2.15	18.81	0.3310	0.0020	0.71232	0.00017
Yacopí-1	Total	2.07	0.70	8.504	0.0700	0.721730	0.00052
Yacopí-2	Resíduo	1.03	9.02	0.330	0.0050	0.710370	0.00021

Table 2 – Rb and Sr concentrations after leaching, residue and whole rock analyses of samples from Colombian emeralds. All analyses by isotopic dilution (ID).

All strontium analyses were normalized assuming a ^{86}Sr/^{88}Sr ratio of 0.1194. Leaching was carried out using a 0.5g of powder sample dissolved on HCl (O.1N) for 15 minutes. Both Rb and Sr were determined by the isotopic dilution technique by adding 50 µl of combined ^{87}Rb/^{84}Sr spike in the proportion of 2ppm/0.43ppm of respectively isotopes.

Three samples were selected (Table 2) to be leached with HCl to obtein higher values of the ^{87}Sr/^{86}Sr ratio for an isochron diagram. The leaching experiments were carried out to extract mainly the associated carbonates, which could have different isotopic ratios from the initial Sr ratio of mineralized system and to test the leaching procedure.

The results summarized in Table 2 indicate that the Rb and Sr contents of Colombian emeralds are very low when compared with those from emeralds of different areas of Precambrian age where the values are between tens to hundreds ppm. Importantly, the leaching technique allowed to make a adequate range in the Rb/Sr values.

Four samples from Table 2 were very similar Rb/Sr (Muzo-3, Muzo-4, Coscuez-1, Yacopi-2) with values around 0.2 to 0.33 ppm and ^{87}Sr/^{86}Sr varying between 0.708 and 0.713.

2- INTERPRETATION

The results of this work combined with data obtained by Vidal et. (1992, Table 1), are shown in an ^{87}Sr/^{86}Sr x ^{87}Rb/^{86}Sr diagram of Fig. 1. The distribution of points in the diagram of Fig. 1 indicate that it is not an isochron but consists of two errorchrons. Thus, the ages from these two errorchrons were calculated by using the Monte Carlo method (Amaral, 1990) for samples of both the Occidental (Fig. 1B) and Oriental Belts (Fig. 1A). The calculated apparent age is 67 Ma for the Occidental Belt, which includes samples from the deposits of Muzo, Coscuez, Yacopi e Peñas Blancas, while the samples from the Oriental Belt show an apparent age of 61 Ma. This last estimated age is concordant within the 2σ errors with the age obtained for mineralization to the Occidental Belt.
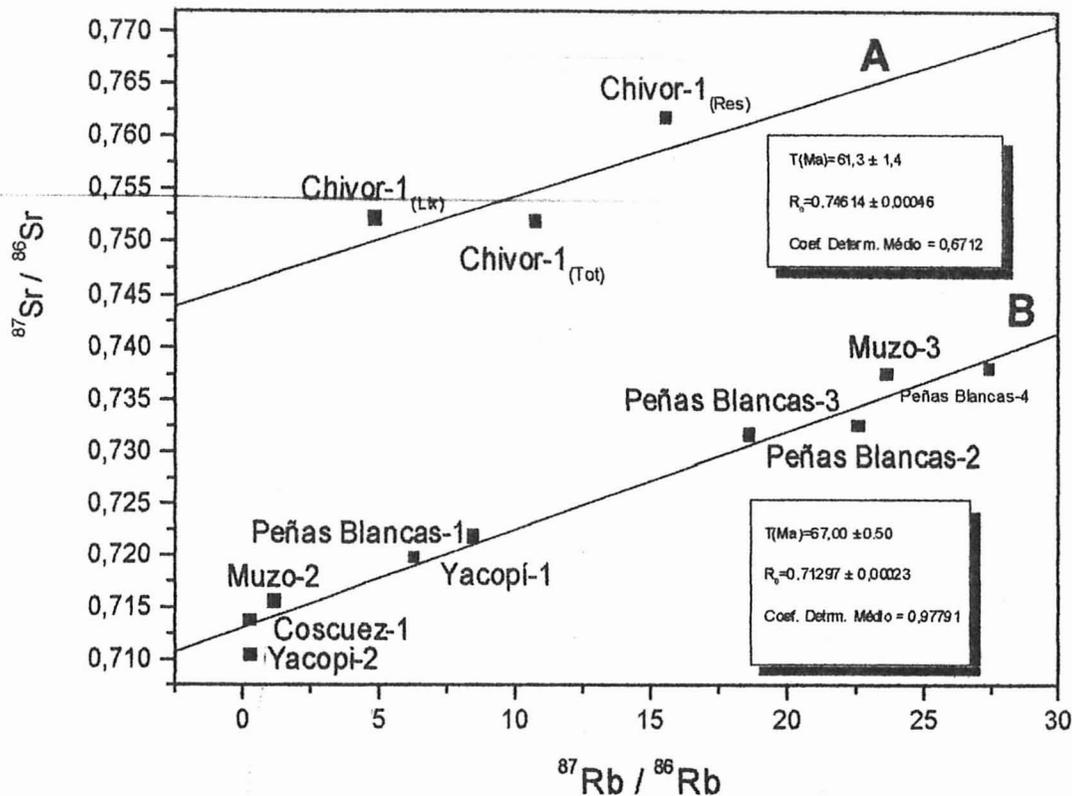
Figure 1. Errorchrons of $^{87}Sr/^{86}Sr$ x $^{87}Rb/^{86}Sr$ from emeralds from Colombia. A) Oriental Belt (samples from Chivor - 1 (leached, whole and residue), with an apparent age of 61.3±1.4 Ma. B) Occidental Belt, Muzo-2, Muzo-3 (residue), Yacopi-1, Coscuez-1 (leached), Yacopi-2 (residue) and data from Vidal et al (1992) of Penas Blancas material, showing and apparent age of 67±1.0 ma (2).

According to Ordoñez (1993), the mineralizing fluids were the same for all Colombian emerald deposits, with small differences in chemistry, depending upon host rock. This could explain the different Sr-isotope initial ratios for emeralds from the two belts.

The preliminary Rb/Sr age of the emeralds from the Oriental Belt (Chivor) presented in this work is very close to previous ages obtained from micas by the $^{40}Ar/^{39}Ar$ method, 62 to 68 Ma, (Cheilletz et al. 1994, 1997) which has been interpreted as the age of emeralds from this belt. However, isotopic determinations by the $^{40}Ar/^{39}Ar$ method on micas collected in mines from Occidental Belt show younger ages between 31 to 38 Ma.

CONCLUSIONS

The range of 31-38 Ma obtained by Cheilletz et al. (1991) do not correspond to the Rb/Sr age range of 68-61 Ma which is interpreted as the age of deposition. To test this, we plot two hypothetical 33 Ma isochrons in the Rb/Sr x Sr/Sr diagram, assuming Sr initial ratios of 0.713 and 0.710. All of Rb-Sr data plot above to the 33 Ma hypothetical isochrons (Ordóñez, 1998). Thus the 38-31 Ma age interpreted by Cheilletz et al (1991, 1994) as the age of emerald deposition could be related instead to the younger diagenetic and/or deformation events in Andean region and unrelated to the mineralizations.

While rubidium and strontium geochemical studies on Colombian emeralds show very low values for these elements, they

513

are sufficient to use Rb/Sr and $^{87}Sr/^{86}Sr$ ratios when the leaching technique is applied. The data plotted in the Rb-Sr and Sr-Sr diagram define two arrays. These arrays are interpreted as two errorchrons: a 67 Ma for emeralds from the Occidental Belt and a 61 Ma for Chivor deposits form the Oriental belt.

Some chemical differences are related to the different fluid-rock interaction with distinct lithology of stratigraphy along the belts and could explain the contrasting strontium initial ratios of emeralds from of two belts.

The initial strontium ratio of 0.713 of emeralds from the Occidental Belt is relatively low and could be related to marine Sr, while the high Sr-initial ratio of 0.746 for the Oriental Belt could have been originated from more maturé materials related to the continental sources.

Geochronological interpretations of errorchrons, combined with data of Vidal et al. (1992) permited us to determine the possible age for emerald mineralization of between 67-61 Ma. This age is consistent with the geology of studied emerald deposits found in the central part of Oriental Cordillera, which were part of a sedimentary basin, buried during the Cretaceous, when the fluids in the porosity of sediments reached temperatures around 350°C (Ordoñez, 1993).

Additionally, the Rb/Sr age of emerald deposits obtained in this work for the Oriental belt (Chivor samples) is very close to the Ar-Ar ages of micas (68-62 Ma) obtained by Cheilletz et al. (1994; 1997) and is here interpreted as the age of deposition of emeralds from these deposits. However, Ar-Ar ages on micas for emerald deposits of the Occidental Belt yielded different values (31 to 38 Ma) in contrast with the of 67 Ma obtained in this work by Rb/Sr method. Thus, the isotopic homogenization for the Rb/Sr system would have occurred ca. 67-61 Ma ago in the mineralized systems along the two studied belts

BIBLIOGRAFY

AMARAL, G. (1990) **Bol. Geoc., USP, 21:** 47-52.

CHEILLETZ, A.; FÉRAUD, G.; GIULIANI, G.; RODRIGUEZ, C. (1991) *In*: PAGEL, M. & LEROY, J. (ed.).Rotterdam, Balkema. p.373-376.

CHEILLETZ, A.; FÉRAUD, G.; GIULIANI, G.; RODRIGUEZ, C. (1994) **Ec. Geol., 89:** 361-380.

CHEILLETZ, A.; GIULIANI, G.; ZIMMERMANN, J.L.; RIBEIRO-ALTHOFF. (1995) *In*: PASAVA; KRÍVEK; ZÁK (ed.). Rotterdam, Balkema. p.569-572.

CHEILLETZ, A. & GIULIANI, G. (1996) **Min. Deposita, 31:** 359-364.

CHEILLETZ, A.; GIULIANI, G.; BRANQUET, Y.; LAUMONIER, B.; SANCHEZ, A.; FÉRAUD, G.;ARHAN, T. (1997) **Compte Rendus de L' Academy de Sciences Paris, 324(2):** 337-369.

FAURE, G. & POWELL, J. (1972) **Strontium Isotope Geology.** 2. ed. New York, Springer-Verlag. 188p.

FAURE, G. (1986) **Principles of Isotope Geology.** 2. ed. New York. John Wiley & Sons, Inc. 589p.

GIULIANI, G.; FRANCE-LANORD, C.; ZIMMERMANN, J. L.; CHEILLETZ, A.; ARBOLEDA, C.; CHAROY, B.; COGET, P., FONTAN, F., GIARD, D. (1997) **Int. Geol. Ver., 39(5):** 400-424.

ORDÓÑEZ, F. H. R. (1993) Dissertação de Mestrado-Instituto de Geociências/USP.

ORDÓÑEZ, F. H. R. (1998) Dissertação de Doutorado-Instituto de Geociências/USP

VIDAL, P.; LASNIER, B.; POIROT, J. (1992) **The Jour. of Gemm.,23(4):**198-200.