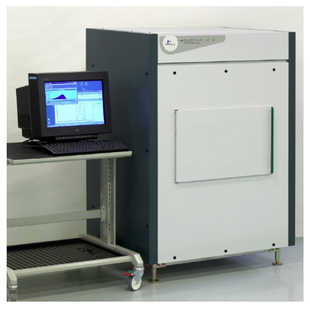
Application of the liquid scintillation alpha and beta spectrometer ***Quantulus 1220*** for dating of natural objects

K. Gruzdov

Federal State Budgetary Institution
«A. P. Karpinsky Russian Geological Research Institute» (FGBU «VSEGEI»)

e-mail: konstantin_gruzdov@vsegei.ru
www.vsegei.ru



Quantulus 1220 is a complete liquid scintillation counting system for the quantitative measurement of extremely low levels of alpha and beta activity.

In the Centre of Isotopic Research (CIR) of FGBU «VSEGEI» ***Quantulus*** is used for radiocarbon dating of various organic objects (wood, peat, soil, bottom sediments, bones), dating young bottom sediments using 210Pb as well as determination the tritium content in water.

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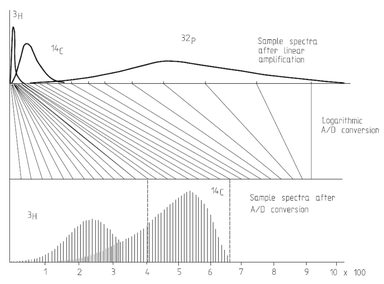
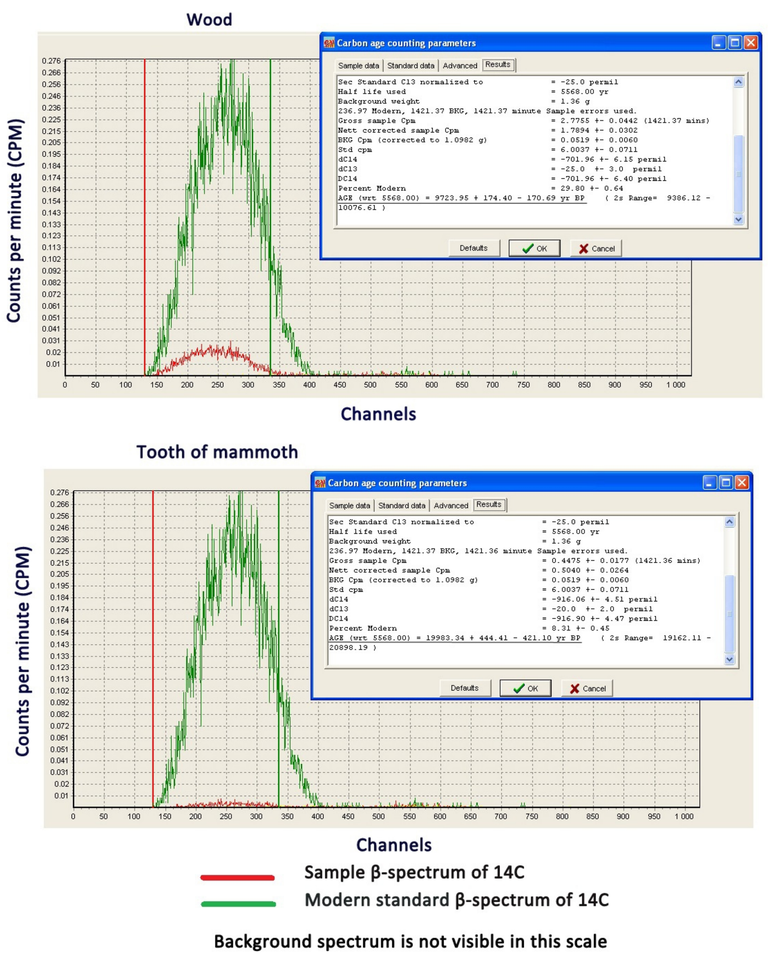


The logarithmic presentation “spreads” the spectra out over a larger channel range than the linear MCA spectra.

Coper-teflon (3-20 ml) and glass sample vials (20 ml).
Plastic vials (20 ml) are used too.



Radiocarbon dating

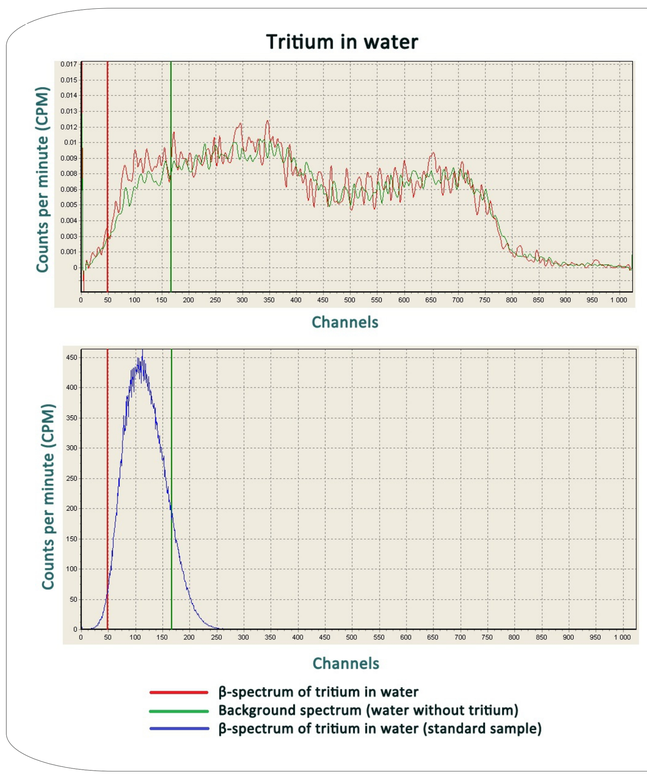
For radiocarbon dating the organic matter of a sample is chemically converted to benzene (C6H6). The 14C activity is measured relative to the modern standard. Also it is necessary to measure the activity of the background sample (benzene without 14C).

The scintillation solvent is a mixture of benzene and PPO (2,5-Diphenyloxazole) and POPOP (1,4-bis(5-phenyloxazol-2-yl)) organic scintillators. The measurement time is usually 24 hours.

Here you can see 14C β-spectra of two organic samples - wood and tooth of mammoth (red) and 14C β-spectrum of modern standard (green).

The radiocarbon age of wood is 9720±170 yr BP (before present, present is 1950).

The radiocarbon age of mammoth tooth is 20000±400 yr BP.



Tritium in water

When measuring the tritium content in water, a water sample (8 ml) is directly mixed with the Optiphase TriSafe liquid scintillator (12 ml). The measurement time is usually 24 hours.

Specific activity of tritium is 1.3 ± 0.2 Bq/L (red line).

The minimum detectable concentration of tritium for this measurement conditions is approximately 0.8 Bq/L.

210Pb in bottom sediments

When dating young bottom sediments by 210Pb, all the lead (99%) in the sample is chemically extracted. Extraction of Pb was executed at heat-shrinkage teflon columns with Sr Spec Eichrom resin (Paquette et al., 2001; Pin et al., 2003.). Output of Pb was about 99%. 8 ml of Pb(NO3)2 solution were added by 12 ml of liquid scintillator Optiphase HiSafe 3.

The 210Pb dating method of young bottom sediments was described e.g. in Pheiffer Madsen et al., 1979.

Transformation chain of 210Pb:

210Pb (β-, $T_{1/2}$=22.3 yr) → 210Bi (β-, $T_{1/2}$=5.013 d) → 210Po (α, $T_{1/2}$= 138.4 d) → 206Pb (stab)

Pulse Shape Analyzer (PSA), standard feature in ***Quantulus***, allows simultaneous acquisition of pure alpha and beta spectra from mixed radiations of a sample. So *β*-spectra of 210Pb and 210Bi and *α*-spectrum of 210Po were detected simultaneously.

The content of 210Pb was calculated by *β*-spectrum of 210Bi. At the moment of analysis 210Pb and 210Bi were in radioactive equilibrium.

The specific activity of 210Pb in our samples was 0.027-0.046 Bq/g (±10%).
It corresponds to the growth rates of bottom sediments 0.2-0.6 cm/yr.

Paquette, J.L., Pin, C. (2001). A new miniaturized extraction chromatography method for precise U-Pb zircon geochronology. Chem. Geol. Isot. Geosci. Sect. 176, 311-319

Pin, C., Joannon, S., Bosq, C., Le Fevre, B. and Gauthier, P. (2003). Precise determination of Rb, Sr, Ba, and Pb in geological materials by isotope dilution and ICP-quadrupole mass spectrometry following selective separation of the analytes. J.Anal.At.Spectrom. 18, 135-141

Pheiffer Madsen, P., Sørensen, J. (1979). Validation of the lead-210 dating method. Journal of Radioanalytical Chemistry. Vol 54, No 1-2 (1979) 39-48