Design of a program in Matlab environment for gamma spectrum analysis of geological samples

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Abstract. In this work we present the analysis of gamma ray spectra Ammonites found in different places. One of the fossils was found near the city of Cusco (Perú) and the other in “Cajón del Maipo” in Santiago (Chile). Spectra were taken with a hyperpure germanium detector (HPGe) in an environment cooled with liquid nitrogen, with the technique of high-resolution gamma spectroscopy. A program for automatic detection and classifying of the samples was developed in Matlab. It program has the advantage of being able to make direct interventions or generalize it even more, or make it automate for specific spectra and make comparison between them. For example it can calibrate the spectrum automatically, only by giving the calibration spectrum, without the necessity of putting them. Finally, it also erases the external noise.

1. Introduction.

The study of fossils is important in different areas of science such as geology and paleontology. Development of automatic procedures of the analysis of gamma spectrums is important for correct datation of samples. There are many ways of analyzing fossil, the most common is based on the gamma radiation emitted by radioactive nuclei present in the fossil, gamma-ray spectroscopy. Unfortunately, the existing programs do not allow any interference. Neither it is possible to plot the spectra in an easier way in order to get a visualization of radioactive series present. For these reason we had to develop our software from scratch.

In this work we obtained and analysed the spectra of two samples of fossilized ammonite. One of the fossils was found near the city of Cusco and the other in the Cajón del Maipo in Santiago. Gamma-ray spectroscopy of high resolution was done at the Center for Experimental Physics, University of Chile.

The article is organized as follows: in section 2 we will describe the experiment, the spectrum analysis; we have plotted, detected and classified in radioactive series the present elements. Section 3 contains conclusions.

2. Gamma-ray spectroscopy in application to the Ammonite.

The spectra of the two Ammonite samples were taken with a detector of hyperpure Germanium (HPGe) cooled with liquid nitrogen, with the technique of Gamma-ray spectroscopy with high resolution.

The spectral data were collected 24 hours for the fossil of Cusco and 50 hours for the fossil of Santiago. In both cases, the detector was calibrated with NA22. Figure 2 and 3 shows both spectra.

For the correct identification of elements it was necessary to compare our spectrum with calibration curves, plot the calibrated spectrum and correctly identify the pecks. This identification is based on a data base of the transitions which help to find the radioactive nucleus and series to which they belong to. Figure 2 contains the summary of algorithms we used. Figures 3 and 4 contain the results of the spectral analysis. It is possible to can clearly visualize the radioactive series, mainly Th-232, U-238 and U-235, the deleted extreme points, Background and peck.
Figure 1. Main algorithms and subroutines.

Figure 2. Graphic spectrum Fossil Cusco.
For the fossil of Cusco and the Cajon del Maipo we can observe the radioactive series of U-238 in magenta, light-blue U-235 and Th-232 in yellow. Both are the peak of annihilation and Potassium 40. The peaks of the fossil of Cajon del Maipo were higher as well as their areas because their data were taken with more time. Another thing to notice is that the areas of the peaks are in simple counts and not in energy counts.

![Fig.3. Graphic spectrum Fossil of Cajón del Maipo.](image)

The results of the gamma-ray spectrum, the Ammonite Cusco and Santiago are presented in Table 1. In order: The Peaks (abscissa and ordinate), FWHM, resolution, area, standard deviation, Failure to detect the isotope compared with the values of library (less than 5% error. which can be changed).

| Ammonite of Cusco |  |  |  |  |  |  |  |  |  |  |  |  |
|-------------------|---|---|---|---|---|---|---|---|---|---|---|---|
| Peak              | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Energy (keV)      | 78.4 | 106.4 | 249 | 355 | 513.6 | 704.5 | 616.4 | 322.4 | 903.3 | 3470.3 | 74.5 |
| FWHM (keV)        | 6.65 | 0.00 | 6.64 | 6.65 | 6.64 | 0.00 | 6.51 | 0.00 | 6.65 | 8.81 | 0.00 |
| Resolution (in %) | 8.5 | 0.0 | 27.2 | 12.9 | 13.0 | 0.0 | 11.4 | 0.0 | 8.7 | 11.8 | 0.0 |
| Area (Cuestas)    | 455 | 929 | 909 | 341 | 850 | 641 | 119 | 515 | 139 | 98 | 845 |
| Error std (keV)   | 2.9 | 0.98 | 2.0 | 2.6 | 2.6 | 1.0 | 0.9 | 0.9 | 0.8 | 1.0 | 0.7 |
| Error (%)         | 1.7 | 1.3 | 0.2 | 0.4 | 1.0 | 0.5 | 0.2 | 0.2 | 0.2 | 0.0 | 0.1 |

| Ammonite of Cajon del Maipo |  |  |  |  |  |  |  |  |  |  |  |  |
|-----------------------------|---|---|---|---|---|---|---|---|---|---|---|---|
| Peak                        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Energy (keV)                | 78.4 | 106.4 | 249 | 355 | 513.6 | 704.5 | 616.4 | 322.4 | 903.3 | 3470.3 | 74.5 |
| FWHM (keV)                  | 6.65 | 0.00 | 6.64 | 6.65 | 6.64 | 0.00 | 6.51 | 0.00 | 6.65 | 8.81 | 0.00 |
| Resolution (in %)           | 8.5 | 0.0 | 27.2 | 12.9 | 13.0 | 0.0 | 11.4 | 0.0 | 8.7 | 11.8 | 0.0 |
| Area (Cuestas)              | 455 | 929 | 909 | 341 | 850 | 641 | 119 | 515 | 139 | 98 | 845 |
| Error std (keV)              | 2.9 | 0.98 | 2.0 | 2.6 | 2.6 | 1.0 | 0.9 | 0.9 | 0.8 | 1.0 | 0.7 |
| Error (%)                   | 1.7 | 1.3 | 0.2 | 0.4 | 1.0 | 0.5 | 0.2 | 0.2 | 0.2 | 0.0 | 0.1 |

Table 1. Results spectrum Fossil Ammonite Cusco and Cajón del Maipo.

3. Conclusion.

Our studies samples of Ammonite fossils were done with a hyperpure Germanium (HPGe) detector, in an environment cooled with liquid nitrogen, and with the technique of Gamma-ray spectroscopy of high resolution. It is shown that both Ammonite fossils contain the same radioactive chemical elements on two, depite the fact that they were found 3000km from one to the other. These results could be useful for Paleontological research.
To do this study we developed a program in Matlab environment, which can show the spectrum in a graphic, detects the peaks, and detects the radioactive series present. The program is free for anyone who requires it. It can be freely manipulated, whether to make it even more general, or to automatize it in the analysis of new particular spectrum. It doesn’t need the values for calibration peaks, for it detects them by itself.

In the future, we could generalize the program even more, making it capable of analyzing more than one spectrum at a time. This would be useful for comparing the different samples.

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