ANALYSIS OF CRYOLITE MINERAL CONTENT BY NUCLEAR EXPLORATION TECHNIQUE

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The mineral Cryolite functions as a catalyser in the aluminium production industry and the natural occurence of this mineral is limited to few regions of the world. In the exploration, the subsurface core samples exhibit high fragmentation and are analysed in the laboratory through chemical and X-ray dispersion techniques for the mineral content. In-situ analysis and logging techniques in prospection and analysis of minerals are increasingly utilizing neutron activation methods (Schweitzer et al,1987 and Schweitzer 1991), and these permit rapid field analysis and cost reductions.

We investigated a short-lived delayed neutron activation method for the in-situ analysis of Cryolite mineral through gamma-ray yield measurements. The method took into consideration the choice of the radioactive source as an essential parameter for rapid analysis, and to minimise the interference of other elements in the formation. The chemical composition of Cryolite being Na_3AlF_6, (Na = 32.85%, Al = 12.85% and F = 54.30% in weight), we focused our investigation on Flourine detection. Besides being the most abundant element, it is singularly suitable to avoid the interference of feldspars unlike elements Na and Al. The determination of Flourine in the mineral through the nuclear reaction :

$$^{19}F\,(n,\alpha)\,^{16}N\,;\quad T_{1/2} = 7.35\ s;\quad E_\gamma = 6.14\ MeV,$$

is very useful from the criteria of analysis mentioned above.

In the laboratory, we investigated the technique by utilizing cyclic method of irradiation of the samples with a relatively weak Am-Be radioactive source. This choice of Am-Be as the source, instead of a powerful 14 Mev neutron generator, is made on the consideration of the mean energy of the Am-Be neutrons (<E> = 4.5 MeV) which highly favours the reaction cross section and at the same time lessens the activation of oxygen element present in the formation samples. The measurement of gamma-rays is performed utilizing a NaI(Tl) detector in combination with a 256 channel analyser (PHA) encompassing the energy range of 0.1 to 10.0 MeV.The 256 channel gamma-ray counts of the detector are integrated into five energy bands; 0.253 to 0.652, 0.652 to 1.003, 1.003 to 1.498, 1.498 to 2.807 and 2.807 to 8.138 MeV. A micro-processor permitted successive 15 second accumulations of the gamma-ray counts of the PHA and the storage of data.

The experiment utilized pure Cryolite mineral and background rock formation parts of the core samples and they were analysed previously for the AL and Na percentages in reactor experiments at IPEN. The gamma rays due to Al and Na activation by the Am-Be source in our experiment and any natural radioactivity have energies below 2.8 MeV and contribute to the first four energy band count rates. The Flourine activation and the associated Compton tail are essentially responsible for the 2.81 to 8.14 MeV energy band count rate. The gamma-ray intensity in the successive 15 s intervals in this band provided a half-life decay time of 6.88 ± 0.88s consistent with the Flourine activation. In the figure 1, we show the two succesive 15 s count rates after activation for the samples of the Cryolite and the background rock. The contributions due to the pure Cryolite samples, as seen in the 2.81 to 8.14 MeV band are predominant as compared to the background samples. Especially, the first 15 s measurement after 1 minute of activation of the Cryolite sample showed a 18.2σ significance. The experimental system, therefore permits estimate of any presence of Cryolite mineral content of ×7.8% in weight (at 3σ sensitivity) in formation samples. This percentage although adequate for the exploration purposes, can be improved to ≤ 2.5% by upgrading the source strength by a factor of ten. We intend to present the results of the experiment and also the details of a sensor which can be used for surface measurements and for well logging purposes.

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REFERENCES:

SCHWEITZER, J.S.; HERTZOG, R.C.; SORAN, P.D. 1987. Nuclear data for spectroscopic logging. Nucl.Geophys., 1:213-225.

SCHWEITZER, J.S. 1991 Nuclear techniques in the oil industry, Nucl. Geophys., 5: 65-90.

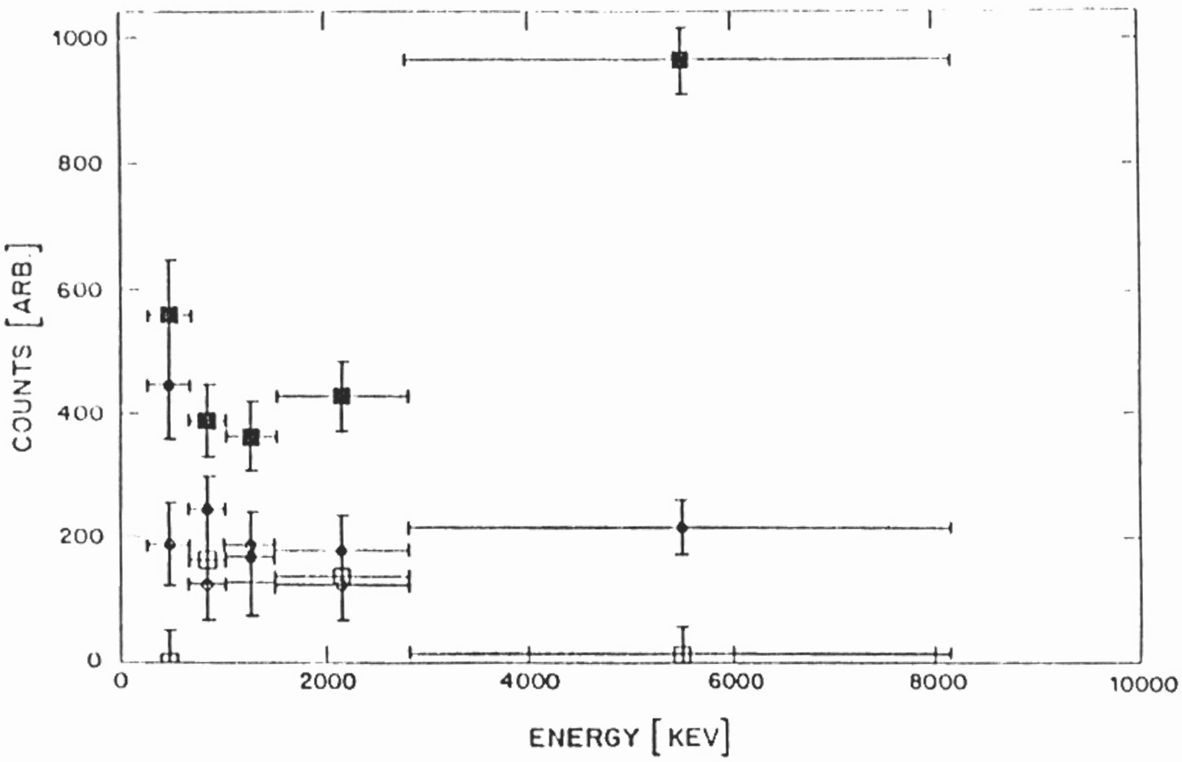

Figure 1: Gamma-ray counts as a function of energy in two successive 15 s measurements after neutron activation in Cryolite (■ , ♦) and background formation (⊞ , ◊) samples.