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REINTERPRETATION OF ISOTOPIC AGE DATA FROM THE GRANJENO SCHIST, CIUDAD VICTORIA, TAMAULIPAS

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RESUMEN

Se hace una revisión y reinterpretación de las edades K-Ar y Rb-Sr, determinadas para la secuencia del Esquisto Granjeno, la cual aflora en el núcleo del Anticlinorio de Huizachal-Peregrina, al noroeste de Ciudad Victoria, Tamaulipas. Una edad promedio K-Ar de 298 ± 16 m. a. (1_σ) fue obtenida para el Esquisto Granjeno y para el esquisto de Aramberri, que aflora 65 km al noroeste del área. Utilizando la información de muscovita-roca entera presentada por Denison *et al.* (1970) y la roca entera presentada por de Cserna *et al.* (1977), se calculó una isócrona de cuatro puntos. La edad isocrónica obtenida es de 333 ± 30 m. a., con una relación inicial de $^{87}Sr/^{86}Sr = 0.7145 \pm 0.0009$. La consistencia de las edades K-Ar y Rb-Sr permite interpretarlas como indicativas de un evento metamórfico ocurrido durante el Pensilvánico Temprano. Esta interpretación apoya el modelo de Ramírez-Ramírez (1978), en el sentido de que el Esquisto Granjeno representa una secuencia alóctona del Paleozoico superior, posiblemente relacionada con un evento orogénico de edad apalachiana.

ABSTRACT

A review and reinterpretation are made of the K-Ar and Rb-Sr isotopic age determinations of the Granjeno Schist sequence exposed within the Huizachal-Peregrina anticlinorium near Ciudad Victoria Tamaulipas. An average K-Ar age of 298 ± 16 m. y. (1_σ) is obtained for the Granjeno Schist and the Aramberri schist, located 65 km to the northwest. A four-point isochron is calculated, using the muscovite-whole rock data reported by Denison *et al.* (1970) and whole rock data reported by de Cserna *et al.* (1977). An isochron age of 333 ± 30 m. y. is obtained and an initial $^{87}Sr/^{86}Sr$ ratio is calculated as 0.7145 ± 0.0009. The K-Ar and Rb-Sr age determinations are consistent with a widespreand Early Pennsylvanian metamorphic event. This interpretation gives support to the model of Ramírez-Ramírez (1978) in that the Granjeno Schist is an upper Paleozoic allochthonous sequence possibly associated with an Appalachian age orogenic event.

INTRODUCTION

Several recent papers have discussed the Paleozoic igneous and metamorphic sequences in the Sierra Madre Oriental (de Cserna, 1971; de Cserna *et al.*, 1977; Denison *et al.*, 1970; Ramírez-Ramírez, 1974). The metamorphic sequence of the Huizachal-Peregrina anticlinorium, near Ciudad Victoria, is the principal outcrop of Paleozoic basement in the Sierra Madre Oriental and, consequently, has received much attention. For excellent descriptions of the gology, see Carrillo-Bravo (1961), de Cserna *et al.* (1977), and Ramírez-Ramírez (1974, 1978).

In the core of the northwest-trending Huizachal-Peregrina anticlinorium is Precambrian Novillo Gneiss. To the southwest, the Paleozoic Granjeno Schist lies in what appears to be tectonic contact with the Novillo Gneiss; locally a cataclastic granite appears along this contact. On the northeastern side of the anticlinorium the Granjeno Schist appears to overlie folded but unmetamorphosed sediments of Siluarian to Permian age (Ramírez-Ramírez, 1974, 1976 and 1978). Fries *et al.* (1962) noted that the Silurian Naranjal Conglomerate, which is part of the Paleozoic sedimentary sequence, contains fragments of gneiss and schist. If the schist fragments are in fact Granjeno Schist, the schist would necessarily be pre-Silurian in age, and the interpretation of de Cserna *et al.* (1977) that the Granjeno Schist is an Upper Ordovician allochthonous sequence would be supported. These authors make no mention of the corresponding autochthonous sequence. An alternative interpretation of the field relationships is given by Ramírez-Ramírez (1978). He proposes that the Granjeno Schist is an allochthonous sequence of upper Paleozoic age (the Paleozoic sediments being the autochthonous sequence).

In the interpretation of de Cserna *et al.* (1977) orogeny and metamorphism took place during the early Paleozoic, whereas in the interpretation of Ramírez-Ramírez, it occurred late in the Paleozoic. Isotopic ages of the Granjeno Schist would help to clarify the issue. If ages of metamorphic minerals correspond to the early Paleozoic, the viewpoint of de Cserna *et al.* (1977) is established. If these ages are equivalent to the late Paleozoic, the situation is less clear-cut. At least the existence of a later period of metamorphism is established. An earlier metamorphism could also have taken place, whose evidence was obliterated by the effects of the later metamorphism. Examples of metamorphic overprinting are well known, but generally in such cases, considerable isotopic evidence for the older metamorphism persists. I shall summarize and reinterpret the currently available isotopic age data pertinent to the age of the Granjeno Schist.

K-AR AGES

Metamorphic mineral assemblages in the Granjeno Schist are consistent with greenschist metamorphism (450°C and 4 kb). The schist varies from a quartz-muscovite-graphite-chlorite schist

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containing interlayered metacherts, to a schist with abundant zoisite and actinolite with only minor graphite.

Fries *et al.* (1962) reported K-Ar age of 315 ± 10 m. y. for schist from Caballeros Canyon. Later, Denison *et al.* (1970) reported two K-Ar ages from the graphite-muscovite schist: 305 ± 6 m. y. and 294 ± 6 m. y. The average of the three ages is 305 ± 10 m. y. (1σ). Fries and Rincón-Orta (1965) reported a 310 ± 10 m. y. age for muscovite from a pegmatitic vein within a granite body at the contact of the Novillo Gneiss and the Granjeno Schist. Recent K-Ar determinations on mica separates from the Granjeno Schist (de Cserna *et al.*, 1977) yield ages of 271 ± 8 m. y. and 262 ± 8 m. y. These two ages are younger than the previously reported ages, although the exact nature of the time-temperature point cannot be evaluated because the type of mica analyzed is not known (*i. e.* biotite or muscovite). From a similar schist sequence, about 65 km northwest of Ciudad Victoria, between Aramberri and La Escondida, Nuevo León, Denison *et al.* (1970) obtained two K-Ar muscovite ages of 270 ± 5 m. y. and 294 ± 6 m. y. The muscovites from the Granjeno Schist and the Aramberri schist provide an average metarmorphic age of 298 ± 16 m. y. (1σ), which appears to represent a widespread late Paleozoic metamorphism.

RB-SR STUDIES

Denison *et al.* (1970) reported a muscovite-whole rock Rb-Sr ischron age for a graphitic muscovite schist from the Granjeno Schist. I have calculated the isochron using $\lambda = 1.39 \times 10^{-11}$ yr.$^{-1}$ and obtained an age of 333 ± 30 m. y., with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7145 ± 0.0009; a strikingly high value, considerably above the range normally encountered. The Rb-Sr age is consistent with the average K-Ar age of 298 ± 16 m. y. The agreement suggests that both the K-Ar and Rb-Sr isotopic systems in muscovite became closed at about the same time.

Two new Rb-Sr whole-rock ages were reported by de Cserna *et al.* (1977): 356 ± 37 m. y. and 429 ± 45 m. y.* These ages, calculated assuming an initial $^{87}Sr/^{86}Sr$ ratio of 0.708, are much older than the calculated muscovite-whole-rock isochron age. It is this age that de Cserna *et al.* use to support the model of a lower Paleozoic allochthonous sequence.

However, the initial $^{87}Sr/^{86}Sr$ ratio in the Granjeno Schist is a datum whose value should not be assumed, but rather it should be calculated by a Rb-Sr isochron analysis. Correct evaluation of initial $^{87}Sr/^{86}Sr$ is especially critical in these samples in which the enrichment of radiogenic ^{87}Sr is small. For example, model calculations in which assumed initial $^{87}Sr/^{86}Sr$ is varied over the limited range between 0.705 and 0.720 causes the calculated Rb-Sr age to vary over a large range between 250 m. y. and 480 m. y.

Another difficulty encountered in the literature was an inconsistency in the data reported by de Cserna *et al.* (1977). The authors reported $^{87}Rb/^{86}Sr$ ratios of 5.09 and 5.61 for samples from Peregrina and Novillo Canyons, respectively. Using the Sr and Rb contents reported by de Cserna *et al.*, I calculated $^{87}Rb/^{86}Sr$ ratios of 5.122 and 4.599 for the samples from Peregrina and Novillo Canyons, respectively (Table 1). This explains the discordancy in the two ages reported by de Cserna *et al.*

Table 1.—Rb-Sr data.

No.	Sample	Rb (ppm)	Sr (ppm)	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Rb/^{86}Sr$
2	whole-rock	145.00	82.0	1.768	0.7385	5.122
3	whole-rock	79.4	50.0	1.588	0.7359	4.599
1080W	whole-rock	24.3	41.6	0.584	0.7224	1.689
1080	muscovite	208.6	78.9	2.644	0.7502	7.667

Samples 2 and 3 are from de Cserna *et. al.* (1977). Samples 1080 and 1080W are from Denison *et al.* (1970).

I have recalculated an isochron for the Granjeno Schist using corrected whole-rock data of de Cserna *et al.* and the whole-rock and muscovite data of Denison *et al.* (Figura 1). Although the two data points fo Denison *et al.* (1970, samples 1080 and 1080W, fig 1) are mostly responsible for defining the slope and intercept of the isochron, the two data points (2 and 3) of de Cserna *et al.* (1977) lie accurately on the same line. It appears reasonable, therefore, to assume that all the analyzed samples are part a of single Rb-Sr isotopic system for which the isochron indicates and initial $^{87}Sr/^{86}Sr$ ratio of 0.7145 ± 0.0009 and an age of 333 ± 30 m. y.

CONCLUSIONS

The average K-Ar age of 298 ± 16 m. y. and the Rb-Sr isochron age of 333 ± 30 m. y. are the same within analytical error, suggesting a widespread metamorphic event during the Early Pensylvanian. The consistency of the data supports the upper Paleozoic model for the age of the Granjeno Schist as proposed by Ramírez-Ramírez (*op. cit.*).

* These ages were recalculated using the $^{87}Rb/^{86}Sr$ data reported by de Cserna *et al.* (1977) and $\lambda = 1.39 \times 10^{-11}$ yr.$^{-1}$.

De Cserna *et al.* (1977) suggested that both K-Ar and Rb-Sr isotopic systems were reset thermally by emplacement of a granitic body along the contact of the Novillo Gneiss and the Granjeno Schist. The consistent K-Ar ages from the Ciudad Victoria and Aramberri area, 65 kilometers distant, argue againts this proposal. The granite appears not to be large enough to have accomplished such extensive isotopic rehomogenization. Moreover, the Novillo Gneis would be expected to show a similar K-Ar age, but instead K-Ar ages of the Novillo Gneiss are Precambrian (Denison *et al.*, 1970; Fries *et al.*, 1962).

These Early Pensylvanian metamorphic ages place doubt on the occurrence of Granjeno Schist fragments within the Silurian Naranjal Conglomerate. These schist fragments must have been derived from a much older source rock of early Paleozoic or even Precambrian age.

Isotopic ages are consistent with an Appalachian age orogeny. The allochthonous schist sequence was tectonically emplaced sometime during Late Pensylvanian to Middle Permian time. The Grangeno Schist sequence was thrust over Silurian-Permian sediments that had been laid down upon Precambrian basement. Gentle arching of the thrust slice and underlying rocks, and later normal faulting can explain stratigraphy of the Huizachal-Peregrina anticlinorium.

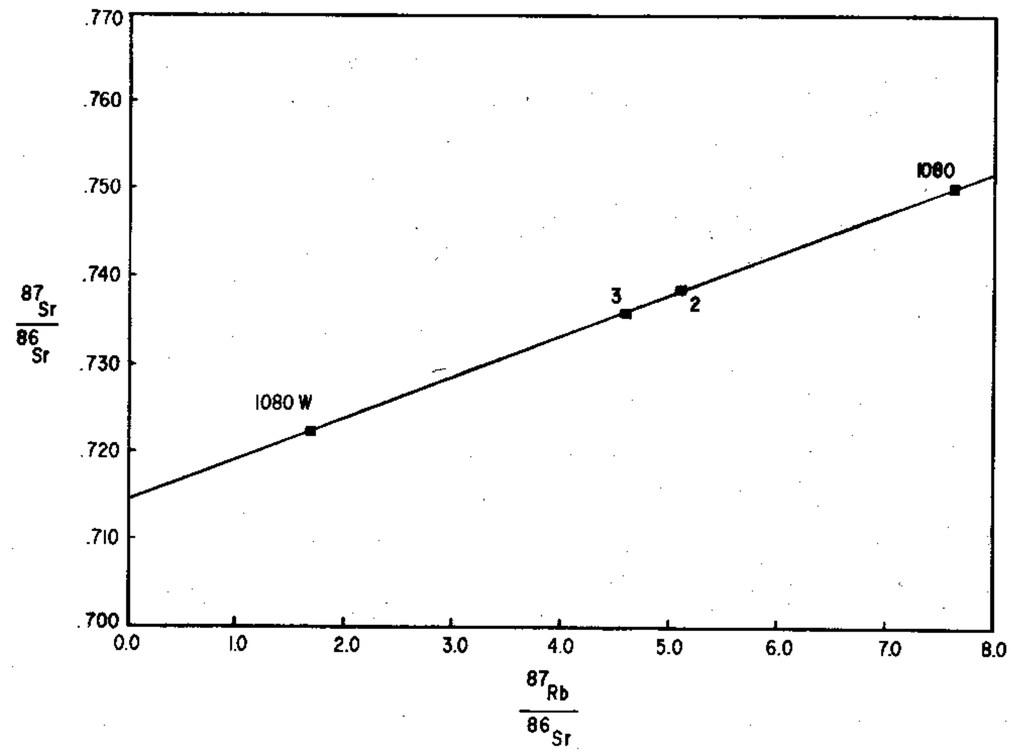

Figure 1.—Rb-Sr isochron. Sample 1080 is muscovite, and all others are whole rocks. Rb-Sr data for these samples are given in Table 1.

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