experiments in many other fields where energetic deuteron beams are used.

The aim of the present paper is to continue the analysis of the experimental work done at the AGLAE facility of the Louvre Museum. It was intended to complete the results (published in [1]), with the presentation of typical γ-ray spectra for the analyzed elements and to construct tables summarizing the most suitable γ-ray lines for elemental analysis of a given element. The thick-target yields for the most characteristic γ-rays of elements with $Z = 3$–20 (except Be, Ne, P and Ar) in the deuteron energy range of 0.7–3.4 MeV are also completed with additional yield curves. DIGE technique has been used in some applied works performed with the deuteron beam of the 5 MV Van de Graaff accelerator of ATOMKI. The experience obtained permits us to point out some features of the method which make DIGE well applicable and complementary to other accelerator-based analytical methods.

2. Experiments and data analysis

Details of experiment for replication

The measurements were performed with deuteron beams from the 6 SDH-2 2 MV Pelletron accelerator of AGLAE. Typical ion currents were in the range of 0.5–10 nA with average measuring times of about 300 s. The collected charge measured by a calibrated current integrator varied between 0.02 and 20 μC depending on the sample and on the deuteron energy. A precision of about 5% in the determination of the ion dose could be achieved with this set-up. Instead of elemental targets, compound samples were used in many cases as stable specimens.

For the detection of γ-rays an Intertechnique n-type HPGe detector (58 mm diameter, 160 cm^3 volume) has been applied at an angle of 135° relative to the incident beam direction with a distance of 10 cm between the front face of the crystal and the samples. The high efficiency of the detection system made it possible to use low ion doses and thus avoid radiation damage of the samples. For other details of the experiment see [1].

The 8k-channel γ-ray spectra were sent to a SUN workstation and analyzed off-line using the programme package FLORENCE available at AGLAE laboratory. The more detailed investigation of the results showed [7] that this package cannot correctly handle either the peaks which are not totally resolved or single peaks showing Doppler broadening. Therefore a reanalysis of the experimental data was made at ATOMKI with the use of the program package FORGAMMA [8] capable of analyzing complex unresolved γ-ray peaks and also line shapes with Doppler broadening.

For the conversion of yields taken with compound samples to those of the respective elements the approximation method of Kenny et al. [9] was followed.

explanation of experimental parameters

Details of why techniques were/were not used

Citation of standard methods

3. Results and discussion

In Figs. 1–14 γ-ray spectra corresponding to each element (bombarded by deuteron beam of 1.8 MeV) and yield curves of the strongest γ-rays are plotted together. Tables listing the γ-ray energies originating from the samples and the nuclear reaction from which the respective γ-rays emerged are added to the figures. The energy values of peaks for which yield curves are showed and proposed to be selected for elemental analysis are typed in bold, contrasted with other peaks originating from the element in question. In the case of the γ-ray spectrum obtained using a $LiSO_4$ sample several other peaks are also marked (their energies are underlined). As for their origin they emerge because the neutrons produced in (d, n) reactions generate (n, n′γ) reactions on nuclei of the Ge crystal and target chamber materials (Al, Fe, Cu). On the other hand, they may come from deuteron-induced reactions on elements like C, O and Si which contaminate mostly the samples but also some parts of the sample chamber or diaphragms of the beam transport line. As it is expected in common γ-ray spectrometry the annihilation peak at 511 keV and the escape peaks (marked by a link to the full energy peaks in the figures) of the high energy peaks also appear. These disturbing peaks are listed in Table 1. (But they are denoted only in the above spectrum to avoid complicate presentation.) The peaks which originate from other