Technique Note

Determination of cadmium in geological samples by aerosol dilution ICP-MS after inverse aqua regia extraction

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Supplementary Information

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Table S1. Spectral interferences on Cd isotopes

Analyte		Interference ions (Abundance, %)	
Isotope	Abundance (%)	Polyatomic	Isobaric
^{106}Cd	1.25	^{89}YOH (100) ^{90}ZrO (51.45)	^{106}Pd (27.33)
^{108}Cd	0.89	^{91}ZrOH (11.22) ^{92}ZrO (17.15) ^{92}MoO (14.53)	^{108}Pd (26.46)
^{110}Cd	12.49	^{93}NbOH (100) ^{94}MoO (9.15) ^{94}ZrO (17.38)	^{110}Pd (11.72)
^{111}Cd	12.8	^{94}ZrOH (17.38) ^{94}MoOH (9.15) ^{95}MoO (15.84)	/
^{112}Cd	24.13	^{95}MoOH (15.84) ^{96}MoO (16.67) ^{96}ZrO (2.8)	^{112}Sn (0.97)
^{113}Cd	12.22	^{96}ZrOH (2.8) ^{96}MoOH (16.67) ^{97}MoO (9.6)	^{113}In (4.29)
^{114}Cd	28.73	^{97}MoOH (9.6) ^{98}MoO (24.39) ^{98}RuO (1.87)	^{114}Sn (0.66)
^{116}Cd	7.49	^{99}RuOH (12.76) ^{100}RuO (12.6) ^{100}MoO (9.82)	^{116}Sn (14.54)

Table S2. The Cd levels in 77 Chinese geological SRMs by the proposed method, μg g^{-1}

Geological SRMs		Description	Determined values (N=3)	Certified values
Soil	GSS-1	Dark-brown earth	4.10 ± 0.10	4.30 ± 0.40
	GSS-2	Chestnut soil	0.061 ± 0.004	0.071 ± 0.014
	GSS-3	Yellow-brown earth	0.054 ± 0.001	0.060 ± 0.009
	GSS-4	Limy red earth	0.321 ± 0.003	0.350 ± 0.060
	GSS-5	Yellow-red earth	0.460 ± 0.020	0.450 ± 0.060
	GSS-6	Yellow-red earth	0.134 ± 0.007	0.130 ± 0.030
	GSS-7	Laterite(latosol)	0.088 ± 0.008	0.080 ± 0.020
	GSS-8	Loess	0.115 ± 0.008	0.130 ± 0.020
	GSS-9	Soil	0.089 ± 0.002	0.100 ± 0.020
	GSS-10	Farming soil	0.099 ± 0.008	0.105 ± 0.013
	GSS-11	Soil	0.115 ± 0.008	0.125 ± 0.012
	GSS-12	Soil	0.140 ± 0.007	0.150 ± 0.020
	GSS-13	Soil	0.120 ± 0.002	0.130 ± 0.010
	GSS-14	Soil	0.200 ± 0.010	0.200 ± 0.020
	GSS-15	Soil	0.213 ± 0.009	0.210 ± 0.020
	GSS-16	Sandy soil	0.264 ± 0.004	0.250 ± 0.020
	GSS-17	Saline-alkali soil	0.055 ± 0.002	0.058 ± 0.011
	GSS-18	Brown desert soil	0.140 ± 0.009	0.150 ± 0.010
	GSS-19	Saline-alkali soil	0.099 ± 0.008	0.108 ± 0.009
	GSS-20	Sierozem soil	0.103 ± 0.005	0.108 ± 0.011
	GSS-21	The Yellow Sea tidal flat soil	0.132 ± 0.002	0.139 ± 0.008
	GSS-22	Soil	0.058 ± 0.003	0.065±0.012
	GSS-23	Tidal flat soil	0.130 ± 0.010	0.150 ± 0.020
	GSS-24	Soil	0.102 ± 0.004	0.106 ± 0.007
	GSS-25	Huai River soil	0.167 ± 0.008	0.175 ± 0.010
	GSS-26	Yangtze River soil	0.130 ± 0.005	0.140 ± 0.010
	GSS-27	Soil	0.570 ± 0.010	0.590 ± 0.040
	GSS-28	Soil	0.520 ± 0.030	0.520 ± 0.030
Sediment	GSD-1	Granite area sediment	0.075 ± 0.008	0.088 ± 0.014
	GSD-2	Stream sediment	0.060 ± 0.003	0.065 ± 0.011
	GSD-3	Porphyry copper deposit sediment	0.090 ± 0.010	0.100 ± 0.020
	GSD-4	Limestone ore district sediment	0.192 ± 0.003	0.190 ± 0.020
	GSD-5	Skarn mining area sediment	0.840 ± 0.030	0.820 ± 0.050
	GSD-6	Porphyry copper deposit sediment	0.425 ± 0.013	0.430 ± 0.030
	GSD-7	Stream sediment	1.20 ± 0.06	1.05 ± 0.06
	GSD-8	Acidic volcano rock area sediment	0.074 ± 0.003	0.081 ± 0.012
	GSD-9	Yangtze River sediment	0.250 ± 0.030	0.260 ± 0.040
	GSD-10	Carbonate area sediment	1.160 ± 0.045	1.12 ± 0.08
	GSD-11	Multi metal mining area sediment	2.33 ± 0.05	2.30 ± 0.20
	GSD-12	Stream sediment	4.20 ± 0.30	4.00 ± 0.30
	GSD-13	Quartz sand area sediment	0.031 ± 0.001	0.045 ± 0.015
	GSD-14	Sediment	0.180 ± 0.010	0.200 ± 0.030
	GSD-15	Multi metal mining area sediment	0.325 ± 0.008	0.340 ± 0.020
	GSD-16	Metamorphic rock area sediment	0.084 ± 0.010	0.093 ± 0.009
	GSD-17	Stream sediment	4.50 ± 0.30	4.30 ± 0.50
	GSD-18	Granite area sediment	0.091 ± 0.005	0.095 ± 0.010
	GSD-19	Stream sediment	0.088 ± 0.007	0.120 ± 0.01
	GSD-20	Copper nickel mine sediment	0.216 ± 0.005	0.220 ± 0.010
	GSD-21	Acidic volcano rock area sediment	0.780 ± 0.04	0.760 ± 0.030
	GSD-22	Copper ore district sediment	0.164 ± 0.002	0.165 ± 0.010
	GSD-23	Stream sediment	4.69 ± 0.07	4.80 ± 0.50
	GSD-1a	Granite area sediment	0.091 ± 0.006	0.110 ± 0.030

	GSD-2a	Granite area sediment	0.102 ± 0.004	0.108 ± 0.009
	GSD-3a	Copper nickel mine sediment	0.493 ± 0.005	0.500 ± 0.060
	GSD-4a	Limestone area sediment	0.850 ± 0.060	0.900 ± 0.050
	GSD-5a	Skarn mining area sediment	1.36 ± 0.08	1.37 ± 0.10
	GSD-7a	Lead zinc mine sediment	5.20 ± 0.20	5.60 ± 0.60
	GSD-8a	Acidic volcano rock area sediment	0.150 ± 0.010	0.160 ± 0.010
Rock	GSR-2	Andesite	0.062 ± 0.007	0.061 ± 0.014
	GSR-4	Quartz sandstone	0.055 ± 0.005	0.060 ± 0.016
	GSR-6	Argillaceous limestone	0.062 ± 0.030	0.070 ± 0.020
	GSR-8	Lujavritite	0.660 ± 0.030	0.610 ± 0.080
	GSR-10	Gabbro	0.069 ± 0.003	0.090 ± 0.030
	GSR-11	Rhyolite	0.150 ± 0.010	0.140 ± 0.020
	GSR-12	Dolomite	0.067 ± 0.003	0.070 ± 0.020
	GSR-16	Diabase	0.370 ± 0.010	0.390 ± 0.080
	GSR-17	Kimberlite	0.570 ± 0.050	0.460 ± 0.200
	GSR-22	Limestone	0.121 ± 0.011	/
	GSR-23	Limestone	0.770 ± 0.040	/
	GSR-24	Limestone	0.063 ± 0.006	/
	GSR-27	Limestone	0.550 ± 0.050	/
	GSR-28	Limestone	0.510 ± 0.030	/
	GUI-1	Limestone	0.042 ± 0.005	/
	GUI-1	Limestone	0.160 ± 0.017	/
	DIAN-1	Limestone	0.520 ± 0.030	/
	DIAN-2	Limestone	0.366 ± 0.027	/
	DIAN-3	Limestone	0.209 ± 0.015	/

Table S3. Closed pressurized digestion with a mixture of HF + HNO_3

Step	Description
1	50 mg sample powder (< 200 mesh) was weighed into a Teflon bomb, moistened with a few drops of ultrapure water.
2	1.0 mL HNO_3+1.0 ml HF were added. The sealed bomb was heated at 190 °C in oven for > 48 h.
3	Open the bomb and evaporate the solution at ∼120 °C to dryness. This was followed by adding 1 ml HNO_3 and evaporating to the second round of dryness.
4	The resultant salt was re-dissolved by adding ∼3 ml of 30% HNO_3 and resealed and heated in the bomb at 190 °C for >12 h.
5	The final solution was diluted to ∼100 g with mixture of 2% HNO_3 for ICP-MS analysis.

Table S4. The Ag levels in 8 geological SRMs by the proposed method, μg g^{-1}

Geological SRMs	Determined values (N=3)	Certified values
GSS-1, Dark-brown earth	0.365±0.004	0.35±0.05
GSS-6, Yellow-red earth	0.180±0.006	0.2±0.02
GSS-7, Laterite (latosol)	0.063±0.009	0.057±0.011
GSD-3, Porphyry copper deposit sediment	0.57±0.01	0.59±0.05
GSD-6, Porphyry copper deposit sediment	0.351±0.011	0.36±0.03
GSR-2, Andesite	0.059±0.003	0.071±0.009
GSR-4, Quartz sandstone	0.057±0.002	0.062±0.007
BCR-2, basalt	0.035±0.001	0.041±0.004

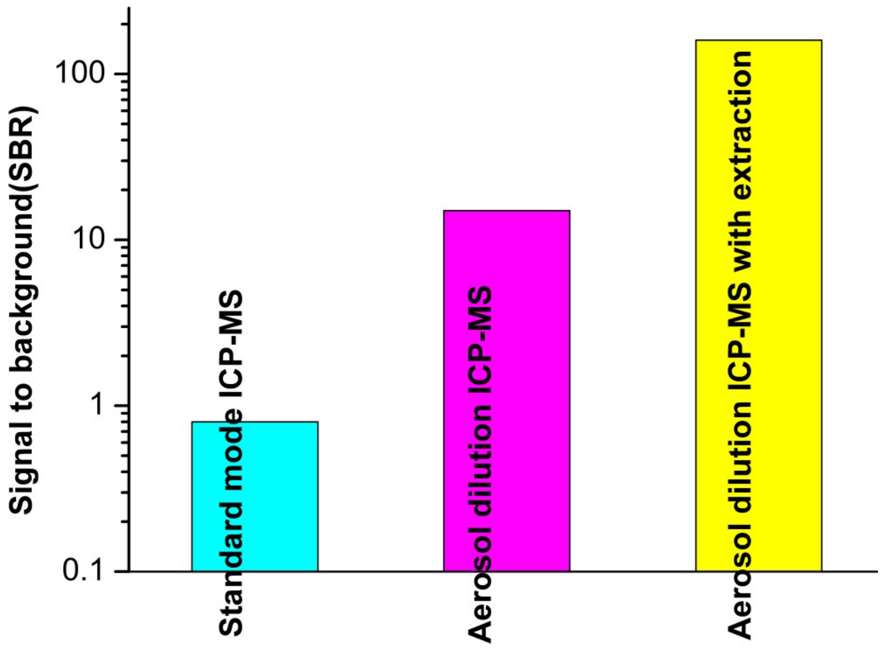

Fig.S1. Comparison of the SBR of three analysis method for Cd determination under the respective optimized conditions. Methods are: conventional standard mode ICP-QMS after complete digestion, aerosol dilution ICP-QMS after complete digestion, and aerosol dilution ICP-QMS after boiling inverse aqua regia extraction. The certified Cd concentration (1 ng mL^{-1}) and the matrix element concentrations (200 ng mL^{-1} Mo and 1000 ng mL^{-1} Zr) were used to calculate the SBR values. 90% Zr was removed by the boiling inverse aqua regia extraction.

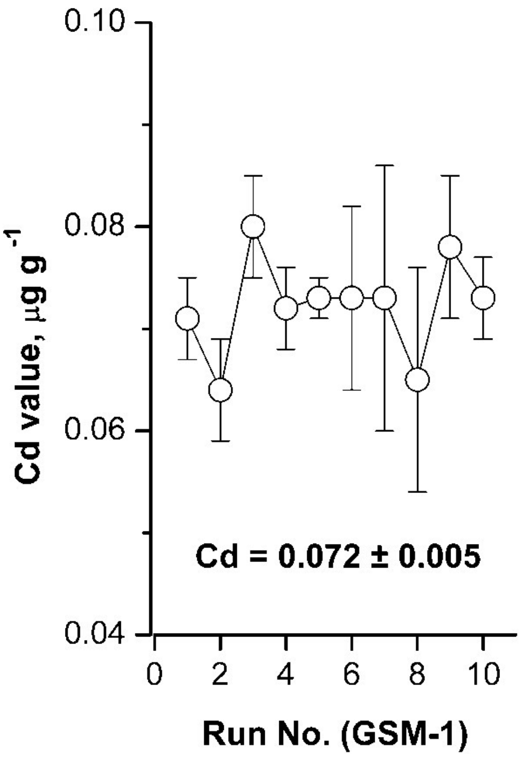

Fig.S2. Stability of Cd values obtained by aerosol dilution ICP-MS in SRM GSM-1. Mean ± SD, the SD is the standard deviation for ten separate aliquots of the samples analyzed over a period of three months. The error bars in Figure were defined as the standard deviation for 3 replicates in single analysis.