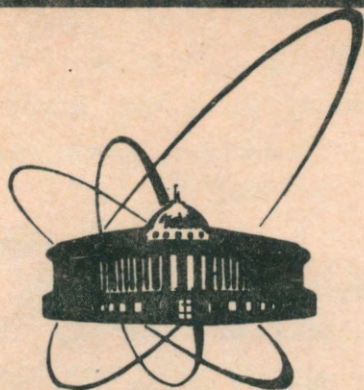


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NEUTRON ACTIVATION ANALYSIS APPLIED
TO THE STUDY OF THE COMPOSITION
OF CUBAN GEOLOGICAL SAMPLES
FROM PETROLEUM ORES

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Introduction

This paper discusses the problem connected with the study of element analysis in collector and seal rocks of specific petroleum ore in the laboratory.

The subsoil rocks present chemical characteristics which can be discovered through nuclear properties [1]. We determined the presence of elements such as having large neutron absorptions or activation cross sections. Furthermore, the variation of the radioactivity in the rocks can be useful in the geological mapping. Those can be used with the purpose of establishing lithological comparisons, or to distinguish between themselves they can furthermore contribute to explain the origin of the rocks, and the petroleum present in them. These characteristics have allowed the use of nuclear sound, which gives information about the elastic and inelastic neutron dispersion, gamma rays by neutron capture, the natural gamma radioactivity and the absorption and dispersion of gamma ray. Nuclear soundings can be used during and after perforation of the petroleum wells; it is an indispensable complement of the acoustic and electric techniques. With the combination of records from different techniques, commonly called "profiles", it is possible to determine the zone of the well with good porosity and saturation characteristics for the extraction of petroleum.

Using INAA with those technique we are able to determine the presence of microelements which affect the geophysical methods, specially those which have high absorption cross sections of neutrons.

Experimental

The multielement analysis in samples of rocks of petroleum ore was performed according to the procedure established by the INAA group of the JINR, Dubna. Similar procedures are described in [2]. The INAA was applied for every sample, using the relative method. In this case as a standard it was used a certified material of soil with composition similar to the rocks.

Twelve samples were studied, and in only one the spectral analysis was done. In all samples we determined the lithology through optical microscopy. The results for four wells at different depths were obtained. The main part of them are nuclei extracted from collector layers, with depth varying from 1680 to 2970 m. The characteristics of these samples appear in Table 1.

Central portions of the nuclei were taken to avoid the contamination with mud. The samples were dried, grinded and homogenized mechanically.

For the NAA the powder was pressed in polyethylene purses to pill-shaped pieces of around 100 mg, with determination errors less than 0.1 mg. The samples for the long irradiations were placed in aluminum container together with the reference sample and flux monitor of Au and Mo. The short irradiations were done through pneumatic guides which warranted the same place of the samples in the reactor moderator.

All the measurements were done at REGATA , one of the utilities of the reactor IBR-2 of the Joint Institute for Nuclear Research, Dubna , USSR. The characteristics of this installation are described in [3].

In the quantitative determinations using the relative method, we employed as standard the certified material IAEA/SOIL-7 [4]. The feasibility of employing this standard of soil was analysed in [2].

The determination of peak areas, the centroid and the identification elements corresponding to each peak was realized using the microcomputer program ACTIV [5,6].

TABLE 1
Characteristics of studied rocks

Sample	Lytology	Layer and well	Depth
A	calcareous with clay	collector 21	2316-2319 m
B	clay	"	2495-2499 m
C	calcareous with clay	"	2911-2916 m
D	calcareous, argilite, marle	"	2965-2970 m
E	calcareous	"	2702-2706 m
F	calcareous and argilyte	collector 200	2302-2306 m
G	calcareous and dolomite	"	2558-2561 m
H	clay and silice	seal 40	1870-1874 m
I	calcareous, clay and dolomite	seal 40	1687-1692 m
J	calcareous with clay	seal 34A	1990-1995 m

The long irradiations were of 72 hours, with measurements of 30 minutes after seven days of the irradiation time and

they were repeated fifteen days after. The cooling and measuring times of the short irradiated samples were 5-15 minutes and 5-10 minutes respectively.

Table 2 shows the determined elements, the active isotope, the half-life and the concentration of the reference material IAEA/SOIL-7 in g/g.

It should be explained that in the case of Gd and Tm, the determination of their concentrations was realized by the absolute method according to the algorithm explained in [7], because they do not appear in the standard.

Results and discussion

Using the INAA 56 spectra between unknown and references samples, as well as calibrations were analysed. The peaks with statistical errors less than 15 % with energies between 58 and 1830 KeV were used. Figures 1, 2 and 3 present the results for samples A to I of Table 1. To enderate the differences, the elements are given in diminishing order, referred to the concentration in sample A.

The results of sample I from Table 1 are shown in Table 3. Comparison with spectral analysis allows us to infer that the concentration of Ba, Mn, and V coincides in order with the results of the present work. Elements in this table were ordered according to the element distribution in sample A.

In Figures 1, 2 and 3 the values of the element concentrations for different rocks are shown; all of them are referred to elemental concentration in the sample A which element appear, in diminishing order of concentration. Elements in the abscissa are ordered as in Table 3. However, the deviations for bromine and arsenic are detected in many samples and

Table 2
Determined elements by INAA

Element	Nuclide	T1/2	E γ (KeV)	SOIL-7(g/g)
Na	Na24	15.02 h	1369.0	2.4E-3
Mg	Mg27	9.46 m	1014.4	11.3E-3
Al	Al28	2.24 m	1778.9	47.0E-3
K	K42	12.36 h	1524.7	12.2E-3
Sc	Sc46	83.83 d	889.2	8.3E-6
Ca	Sc47	3.35 d	159.4	16.3E-1
V	V51	3.75 m	1434.1	6.6E-5
Mn	Mn56	2.58 h	1810.7	6.31E-4
Fe	Fe59	44.5 d	1099.2	2.57E-2
Co	Co60	5.27 y	1173.1	8.90E-6
Zn	Zn65	243.9 d	1116.0	1.04E-4
Ga	Ga72	14.1 h	834.0	10.0E-6
As	As76	26.32 h	559.1	1.34E-5
Br	Br82	35.3 h	776.5	7.00E-6
Sr	Sr85	64.84 d	514.0	1.08E-4
Rb	Rb86	18.66 d	1076.6	5.10E-5
Mo	Mo99	66.0 h	140.5	2.5E-6
Sb	Sb124	62.2 d	1691.0	1.7E-6
Ba	Ba131	11.8 d	496.3	1.59E-4
Cs	Cs134	2.06 y	604.7	5.40E-6
La	La140	40.27 h	1596.5	2.8E-5
Ce	Ce141	32.5 d	145.4	6.1E-5
Nd	Nd147	10.98 d	531.0	3.0E-5
Eu	Eu152	13.33 y	1407.5	1.0E-6
Sm	Sm153	46.7 h	103.2	5.1E-6
Tb	Tb160	72.3 d	879.4	6.0E-7
Gd	Tb161	6.9 d	74.6	-----
Yb	Yb169	32.02 d	177.2	2.4E-6
Tm	Tm170	128.6 d	84.3	-----
Hf	Hf181	42.4 d	482.0	5.1E-6
Ta	Ta182	115 d	1121.3	0.52E-6
Th	Pa233	27 d	311.9	8.2E-6
U	Np239	2.36 d	228.2	2.6E-6

Table 3
Concentration of sample I (Seals 40 N3) in g/g

N	Element	INAA	Spectral A.
0	Ca	(3.79 \pm 0.06) E - 2	-
1	Fe	(6.19 \pm 0.40) E - 3	-
2	K	(7.25 \pm 0.82) E - 6	-
3	Na	(2.89 \pm 0.14) E - 3	-
4	Mg	(9.53 \pm 1.21) E - 3	-
5	Ti	-	(3.0 \pm 0.9) E - 4
6	Mn	(1.72 \pm 0.13) E - 3	(6.0 \pm 1.8) E - 3
7	Sr	(1.41 \pm 0.21) E - 4	-
8	Ba	(4.54 \pm 0.35) E - 3	(1.0 \pm 0.3) E - 3
9	Y	(3.57 \pm 0.37) E - 5	(8.0 \pm 2.4) E - 5
10	Nd	(1.77 \pm 0.32) E - 5	-
11	Ce	(8.79 \pm 0.69) E - 5	-
12	Zn	(3.40 \pm 0.16) E - 6	-
13	Mo	(8.22 \pm 1.18) E - 7	-
14	As	(7.52 \pm 0.15) E - 6	-
15	Rb	(5.72 \pm 0.32) E - 5	-
16	Co	(1.67 \pm 0.10) E - 5	-
17	Gd	(2.77 \pm 0.42) E - 5	-
18	Al	(5.76 \pm 0.25) E - 6	-
19	U	(3.57 \pm 0.31) E - 7	-
20	Ga	(2.48 \pm 0.32) E - 6	-
21	Sc	(9.93 \pm 0.64) E - 6	-
22	Tm	(3.04 \pm 0.20) E - 6	-
23	La	(6.79 \pm 0.14) E - 6	-
24	Br	(1.33 \pm 0.23) E - 5	-
25	Sm	(3.82 \pm 0.04) E - 6	-
26	Cs	(5.79 \pm 0.41) E - 6	-
27	Sb	(4.48 \pm 0.26) E - 6	-
28	Hf	(6.01 \pm 0.14) E - 7	-
29	Th	(1.18 \pm 0.08) E - 7	-
30	Eu	(4.63 \pm 0.51) E - 7	-
31	Yb	(4.20 \pm 0.64) E - 6	-
32	Tb	(1.25 \pm 0.21) E - 6	-
33	Ta	(7.37 \pm 1.90) E - 7	-

also the low concentration of manganese in the collectors 200.
Due to the fact that the neutron absorption cross section for

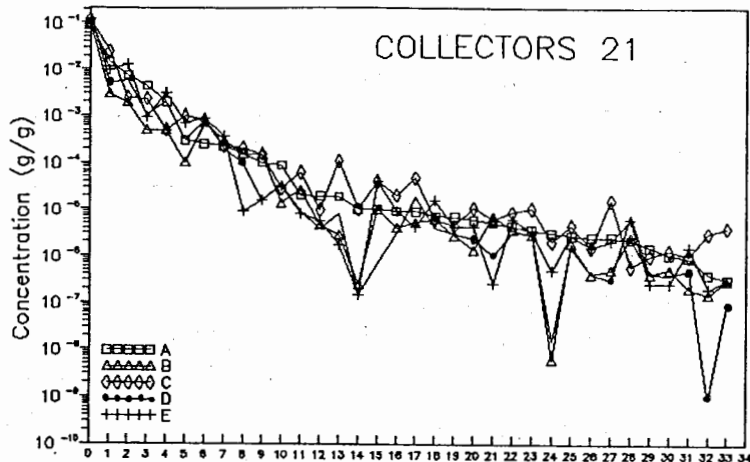


Figure 1

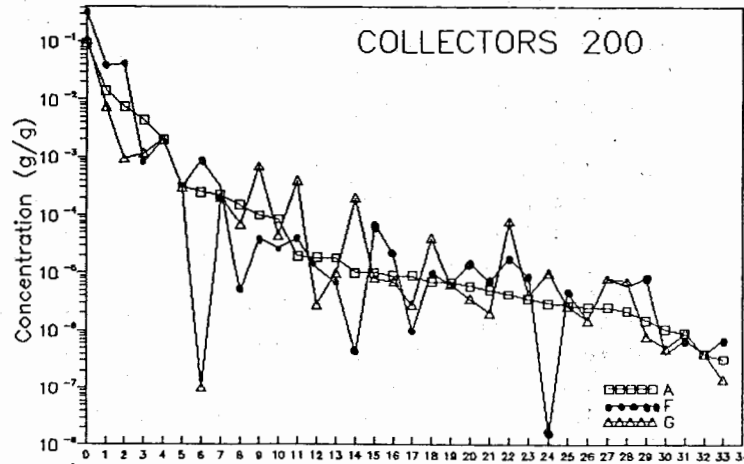


Figure 2

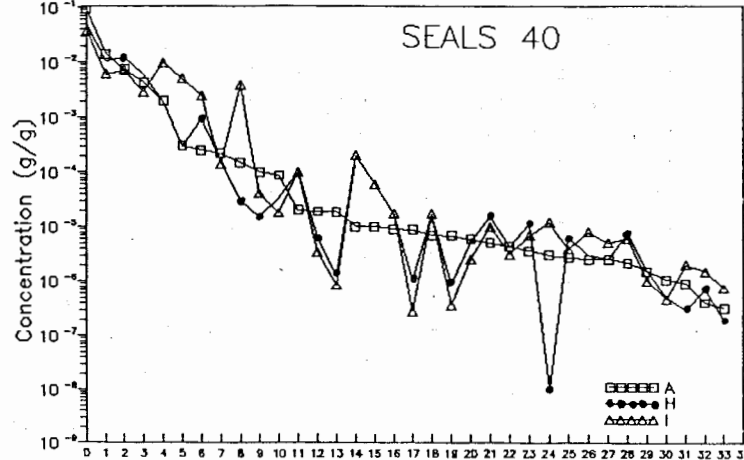


Figure 3

the manganese is relatively large, this absence of manganese could affect the sounding record, which is based on the neutron interaction. As there are not enough samples of collectors and seals from the same well, no conclusion can be drawn with respect to the preferential presence of any microelement when the layer is productive.

Fluctuations in the content of bromine in different samples of the same type (but different lithology), were also observed in the qualitative study of samples by XRFA as reported in [2], where in any cases appears the corresponding line, and other content is below on the detection limit. It suggests some correlation between the content of bromine and the changes in the lithology, what can be the propose to study in the future.

To get more definitive conclusion, is necessary to study ores with samples more representative statistically.

Conclusions

The fluctuations of the elements Mn, Br, and As in the rocks of these ores could affect the record of the nuclear sounding. However, this results do not show an evident correlation to the lithology, the origin or the productive character of the rocks. We consider that these elements should be studied together with V and Sb as reported in [2].

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Нейтронный активационный анализ
в изучении состава геологических
образцов из нефтяных регионов Кубы

Многоэлементное содержание нефтяных пород исследовалось с помощью инструментального нейтронного активационного анализа (ИНАА). Определены концентрации следующих элементов: Na, Mg, Al, K, Sc, Ca, V, Mn, Fe, Co, Zn, Ga, As, Br, Sr, Rb, Mo, Sb, Ba, Cs, La, Ce, Nd, Eu, Sm, Tb, Gd, Yb, Tm, Hf, Ta, Th и U.

Работа выполнена в Лаборатории нейтронной физики ОИЯИ.

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Neutron Activation Analysis Applied
to the Study of the Composition of Cuban
Geological Samples from Petroleum Ores

The element compositions of rocks from petroleum wells were investigated by means of instrumental neutron activation analysis (INAA). The concentrations were obtained for Na, Mg, Al, K, Sc, Ca, V, Mn, Fe, Co, Zn, Ga, As, Br, Sr, Rb, Mo, Sb, Ba, Cs, La, Ce, Nd, Eu, Sm, Tb, Gd, Yb, Tm, Hf, Ta, Th and U.

The investigation has been performed at the Laboratory of Neutron Physics, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1991