

CLASSIFICATION OF THE ARCHAEOLOGICAL CERAMICS UTILISING THE STRAY NEUTRONS FROM A MEDICAL CYCLOTRON

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Introduction: A batch of finely ground ceramic samples prepared from archaeological shreds including the standard (Ohio Red Clay) were irradiated with thermal neutrons from the irradiation facility developed at the Australian National Medical Cyclotron. The gamma spectra of the samples were assayed with a High Purity Germanium Detector and the concentrations of 10 important trace elements were quantitatively evaluated. This paper highlights the application of the stray neutrons produced during the routine isotope production operation at the cyclotron in the activation analysis of trace elements in archaeological ceramics.

Material and Methods: Four finely ground archaeological ceramic samples and the Ohio Red Clay (standard) were weighed with a chemical balance, enclosed in small nylon vials and irradiated in the thermal neutron irradiation facility (B. Mukherjee et al. Appl. Radiat. Isot. Vol. 46, No. 12, 1333-1335, 1995) at the 30 MeV H^- ion Medical Cyclotron operated by the Radiopharmaceutical Division of ANSTO. The samples were irradiated at an average neutron flux of 3.88×10^9 neutrons. $cm^{-2}.s^{-1}$ for 40 hours in course of a weekly routine radioisotope production run at the cyclotron. After the irradiation the gamma spectra of the samples were assayed with a 30 cm^3 High Purity Germanium Detector for 1000 seconds and the following trace elements a) Arsenic (As), b) Cerium (Ce), c) Chromium (Cr), d) Iron (Fe), e) Lanthanum (La), f) Potassium (K), g) Sodium (Na), h) Scandium (Sc), i) Samarium (Sm) and j) Ytterbium (Yb) were identified and the normalised concentrations (counts $s^{-1}.mg^{-1}$) are shown in Table 1.

Table 1: Normalised concentrations of trace elements in the archaeological samples and the Ohio Red Clay standard identified by thermal neutron activation at the National Medical Cyclotron.

Parent Element	Nuclide Identified	Eg [keV]	HL [h]	Activity Concentrations [count $s^{-1}.mg^{-1}$] of Radionuclides identified in the Ceramic Samples				
				Standard	Nr.1	Nr. 2	Nr.3	Nr.4
Na	Na-22	1369.6	15	6.92E-2	2.99E-1	3.89E-1	7.36E-1	5.30E-1
K	K-42	1525.8	12.4	1.74E-2	6.03E-3	9.51E-3	2.05E-2	1.34E-2
Sc	Sc-46	889.7	2016	8.69E-3	6.58E-3	8.89E-3	1.06E-2	6.22E-3
Cr	Cr-51	319.6	665	1.04E-3	4.09E-3	6.03E-3	1.57E-2	none
Fe	Fe-59	1099.9	1071	2.13E-3	1.58E-3	2.07E-3	none	none
As	As-76	559.0	26.3	4.69E-3	1.07E-3	3.09E-3	4.42E-3	3.22E-3
La	La-140	1597.4	40.2	1.68E-2	6.90E-3	1.09E-3	1.91E-2	1.40E-2
Ce	Ce-141	144.8	780	4.63E-3	1.21E-3	1.92E-3	5.11E-3	none
Sm	Sm-153	103.3	46.7	8.64E-2	3.72E-2	5.76E-2	1.09E-1	7.96E-2
Yb	Yb-175	396.3	100.6	1.56E-3	4.47E-4	1.00E-3	none	none

Conclusion: This experimental work has demonstrated that stray neutrons produced during the routine isotope production run at a commercial Medical Cyclotron could be utilised for activation analysis of archaeological samples. By comparing the activity concentrations of corresponding trace elements relative to the standard (Ohio Red Clay) four unknown archaeological ceramic specimens were successfully classified.