Data Article

Chemical data on environmental matrices from an abandoned mining site

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A B S T R A C T

This article contains analytical data on chemical composition of waters and solid samples (mining wastes and biominerals) collected in an abandoned mining area, 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).

Specifically, we present physicochemical data (temperature, electrical conductivity, pH, and redox potential), major components and the main contaminants (Zn, Mn, Cd, Ni, Cu, Pb) detected in stream waters and drainages from mine wastes. Waters were monitored from 2009 to 2011 during different seasonal conditions to give an insight into metal dispersion under different hydrological conditions.

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1. Data

Water and solid samples were collected in the Ingurtosu Zn-Pb abandoned mining site, located in the South-West of Sardinia, Italy. Physicochemical data and major components of the Rio Naracauli waters are reported in Tables 1–3; Tables 4–6 show concentrations of selected metals (Mn, Cd, Ni, Cu and Pb) in the stream waters. Physicochemical data, major components, and selected metals (Mn, Cd, Ni, Cu and Pb) of the Rio Pitzinarri tributary are reported in Tables 7 and...
Tables 9 and 10 show the physicochemical data, major components, and selected metals (Mn, Cd, Ni, Cu and Pb) in waters draining mine tailings. Data on solid samples (mine tailings and biominerals) are reported in Tables 11 and 12. For a detailed description and discussion of the data see Ref. [1].

2. Experimental design, materials, and methods

2.1. Study area

Environmental and health problems [2–7] associated with the dispersion of metals and with their transfer from the geosphere to the biosphere [8–11] are becoming increasingly common worldwide. The knowledge of metal pathways is a fundamental parameter to plan efficient remediation actions of waters and soils and it can be achieved by an accurate geochemical investigation. In this context, chemical composition of stream waters and drainages from mine tailings were monitored from 2009 to 2011, and mine wastes and biominerals were analyzed. During the mining activity, wastes were disposed near the Rio Naracauli, the main stream of the area, resulting in a relevant threat for the health of living organisms. When the mine was closed (1968), dump and tailings were abandoned without applying any remediation technique [1,12]. Zinc dispersion along the stream is controlled by the bioprecipitation of two biominerals: hydrozincite, Zn₅(CO₃)₂(OH)₆ [9,10], and an amorphous Zn-silicate [13–15].

2.2. Materials and methods

Biominerals and mine waste samples were dried at room temperature, and ground for acid digestion by a microwave (ETHOS One, Advanced Microwave Digestion System, Milestone), according to Ref. [1]. Samples were digested in duplicate and analyzed to estimate method precision (expressed as standard deviation/mean concentration) that was in the range 0.1–5%. To evaluate
The analytical accuracy of the acid digestion procedure, experimental values and the certified values of the reference material RTS-3 (CANMET, Canadian Certified Reference Materials Project (CCRMP)), prepared with the same mixture, were compared, and the percentage recovery of each metal was calculated as:

\[
\text{% Recovery} = \frac{\text{Mean value of the measured concentration}}{\text{Certified concentration}} \times 100
\]

Recovery was between 85 and 102%.
Zn and S\(_{\text{tot}}\) were analyzed by inductively coupled plasma optical emission spectrometry (ICP-OES, ARL Fisons ICP Analyzer 3520 B), and Fe, Zn, Pb, Cd, Mn, Co, Ni, Cu, Al, As, Cr, Sb and Ag were determined by inductively coupled plasma mass spectrometry (ICP-MS, Perkin-Elmer, Elan 5000/DRC-e, USA).

Stream waters, from the Rio Naracauli (NS-100 to NS-1600) and the Rio Pitzinurri tributary (sample D), and drainages from tailings (samples A and B) were collected from 2009 to 2011. Temperature, electrical conductivity (Cond), pH, redox potential (Eh), and alkalinity were determined on site according to Ref. [1]. Major cations were determined by ICP-OES and Zn, Cu, Ni, Cd, Mn and Pb were determined by ICP-MS on filtered (0.4 \(\mu\)m, Nuclepore 111130) and acidified samples (1% HNO\(_3\) suprapure grade). Anions were analyzed by ion chromatography (Dionex ICS3000) on filtered and non-acidified aliquots.

Procedural blanks, standard solutions and reference solutions (SRM 1643e and EnviroMAT Drinking Water, High EP-H-3 and Low EP-L-3) were analyzed after every five samples to estimate potential

**Table 2**

| Sample | Date       | T \(\degree\)C | pH | Eh \(\text{mV}\) | Cond \(\mu\)S/cm | Ca \(\text{mg/l}\) | Mg \(\text{mg/l}\) | Na \(\text{mg/l}\) | K \(\text{mg/l}\) | Zn \(\text{mg/l}\) | HCO\(_3\) \(\text{mg/l}\) | Cl \(\text{mg/l}\) | SO\(_4^{2-}\) \(\text{mg/l}\) | SiO\(_2\) \(\text{mg/l}\) |
|--------|------------|----------------|----|--------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| NS-100 | 10 June 2009 | 18              | 7.5 | 445          | 1396            | 149            | 61             | 57             | 6.4            | 34             | 218            | 104            | 512            | 7.7            |
| NS-170 | 10 June 2009 | 21              | 7.6 | 429          | 1370            | 149            | 61             | 57             | 6.5            | 23             | 209            | 106            | 500            | 9.8            |
| NS-330 | 10 June 2009 | 20              | 7.8 | 424          | 1814            | 249            | 87             | 67             | 7.2            | 16             | 245            | 104            | 500            | 10            |
| NS-420 | 10 June 2009 | 21              | 7.9 | 407          | 1808            | 254            | 88             | 80             | 7.6            | 11             | 232            | 104            | 476            | 9.4            |
| NS-590 | 10 June 2009 | 24              | 8.2 | 387          | 1793            | 254            | 90             | 68             | 7.5            | 4.2            | 211            | 104            | 787            | 8.8            |
| NS-100 | 17 June 2009 | 19              | 7.3 | 471          | nd              | 157            | 65             | 62             | 6.2            | 35             | 218            | 106            | 512            | 11            |
| NS-170 | 17 June 2009 | 22              | 7.5 | 451          | nd              | 150            | 64             | 61             | 6.0            | 22             | 198            | 104            | 503            | 10            |
| NS-330 | 17 June 2009 | 20              | 7.6 | 447          | nd              | 242            | 82             | 60             | 7.2            | 15             | 253            | 109            | 835            | 10            |
| NS-420 | 17 June 2009 | 21              | 7.8 | 435          | nd              | 248            | 90             | 67             | 7.6            | 11             | 232            | 104            | 503            | 10            |
| NS-590 | 17 June 2009 | 24              | 8.0 | 417          | nd              | 253            | 89             | 66             | 7.3            | 2.9            | 228            | 109            | 874            | 9.3            |
Table 3
Temperature, pH, redox potentials (Eh), electrical conductivity (Cond) and major components in the Rio Naracauli waters.

| Sample | Date            | T °C | pH  | Eh  | Cond μS/cm | Ca  | Mg  | Na  | K  | Zn  | HCO₃⁻ | Cl  | SO₂⁻  | SiO₂ |
|--------|-----------------|------|-----|-----|------------|-----|-----|-----|----|-----|--------|-----|--------|------|
| NS-100 | 11 November 2009| 10   | 7.0 | 494 | 1182       | 96  | 29  | 54  | 8.0| 119 | 77     | 68  | 471    | 11   |
| NS-420 | 11 November 2009| 16   | 7.0 | 468 | 1431       | 157 | 53  | 63  | 7.6| 69  | 115    | 79  | 590    | 8.6  |
| NS-100 | 28 November 2009| 16   | 7.1 | 482 | 1113       | 104 | 34  | 56  | 7.2| 56  | 101    | 87  | 398    | 11   |
| NS-420 | 28 November 2009| 17   | 7.6 | 472 | 1740       | 240 | 80  | 66  | 8.1| 13  | 225    | 93  | 752    | 8.1  |
| NS-590 | 28 November 2009| 17   | 7.6 | 472 | 1740       | 300 | 100 | 72  | 8.2| 130 | 235    | 97  | 798    | 8.6  |
| NS-100 | 13 March 2010   | 18   | 7.3 | 437 | 1420       | 152 | 64  | 57  | 7.4| 31  | 209    | 88  | 495    | 8.9  |
| NS-420 | 13 March 2010   | 17   | 7.6 | 451 | 1719       | 226 | 83  | 65  | 8.0| 15  | 225    | 93  | 752    | 8.1  |
| NS-590 | 13 March 2010   | 16   | 7.6 | 451 | 1719       | 256 | 97  | 72  | 8.4| 130 | 235    | 97  | 798    | 8.6  |
| NS-100 | 28 June 2010    | 16   | 7.0 | 469 | 1417       | 143 | 51  | 58  | 10.0|57  | 134    | 90  | 540    | 13   |
| NS-420 | 28 June 2010    | 17   | 7.6 | 490 | 1519       | 160 | 60  | 56  | 9.0| 11  | 245    | 100 | 725    | 9.5  |
| NS-590 | 28 June 2010    | 19   | 7.8 | 435 | 1975       | 280 | 97  | 72  | 8.0| 9.7 | 216    | 96  | 895    | 8.2  |
| NS-100 | 28 June 2010    | 19   | 8.0 | 431 | 1965       | 280 | 97  | 72  | 7.6| 9.7 | 216    | 96  | 895    | 8.2  |
| NS-420 | 28 June 2010    | 16   | 7.8 | 450 | 1453       | 156 | 65  | 61  | 8.0| 18  | 208    | 92  | 500    | 9.7  |
| NS-590 | 28 June 2010    | 17   | 7.7 | 474 | 1680       | 231 | 76  | 65  | 8.0| 5.9 | 216    | 96  | 696    | 6.2  |
| NS-100 | 29 October 2010 | 17   | 7.2 | 475 | 1266       | 121 | 43  | 56  | 10.0|58  | 97     | 91  | 510    | 12   |
| NS-420 | 29 October 2010 | 15   | 7.3 | 437 | 1394       | 143 | 51  | 58  | 10.0|57  | 134    | 90  | 540    | 13   |
| NS-590 | 29 October 2010 | 15   | 7.3 | 437 | 1394       | 143 | 51  | 58  | 10.0|57  | 134    | 90  | 540    | 13   |
| NS-100 | 29 October 2010 | 15   | 7.3 | 437 | 1394       | 143 | 51  | 58  | 10.0|57  | 134    | 90  | 540    | 13   |
| NS-420 | 29 October 2010 | 15   | 7.3 | 437 | 1394       | 143 | 51  | 58  | 10.0|57  | 134    | 90  | 540    | 13   |
| NS-590 | 29 October 2010 | 15   | 7.3 | 437 | 1394       | 143 | 51  | 58  | 10.0|57  | 134    | 90  | 540    | 13   |
| NS-100 | 29 October 2010 | 15   | 7.3 | 437 | 1394       | 143 | 51  | 58  | 10.0|57  | 134    | 90  | 540    | 13   |
Table 4
Mn, Cd, Ni, Cu and Pb in the Rio Naracauli waters, continues.

| Sample | Date        | Mn  | Cd  | Ni  | Cu | Pb  |
|--------|-------------|-----|-----|-----|----|-----|
| NS-100 | 18 March 2009 | 1160 | 345 | 130 | 5.1 | 76  |
| NS-170 | 18 March 2009 | 1160 | 342 | 127 | 4.6 | 51  |
| NS-330 | 18 March 2009 | 750  | 223 | 131 | 3.6 | 32  |
| NS-420 | 18 March 2009 | 720  | 220 | 108 | 2.2 | 18  |
| NS-590 | 18 March 2009 | 700  | 210 | 110 | 1.6 | 7.6 |
| NS-630 | 18 March 2009 | 220  | 98  | 43  | 2.2 | 8.7 |
| NS-1200| 18 March 2009 | 173  | 103 | 34  | 3.4 | 15  |
| NS-1600| 18 March 2009 | 170  | 74  | 28  | 1.6 | 8.3 |
| NS-100 | 25 March 2009 | 1242 | 318 | 150 | 5.0 | 59  |
| NS-170 | 25 March 2009 | 1230 | 307 | 124 | 2.9 | 28  |
| NS-330 | 25 March 2009 | 757  | 204 | 122 | 4.4 | 31  |
| NS-420 | 25 March 2009 | 752  | 202 | 127 | 3.3 | 19  |
| NS-590 | 25 March 2009 | 750  | 192 | 94  | 2.2 | 6.3 |
| NS-100 | 17 April 2009 | 620  | 173 | 99  | 2.4 | 32  |
| NS-170 | 17 April 2009 | 550  | 153 | 91  | <2.3| 12  |
| NS-330 | 17 April 2009 | 469  | 139 | 71  | <2.3| 8.9 |
| NS-420 | 17 April 2009 | 1040 | 242 | 124 | 5.2 | 34  |
| NS-590 | 17 April 2009 | 1120 | 229 | 112 | <2.3| 25  |
| NS-100 | 03 June 2009  | 1000 | 311 | 113 | 4.7 | 81  |
| NS-170 | 03 June 2009  | 1080 | 296 | 106 | 2.5 | 41  |
| NS-330 | 03 June 2009  | 583  | 192 | 96  | 2.4 | 34  |
| NS-420 | 03 June 2009  | 522  | 176 | 89  | <2.3| 19  |
| NS-590 | 03 June 2009  | 498  | 160 | 66  | <2.3| 11  |
Table 5
Mn, Cd, Ni, Cu and Pb in the Rio Naraculi waters, continues.

| Sample  | Date         | Mn  | Cd  | Ni  | Cu  | Pb  |
|---------|--------------|-----|-----|-----|-----|-----|
|         |              | µg/l|     |     |     |     |
| NS-100  | 10 June 2009 | 1200| 246 | 126 | 4.2 | 71  |
| NS-170  | 10 June 2009 | 1270| 233 | 110 | 2.7 | 26  |
| NS-330  | 10 June 2009 | 560 | 156 | 98  | 2.54| 29  |
| NS-420  | 10 June 2009 | 495 | 144 | 92  | <2.3| 21  |
| NS-590  | 10 June 2009 | 446 | 127 | 65  | <2.3| 6.9 |
| NS-100  | 17 June 2009 | 1213| 246 | 122 | 4.1 | 70  |
| NS-170  | 17 June 2009 | 1260| 224 | 108 | <2.3| 23  |
| NS-330  | 17 June 2009 | 451 | 137 | 99  | <2.3| 27  |
| NS-420  | 17 June 2009 | 409 | 130 | 90  | <2.3| 11  |
| NS-590  | 17 June 2009 | 367 | 118 | 62  | <2.3| 6.5 |
| NS-100  | 25 June 2009 | 1124| 281 | 121 | 3.7 | 70  |
| NS-170  | 25 June 2009 | 1025| 260 | 105 | 1.6 | 15  |
| NS-330  | 25 June 2009 | 285 | 134 | 102 | 2.1 | 13  |
| NS-420  | 25 June 2009 | 271 | 127 | 94  | 9.6 | 6.4 |
| NS-590  | 25 June 2009 | 258 | 125 | 71  | 1.7 | 4.2 |
| NS-100  | 08 July 2009 | 666 | 365 | 83  | 5.9 | 122 |
| NS-170  | 08 July 2009 | 583 | 350 | 78  | 2.5 | 39  |
| NS-330  | 08 July 2009 | 235 | 162 | 94  | 3.0 | 3.0 |
| NS-420  | 08 July 2009 | 206 | 154 | 84  | 1.7 | 8.9 |
| NS-590  | 08 July 2009 | 180 | 150 | 62  | 1.6 | 5.5 |
| NS-100  | 15 July 2009 | 607 | 350 | 75  | 5.4 | 116 |
| NS-170  | 15 July 2009 | 540 | 342 | 71  | 2.6 | 44  |
| NS-330  | 15 July 2009 | 213 | 152 | 91  | 2.5 | 22  |
| NS-420  | 15 July 2009 | 190 | 148 | 81  | 1.7 | 10  |
| NS-590  | 15 July 2009 | 160 | 136 | 59  | 1.4 | 6.0 |
| NS-100  | 29 July 2009 | 620 | 289 | 70  | 3.9 | 99  |
| NS-170  | 29 July 2009 | 563 | 264 | 63  | 1.5 | 16  |
| NS-330  | 29 July 2009 | 173 | 102 | 86  | 2.4 | 18  |
| NS-420  | 29 July 2009 | 141 | 99  | 77  | 1.8 | 8.5 |
| NS-590  | 29 July 2009 | 118 | 92  | 53  | 1.3 | 7.7 |
| NS-330  | 19 August 2009 | 220 | 152 | 88  | <3.5| 18  |
| NS-420  | 19 August 2009 | 93  | 149 | 82  | <3.5| 7.8 |
| NS-590  | 19 August 2009 | 92  | 140 | 58  | <3.5| 7.7 |
| NS-100  | 19 October 2009 | 113 | 456 | 52  | 5.5 | 150 |
| NS-170  | 19 October 2009 | 106 | 398 | 45  | 3.5 | 82  |
| NS-420  | 19 October 2009 | 326 | 213 | 88  | <3.5| 18  |
| NS-590  | 19 October 2009 | 287 | 173 | 72  | <3.5| 6.4 |
| NS-1200 | 19 October 2009 | 12  | 130 | 24  | 3.8 | 61  |
| NS-100  | 11 November 2009 | 81  | 1215| 80  | 20  | 278 |
| NS-420  | 11 November 2009 | 290 | 700 | 96  | 6.5 | 82  |
| NS-100  | 28 November 2009 | 283 | 674 | 62  | 5.7 | 137 |
| NS-420  | 28 November 2009 | 430 | 183 | 90  | <3.5| 16  |
| NS-590  | 28 November 2009 | 352 | 163 | 70  | <3.5| 6.7 |
contaminations, and the accuracy and precision of trace element analysis. The limits of detection (LOD) and of quantification (LOQ) were calculated as 3 times and 10 times the standard deviation of the blank measurements, respectively. Rhodium was added as internal standard for ICP-MS analysis to correct for instrumental drift.

### Table 6
Mn, Cd, Ni, Cu and Pb in the Rio Naracauli waters.

| Sample | Date       | Mn  | Cd  | Ni  | Cu  | Pb  |
|--------|------------|-----|-----|-----|-----|-----|
| NS-100 | 17 March 2010 | 1459| 290 | 132 | 5   | 55  |
| NS-420 | 17 March 2010 | 580 | 187 | 99  | 2.3 | 17  |
| NS-590 | 17 March 2010 | 534 | 184 | 92  | 1.8 | 11  |
| NS-100 | 21 April 2010 | 1470| 266 | 122 | 3.6 | 53  |
| NS-170 | 21 April 2010 | 1407| 247 | 114 | 1.7 | 15  |
| NS-330 | 21 April 2010 | 423 | 144 | 100 | 3.2 | 23  |
| NS-420 | 21 April 2010 | 345 | 140 | 88  | 1.9 | 11  |
| NS-590 | 21 April 2010 | 302 | 119 | 65  | 1.3 | 3.5 |
| NS-1200| 21 April 2010 | 55  | 76  | 24  | 2.2 | 14  |
| NS-100 | 30 June 2010  | 471 | 609 | 79  | 5   | 74  |
| NS-170 | 30 June 2010  | 439 | 584 | 82  | <3  | 15  |
| NS-330 | 30 June 2010  | 242 | 117 | 85  | 3.6 | 23  |
| NS-420 | 30 June 2010  | 165 | 108 | 71  | <3  | 7.3 |
| NS-590 | 30 June 2010  | 112 | 83  | 46  | <3  | 6.3 |
| NS-1200| 30 June 2010  | 31  | 162 | 33  | <3  | 25  |
| NS-100 | 29 October 2010 | 5.1 | 645 | 69  | 3.6 | 134 |
| NS-170 | 29 October 2010 | 8.8 | 637 | 69  | 2.2 | 47  |
| NS-420 | 29 October 2010 | 390 | 119 | 95  | 3.7 | 15  |
| NS-590 | 29 October 2010 | 300 | 109 | 55  | 1.1 | 12  |
| NS-1200| 29 October 2010 | 19  | 84  | 18  | 2.7 | 34  |
| NS-1600| 29 October 2010 | 55  | 49  | 13  | 1.2 | 3.6 |
| NS-100 | 01 December 2010 | 840 | 870 | 114 | 10  | 144 |
| NS-420 | 01 December 2010 | 640 | 700 | 110 | 5.9 | 67  |
| NS-590 | 01 December 2010 | 430 | 690 | 99  | 3.2 | 30  |
| NS-1600| 01 December 2010 | 58  | 95  | 18  | 3.5 | 20  |
| NS-100 | 26 January 2011 | 1400| 320 | 120 | 4.2 | 26  |
| NS-330 | 26 January 2011 | 770 | 210 | 100 | 2.8 | 24  |
| NS-420 | 26 January 2011 | 720 | 210 | 90  | 2.0 | 19  |
| NS-590 | 26 January 2011 | 500 | 210 | 90  | 1.7 | 20  |
| NS-1200| 26 January 2011 | 130 | 87  | 33  | 2.7 | 24  |
| NS-1600| 26 January 2011 | 96  | 66  | 26  | 2.2 | 21  |
| NS-100 (h 10:50) | 02 February 2011 | 810 | 510 | 100 | 7.8 | 53  |
| NS-100 (h 13:30) | 02 February 2011 | 820 | 520 | 100 | 12  | 57  |
| NS-330 (h 11:00) | 02 February 2011 | 580 | 360 | 113 | 5.6 | 49  |
| NS-330 (h 13:42) | 02 February 2011 | 570 | 360 | 107 | 5.3 | 44  |
| NS-590 (h 11:05) | 02 February 2011 | 470 | 420 | 90  | 2.9 | 31  |
| NS-590 (h 13:56) | 02 February 2011 | 470 | 430 | 90  | 2.8 | 27  |
| NS-100 | 11 February 2011 | 1300| 260 | 110 | 4.2 | 20  |
| NS-330 | 11 February 2011 | 750 | 200 | 122 | 3.0 | 26  |

### Table 7
Temperature, pH, redox potentials (Eh), electrical conductivity (Cond) and major components in the tributary waters.

| Sample          | Date          | T °C | pH | Eh mV | Cond μS/cm | Ca | Mg | Na | K | Zn | HCO3⁻ | Cl | SO4⁻ | SiO2 mg/l |
|-----------------|---------------|------|----|------|------------|----|----|----|----|----|--------|----|------|----------|
| Rio Pitzinurri (D) | 21 April 2010 | 15   | 8.3| 471  | 546        | 28 | 13 | 57 | 3.2| 0.3| 102    | 91 | 37  | 24       |
| Rio Pitzinurri (D) | 29 October 2010 | 13  | 7.9| 450  | 702        | 37 | 17 | 71 | 3.6| 2.1| 132    | 124| 56  | 23       |
| Rio Pitzinurri (D) | 18 March 2009 | 13  | 8.2| 440  | 524        | 25 | 12 | 59 | 3.3| 0.3| 96     | 79 | 38  | 21       |
| Rio Pitzinurri (D) | 19 October 2009 | 17  | 7.3| 458  | 690        | 44 | 20 | 82 | 3.9| 2.7| 143    | 136| 71  | 22       |
**Table 8**
Mn, Cd, Ni, Cu and Pb in the tributary waters.

| Sample          | Date       | Mn (µg/l) | Cd (µg/l) | Ni (µg/l) | Cu (µg/l) | Pb (µg/l) |
|-----------------|------------|-----------|-----------|-----------|-----------|-----------|
| Rio Pitzinurri (D) | 21 April 2010 | 47        | 2.4       | 3         | 0.9       | 2.1       |
| Rio Pitzinurri (D) | 29 October 2010 | 15        | 15        | 4.4       | 3.3       | 4.9       |
| Rio Pitzinurri (D) | 18 March 2009  | 26        | 4.2       | 1.6       | 1.3       | 3.0       |
| Rio Pitzinurri (D) | 19 October 2009 | 41        | 22        | 7.8       | 3.8       | 2.9       |

**Table 9**
Temperature, pH, redox potentials (Eh), electrical conductivity (Cond) and major components in the tailing drainages.

| Sample | Date       | T (°C) | pH  | Eh (mV) | Cond (µS/cm) | Ca (mg/l) | Mg (mg/l) | Na (mg/l) | K (mg/l) | Zn (mg/l) | HCO₃⁻ (mg/l) | Cl (mg/l) | SO₄²⁻ (mg/l) | SiO₂ (mg/l) |
|--------|------------|--------|-----|---------|---------------|-----------|-----------|-----------|----------|-----------|--------------|-----------|--------------|-------------|
| A      | 18 March 2009 | 19     | 6.9 | 473     | 2660          | 148       | 42        | 55        | 6.3      | 600       | 21           | 99        | 1347         | 11          |
| A      | 25 March 2009 | 12     | 6.6 | 547     | 2760          | 153       | 42        | 55        | 7.5      | 630       | 23           | 101       | 1365         | 12          |
| A      | 17 April 2009 | 18     | 6.5 | 659     | 1940          | 158       | 40        | 55        | 6.1      | 640       | 34           | 87        | 1568         | 13          |
| A      | 07 May 2009   | 22     | 6.5 | 539     | 2460          | 160       | 42        | 56        | 6.7      | 690       | 22           | 94        | 1503         | 14          |
| A      | 11 November 2009 | 14   | 6.6 | 452     | 2680          | 209       | 48        | 59        | 9.0      | 704       | 21           | 71        | 1700         | 8.6         |
| A      | 01 December 2010 | 16  | 6.7 | 503     | 2290          | 161       | 38        | 51        | 9.0      | 710       | 21           | 71        | 1672         | 13          |
| A      | 02 February 2011 | 13   | 6.6 | 591     | 2280          | 141       | 32        | 50        | 6.1      | 699       | 39           | 70        | 1360         | 12          |
| A      | 02 February 2011 | 14   | 6.9 | 646     | 2130          | 140       | 32        | 47        | 5.9      | 634       | 22           | 77        | 1683         | 13          |
| A      | 11 February 2011 | 10  | 6.8 | 531     | 3280          | 170       | 42        | 52        | 6.5      | 760       | 26           | 79        | 1690         | 14          |
| B      | 25 March 2009 | 16     | 6.6 | 508     | 2600          | 107       | 67        | 70        | 5.6      | 530       | 17           | 154       | 1263         | 12          |
| B      | 17 April 2009 | 21     | 6.4 | 656     | 1510          | 76        | 49        | 73        | 4.2      | 300       | 28           | 134       | 796          | 17          |
| B      | 07 May 2009   | 25     | 6.5 | 516     | 2100          | 95        | 62        | 75        | 5.0      | 463       | 20           | 155       | 1051         | 12          |
| B      | 21 May 2009   | 24     | 6.2 | 580     | 2190          | 111       | 71        | 84        | 5.7      | 514       | 13           | 172       | 1171         | 13          |
| B      | 27 May 2009   | 21     | 6.4 | 529     | 2220          | 117       | 75        | 83        | 5.1      | 533       | 13           | 165       | 1213         | 13          |
| B      | 01 December 2010 | 18  | 7.0 | 606     | 2350          | 104       | 71        | 55        | 8.0      | 540       | 45           | 77        | 1400         | 13          |
| B      | 02 February 2011 | 13  | 6.6 | 541     | 1428          | 61        | 40        | 61        | 3.6      | 280       | 27           | 106       | 680          | 6.5         |
| B      | 02 February 2011 | 15  | 7.0 | 524     | 1449         | 65        | 41        | 64        | 3.4      | 280       | 35           | 106       | 664          | 6.5         |
| B      | 11 February 2011 | 14 | 7.0 | 515     | 1821         | 87        | 53        | 66        | 4.2      | 390       | 20           | 116       | 920          | 13          |

**Table 10**
Mn, Cd, Ni, Cu and Pb in the tailing drainages.

| Sample | Date       | Mn (µg/l) | Cd (µg/l) | Ni (µg/l) | Cu (µg/l) | Pb (µg/l) |
|--------|------------|-----------|-----------|-----------|-----------|-----------|
| A      | 18 March 2009 | 144      | 5700      | 320       | 19        | 875       |
| A      | 25 March 2009 | 154      | 5980      | 273       | 15        | 611       |
| A      | 17 April 2009 | 1100     | 5500      | 287       | 29        | 507       |
| A      | 07 May 2009   | 101      | 6130      | 279       | 12        | 970       |
| A      | 11 November 2009 | 675   | 7170      | 360       | 112       | 1010      |
| A      | 01 December 2010 | 1115  | 6500      | 59        | 68        | 600       |
| A      | 02 February 2011 | 980   | 5300      | 333       | 87        | 490       |
| A      | 02 February 2011 | 1003  | 5500      | 344       | 83        | 566       |
| A      | 11 February 2011 | 820   | 5800      | 350       | 79        | 700       |
| B      | 25 March 2009 | 2960     | 5040      | 128       | 7.5       | 87         |
| B      | 17 April 2009 | 1570     | 3000      | 100       | 4.2       | 35         |
| B      | 07 May 2009   | 1995     | 3900      | 102       | 4.9       | 88         |
| B      | 21 May 2009   | 2350     | 4575      | 112       | 5.5       | 134        |
| B      | 27 May 2009   | 2320     | 4660      | 119       | 5.5       | 154        |
| B      | 01 December 2010 | 2315 | 5065      | 120       | 11        | 94         |
| B      | 02 February 2011 | 980   | 2300      | 72        | 5.8       | 43         |
| B      | 02 February 2011 | 973    | 2300      | 66        | 6.6       | 45         |
| B      | 11 February 2011 | 1200  | 3200      | 95        | 7.1       | 64         |
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Table 11
Sulphur, Fe, Zn, Al, Pb, Mn, Cu, As, Cd, Cr, Sb, Co, and Ag concentrations in mine tailings.

| Sample | Date     | S  | Fe | Zn  | Al | Pb  | Mn  | Cu  | As  | Cd  | Cr  | Sb  | Co  | Ag  |
|--------|----------|----|----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|        |          | g/kg|    | mg/kg |    |     | mg/kg |    |     | mg/kg |    |     |     |     |     |
| MTA - 1| 28-Apr-12| 12 | 27 | 19  | 2.6| 10  | 1160 | 880 | 170 | 80  | 60  | 100 | 20  | 20  |
| MTA - 2| 28-Apr-12| 13 | 36 | 19  | 39.5| 17  | 1800 | 720 | 250 | 130 | 90  | 30  | 40  | 25  |
| MTA - 3| 28-Apr-12| 7.1| 29 | 18  | 7.2 | 10  | 1300 | 710 | 230 | 90  | 60  | 90  | 40  | 20  |
| MTB - 1| 28-Apr-12| 10 | 20 | 22  | 6.5 | 1.8 | 1010 | 530 | 140 | 100 | 40  | 40  | 55  | 4   |
| MTB - 2| 28-Apr-12| 8.3| 27 | 25  | 2.8 | 2.1 | 1240 | 370 | 100 | 100 | 40  | 50  | 10  | 5   |
| MTB - 3| 28-Apr-12| 8.9| 14 | 27  | 3.9 | 0.7 | 710  | 370 | 80  | 130 | 40  | 40  | 10  | 4   |

Table 12
Sulphur, Zn, Pb, Ni, Cd, Fe, Mn, Cu and Co concentrations in the bio-hydrozincites (N34-42) and Fe-hydrozincite + bio-hydrozincite sample (N32).

| Sample | Station | Date     | S  | Zn  | Pb  | Ni  | Cd  | Fe  | Mn  | Cu  | Co  |
|--------|---------|----------|----|-----|-----|-----|-----|-----|-----|-----|-----|
|        |         |          | g/kg| mg/kg |     |      |     |     |     |     |     |
| N32    | NS170   | 21 May 2009| 1.8| 465 | 5.5 | 420 | 510 | 50500| 400 | 420 | 50  |
| N34    | NS590   | 27 May 2009| 1.8| 530 | 0.9 | 930 | 850 | 630  | 650 | 70  | 70  |
| N36    | NS590   | 03 June 2009| 1.8| 460 | 1.5 | 890 | 790 | 2600| 610 | 80  | 70  |
| N37B   | NS420   | 10 June 2009| 1.7| 490 | 1.6 | 650 | 600 | 1700| 470 | 120 | 50  |
| N39    | NS420   | 15 July 2009| 1.6| 520 | 0.9 | 900 | 750 | 130 | 400 | 65  | 41  |
| N41A   | NS420   | 29 July 2009| 1.4| 510 | 1.1 | 830 | 620 | 260 | 310 | 80  | 30  |
| N42    | NS420   | 29 July 2009| 1.7| 540 | 0.9 | 1000| 720 | 180 | 360 | 60  | 40  |

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