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Data Article

Data on rare earth elements in mining environments under non-acidic conditions

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ABSTRACT

This article contains analytical data on Rare Earth Elements (REE) concentration in waters and solid samples (mining wastes and biominerals) collected in an abandoned mining site characterized by near-neutral conditions, and they are related with the research article "Geochemistry of rare earth elements in water and solid materials at abandoned mines in SW Sardinia (Italy)" (Medas et al., 2013).

REE can show specific signatures due to fractionation processes, giving an insight to the understanding of the natural processes ruling the water–rock interactions and the geo–bio-interactions. Most researches on REE behavior were performed in acidic environments, while only few data on REE are available for neutral waters. Elaboration of this dataset can be useful to evaluate the reactions controlling the geochemical behavior of REE under near-neutral to slightly alkaline conditions, driving the scientific community toward an efficient management of monitoring actions and remediation technologies.

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Specifications table

Subject area	*Earth and Planetary Sciences*
More specific subject area	*Geochemistry and Petrology*
Type of data	Figures and Tables.
How data was acquired	Inductively coupled plasma mass spectrometry (ICP-MS, Perkin-Elmer, Elan 5000/DRC-e, USA), X ray diffraction (conventional θ–2θ equipment – Panalytical – with Cu K_α wavelength radiation – $\lambda = 1.54060$ Å, operating at 40 kV and 40 mA, using the X'Celerator detector).
Data format	Analyzed, elaborated.
Experimental factors	Water samples were collected and stabilized according to established protocols, then they were stored in a refrigerator until the analysis. Solid samples were dried, grounded and acid digested by a microwave (ETHOS One, Advanced Microwave Digestion System, Milestone) prior to the analysis by ICP-MS.
Experimental features	Mineralogical composition of mine wastes and biominerals and REE contents were determined.
Data source location	Ingurtosu, SW Sardinia, Italy.
Data accessibility	Data are with this article.
Related research article	Medas D, Cidu R, De Giudici G, Podda F, Geochemistry of rare earth elements in water and solid materials at abandoned mines in SW Sardinia (Italy), J Geochem. Explor., 2013, 133, 149–159.

Value of the data

- The presented data contribute to create a database of Rare Earth Element contents in different environmental matrices collected in abandoned mining areas.
- The collected data can be compared with literature and new acquired data from other researchers for the understanding of the geochemical and mineralogical processes.
- The investigation of Rare Earth Element fractionation processes can help to design efficient remediation actions.

1. Data

Samples were collected in the Ingurtosu Zn–Pb abandoned mining area, located in the South–West of Sardinia, Italy (Fig. 1). After the mine closure (1968), no remediation actions were undertaken to avoid the dispersion of metals, resulting in the pollution of both waters and soils [1–2]. Rio Naracauli is the main stream of the area, it receives drainages from mine tailings, and then flows into the Mediterranean Sea. Naracauli waters have pH values (6.9–8.4) near neutral to slightly alkaline. Along the stream, the peculiar precipitation of two biominerals is observed during the spring and summer seasons, namely hydrozincite, $Zn_5(CO_3)_2(OH)_6$ [3–5], and an amorphous Zn-silicate [6–10], making this area an distinctive system for the investigation of both water–rock interaction and geo–bio interaction processes.

Rare Earth Elements (REE) were determined in stream waters, drainages from mine tailings and solid materials (mine wastes and biominerals) to elucidate REE fractionation processes occurring in a near-neutral environment. Data are reported in Figs. 2 and 3 and Tables 1–9. For a detailed description and discussion of the data see [1].

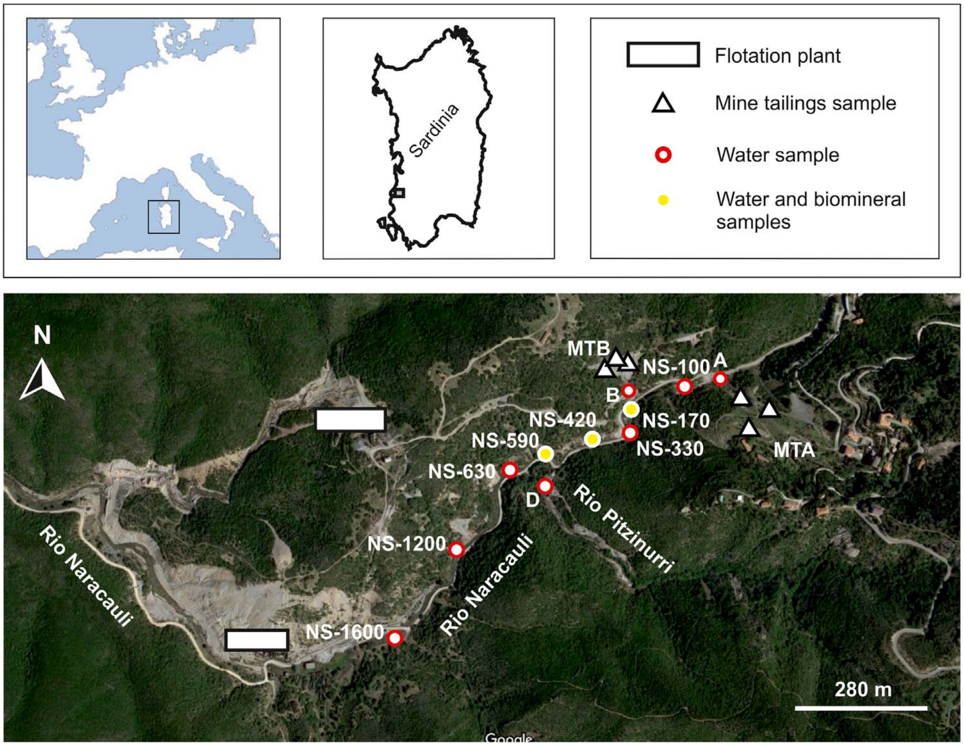

Fig. 1. Map with the location of the sampling points in the Ingurtosu mining district. Image from Google Maps, modified.

2. Experimental design, materials, and methods

Mine waste samples were dried at room temperature, and ground for X ray diffraction analysis that was performed using a conventional θ–2θ equipment (Panalytical) with Cu K_α wavelength radiation ($\lambda = 1.54060$ Å), operating at 40 kV and 40 mA, using the X'Celerator detector. For chemical analysis, biominerals (hydrozincite) and mine waste samples were ground and acid digested by a microwave (ETHOS One, Advanced Microwave Digestion System, Milestone), according to [1]. To evaluate accuracy and precision of the laboratory procedures, samples were processed together with the reference material RTS-3 (CANMET, Canadian Certified Reference Materials Project (CCRMP)) prepared with the same mixture.

Water samples were collected from 2009 to 2011 and consist of i) stream waters (NS-100 to NS-1600), ii) tributary (labeled by D), and iii) tailing drainages (labeled by A and B). Redox potential (Eh) and pH were determined on site according to [1].

REE in acid digested samples and in water samples were determined on filtered (0.4 µm, Nuclepore 111130) and acidified aliquots (1% HNO_3 ultrapure grade) by inductively coupled plasma mass spectrometry (ICP-MS, Perkin-Elmer, Elan 5000/DRC-e, USA) with the desolvation system Apex-Q, that increases the sensitivity and reduces the interferences due to oxides according to [11]. Also, the standard addition method [12] was used in some water samples characterized by different compositions. To quantify yttrium and REE in the water and solid samples the isotopes ^{89}Y, ^{139}La, ^{140}Ce, ^{141}Pr, ^{142}Nd, ^{146}Nd, ^{147}Sm, ^{152}Sm, ^{151}Eu, ^{153}Eu, ^{157}Gd, ^{158}Gd, ^{159}Tb, ^{163}Dy, ^{164}Dy, ^{165}Ho, ^{166}Er, ^{167}Er, ^{169}Tm, ^{172}Yb, ^{174}Yb, and ^{175}Lu were used.

For investigating fractionation processes of REE during precipitation of the solid phases, solid samples and waters were collected in the same station at the same time.

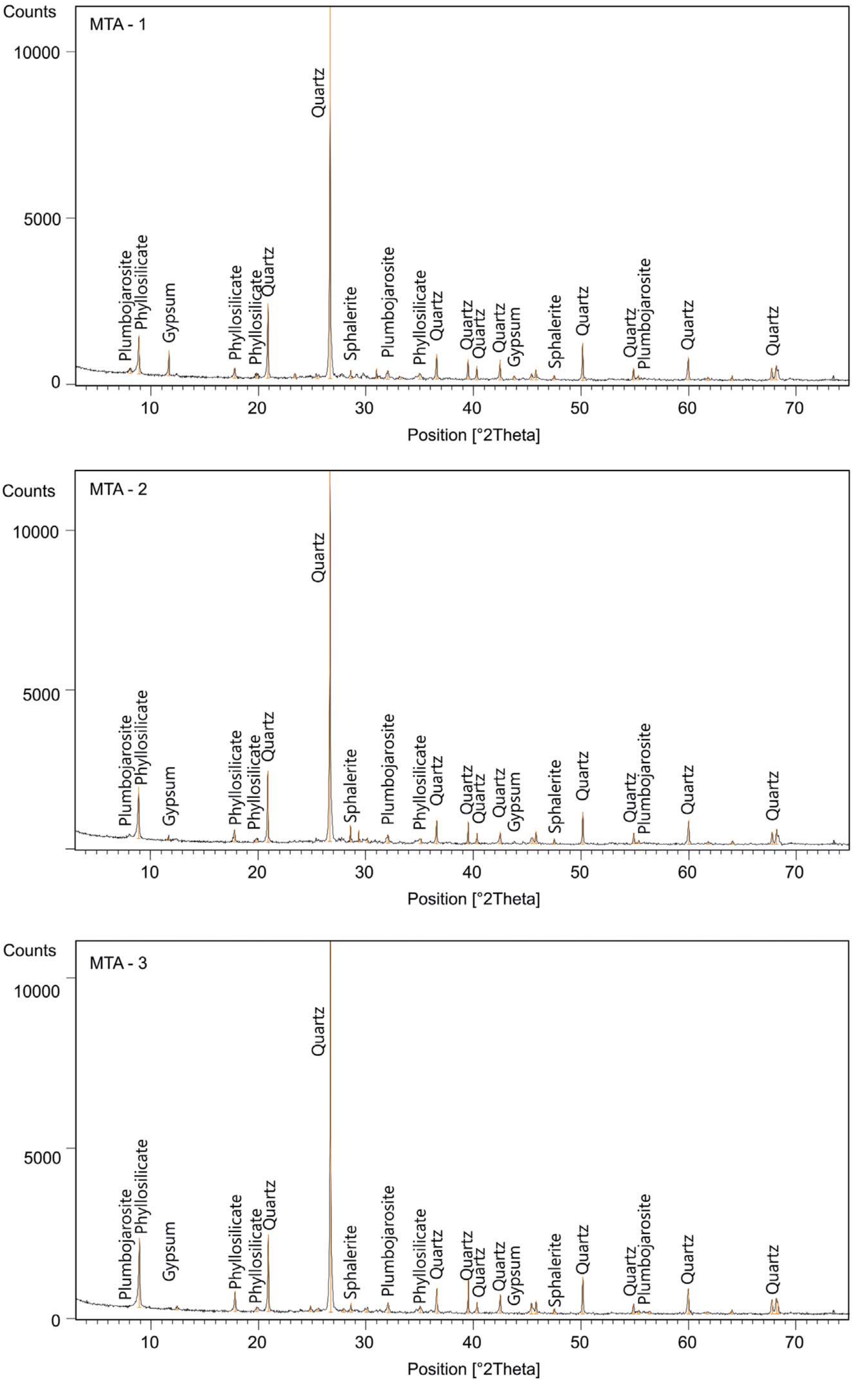

Fig. 2. X ray diffraction patterns of the mine tailings samples collected in the Ingurtosu mining district (sampling site MTA).

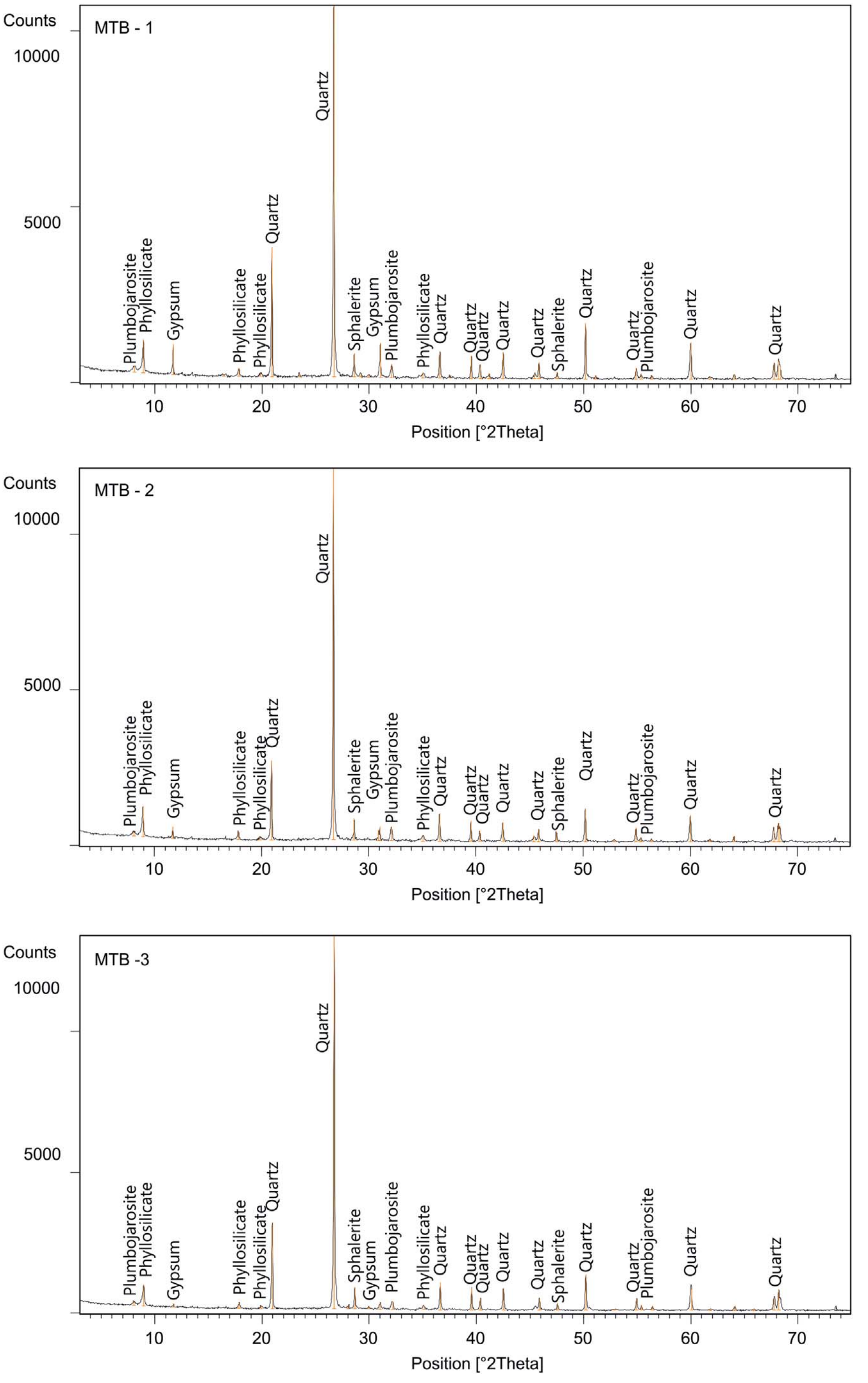

Fig. 3. X ray diffraction patterns of the mine tailings samples collected in the Ingurtosu mining district (sampling site MTB).

Table 1
pH, redox potential (Eh), total dissolved solids (TDS) and Y-REE in the Rio Naracauli waters, continues. ΣREE indicates the sum from La to Lu.

Sample	**Date**	**pH**	**Eh**	**TDS**	**Y**	**La**	**Ce**	**Pr**	**Nd**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**	**∑ REE**
			mV	mg/l	ng/l															
NS-100	18 March 2009	7.4	466	1042	590	740	367	81	290	58	26	90	12	58	11	24	2.2	11	1.7	1772
NS-170	18 March 2009	7.5	466	1020	360	404	123	38	129	19	9.7	37	5.4	24	4.9	12	1.4	7.4	1.2	816
NS-330	18 March 2009	7.7	475	1310	180	166	53	18	63	12	7	18	3	13	< 4	5.7	< 1	4.5	< 1	363
NS-420	18 March 2009	7.8	492	1239	60	44	< 25	< 13	< 34	< 6	3.8	< 5	1.2	3.1	< 4	< 3	< 1	< 3	< 1	52
NS-590	18 March 2009	7.9	492	1255	22	26	23	< 13	< 34	< 6	3.7	< 5	< 1	< 3	< 4	< 2	< 1	< 3	< 1	53
NS-630	18 March 2009	7.4	497	637	44	34	45	< 13	< 34	< 6	4.4	7.2	1.2	4.3	< 4	3	< 1	3	< 1	102
NS-1200	18 March 2009	7.7	511	645	64	40	30	< 13	< 34	< 6	3.3	7	1.1	5.6	< 4	3	< 1	3	< 1	93
NS-1600	18 March 2009	7.8	480	597	84	47	23	< 13	< 34	3.5	5.3	7.9	1.2	4.9	< 4	4.2	< 1	3	< 1	100
NS-100	25 March 2009	7.3	488	1006	380	404	60	32	120	20	10	34	4.5	22	5.2	14	1.6	7.9	1.4	737
NS-170	25 March 2009	7.4	483	1001	149	124	31	11	36	6	5.2	11	1.8	7.7	2	4.8	< 1	3	< 1	244
NS-330	25 March 2009	7.6	480	1283	153	140	44	14	44	15	6.1	13	2.2	9	< 4	7	< 1	3.6	< 1	297
NS-420	25 March 2009	7.8	458	1269	67	94	72	8.8	26	< 6	4.2	7	< 1	4	< 4	3	< 1	< 3	< 1	219
NS-590	25 March 2009	7.9	446	1265	18	28.9	32	< 13	< 34	< 6	3.8	< 5	< 3	< 1	< 4	< 2	< 1	< 3	< 1	65
NS-100	17 April 2009	6.9	602	1134	770	943	341	92	341	59	26	110	13	62	13	32	3.7	19	2.5	2057
NS-170	17 April 2009	7.1	571	1147	760	940	580	117	430	90	37	137	17	77	15	33	3.6	17	2.5	2496
NS-330	17 April 2009	7.2	615	1284	470	514	183	54	200	33	13	56	7.5	36	8	19	2.5	11	1.6	1139
NS-420	17 April 2009	7.2	619	1261	192	141	63	< 13	48	7	5.9	11	2.1	9.3	< 4	4.9	< 1	4	< 1	296
NS-590	17 April 2009	7.3	474	1224	78	77	41	< 13	< 34	8	4.2	7	1.5	5.4	< 4	2	< 1	< 3	< 1	146
NS-1200	17 April 2009	7.2	483	571	198	2190	268	33	128	31	11	35	5.3	28	5.9	14	2.3	11	2	2765
NS-100	07 May 2009	7.2	536	1146	360	410	132	40	145	28	11	44	6.1	26	5.7	14	1.5	7	1.4	871
NS-170	07 May 2009	7.4	524	1162	146	226	81	18	55	12	6.5	18	2.5	11	2.7	5	< 1	1.9	< 1	440
NS-330	07 May 2009	7.6	513	1281	133	131	49	14	47	9.2	6	15	2.2	9.2	1.9	6	< 1	3	< 1	294
NS-420	07 May 2009	7.8	516	1393	60	53	22	5.2	17	< 5	3.5	5	1	4	< 2	2	< 1	< 2	< 1	112
NS-590	07 May 2009	7.8	505	1339	25	26	< 25	< 5	12	< 5	3	< 4	< 1	2	< 2	< 2	< 1	< 2	< 1	43
NS-1200	07 May 2009	7.9	499	726	75	73	42	11	33	7	4	12	1.3	5	< 2	4.4	< 1	3.8	< 1	196
NS-100	21 May 2009	7.2	523	1093	259	268	68	20	73	15	11.2	22	3.3	15	4.2	9	1.1	4	< 1	514
NS-170	21 May 2009	7.5	505	1090	95	91	44	9.3	32	8	5.5	9.7	1.5	6.8	< 2	2.8	< 1	< 2	< 1	211
NS-330	21 May 2009	7.7	490	1343	71	57	< 25	6	19	< 5	4.5	8	1.4	5.2	< 2	2.1	< 1	< 2	< 1	103
NS-420	21 May 2009	7.8	545	1354	28	< 17	< 25	< 5	7	< 5	< 3	< 4	< 1	< 3	< 2	< 2	< 1	< 2	< 1	7
NS-590	21 May 2009	8.0	513	1364	24	24	< 25	< 5	10	< 5	3.7	< 4	< 1	3.2	< 2	< 2	< 1	< 2	< 1	41

Table 2
pH, redox potential (Eh), total dissolved solids (TDS) and Y-REE in the Rio Naracauli waters, continues. ΣREE indicates the sum from La to Lu.

Sample	Date	pH	Eh	TDS	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	∑ REE
			mV	mg/l	ng/l															
NS-100	27 May 2009	7.3	525	1090	252	260	57	21	71	15	8	22	2.6	13	3.8	8	1.1	5	1.3	489
NS-170	27 May 2009	7.6	502	1076	99	89	27	68	27	7	5.1	6	1.5	5.7	< 2	3.3	< 1	2.3	< 1	242
NS-330	27 May 2009	7.8	490	1398	135	140	52	15	56	12	6.5	16	2.6	11	2.1	5	< 1	4.5	< 1	323
NS-420	27 May 2009	8.0	473	1396	44	52	38	5.8	21	5	5.5	6.1	1.5	3.9	< 2	< 2	< 1	< 2	< 1	139
NS-590	27 May 2009	8.2	436	1396	19	28	< 25	< 5	16	< 15	4.2	4.2	< 1	< 2	< 2	< 2	< 1	< 2	< 1	53
NS-100	03 June 2009	7.4	525	1045	236	276	72	24	80	17	10	25	3.5	17	4	9	1.2	5.6	< 1	545
NS-170	03 June 2009	7.6	486	1007	111	113	49	10	37	9	6.2	12	2.1	6.9	2	4	< 1	2.2	< 1	254
NS-330	03 June 2009	7.8	467	1434	96	89	41	11	37	8	6	12	2.2	7.6	< 2	3	< 1	3.2	< 1	220
NS-420	03 June 2009	7.9	450	1365	50	48	32	< 5	23	5	5	7	1.2	3	< 2	< 2	< 1	< 2	< 1	124
NS-590	03 June 2009	8.1	450	1373	23	40	33	< 5	17	< 5	5	< 4	1.2	< 2	< 2	< 2	< 1	< 2	< 1	96
NS-100	10 June 2009	7.5	445	1038	290	340	154	33	123	25	13	42	5.1	23	5.4	12	1	5.6	< 1	782
NS-170	10 June 2009	7.6	429	1015	69	67	34	5.9	23	6	5.2	7	1.6	4.2	< 2	3	< 1	< 2	< 1	157
NS-330	10 June 2009	7.8	424	1484	113	120	69	15	59	9	6	15	2.3	9.3	2.3	4.7	< 1	3.2	< 1	315
NS-420	10 June 2009	7.9	407	1464	55	62	71	9.7	40	14	5.7	9.1	2	5.6	< 2	3	< 1	2.6	< 1	225
NS-590	10 June 2009	8.2	387	1427	13	< 22	< 25	< 5	< 10	< 4	4.1	< 3	< 1	< 2	< 2	< 2	< 1	< 2	< 1	4
NS-100	17 June 2009	7.3	471	1061	223	313	216	38	134	32	14	40	5.1	23	4.2	9.2	1.1	5	1	836
NS-170	17 June 2009	7.5	451	1017	48	41	< 25	< 5	15	< 5	4.9	5.2	< 1	3.7	< 2	< 2	< 1	< 2	< 1	70
NS-330	17 June 2009	7.6	447	1485	95	86	29	9	33	9	6	9	2.2	7	< 2	4	< 1	2	< 1	196
NS-420	17 June 2009	7.8	435	1526	27	24	< 25	< 5	< 10	< 5	3.3	3.4	1	< 3	< 2	< 2	< 1	< 2	< 1	32
NS-590	17 June 2009	8.0	417	1523	15	28	25	< 5	12	< 5	4	3	< 1	< 3	< 2	< 2	< 1	< 2	< 1	72
NS-100	25 June 2009	7.4	457	1060	136	117	< 25	11	37	8	6	12	2.1	7.4	< 2	5	< 1	3	< 1	208
NS-170	25 June 2009	7.5	449	1009	24	23	< 25	< 5	< 10	< 5	4.2	< 3	< 1	< 3	< 2	< 2	< 1	< 2	< 1	27
NS-330	25 June 2009	7.7	446	1490	49	44	< 25	< 5	12	< 5	4.1	4.3	1.13	< 3	< 2	2	< 1	< 2	< 1	68
NS-420	25 June 2009	7.8	450	1512	21	< 22	< 25	< 5	10	< 5	< 3	< 3	< 1	< 3	< 2	< 2	< 1	< 2	< 1	10
NS-590	25 June 2009	8.0	448	1469	12	< 22	< 25	< 5	< 10	< 5	3.1	< 3	< 1	< 2	< 2	< 2	< 1	< 2	< 1	3
NS-100	08 July 2009	7.1	422	887	188	201	61	21	75	14	7.4	22	3.6	14	3.8	11	1.1	6	1	442
NS-170	08 July 2009	7.3	418	879	47	45	35	6	23	5	6.4	7	1.2	4.5	< 2	2	< 1	< 2	< 1	135
NS-330	08 July 2009	7.9	422	1405	101	87	51	12	44	7.5	5.4	12	2.2	8.8	2	5.4	< 1	3.1	< 1	241
NS-420	08 July 2009	7.7	422	1456	33	33	< 25	< 5	15	5	4.2	3.4	< 1	3	< 2	< 2	< 1	< 2	< 1	64
NS-590	08 July 2009	7.9	416	1396	14	< 22	< 25	< 5	< 10	< 5	4	< 3	< 1	< 2	< 2	< 2	< 1	< 2	< 1	4

Table 3
pH, redox potential (Eh), total dissolved solids (TDS) and Y-REE in the Rio Naracauli waters, continues. ΣREE indicates the sum from La to Lu.

Sample	Date	pH	Eh	TDS	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	∑ REE
			mV	mg/l	ng/l															
NS-100	15 July 2009	7.3	460	837	186	228	136	30	110	23	6	26	3.5	18	4.2	8	1	9.7	1	604
NS-170	15 July 2009	7.3	451	820	57	< 70	42	< 13	31	< 10	4.4	< 8	1.2	8	< 2	4	< 1	< 3	< 1	91
NS-330	15 July 2009	7.6	442	1389	87	78	46	< 13	36	10	4.1	8.7	1.5	8.1	< 2	4.9	< 1	3	< 1	200
NS-420	15 July 2009	7.7	445	1361	39	< 70	39	< 13	< 24	< 10	< 3	< 8	1	4	< 2	< 4	< 1	< 3	< 1	44
NS-590	15 July 2009	8.0	432	1343	22	< 70	31	< 13	< 24	< 10	< 3	< 8	< 1	< 6	< 2	< 4	< 1	< 3	< 1	31
NS-100	29 July 2009	7.4	445	775	119	114	52	14.4	53	< 10	5	14	1.7	9	2.4	5.4	< 1	4.2	< 1	275
NS-170	29 July 2009	7.5	426	736	24	< 70	28	< 13	< 23	< 10	3	< 8	< 1	< 6	< 2	< 4	< 1	< 3	< 1	31
NS-330	29 July 2009	7.7	404	1381	94	67	45	< 13	38	< 10	4.5	< 8	1.8	9	< 2	4.8	< 1	3.2	< 1	173
NS-420	29 July 2009	7.8	422	1349	68	81	135	16	58	12	5	15	2.1	11	2.6	6	< 1	4.9	< 1	348
NS-590	29 July 2009	8.1	407	1333	35	< 70	57	< 13	30	< 10	3	9.1	1	< 6	< 2	< 4	< 1	< 3	< 1	100
NS-330	19 August 2009	7.5	459	1210	41	< 44	< 40	4	9	4	< 3	< 4	< 1.2	5	1	< 3	< 1	< 3	< 1	23
NS-420	19 August 2009	7.7	452	1162	10	< 44	< 40	< 3	8	< 5	< 3	< 2	< 1.2	< 2	< 1	< 3	< 1	< 3	< 1	8
NS-590	19 August 2009	8.0	440	1160	9	< 44	< 40	< 3	8	< 5	< 3	< 2	< 1.2	< 2	< 1	< 3	< 1	< 3	< 1	8
NS-100	19 October 2009	6.9	473	557	76	90	< 40	13	37	8	3	6	< 1.2	6	1.4	3	< 1	< 3	< 1	167
NS-170	19 October 2009	7.3	490	563	36	56	< 40	6	19	5	< 3	< 4	< 1	2.6	< 1	< 3	< 1	< 3	< 1	89
NS-420	19 October 2009	7.7	475	1205	22	< 44	< 40	< 3	< 8	< 5	< 3	2.2	< 1	< 3	< 1	< 3	< 1	< 3	< 1	2.2
NS-590	19 October 2009	8.0	407	1192	8	< 44	< 40	< 3	< 8	< 5	< 3	< 2	< 1.2	< 2	< 1	< 3	< 1	< 3	< 1	
NS-1200	19 October 2009	7.4	453	803	45	64	< 40	8	26	5	< 3	6	< 1.2	3	< 1	< 3	< 1	< 3	< 1	112
NS-100	11 November 2009	7.0	494	894	1720	4000	1560	550	1750	272	124	350	39	195	30	71	7.5	35	4	8988
NS-420	11 November 2009	7.0	468	1084	310	740	360	76	220	32	14	46	5.1	24	4.8	13	1.2	7	< 1	1543
NS-100	28 November 2009	7.1	482	803	104	214	46	21	70	12	5	12	2	11	1.8	4	< 1	3	< 1	402
NS-420	28 November 2009	7.6	472	1371	25	< 44	< 40	4	12	3	< 3	3	< 1	< 2	< 1	< 3	< 1	< 3	< 1	22
NS-590	28 November 2009	7.7	474	1284	10	< 44	< 40	< 3	< 8	3	< 3	< 2	< 1	< 2	< 1	< 3	< 1	< 3	< 1	3
NS-100	17 March 2010	7.3	437	1006	389	590	439	69	218	33	21	51	7	34	6	14	1	6	1	1490
NS-420	17 March 2010	7.6	451	1263	46	56	60	8	21	4	1	6	< 0.3	5	1	1	< 0.3	< 1	< 0.5	163
NS-590	17 March 2010	7.7	465	1316	16	26	16	1.8	7	< 4	1	2	< 0.3	< 2	< 0.3	< 1	< 0.3	< 1	< 0.5	54

Table 4
pH, redox potential (Eh), total dissolved solids (TDS) and Y-REE in the Rio Naracauli waters, continues. ΣREE indicates the sum from La to Lu.

Sample	Date	pH	Eh	TDS	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	∑ REE
			mV	mg/l	ng/l															
NS-100	21 April 2010	7.4	456	1024	120	137	19	11	40	8	2.6	10	1.1	4.5	1.9	3.5	0.5	< 2	< 0.5	240
NS-170	21 April 2010	7.5	450	1012	24	18	5	< 2	5.7	1	1.1	< 2	0.3	< 2	0.4	< 1	< 0.3	< 2	< 0.5	32
NS-330	21 April 2010	7.6	445	1601	56	69	13	7.1	19	< 4	1.9	4	0.9	3	1	1.5	< 0.3	< 2	< 0.5	121
NS-420	21 April 2010	7.8	435	1587	21	12	< 4	< 2	< 5	4	1	< 2	< 0.3	< 2	< 0.3	< 1	< 0.3	< 2	< 0.5	17
NS-590	21 April 2010	8.0	431	1563	5.2	5.7	4	< 2	< 5	1.9	< 1	< 2	< 0.3	< 2	0.3	< 1	< 0.3	< 2	< 0.5	12
NS-1200	21 April 2010	7.8	450	648	38	34	17	5	17	3	1	3	0.8	2	1.0	1.8	< 0.3	2	< 0.5	88
NS-100	30 June 2010	7.5	469	1028	60	90	46	9	27	< 8	< 5	< 6	< 5	< 5	< 5	< 5	< 4	< 6	< 5	172
NS-170	30 June 2010	7.5	457	996	26	85	108	13	36	< 8	< 5	< 6	< 5	< 5	< 5	< 5	< 4	< 6	< 5	242
NS-330	30 June 2010	7.9	467	1493	62	66	70	10	33	< 10	< 5	< 6	< 5	< 5	< 5	< 5	< 4	< 6	< 5	179
NS-420	30 June 2010	8.1	469	1485	15	27	36	< 9	12	< 8	< 5	< 6	< 5	< 5	< 5	< 5	< 4	< 6	< 5	75
NS-590	30 June 2010	8.4	486	1473	14	42	60	< 9	19	< 8	< 5	< 6	< 5	< 5	< 5	< 5	< 4	< 6	< 5	121
NS-1200	30 June 2010	8.0	447	1081	59	66	36	< 9	18	< 8	< 5	< 6	< 5	5	< 5	< 5	< 4	< 6	< 5	125
NS-100	29 October 2010	7.2	475	949	100	93	20	8	29	< 4	4	9	< 1	6	1.9	< 3	< 1	2.8	< 1	174
NS-170	29 October 2010	7.3	480	936	42	31	16	3.2	12	< 4	4	3.7	< 1	< 3	< 1	< 2	< 1	< 2	< 1	70
NS-420	29 October 2010	7.8	475	1391	33	19	< 16	2	10	< 4	2.5	3.3	< 1	< 3	< 1	< 2	< 1	< 2	< 1	37
NS-590	29 October 2010	8.0	482	1352	25	12	< 16	2	9	< 4	2	2	< 1	3	< 1	2	< 1	2	< 1	34
NS-1200	29 October 2010	7.6	490	738	69	47	28	7	24	5	3	8	1.1	6	1.4	3.2	< 1	4	< 1	138
NS-1600	29 October 2010	7.9	480	634	57	30	33	5	20	5	5	6	1.3	4	1.1	3	< 1	2.5	< 1	116
NS-100	01 December 2010	7.2	608	1048	1580	3100	1180	290	1130	180	77	304	34	167	29	75	6	37	6	6615
NS-420	01 December 2010	7.5	609	1145	610	1230	690	110	390	68	27	100	12	53	10	23	2.5	13	1.6	2730
NS-590	01 December 2010	7.6	583	1089	130	195	< 260	18	60	9	6	17	2	8	1	5	< 1	< 3	< 1	321
NS-1600	01 December 2010	8.0	555	452	100	117	< 260	21	83	17	8	18	3	15	3	8	< 1	7	1	301
NS-100	26 January 2011	7.3	511	1034	375	341	75	28	100	18	9	31	4	22	6	13	1.4	7	1.1	657
NS-330	26 January 2011	7.7	518	1290	136	117	28	8	34	7	4	12	1.5	7	1.8	6	< 1	< 10	< 1	226
NS-420	26 January 2011	7.8	517	1243	76	74	32	7	24	7	3	8	1.5	5	1.7	3	< 1	< 3	< 1	166
NS-590	26 January 2011	7.9	519	1208	36	62	29	5	20	< 10	4	5	< 1	3	< 1	2	< 1	< 3	< 1	130
NS-1200	26 January 2011	7.8	548	607	65	243	73	10	40	10	4	9	1.5	7	2.4	5	< 1	4	1	410
NS-1600	26 January 2011	7.9	585	535	86	128	58	13	47	12	5	14	1.7	8	2	5	< 1	3	< 1	297

Table 5
pH, redox potential (Eh), total dissolved solids (TDS) and Y-REE in the Rio Naracauli waters, ΣREE indicates the sum from La to Lu.

Sample	Date	pH	Eh	TDS	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	∑ REE
			mV	mg/l	ng/l															
NS-100 (h 10:50)	02 February 2011	7.0	542	933	830	1100	330	107	420	70	30	120	14	61	14	34	3	20	3	2326
NS-100 (h 13:30)	02 February 2011	7.1	609	944	900	1500	480	150	550	90	35	150	18	77	16	43	4	23	4	3140
NS-330 (h 11:00)	02 February 2011	7.3	516	1138	460	550	175	56	220	38	17	58	8	38	8	18	2	11	2	1201
NS-330 (h 13:42)	02 February 2011	7.5	515	1133	420	520	176	58	200	37	17	56	8	35	7	16	2.3	10	1.8	1144
NS-590 (h 11:05)	02 February 2011	7.4	518	1086	143	200	69	15	62	13	6	12	2.5	9	2.2	5	< 1	3	< 1	399
NS-590 (h 13:56)	02 February 2011	7.4	533	1071	128	159	63	16	55	7	8	16	2.6	9	2	6	< 1	< 10	< 1	344
NS-100	11 February 2011	7.3	519	1024	420	440	130	40	150	27	13	48	6	27	6	16	1.7	7	1.2	913
NS-330	11 February 2011	7.8	513	1225	220	220	115	26	95	16	11	30	3.6	18	3.5	8	< 1	5	< 1	551

Table 6
pH, redox potential (Eh), total dissolved solids (TDS) and Y-REE in the tributary waters.

Sample	Date	pH	Eh	TDS	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	$\sum$ REE
			mV	mg/l	ng/l															
Rio Pitzinurri (D)	18 March 2009	8.3	471	304	50	46	73	< 13	39	11	3.2	9	1.5	7.3	< 4	4.8	< 1	3.9	< 1	199
Rio Pitzinurri (D)	19 October 2009	7.9	450	399	23	< 44	< 40	4.3	12	3	< 3	4	< 1.2	2.7	< 1	< 3	< 1	< 3	< 1	26
Rio Pitzinurri (D)	21 April 2010	8.2	440	285	19	18	23	4	13	4	1	2	0.7	2	0.8	2	0.51	2	< 0.5	73
Rio Pitzinurri (D)	29 October 2010	7.3	458	452	41	29	23	5.5	22	< 4	4	4	< 1	4	1	3	< 1	3	< 1	99

Table 7
pH, redox potential (Eh), total dissolved solids (TDS) and Y-REE in the tailing drainages.

Sample	Date	pH	Eh	TDS	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	∑ REE
			mV	mg/l	ng/l															
A	18 March 2009	6.9	473	2319	11100	29100	7700	3160	10800	1670	551	2368	255	1090	200	450	49	239	38	57670
A	25 March 2009	6.6	547	2377	11400	29900	8300	3000	10200	1520	508	2320	247	1060	192	455	46	228	34	58010
A	17 April 2009	6.5	659	2584	24400	35200	15100	4380	16100	2660	1020	4470	511	2260	430	1040	109	550	79	83909
A	07 May 2009	6.5	539	2577	11800	35000	9600	3860	13300	1900	720	3210	330	1360	230	570	59	290	44	70473
A	11 November 2009	6.6	452	2819	14200	33100	15300	4800	15400	2480	1100	3300	332	1600	250	600	66	280	32	78640
A	01 December 2010	6.7	503	2740	22000	46000	18000	4700	17700	2900	1120	4800	560	2300	400	800	100	490	77	99947
A	02 February 2011	6.6	591	2389	19000	37000	15000	4600	18000	2800	1000	4700	500	2100	400	900	100	420	70	87590
A	02 February 2011	6.9	646	2332	17000	32000	13000	4000	15000	2200	830	3700	400	1800	340	800	80	400	60	74610
A	11 February 2011	6.8	531	2826	18000	35000	14000	4400	17000	2500	1000	4400	500	2100	400	900	90	450	70	82810
B	25 March 2009	6.6	508	2220	6900	14500	8200	1255	4520	680	228	1230	127	560	104	236	21	107	17	31785
B	17 April 2009	6.4	656	1467	2970	6470	4030	574	2000	300	118	546	60	234	45	106	10	46	6.6	14546
B	07 May 2009	6.5	516	1928	5600	12800	7870	1170	3900	550	190	1030	110	460	91	190	20	76	12	28469
B	21 May 2009	6.2	580	2148	7470	18100	11800	1768	6120	930	334	1660	168	680	139	290	30	133	20	42170
B	27 May 2009	6.4	529	2210	6800	16900	10400	1570	5420	820	293	1490	154	610	123	270	27	123	20	38218
B	01 December 2010	7.0	606	2290	9900	27000	21000	2360	8750	1320	490	2270	220	940	160	410	33	150	28	65131
B	02 February 2011	6.6	541	1251	2600	5500	3500	550	1900	300	120	500	60	250	48	115	11	56	9	12919
B	02 February 2011	7.0	524	1247	2500	5700	3600	540	2000	310	120	540	60	250	50	110	12	55	8	13355
B	11 February 2011	7.0	515	1659	3700	8600	5100	820	3000	460	160	800	80	330	69	160	15	67	11	19672

Table 8
Y-REE and Th concentrations in mine tailings.

Sample	Date	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Th	∑ REE
		mg/kg																
MTA - 1	28 April 2012	6	14	30	3	11	3	1	3	0.26	2	0.32	0.88	0.1	0.76	0.08	1.7	69
MTA - 2	28 April 2012	20	76	131	14	50	10	3.2	8.6	0.73	3.3	0.5	1.3	0.15	1	0.13	7.3	300
MTA - 3	28 April 2012	3	25	53	5.4	20	3.5	0.97	2.6	0.29	1.3	0.2	0.57	0.05	0.45	0.05	3.9	113
MTB - 1	28 April 2012	3.7	9.8	23	2.2	10	2.2	1	2.1	0.23	0.99	0.16	0.42	0.04	0.23	0.04	1.1	52
MTB - 2	28 April 2012	1.2	6.9	14	1.5	5.5	1.2	0.47	1	0.12	0.62	0.1	0.26	0.04	0.22	0.02	1	32
MTB - 3	28 April 2012	0.98	2.8	6.37	0.7	2.9	0.77	0.3	0.7	0.1	0.5	0.09	0.23	0.03	0.2	0.02	0.7	16

Table 9
Y-REE and Th concentrations in the bio-hydrozincites (N34-42) and Fe-hydrozincite + bio-hydrozincite sample (N32).

Sample	Date	Location	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Th	∑ REE
			mg/kg																
N32	21 May 2009	NS-170	60	70	55	7.5	30	5.7	2.6	10	1.3	6	1	2.3	0.2	1	0.1	< 0.44	193
N34	27 May 2009	NS-590	3.4	3.7	2.0	0.42	1.5	0.3	0.1	0.42	0.06	0.25	0.06	0.13	0.02	0.08	0.01	0.76	9.0
N36	03 June 2009	NS-590	5.2	8.4	8.8	1.4	5.2	1	0.25	1.2	0.14	0.67	0.12	0.31	0.04	0.26	0.03	1.3	28
N37B	10 June 2009	NS-420	8.2	8.8	5.1	1.1	3.9	0.7	0.24	1.0	0.13	0.65	0.13	0.33	0.04	0.24	0.03	0.47	22
N39	15 July 2009	NS-420	3.1	1.9	0.67	0.2	0.78	0.15	0.05	0.19	0.04	0.21	0.03	0.11	0.01	0.08	0.01	< 0.44	4.4
N41A	29 July 2009	NS-420	4.6	3.4	1.3	0.4	1.4	0.25	0.1	0.42	0.06	0.3	0.08	0.15	0.03	0.12	0.02	< 0.44	8.0
N42	29 July 2009	NS-420	2.9	2.1	1.1	0.3	0.94	0.16	0.06	0.28	0.04	0.19	0.04	0.1	0.01	0.08	0.01	< 0.44	5.4

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