BRUKER ELEMENTAL

Uranium/Thorium Analysis in Obsidian

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BRUKER TEST RESULTS

Objective

Uranium concentrations are typically low, and can be missed by many different calibrations. The goal is to assess a) can we analyze uranium in trace concentrations? And b) can we identify its relationships with other elements?

Method

Obsidian, a volcanic glass that emerges from volcano eruptions, was gathered from 40 different sites around the world, including Africa, Eurasia, North and South America. These data were analyzed using 3 different methods, the first was X-ray fluorescence (XRF) with a Bruker Tracer IIISD, the second was Inductively-Coupled Plasma Mass Spectrometry (ICP-MS), and Neutron Activation Analysis (NAA). These data were used to build a quantitative calibration, the most accurate of its kind for XRF.

Data were collected at 40 keV with a current of 30 μA in dry air conditions with a 0.1524mm Cu/0.0254mm Ti/ 0.3048mm Al filter. This allowed for minimal detection of elements which fluoresce in the 13 - 15 keV range, including Thorium, Rubidium, Uranium, Strontium, Yttrium, Zirconium, Niobium, and Molybdenum. These data were then analyzed semi-quantitatively using Bayesian deconvolution in Bruker Artax software (7.4.0).

Background

Uranium has a characteristic L-shell fluorescence at 13.61 keV, and can frequently be overwhelmed by the appearance of Rubidium which has a K-shel fluorescence at 13.40 keV. As a consequence, this can be missed in many calibrations.

Results

Uranium, which exists in a range from 0-35 ppm, was detected using XRF in combination with Bayesian Deconvolution:

- A significant correlation between Uranium and Thorium can be seen ($R2 = 0.46$, $p < 0.01$).
- Uranium can be detected at close to 10 ppm under proper conditions with handheld XRF, though this depends on other elemental concentrations.

RESULTS

Bayesian Deconvolution

Bayesian Deconvolution was run using Bruker's Artax software, with 10 stripping cycles. This was used to generate net photon count rates that can be converted into quantitative results.

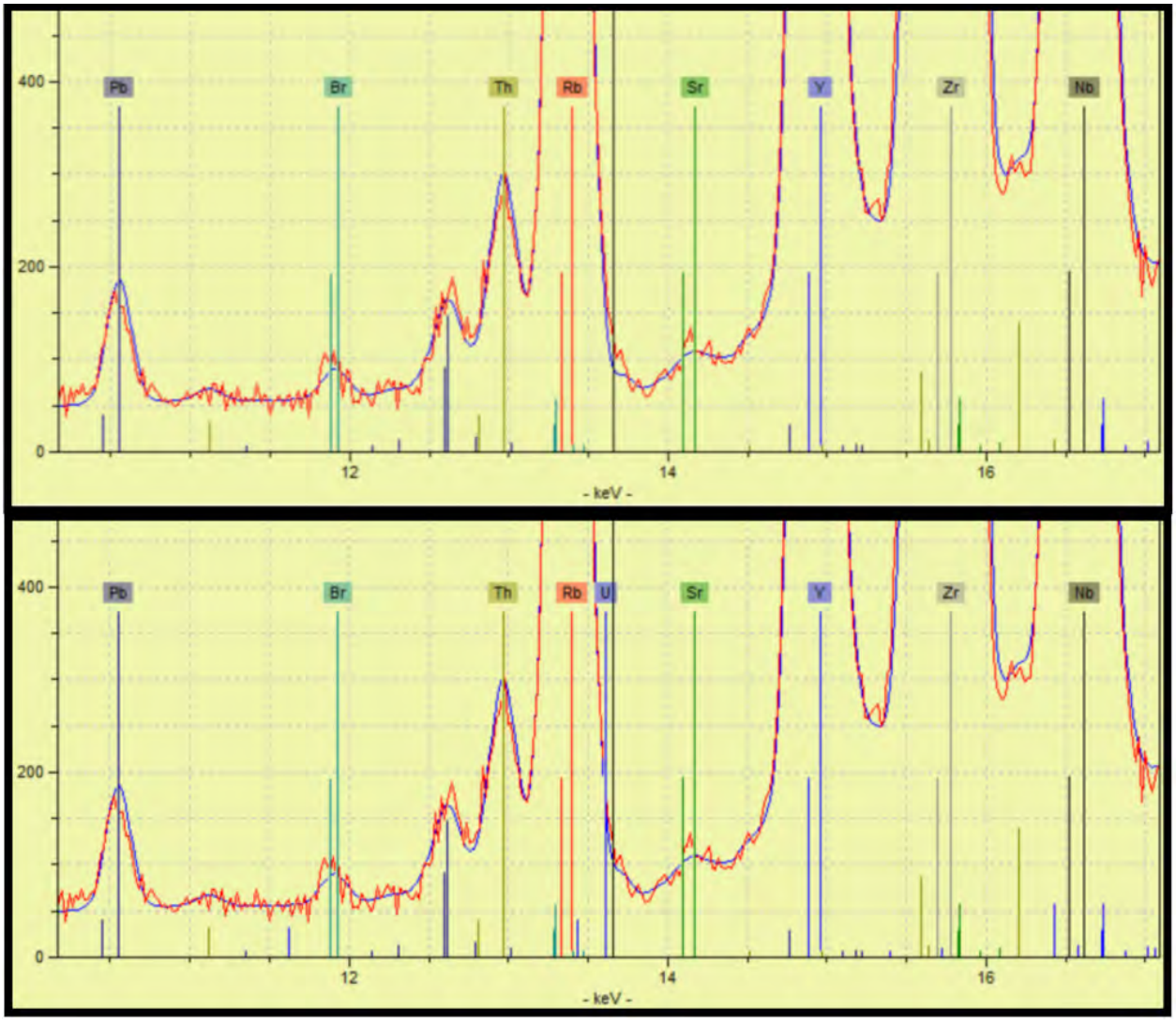

Figure 1: Spectral results of different oil standards. The upper figure shows the empirical data (red spectrum) and the simulated data (blue spectrum). There is a bad fit at 13.7 keV. Uranium was added to the simulated spectrum, and both empirical and simulated data agree.

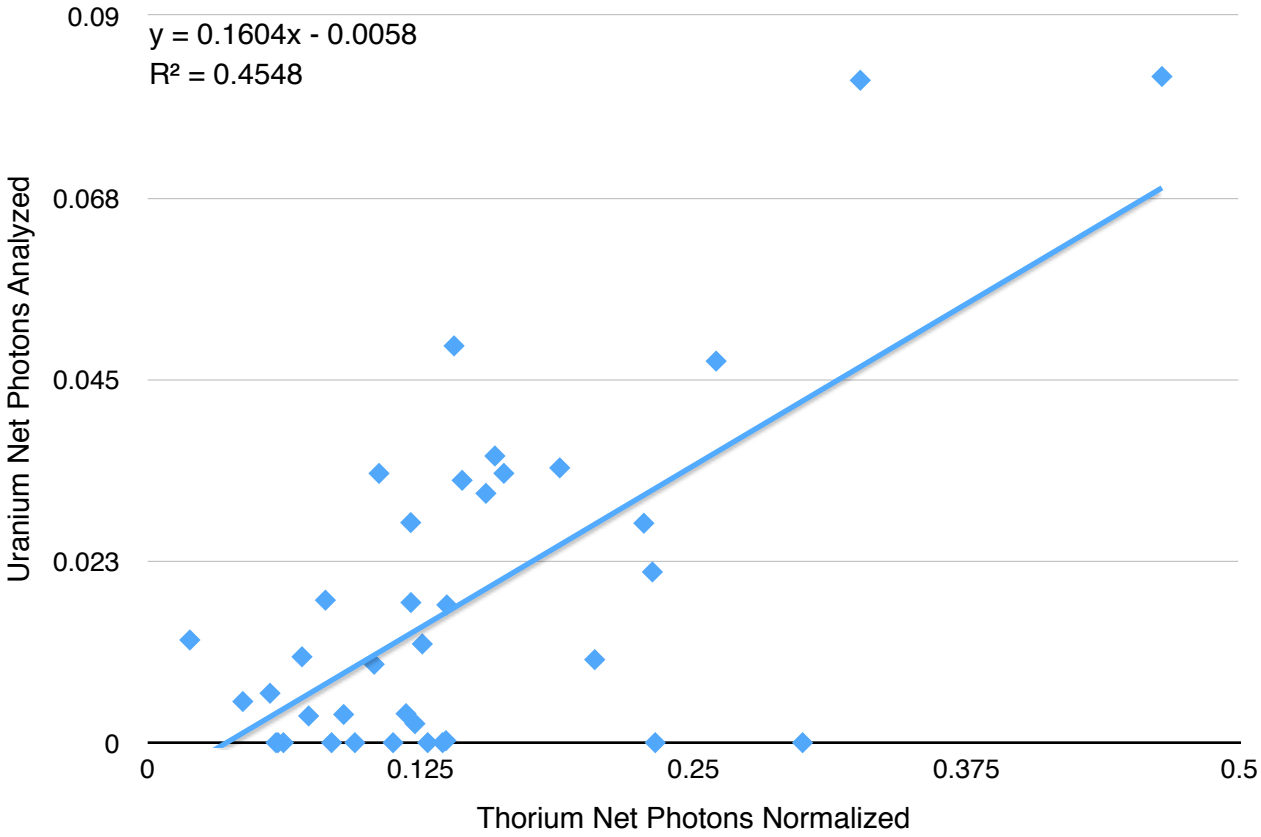

Figure 2: Calibration Validation. Sulfur Net Photons has a strong correlation with sulfur concentrations (ppm).

Obsidian Source	Th/Rh Net Photon Ratio	U/Rh Net Photon Ratio	Th (ppm)	U (ppm)
OB40Archibarca35	0.1180	0.0040	14.87	3.23
OB40Basaltic_Plateau20	0.0080	0.0000	0.75	
OB40Big_Southern_Butte06	0.1630	0.0330	18.96	16.07
OB40Blue_Mountain04	0.0600	0.0000	6.17	2.42
OB40Burns_Green15	0.0810	0.0180	7.71	2.58
OB40Cannonball1_22	0.3000	0.0000	40.65	10.94
OB40Casa_Diablo10	0.1120	0.0000	15.29	5.50

Obsidian Source	Th/Rh Net Photon Ratio	U/Rh Net Photon Ratio	Th (ppm)	U (ppm)
OB40Cerro_del_Medio28	0.1350	0.0000	16.22	6.61
OB40Chickahominy26	0.0900	0.0030	7.73	3.34
OB40Cougar_Mountain29	0.0710	0.0110	6.88	2.88
OB40Davis_Creek27	0.0740	0.0030	9.58	3.64
OB40East_Medicine_lake12	0.1200	0.0270	15.13	6.04
OB40El_Paraiso24	0.2310	0.0210	29.81	8.12
OB40El_Peceno40	0.1060	0.0330	11.48	9.01
OB40Glass_Buttes03	0.0840	0.0000	8.50	3.35
OB40Grasshopper_Flat13	0.1210	0.0170	13.01	5.21
OB40Gregory_Creek38	0.0440	0.0050	3.82	2.37
OB40Guadalupe_Victoria02	0.0620	0.0000	7.64	4.63
OB40Inman_Creek14	0.0590	0.0000	6.71	2.79
OB40KES_276_18	0.2270	0.0270	35.76	16.61
OB40KES_362_17	0.4650	0.0830	82.93	35.28
OB40La_Joya16	0.1370	0.0000	15.84	6.85
OB40McDaniel_Tank21	0.1220	0.0020	17.87	5.42
OB40Meydan_Tepe36	0.2050	0.0100	23.66	8.40
OB40Mono_Craters07	0.1440	0.0320	18.84	6.96
OB40Mule_Creek19	0.2320	0.0000	28.62	7.67
OB40Obsidian_Cliffs39	0.0560	0.0060	6.85	3.17
OB40Pachuca30	0.1550	0.0310	18.66	8.94
OB40Paredon34	0.1370	0.0170	17.35	7.27
OB40Polvadera31	0.1400	0.0490	16.42	10.28
OB40RS_Hill08	0.3260	0.0820	42.65	25.12
OB40San_Leonel32	0.1280	0.0000	14.39	5.14

Obsidian Source	Th/Rh Net Photon Ratio	U/Rh Net Photon Ratio	Th (ppm)	U (ppm)
OB40Sarikamis37	0.1590	0.0360	16.44	6.72
OB40Timber_Butte01	0.1260	0.0120	11.97	6.50
OB40Tucker_Hill11	0.0950	0.0000	7.58	4.17
OB40VNN-2_25	0.1410	0.0000	21.53	10.16
OB40West_New_Britain1_05	0.0190	0.0130	1.48	1.11
OB40Whitewater_Ridge09	0.1040	0.0100	9.21	4.54
OB40Witham_Creek23	0.1890	0.0340	26.11	12.76
OB40Zacualtipan33	0.2600	0.0470	35.83	11.56

Table 1: Bayesian Deconvolution and quantitative results from NAA/ICP-MS