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Measurements of Th/Fe Ratios in Rocks Collected In and Around the SNO Detector Site

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We have performed neutron activation analysis on three samples of rock that were collected at the 6800 foot level in or near the SNO detector site. Peter Purgalis picked up several large rocks (that are presumably Norite) from the area of the SNO cavity dome. Hugh Evans collected six samples of dust and rock from a number of locations around the cavity. One of Peter's rocks was broken up into small pieces and one 0.66-gram piece was selected for analysis. From Hugh Evans' samples #2 (collected between the tracks at the refuge station) and #4 (collected 40 feet into the chiller drift) small rocks were chosen for analysis. In all cases the rocks were rinsed and then wiped clean with methyl alcohol. In the case of Hugh's sample #4, a lot of dark grey grit and dust was removed and what was left behind were whitish colored rocks. The final masses of the cleaned rocks from samples #2 and #4 were 0.071 and 0.10 grams, respectively.

Each of the three samples were placed into small quartz ampules, which were then evacuated and sealed. The three samples were irradiated for 1 hour at the University of Missouri Reactor Facility in Columbia, Missouri, in a thermal neutron flux nominally rated at $8 \times 10^{13}/cm^2$-sec. In the first irradiation, the sample from Peter Purgalis's Norite was irradiated along with a separately encapsulated flux monitor consisting of a chip of metallic iron. In the second irradiation, the rocks from Hugh Evans' samples were irradiated at the same position in the reactor. Following the irradiations, the samples were allowed to cool for a suitable period and then were returned to LBL. The quartz ampules were then opened and the irradiated rocks were counted using a 100-cm^3 coaxial germanium detector. The efficiency of the detector was measured with standard γ-ray sources.

The counting of the iron flux monitor yielded a value for the neutron flux of $(7.7 \pm 0.5) \times 10^{13}/cm^2$-sec, in very good agreement with the value quoted by the reactor facility. Figures 1 and 2 show the γ-ray spectrum observed from one day's counting of the irradiated Norite collected by Peter Purgalis. Approximately twenty-five different elements have been identified in this sample and quantitative abundances have been measured for 20 of these. The results are listed in Table I. For those elements where comparisons can be made between the present results and those reported from the neutron activation analysis of Heaton et al. (SNO-87-12), the agreement is quite good.

In the case of Hugh Evans' samples similar spectra were obtained, but quantitative results have, so far, only been obtained for Fe and Th. In the case of iron, the 1099- and 1292-keV lines from the decay of ^{59}Fe were measured. In the case of Th, the 312-kev γ-ray from the decay of ^{233}Pa was measured.

The results for the iron and thorium concentrations in the three different rock samples ar listed in Table II. As can be clearly seen, the Th/Fe ratio varies by more than a factor of three. In the three examples studied here, it is interesting to note that this is not a result of Th variations, but in fact because of large variations in the Fe concentration in the different rocks.

Table I. Elemental abundances in Norite determined by neutron activation analysis. The uncertainties in the abundances are approximately 10%.

Element	Abundance
Na	2.1 %
Ca	4.4 %
Fe	5.9 %
Sc	21 ppm
Cr	790 "
Co	38 "
Br	1.3 "
Rb	50 "
Zr	310 "
Cs	2.1 "
Ba	430 "
La	14 "
Nd	14 "
Eu	0.71 "
Tb	0.64 "
Lu	0.45 "
Hf	5.4 "
Ta	0.37 "
Th	4.3 "
U	3.7 "

Table II. Abundances of iron and thorium measured by neutron activation analysis. The uncertainties in the abundances are approximately 10%.

Sample	Fe (%)	Th(ppm)	Th(ppm)/Fe(%)
HE #2	1.72	3.4	1.98
HE #4	1.63	3.9	2.39
PP Norite	5.87	4.3	0.73

Note: HE = Hugh Evans
PP = Peter Purgalis

0.66 grams of NORITE irradiated with 2.88×10^{17} neutrons/cm^2

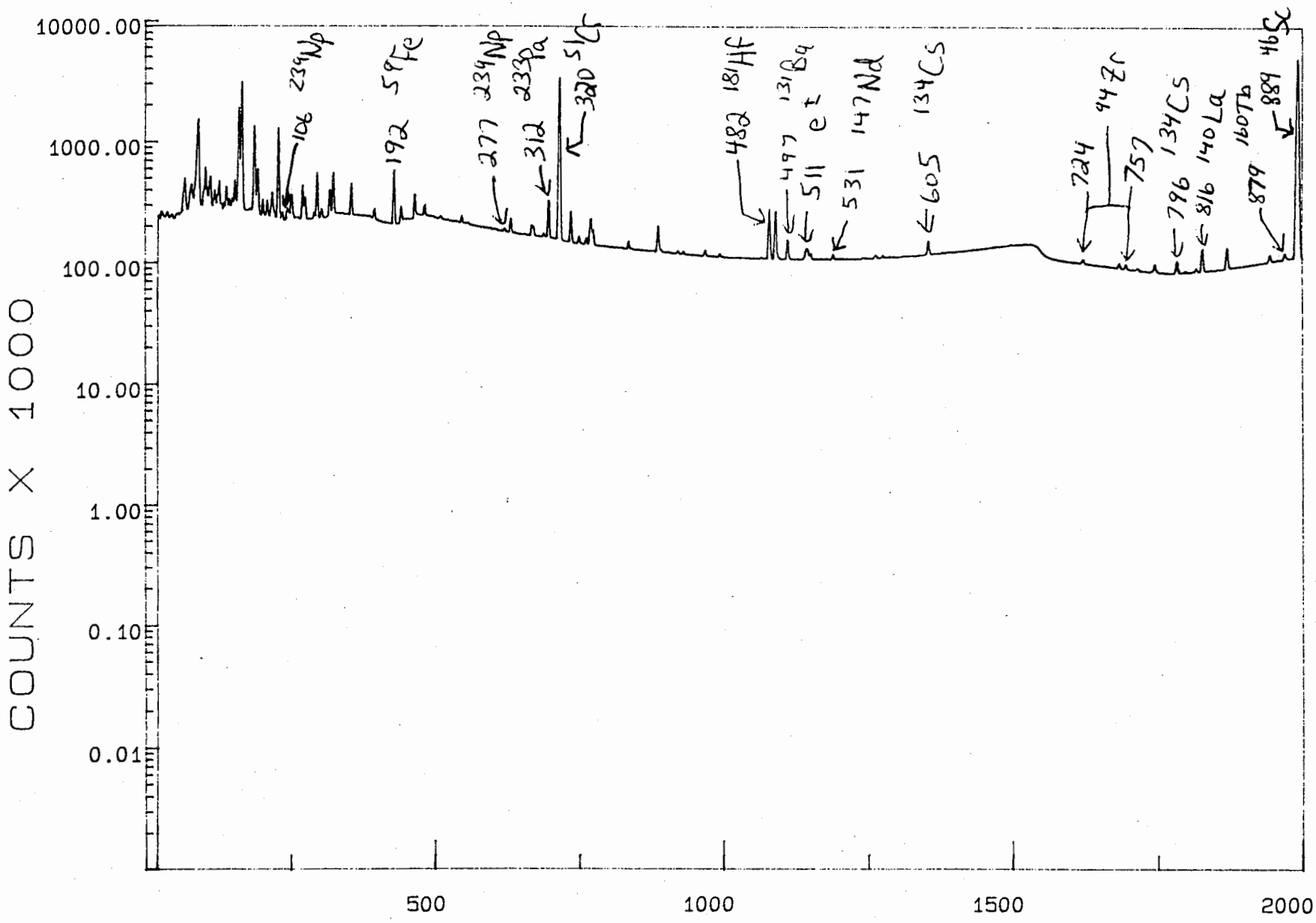

Figure 1

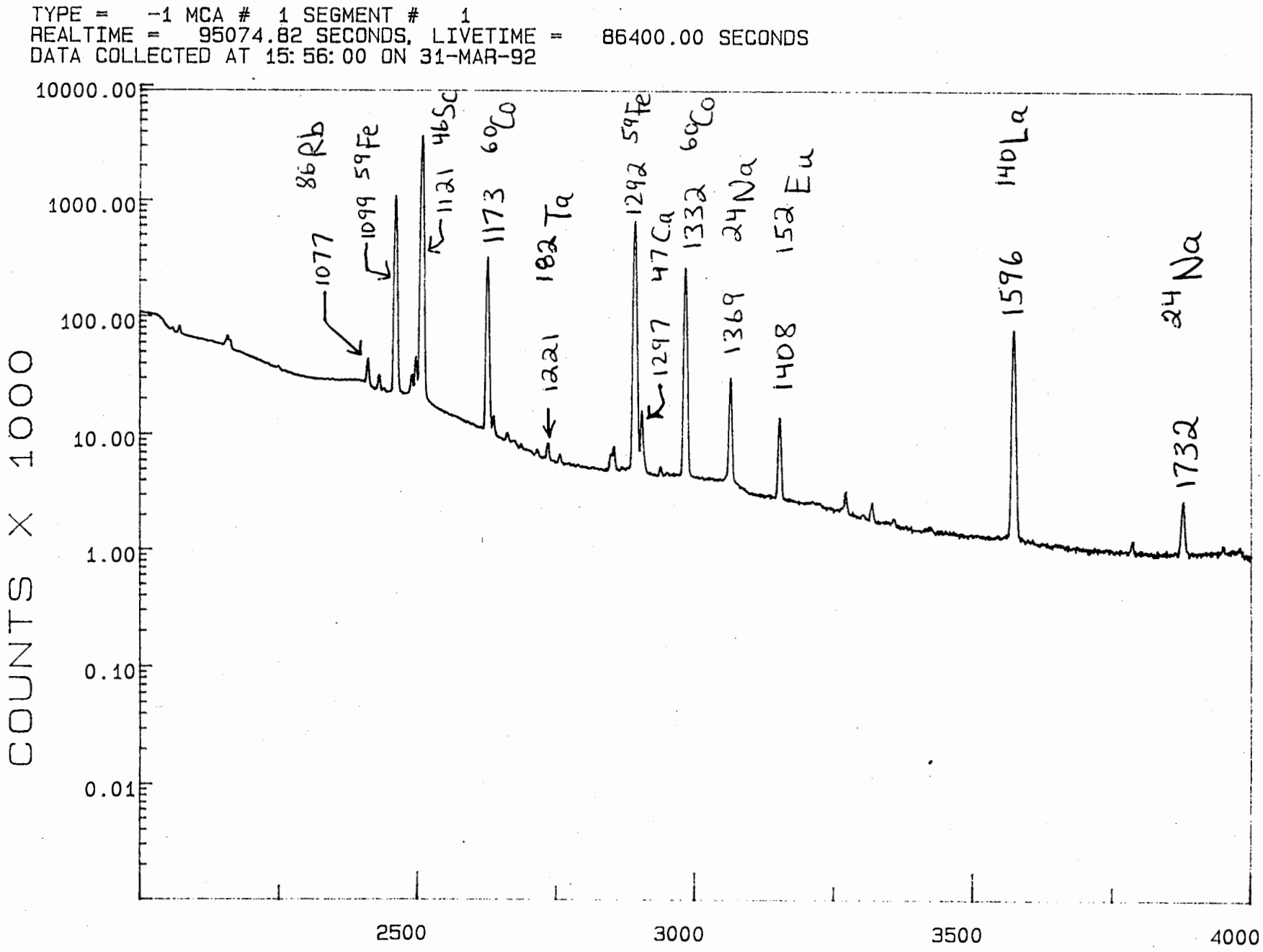
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Figure 7