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USE OF ISOTOPIC COMPOSITION OF ARGON IN GEOTHERMAL AREAS

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RESUMEN

Se presenta un ejemplo para demostrar que un monitoreo sistemático de cambios en composición isotópica de argon de un campo geotérmico bajo explotación, puede ayudar a estimar la cantidad del fluido en el yacimiento geotérmico. Esta información se puede usar como guía para una adecuada explotación del campo geotérmico.

ABSTRACT

An example is given to show that systematic monitoring of the changes in isotopic composition of argon from a geothermal field under exploitation can help in estimating the amount of the fluid in the reservoir. This information can be used as a useful guide to an adequate exploitation of the geothermal field.

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INTRODUCTION

Several workers have shown that argon in natural gases is usually enriched in ^{40}Ar with respect to atmospheric argon because of the contribution of the radioactive decay of ^{40}K in rocks (e.g., Boato *et al.*, 1951, Zartman *et al.*, 1961; Wasserburg *et al.*, 1963; Ferrara *et al.*, 1963).

More recently Mazor (1975) discussed results on contents of rare gases such as helium, neon, argon, krypton and xenon, of both atmospheric and radiogenic origin, in geothermal fluids. The atmospheric component appears to be related to the temperature and altitude of the recharge areas (saturation) equilibrium with atmosphere) while the radiogenic component depends on the characteristics of the geothermal field, such as temperature, circulation time, lithology, etc.

The geology of Larderello and surrounding geothermal fields of Italy has been given by Cataldi *et al.* (1963). Argon from steam-jets in Tuscany was earlier collected and analyzed for its isotopic composition by Boato *et al.* (1952) and Ferrara *et al.* (1963). The results obtained by these workers are summarized in Table 1. This area was later sampled in 1966 and 1967 by G. Ferrara. Purified argon was analyzed by the author for its isotopic composition (^{40}Ar, ^{36}Ar) using a Reynolds type gas source mass spectrometer. The results are summarized in Table 2. Some of the results are plotted in Fig. 1 where a general decreasing trend of the excesse radiogenic argon fraction (∈) with time can be seen. For the Larderello area, in particular, this trend is shown by the average ∈ values (Tables 1 and 2). The average excess radiogenic argon in Larderello decreased from 18% in 1951, to 17% in 1953, to 13% in 1963 to aboult 10% in 1967. It should be pointed our that this observation is subject to uncertainties due to the rather low number of bores sampled in each group of data and the variability in ∈ itself. Nevertheless, the conclusion reached by Ferrara *et al.* (1963) that the excess radiogenic argon fraction is related to the capacity of the geothermal field, is supported by the present data obtained on samples collected in 1967.

The model proposed by Ferrara *et al.* (1963) for the balance calculations of argon in the Larderello field seems to be valid in the light of later results. The amount of fluid in the reservoir can be estimated to be

$\sim 2.2 \times 10^8$ tons (using the model of Ferrara *et al.*, 1963 and the average $\in$ for Larderello given in Table 1 & 2). This value is only approximate and can be improved if more parameters regarding the field are measured and taken into account such as the contribution of argon from potassium bearing rocks to the reservoir during exploitation of the field, change in gas/steam ratio of the fluid and a more extensive sampling of the bores. Knowing the fluid reserves more precisely, other parameters such as circulation and residence time of the fluid underground can be estimated. These parameters are useful in a better exploitation of a geothermal area.

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Table 1

Excess radiogenic argon fraction of some Italian geothermal fields

Bore	Geothermal field	Excess radiogenic argon fraction (Є)		
		1951 (1)	1953 (2)	1963 (3)
44	Larderello			0.12
53	"			0.12
58	"	0.19		0.15
71	"	0.14		
89	"			0.20
114	"		0.19	0.15
134	"			0.15
136	"			0.03
Campo Sportivo	"	0.22	0.15	0.13
Fabiani	"	0.18	0.20	0.15
Pineta	"	0.16	0.15	
Trauzl 3	"			0.12
S.Vincenzo 9	"			0.09
Average ($\bar{Є}$)	Larderello	0.18±0.03	0.17±0.03	0.13±0.04
26	Castelnuovo			0.02
Bianchi	"			0.06
Mirolli	"	0.11		
S.Luigi 3	"	0.29		0.05
Avalle	Serrazzano	0.38		
BCF 3	"	0.42	0.30	0.19
Tassinaie	Lago	0.20		
Villa Madame	Monte rotondo	0.31		
Le prata	"	0.20		
Bagnore 1	Monte Amiata			0.02
" 2 bis	"			0.00
" 5	"			0.00

(1) Boato et al., 1952. Accuracy ± 0.01

(2) Boato, Unpublished data

(3) Ferrara et al., 1963. Accuracy ± 0.01

Table 2

Excess radiogenic argon fraction of some Italian geothermal fields.

Bore	Geothermal field	Excess radiogenic argon fraction (ϵ) 1966(4)	1967(5)
58	Larderello		0.07_5
59	"		0.03
73	"		0.04
95	"		0.15
110	"		0.03
114	"		0.18
135	"		0.17
137	"		0.08
Campo Sportivo	"		0.05
Fabiani	"		0.03
Pineta	"		0.04
Belli	"		0.20
Secolo Q	"		0.17
Profondo	"		0.20
Average ($\bar{\epsilon}$)	Larderello		0.10 ± 0.07
S.Vincenzo 4	Castelnuovo		0.23
S.Luigi 3	"		0.04
BCF 3	Serrazzano		~ 0.0
Lago 7	Lago	0.10	
Villa Madame	Monte rotondo	0.09	
Le preta	" "	0.09	

(4) & (5) present study. Accuracy ± 0.01

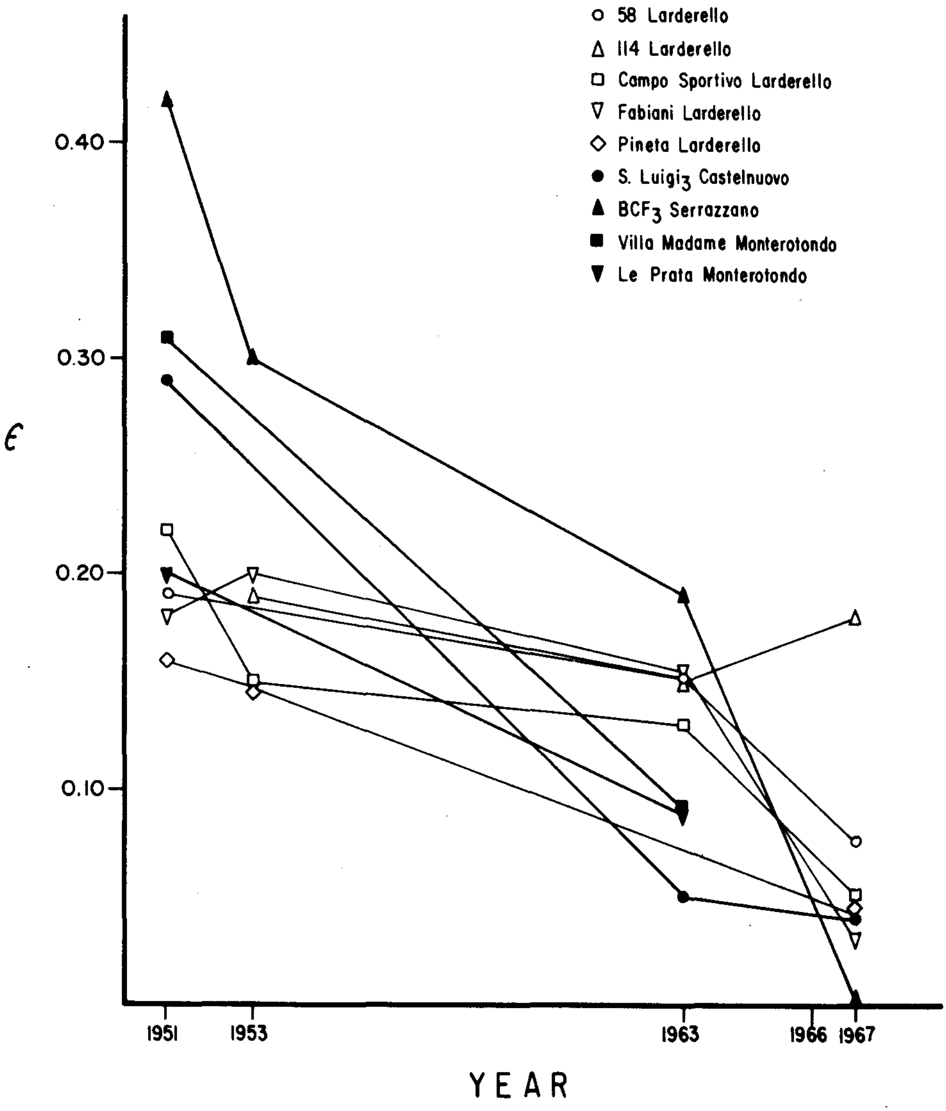

Fig. 1 Changes in ϵ values with time in some geothermal bores of Italy.

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