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**CERTIFICATE OF ANALYSIS FOR**

# CERTIFIED REFERENCE MATERIAL

# OREAS 554b

## Copper-Cobalt Ore (Kinsevere Mine, Katanga Province, Democratic Republic of the Congo)

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**Table 1. Certified Values, Uncertainty & Tolerance Intervals for elements by 4-Acid Digestion and Aqua Regia Digestion in OREAS 554b.**

| Constituent | Certified Value† | 95% Expanded Uncertainty | | 95% Tolerance Limits | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| **4-Acid Digestion** | | | | | |
| Ag, Silver (ppm) | 0.135 | 0.103 | 0.168 | 0.123 | 0.148 |
| Al, Aluminium (wt.%) | 6.47 | 6.26 | 6.67 | 6.34 | 6.59 |
| As, Arsenic (ppm) | 75 | 73 | 78 | 72 | 78 |
| Ba, Barium (ppm) | 586 | 543 | 630 | 564 | 609 |
| Be, Beryllium (ppm) | 4.17 | 3.99 | 4.36 | 4.06 | 4.28 |
| Bi, Bismuth (ppm) | 1.29 | 1.22 | 1.35 | 1.25 | 1.32 |
| Ca, Calcium (wt.%) | 0.114 | 0.106 | 0.122 | 0.111 | 0.117 |
| Cd, Cadmium (ppm) | 0.38 | 0.34 | 0.42 | 0.36 | 0.41 |
| Ce, Cerium (ppm) | 134 | 129 | 138 | 130 | 138 |
| Co, Cobalt (wt.%) | 0.788 | 0.766 | 0.810 | 0.777 | 0.799 |
| Cr, Chromium (ppm) | 93 | 89 | 98 | 90 | 97 |
| Cs, Caesium (ppm) | 2.44 | 2.34 | 2.55 | 2.36 | 2.53 |
| Cu, Copper (wt.%) | 3.70 | 3.62 | 3.77 | 3.63 | 3.76 |
| Dy, Dysprosium (ppm) | 4.48 | 3.96 | 5.00 | 4.26 | 4.70 |
| Er, Erbium (ppm) | 2.69 | 2.31 | 3.06 | 2.52 | 2.86 |
| Eu, Europium (ppm) | 0.97 | 0.91 | 1.03 | 0.92 | 1.02 |
| Fe, Iron (wt.%) | 3.66 | 3.59 | 3.73 | 3.59 | 3.72 |
| Ga, Gallium (ppm) | 26.5 | 25.4 | 27.6 | 25.8 | 27.3 |
| Gd, Gadolinium (ppm) | 5.08 | 4.41 | 5.74 | 4.86 | 5.29 |
| Ge, Germanium (ppm) | 0.18 | 0.14 | 0.23 | 0.17 | 0.20 |
| Hf, Hafnium (ppm) | 4.75 | 4.55 | 4.94 | 4.56 | 4.94 |
| Ho, Holmium (ppm) | 0.88 | 0.79 | 0.98 | 0.84 | 0.93 |
| In, Indium (ppm) | 2.08 | 2.00 | 2.15 | 2.01 | 2.14 |
| K, Potassium (wt.%) | 2.57 | 2.50 | 2.63 | 2.52 | 2.62 |
| La, Lanthanum (ppm) | 64 | 61 | 67 | 62 | 66 |
| Li, Lithium (ppm) | 52 | 50 | 53 | 51 | 53 |
| Lu, Lutetium (ppm) | 0.41 | 0.39 | 0.42 | 0.38 | 0.44 |
| Mg, Magnesium (wt.%) | 2.46 | 2.39 | 2.54 | 2.42 | 2.51 |
| Mn, Manganese (wt.%) | 0.065 | 0.063 | 0.066 | 0.063 | 0.066 |
| Mo, Molybdenum (ppm) | 14.7 | 14.0 | 15.4 | 14.3 | 15.2 |
| Na, Sodium (wt.%) | 0.063 | 0.058 | 0.068 | 0.061 | 0.065 |
| Nb, Niobium (ppm) | 15.0 | 13.3 | 16.6 | 14.3 | 15.6 |
| Nd, Neodymium (ppm) | 58 | 54 | 62 | 56 | 60 |
| Ni, Nickel (ppm) | 151 | 147 | 155 | 148 | 154 |
| P, Phosphorus (wt.%) | 0.033 | 0.032 | 0.035 | 0.032 | 0.034 |
| Pb, Lead (ppm) | 15.9 | 15.1 | 16.6 | 15.3 | 16.5 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

Note: intervals may appear asymmetric due to rounding.

**Table 1 continued.**

| Constituent | Certified Value† | 95% Expanded Uncertainty | | 95% Tolerance Limits | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| **4-Acid Digestion continued** | | | | | |
| Pr, Praseodymium (ppm) | 15.5 | 14.3 | 16.6 | 14.9 | 16.0 |
| Rb, Rubidium (ppm) | 106 | 101 | 112 | 103 | 110 |
| Re, Rhenium (ppm) | 0.024 | 0.021 | 0.027 | 0.022 | 0.026 |
| S, Sulphur (wt.%) | 3.57 | 3.48 | 3.65 | 3.49 | 3.64 |
| Sb, Antimony (ppm) | 3.79 | 3.58 | 3.99 | 3.61 | 3.97 |
| Sc, Scandium (ppm) | 12.4 | 11.8 | 12.9 | 12.0 | 12.7 |
| Se, Selenium (ppm) | 5.99 | 5.40 | 6.59 | 5.66 | 6.33 |
| Sm, Samarium (ppm) | 8.29 | 7.87 | 8.70 | 7.96 | 8.62 |
| Sn, Tin (ppm) | 3.21 | 3.05 | 3.37 | 3.07 | 3.35 |
| Sr, Strontium (ppm) | 66 | 64 | 68 | 64 | 67 |
| Ta, Tantalum (ppm) | 1.05 | 0.92 | 1.18 | 0.98 | 1.11 |
| Tb, Terbium (ppm) | 0.77 | 0.64 | 0.91 | 0.73 | 0.82 |
| Te, Tellurium (ppm) | 0.078 | 0.058 | 0.098 | IND | IND |
| Th, Thorium (ppm) | 15.4 | 14.6 | 16.3 | 14.9 | 15.9 |
| Ti, Titanium (wt.%) | 0.275 | 0.241 | 0.310 | 0.266 | 0.285 |
| Tl, Thallium (ppm) | 0.98 | 0.93 | 1.03 | 0.95 | 1.02 |
| Tm, Thulium (ppm) | 0.39 | 0.33 | 0.44 | 0.36 | 0.41 |
| U, Uranium (ppm) | 8.26 | 7.86 | 8.66 | 8.00 | 8.51 |
| V, Vanadium (ppm) | 316 | 307 | 324 | 309 | 323 |
| W, Tungsten (ppm) | 2.63 | 2.49 | 2.78 | 2.49 | 2.78 |
| Y, Yttrium (ppm) | 22.8 | 21.6 | 24.0 | 22.2 | 23.4 |
| Yb, Ytterbium (ppm) | 2.70 | 2.44 | 2.96 | 2.58 | 2.81 |
| Zn, Zinc (ppm) | 31.6 | 30.3 | 33.0 | 30.2 | 33.0 |
| Zr, Zirconium (ppm) | 165 | 161 | 170 | 162 | 169 |
| **Aqua Regia Digestion** | | | | | |
| Ag, Silver (ppm) | 0.088 | 0.076 | 0.101 | IND | IND |
| Al, Aluminium (wt.%) | 0.868 | 0.779 | 0.956 | 0.835 | 0.901 |
| As, Arsenic (ppm) | 72 | 70 | 75 | 71 | 74 |
| Au, Gold (ppm) | < 0.02 | IND | IND | IND | IND |
| B, Boron (ppm) | < 10 | IND | IND | IND | IND |
| Ba, Barium (ppm) | 81 | 71 | 91 | 78 | 84 |
| Be, Beryllium (ppm) | 1.84 | 1.71 | 1.96 | 1.80 | 1.87 |
| Bi, Bismuth (ppm) | 1.19 | 1.14 | 1.24 | 1.15 | 1.22 |
| Ca, Calcium (wt.%) | 0.108 | 0.103 | 0.113 | 0.105 | 0.111 |
| Cd, Cadmium (ppm) | 0.38 | 0.35 | 0.42 | 0.35 | 0.41 |
| Ce, Cerium (ppm) | 46.3 | 42.2 | 50.3 | 45.0 | 47.5 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

**Table 1 continued.**

| Constituent | Certified Value† | 95% Expanded Uncertainty | | 95% Tolerance Limits | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| **Aqua Regia Digestion continued** | | | | | |
| Co, Cobalt (wt.%) | 0.759 | 0.733 | 0.785 | 0.748 | 0.770 |
| Cr, Chromium (ppm) | 33.3 | 31.0 | 35.5 | 31.9 | 34.6 |
| Cs, Caesium (ppm) | 0.43 | 0.36 | 0.50 | 0.41 | 0.45 |
| Cu, Copper (wt.%) | 3.74 | 3.68 | 3.79 | 3.68 | 3.79 |
| Dy, Dysprosium (ppm) | 1.10 | 0.86 | 1.33 | 1.05 | 1.15 |
| Er, Erbium (ppm) | 0.46 | 0.33 | 0.58 | 0.43 | 0.49 |
| Eu, Europium (ppm) | 0.43 | 0.29 | 0.56 | 0.41 | 0.44 |
| Fe, Iron (wt.%) | 3.51 | 3.40 | 3.63 | 3.45 | 3.58 |
| Ga, Gallium (ppm) | 7.13 | 6.48 | 7.78 | 6.91 | 7.35 |
| Gd, Gadolinium (ppm) | 2.31 | 2.06 | 2.56 | 2.11 | 2.50 |
| Ge, Germanium (ppm) | 0.093 | 0.060 | 0.127 | IND | IND |
| Hf, Hafnium (ppm) | 0.33 | 0.30 | 0.36 | 0.31 | 0.35 |
| Hg, Mercury (ppm) | 0.054 | 0.039 | 0.070 | IND | IND |
| Ho, Holmium (ppm) | 0.18 | 0.14 | 0.22 | IND | IND |
| In, Indium (ppm) | 1.47 | 1.41 | 1.53 | 1.44 | 1.51 |
| K, Potassium (wt.%) | 0.203 | 0.186 | 0.220 | 0.193 | 0.214 |
| La, Lanthanum (ppm) | 20.9 | 19.4 | 22.5 | 20.2 | 21.7 |
| Li, Lithium (ppm) | 27.7 | 24.7 | 30.7 | 26.7 | 28.7 |
| Mg, Magnesium (wt.%) | 1.88 | 1.77 | 1.98 | 1.83 | 1.92 |
| Mn, Manganese (wt.%) | 0.064 | 0.062 | 0.066 | 0.063 | 0.065 |
| Mo, Molybdenum (ppm) | 14.0 | 13.4 | 14.5 | 13.6 | 14.3 |
| Na, Sodium (wt.%) | 0.010 | 0.009 | 0.012 | 0.010 | 0.011 |
| Nb, Niobium (ppm) | 0.083 | 0.066 | 0.100 | IND | IND |
| Nd, Neodymium (ppm) | 21.1 | 15.0 | 27.3 | 20.4 | 21.9 |
| Ni, Nickel (ppm) | 147 | 142 | 152 | 144 | 150 |
| P, Phosphorus (wt.%) | 0.020 | 0.020 | 0.021 | 0.019 | 0.021 |
| Pb, Lead (ppm) | 11.8 | 11.0 | 12.6 | 11.5 | 12.1 |
| Pr, Praseodymium (ppm) | 5.46 | 3.85 | 7.07 | 5.24 | 5.67 |
| Rb, Rubidium (ppm) | 8.01 | 7.20 | 8.82 | 7.68 | 8.34 |
| Re, Rhenium (ppm) | 0.021 | 0.019 | 0.024 | 0.019 | 0.023 |
| S, Sulphur (wt.%) | 3.48 | 3.38 | 3.58 | 3.42 | 3.54 |
| Sb, Antimony (ppm) | 2.22 | 2.02 | 2.42 | 2.12 | 2.31 |
| Sc, Scandium (ppm) | 2.91 | 2.71 | 3.11 | 2.75 | 3.07 |
| Se, Selenium (ppm) | 5.95 | 5.35 | 6.56 | 5.61 | 6.29 |
| Sm, Samarium (ppm) | 3.72 | 2.88 | 4.56 | 3.53 | 3.91 |
| Sn, Tin (ppm) | 1.31 | 1.21 | 1.41 | 1.27 | 1.35 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to limited reading resolution of the methods employed).

**Table 1 continued.**

| Constituent | Certified Value† | 95% Expanded Uncertainty | | 95% Tolerance Limits | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| **Aqua Regia Digestion continued** | | | | | |
| Sr, Strontium (ppm) | 15.8 | 13.8 | 17.8 | 15.1 | 16.5 |
| Ta, Tantalum (ppm) | < 0.01 | IND | IND | IND | IND |
| Tb, Terbium (ppm) | 0.26 | 0.21 | 0.30 | 0.24 | 0.28 |
| Te, Tellurium (ppm) | 0.057 | 0.047 | 0.068 | IND | IND |
| Th, Thorium (ppm) | 6.93 | 6.33 | 7.54 | 6.70 | 7.17 |
| U, Uranium (ppm) | 3.22 | 3.04 | 3.39 | 3.12 | 3.31 |
| V, Vanadium (ppm) | 52 | 48 | 56 | 50 | 54 |
| W, Tungsten (ppm) | 0.91 | 0.83 | 1.00 | 0.86 | 0.97 |
| Y, Yttrium (ppm) | 4.37 | 4.04 | 4.70 | 4.24 | 4.50 |
| Yb, Ytterbium (ppm) | 0.37 | 0.25 | 0.48 | 0.33 | 0.41 |
| Zn, Zinc (ppm) | 28.2 | 27.1 | 29.3 | 27.2 | 29.2 |
| Zr, Zirconium (ppm) | 10.4 | 9.7 | 11.2 | 10.1 | 10.8 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg. Note: intervals may appear asymmetric due to rounding.

†This operationally defined measurand meets the requirements of ISO 17034 and all participating laboratories comply with the requirements of ISO 17025.

IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

**Table 2. Certified Value, Uncertainty & Tolerance Intervals for other measurands in OREAS 554b.**

| Constituent | Certified Value | 95% Expanded Uncertainty | | 95% Tolerance Limits | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| **Borate Fusion XRF** | | | | | |
| $Al_2O_3$, Aluminium(III) oxide (wt.%) | 12.54 | 12.40 | 12.68 | 12.41 | 12.68 |
| BaO, Barium oxide (ppm) | 707 | 630 | 784 | 682 | 732 |
| CaO, Calcium oxide (wt.%) | 0.158 | 0.151 | 0.165 | IND | IND |
| Co, Cobalt (wt.%) | 0.794 | 0.767 | 0.820 | 0.783 | 0.805 |
| Cu, Copper (wt.%) | 3.67 | 3.60 | 3.75 | 3.64 | 3.71 |
| $Fe_2O_3$, Iron(III) oxide (wt.%) | 5.30 | 5.22 | 5.39 | 5.26 | 5.35 |
| $K_2O$, Potassium oxide (wt.%) | 3.13 | 3.06 | 3.20 | 3.10 | 3.16 |
| MgO, Magnesium oxide (wt.%) | 4.15 | 4.10 | 4.21 | 4.10 | 4.20 |
| MnO, Manganese oxide (wt.%) | 0.085 | 0.082 | 0.088 | 0.083 | 0.087 |
| Ni, Nickel (ppm) | 159 | 148 | 170 | IND | IND |
| $P_2O_5$, Phosphorus(V) oxide (wt.%) | 0.079 | 0.075 | 0.084 | 0.077 | 0.082 |
| $SiO_2$, Silicon dioxide (wt.%) | 56.28 | 55.88 | 56.68 | 55.90 | 56.66 |
| $SO_3$, Sulphur trioxide (wt.%) | 8.91 | 8.56 | 9.26 | 8.81 | 9.01 |
| Sr, Strontium (ppm) | 66 | 52 | 79 | IND | IND |
| $TiO_2$, Titanium dioxide (wt.%) | 0.747 | 0.729 | 0.766 | 0.731 | 0.764 |
| $V_2O_5$, Vanadium(V) oxide (ppm) | 558 | 490 | 626 | 519 | 598 |
| Zr, Zirconium (ppm) | 207 | 197 | 217 | IND | IND |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

IND = indeterminate (due to limited reading resolution of the methods employed).

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to limited reading resolution of the methods employed).

**Table 2 continued.**

| Constituent | Certified Value | 95% Expanded Uncertainty | | 95% Tolerance Limits | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| **Thermogravimetry** | | | | | |
| LOI[1000], Loss On Ignition @1000°C (wt.%) | 10.98 | 10.78 | 11.19 | 10.89 | 11.08 |
| **Infrared Combustion** | | | | | |
| C, Carbon (wt.%) | 3.77 | 3.71 | 3.83 | 3.73 | 3.81 |
| S, Sulphur (wt.%) | 3.60 | 3.54 | 3.65 | 3.55 | 3.64 |
| **Sulphuric Acid 5% Leach** | | | | | |
| Co, Cobalt (wt.%) | 0.269 | 0.235 | 0.302 | 0.262 | 0.276 |
| Cu, Copper (wt.%) | 0.948 | 0.916 | 0.981 | 0.935 | 0.962 |
| **Peroxide Fusion ICP** | | | | | |
| Al, Aluminium (wt.%) | 6.54 | 6.43 | 6.65 | 6.41 | 6.67 |
| As, Arsenic (ppm) | 75 | 68 | 83 | 73 | 78 |
| B, Boron (ppm) | 209 | 177 | 242 | 197 | 222 |
| Ba, Barium (ppm) | 650 | 623 | 676 | 633 | 666 |
| Be, Beryllium (ppm) | 4.79 | 4.27 | 5.30 | IND | IND |
| Bi, Bismuth (ppm) | 1.41 | 1.29 | 1.53 | IND | IND |
| Ca, Calcium (wt.%) | 0.115 | 0.093 | 0.138 | 0.103 | 0.128 |
| Ce, Cerium (ppm) | 148 | 139 | 156 | 141 | 154 |
| Co, Cobalt (wt.%) | 0.795 | 0.774 | 0.815 | 0.780 | 0.809 |
| Cr, Chromium (ppm) | 112 | 101 | 123 | 107 | 117 |
| Cs, Caesium (ppm) | 2.62 | 2.29 | 2.96 | 2.46 | 2.79 |
| Cu, Copper (wt.%) | 3.73 | 3.66 | 3.79 | 3.64 | 3.81 |
| Dy, Dysprosium (ppm) | 6.54 | 6.01 | 7.08 | 6.11 | 6.97 |
| Er, Erbium (ppm) | 3.73 | 3.39 | 4.07 | 3.44 | 4.02 |
| Eu, Europium (ppm) | 1.10 | 1.02 | 1.18 | 1.05 | 1.15 |
| Fe, Iron (wt.%) | 3.69 | 3.60 | 3.78 | 3.64 | 3.75 |
| Ga, Gallium (ppm) | 27.0 | 25.4 | 28.7 | 25.3 | 28.7 |
| Gd, Gadolinium (ppm) | 7.06 | 6.26 | 7.87 | 6.64 | 7.49 |
| Ge, Germanium (ppm) | 2.28 | 1.63 | 2.93 | 2.00 | 2.56 |
| Ho, Holmium (ppm) | 1.28 | 1.15 | 1.41 | 1.20 | 1.36 |
| In, Indium (ppm) | 2.04 | 1.89 | 2.19 | 1.88 | 2.21 |
| K, Potassium (wt.%) | 2.58 | 2.50 | 2.65 | 2.51 | 2.64 |
| La, Lanthanum (ppm) | 73 | 70 | 76 | 70 | 76 |
| Li, Lithium (ppm) | 54 | 50 | 57 | 52 | 55 |
| Lu, Lutetium (ppm) | 0.55 | 0.42 | 0.67 | 0.49 | 0.60 |
| Mg, Magnesium (wt.%) | 2.50 | 2.44 | 2.56 | 2.45 | 2.55 |
| Mn, Manganese (wt.%) | 0.067 | 0.064 | 0.070 | 0.066 | 0.069 |
| Mo, Molybdenum (ppm) | 15.0 | 13.7 | 16.3 | 14.4 | 15.7 |
| Nb, Niobium (ppm) | 22.9 | 20.5 | 25.2 | 21.3 | 24.4 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to limited reading resolution of the methods employed).

**Table 2 continued.**

| Constituent | Certified Value | 95% Expanded Uncertainty | | 95% Tolerance Limits | |
|---|---|---|---|---|---|
| | | Low | High | Low | High |
| **Peroxide Fusion ICP continued** | | | | | |
| Nd, Neodymium (ppm) | 61 | 56 | 66 | 58 | 64 |
| Ni, Nickel (ppm) | 157 | 147 | 167 | 151 | 163 |
| P, Phosphorus (wt.%) | 0.032 | 0.024 | 0.041 | IND | IND |
| Pb, Lead (ppm) | 21.0 | 17.4 | 24.6 | 17.9 | 24.1 |
| Pr, Praseodymium (ppm) | 17.0 | 15.7 | 18.4 | 16.1 | 18.0 |
| Rb, Rubidium (ppm) | 107 | 101 | 113 | 103 | 111 |
| S, Sulphur (wt.%) | 3.60 | 3.51 | 3.70 | 3.53 | 3.68 |
| Sb, Antimony (ppm) | 3.96 | 3.49 | 4.44 | IND | IND |
| Sc, Scandium (ppm) | 11.4 | 10.1 | 12.6 | IND | IND |
| Si, Silicon (wt.%) | 26.68 | 26.11 | 27.25 | 26.13 | 27.22 |
| Sm, Samarium (ppm) | 8.83 | 8.10 | 9.56 | 8.11 | 9.56 |
| Sn, Tin (ppm) | 3.10 | 2.41 | 3.78 | IND | IND |
| Sr, Strontium (ppm) | 73 | 68 | 77 | 70 | 76 |
| Ta, Tantalum (ppm) | 1.77 | 1.45 | 2.09 | IND | IND |
| Tb, Terbium (ppm) | 1.14 | 1.00 | 1.27 | 1.05 | 1.22 |
| Th, Thorium (ppm) | 15.6 | 14.9 | 16.2 | 15.0 | 16.1 |
| Ti, Titanium (wt.%) | 0.436 | 0.422 | 0.450 | 0.426 | 0.445 |
| Tl, Thallium (ppm) | 1.03 | 0.88 | 1.18 | IND | IND |
| Tm, Thulium (ppm) | 0.53 | 0.49 | 0.56 | 0.49 | 0.56 |
| U, Uranium (ppm) | 8.62 | 8.00 | 9.24 | 8.23 | 9.01 |
| V, Vanadium (ppm) | 333 | 318 | 348 | 325 | 340 |
| W, Tungsten (ppm) | 3.10 | 1.89 | 4.31 | IND | IND |
| Y, Yttrium (ppm) | 34.8 | 33.1 | 36.5 | 33.1 | 36.5 |
| Yb, Ytterbium (ppm) | 3.51 | 3.14 | 3.88 | 3.19 | 3.83 |
| Zn, Zinc (ppm) | 33.5 | 28.2 | 38.8 | 31.5 | 35.6 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note: intervals may appear asymmetric due to rounding; IND = indeterminate (due to limited reading resolution of the methods employed. For practical purposes the 95% Expanded Uncertainty can be set between zero and a two times multiple of the upper bound/non-detect limit value).

**Table 3. Indicative Values for OREAS 554b.**

| Constituent | Unit | Value | Constituent | Unit | Value | Constituent | Unit | Value |
|---|---|---|---|---|---|---|---|---|
| **Borate Fusion XRF continued** | | | | | | | | |
| Ag | ppm | *0.040* | $HfO_2$ | ppm | *312* | Sc | ppm | *13.6* |
| As | ppm | *78* | Hg | ppm | *< 100* | Se | ppm | *2.33* |
| Be | ppm | *2.17* | Ho | ppm | *1.18* | Sm | ppm | *7.74* |
| Bi | ppm | *< 100* | In | ppm | *2.38* | Sn | ppm | *57* |
| Cd | ppm | *< 100* | La | ppm | *73* | Ta | ppm | *1.90* |
| Ce | ppm | *115* | Lu | ppm | *0.48* | Tb | ppm | *1.09* |
| Cl | ppm | *171* | Mo | ppm | *< 50* | Te | ppm | *11.9* |
| $Cr_2O_3$ | ppm | *152* | $Na_2O$ | wt.% | *0.102* | Th | ppm | *15.3* |
| Cs | ppm | *2.63* | Nb | ppm | *28.8* | Tl | ppm | *0.79* |
| Dy | ppm | *5.78* | Nd | ppm | *54* | Tm | ppm | *0.50* |
| Er | ppm | *3.41* | Pb | ppm | *< 100* | U | ppm | *8.27* |
| Eu | ppm | *0.94* | Pr | ppm | *14.8* | W | ppm | *7.22* |
| Ga | ppm | *26.8* | Rb | ppm | *88* | Y | ppm | *34.7* |
| Gd | ppm | *6.13* | Re | ppm | *18.9* | Yb | ppm | *3.28* |
| Ge | ppm | *< 100* | Sb | ppm | *< 50* | Zn | ppm | *43.9* |
| **Peroxide Fusion ICP** | | | | | | | | |
| Ag | ppm | *0.386* | Hg | ppm | *< 0.1* | Se | ppm | *10.3* |
| Cd | ppm | *< 10* | Na | wt.% | *0.057* | Te | ppm | *< 2* |
| Hf | ppm | *5.79* | Re | ppm | *0.052* | Zr | ppm | *214* |
| Ag | ppm | *0.386* | Hg | ppm | *< 0.1* | Se | ppm | *10.3* |
| **4-Acid Digestion** | | | | | | | | |
| Hg | ppm | *< 1* | Pt | ppb | *9.33* | | | |
| **Aqua Regia Digestion** | | | | | | | | |
| Ir | ppm | *< 0.003* | Pt | ppb | *5.81* | Tm | ppm | *0.065* |
| Lu | ppm | *0.066* | Ti | wt.% | *0.002* | | | |
| Pd | ppb | *< 10* | Tl | ppm | *0.33* | | | |
| **3-Acid Digestion (no HF)** | | | | | | | | |
| Ag | ppm | *0.407* | Gd | ppm | *5.67* | S | wt.% | *3.40* |
| $Al_2O_3$ | wt.% | *12.37* | Hf | ppm | *5.32* | Sc | ppm | *13.0* |
| Ba | ppm | *635* | Ho | ppm | *0.88* | Sm | ppm | *7.88* |
| Be | ppm | *5.30* | $K_2O$ | wt.% | *3.15* | Sn | ppm | *3.18* |
| Bi | ppm | *1.82* | La | ppm | *72* | Sr | ppm | *69* |
| CaO | wt.% | *0.152* | Li | ppm | *54* | Ta | ppm | *0.32* |
| Cd | ppm | *0.50* | MgO | wt.% | *4.15* | Tb | ppm | *0.72* |
| Ce | ppm | *130* | MnO | wt.% | *0.081* | Th | ppm | *17.4* |
| Co | wt.% | *0.858* | Mo | ppm | *16.8* | $TiO_2$ | wt.% | *0.739* |
| Cr | ppm | *103* | $Na_2O$ | wt.% | *0.082* | U | ppm | *9.04* |
| Cs | ppm | *2.43* | Nb | ppm | *20.8* | V | ppm | *332* |
| Cu | wt.% | *3.97* | Nd | ppm | *59* | W | ppm | *3.53* |
| Dy | ppm | *4.74* | Ni | ppm | *181* | Y | ppm | *26.9* |
| Er | ppm | *2.77* | $P_2O_5$ | wt.% | *< 0.002* | Yb | ppm | *2.75* |
| Eu | ppm | *1.11* | Pb | ppm | *19.0* | Zn | ppm | *73* |
| $Fe_2O_3$ | wt.% | *5.19* | Pr | ppm | *15.8* | Zr | ppm | *179* |

SI unit equivalents: ppb (parts per billion; 1 x $10^{-9}$) ≡ µg/kg; ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note: the number of significant figures reported is not a reflection of the level of certainty of stated values. They are instead an artefact of ORE's in-house CRM-specific LIMS.

# INTRODUCTION

OREAS reference materials are intended to provide a low-cost method of evaluating and improving the quality of analysis of geological samples. To the geologist they provide a means of implementing quality control in analytical data sets generated in exploration from the grass roots level through to prospect evaluation, and in grade control at mining operations. To the analyst they provide an effective means of calibrating analytical equipment, assessing new techniques and routinely monitoring in-house procedures. OREAS reference materials enable users to successfully achieve process control of these tasks because the observed variance from repeated analysis has its origin almost exclusively in the analytical process rather than the reference material itself. In evaluating laboratory performance with this CRM, the section headed 'Instructions for correct use' should be read carefully.

Table 1 and 2 provides the certified values and their associated 95% expanded uncertainty and tolerance intervals, Table 3 shows indicative values, Table 4 provides some indicative physical properties, Table 5 provides indicative mineralogy based on semi-quantitative XRD analysis and Table 6 presents the performance gate intervals for all certified values. Tabulated results of all elements together with uncorrected means, medians, standard deviations, relative standard deviations and per cent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 554b-DataPack.1.0.240216_184819.xlsx**).

Results are also presented in scatter plots for Co and Cu by multiple operationally defined methods including borate fusion with XRF finish, peroxide fusion with ICP-OES/MS finish, 4-acid digestion with ICP-OES/MS finish (and/or AAS finish) and aqua regia digestion with ICP-OES/MS finish (and/or AAS finish) in Figures 1 to 8 respectively, together with ±3SD (magenta) and ±5% (yellow) control lines and certified value (green line). Accepted individual results are coloured blue and individual and dataset outliers are identified in red and violet, respectively.

# SOURCE MATERIAL

OREAS 554b was prepared from copper-cobalt sulphide ore samples sourced from MMG's Kinsevere Mine blended with barren black slate and a minor addition of cobalt concentrate. The Kinsevere Mine is located in the Haut-Katanga province about 30 km from Lubumbashi in the south-east of the Democratic Republic of the Congo (DRC). The hypogene mineralisation at Kinsevere occurs as stratabound, veins and breccias consisting of mainly chalcopyrite, carrolite, bornite and occasionally pyrite and chalcocite, hosted within the Mine series carbonaceous shales, siltstones, and dolomites of the Roan Group belonging to the Katangan Supergroup stratigraphy.

# COMMINUTION AND HOMOGENISATION PROCEDURES

The material constituting OREAS 554b was prepared in the following manner:

- Drying of ore and barren materials to constant mass at 105°C;
- Drying of cobalt concentrate to constant mass at 95°C;
- Crushing and milling of the ore materials to 100% minus 30 microns;
- Crushing and milling of the barren materials to >98% minus 75 microns;

- Deagglomeration of cobalt concentrate and screening at 150 microns;
- Check analysis of ores and concentrate for contained Co and Cu concentrations;
- Blending ores, Co concentrate and barren materials in appropriate proportions to achieve the desired grades;
- Homogenisation using OREAS' novel processing technologies;
- Packaging in 10g units sealed under nitrogen in laminated foil pouches.

## PHYSICAL PROPERTIES

OREAS 554b was tested at ORE Research & Exploration Pty Ltd's onsite facility for various physical properties. Table 4 presents these findings that should be used for informational purposes only.

**Table 4. Physical properties of OREAS 554b.**

| Bulk Density (kg/m$^3$) | Moisture (wt.%) | Munsell Notation‡ | Munsell Color‡ |
|---|---|---|---|
| 730 | 0.84 | N2 | GrayishBlack |

‡The Munsell Rock Color Chart helps geologists and archeologists communicate with colour more effectively by cross-referencing ISCC-NBS colour names with unique Munsell alpha-numeric colour notations for rock colour samples.

## MINERALOGY

The semi-quantitative XRD results shown in Table 5 below have been normalised to 100 % and represent the relative proportion of crystalline material. Totals greater or less than 100 % are due to rounding errors. Some amorphous material might be present. A trace amount of plagioclase appears to be present. The quantification of the kandite group is performed on a largely overlapped pattern and carriers high than usual uncertainty. A trace amount of arsenopyrite, malachite and talc may also be present.

**Table 5. Indicative mineralogy of OREAS 554b based on semi-quantitative XRD analysis.**

| Mineral / Mineral Group | % (mass ratio) |
|---|---|
| Chlorite | 3 |
| Kandite group | 2 |
| Annite - biotite - phlogopite | 4 |
| Muscovite | 17 |
| K-feldspar and/or rutile | 0 |
| Tourmaline | < 1 |
| Quartz | 42 |
| Dolomite - ankerite | 1 |
| Pyrite | 0 |
| Chalcopyrite | 6 |
| Linnaeite group | 1 |
| Magnetite and/or antlerite | 1 |
| Goethite | < 1 |
| Malachite | 0 |
| Magnesite | 22 |
| Rutile | 1 |

## ANALYTICAL PROGRAM

Thirty analytical laboratories participated in the program to characterise the elements reported in Tables 1 and 2. The following elements and methods were undertaken:

- Lithium borate fusion whole rock analysis package by X-ray fluorescence (up to 20 laboratories depending on the element; except for one laboratory that used pressed powder pellet with XRF);
- Loss on Ignition (LOI) at 1000° C (14 laboratories used a thermogravimetric analyser, 6 laboratories included LOI with their fusion package and 4 laboratories used a conventional muffle furnace);
- Infrared combustion furnace/CS analyser to determine C (25 laboratories) and S (26 laboratories);
- Co (9 laboratories) and Cu (19 laboratories) by *5% sulphuric acid leach with ICP-OES or AAS finish;
- Full ICP-OES and ICP-MS elemental suites by sodium peroxide fusion (up to 22 laboratories depending on the element);
- Full ICP-OES and ICP-MS elemental suites by 4-acid ($HCl$-$HNO_3$-$HF$-$HClO_4$) digestion (up to 27 laboratories depending on the element);
- Full ICP-OES and ICP-MS elemental suites by aqua regia digestion (up to 27 laboratories depending on the element).

*See 'Appendix' for specified methodology.

For the round robin program, ten 800g test units were taken at predetermined intervals immediately following homogenisation and are considered representative of the entire prepared batch. The six samples received by each laboratory were obtained by taking two 30g scoop splits from each of three separate 800g test units. This format enabled a nested ANOVA treatment of the results to evaluate homogeneity, i.e., to ascertain whether between-unit variance is greater than within-unit variance (see 'Homogeneity Evaluation' section below).

## STATISTICAL ANALYSIS

**Certified Values and their uncertainty intervals** (Tables 1 and 2) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration).

For individual outliers within a laboratory batch the z-score test is used in combination with a second method that determines the per cent deviation of the individual value from the batch median. Outliers in general are selected on the basis of z-scores > 2.5 and with per cent deviations (i) > 3 and (ii) more than three times the average absolute per cent deviation for the batch. Each laboratory data set mean is tested for outlying status based on z-score discrimination and rejected if > 2.5. After individual and laboratory data set (batch) outliers have been eliminated a non-iterative 3 standard deviation filter is applied, with those values lying outside this window also relegated to outlying status. However, while statistics are taken into account, the exercise of a statistician's prerogative plays a significant role in identifying outliers.

**95% Expanded Uncertainty** provides a 95% probability that the true value of the analyte under consideration lies between the upper and lower limits and is calculated according to the method outlined in ISO 98-3:2008 [5]. All known or suspected sources of bias have been investigated or taken into account.

**Indicative (uncertified) values** (Table 3) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where interlaboratory consensus is poor.

**Standard Deviation** intervals (see Table 5) provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. They take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The Standard Deviation values include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability.

In the application of SD's in monitoring performance it is important to note that not all laboratories function at the same level of proficiency and that different methods in use at a particular laboratory have differing levels of precision. Each laboratory has its own inherent SD (for a specific concentration level and analyte-method pair) based on the analytical process and this SD is not directly related to the round robin program (see 'Intended Use' section for more detail).

The SD for each analyte's certified value is calculated from the same filtered data set used to determine the certified value, i.e., after removal of all individual, lab dataset (batch) and 3SD outliers (single iteration). These outliers can only be removed after the absolute homogeneity of the CRM has been independently established, i.e., the outliers must be confidently deemed to be analytical rather than arising from inhomogeneity of the CRM. ***The standard deviation is then calculated for each analyte from the pooled accepted analyses generated from the certification program.***

**Homogeneity Evaluation**

The tolerance limits (ISO 16269:2014) shown in Tables 1 and 2 were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for copper by fusion with XRF, where 99% of the time (1-α=0.99) at least 95% of subsamples (ρ=0.95) will have concentrations lying between 3.64 and 3.71 wt.%. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99% of the tolerance intervals so constructed would cover at least 95% of the total population, and 1% of the tolerance intervals would cover less than 95% of the total population (ISO Guide 35). ***Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.***

The homogeneity of OREAS 554b has also been evaluated in an ANOVA study for all certified analytes present in concentrations well above detection levels (i.e. >20 x Lower Limit of Detection) for the various methods undertaken. This study tests the null hypothesis that no statistically significant difference exists between the between-unit variance and the within-unit variance (i.e. *p*-values <0.05 indicate rejection of the null hypothesis). Of the 195 certified values, no failures were observed indicating no evidence to reject the null hypothesis.

Based on the statistical analysis of ANOVA and the results of the interlaboratory certification program, it can be concluded that OREAS 554b is fit-for-purpose as a certified reference material (see 'Intended Use' below).

## PERFORMANCE GATES

The standard deviations (SD's) intervals reported in Table 6 provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. They take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The Standard Deviation values include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability.

In the application of SD's in monitoring performance it is important to note that not all laboratories function at the same level of proficiency and that different methods in use at a particular laboratory have differing levels of precision. Each laboratory has its own inherent SD (for a specific concentration level and analyte-method pair) based on the analytical process and this SD is not directly related to the round robin program (see 'Instructions for handling and correct use' section for more detail). The SD for each analyte's certified value is calculated from the same filtered data set used to determine the certified value, i.e., after removal of all individual, lab dataset (batch) and 3SD outliers (single iteration). These outliers can only be removed after the absolute homogeneity of the CRM has been independently established, i.e., the outliers must be confidently deemed to be analytical rather than arising from inhomogeneity of the CRM.

***The standard deviation is then calculated for each analyte from the pooled accepted analyses generated from the certification program.***

Table 6 below shows intervals calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned (also see 'Intended Use' section below). Westgard Rules extend the basics of single-rule QC monitoring using multi-rules (for more information visit www.westgard.com/mltirule.htm). A second method utilises a 5% window calculated directly from the certified value. Standard deviation is also shown in relative percent for one, two and three relative standard deviations (1RSD, 2RSD and 3RSD) to facilitate an appreciation of the magnitude of these numbers and a comparison with the 5% window. Caution should be exercised when concentration levels approach lower limits of detection of the analytical methods employed as performance gates calculated from standard deviations tend to be excessively wide whereas those determined by the 5% method are too narrow. One approach used at commercial laboratories is to set the acceptance criteria at twice the detection level (DL) ± 10%.

*i.e., Certified Value ± 10% ± 2DL* [1].

**Table 6. Performance Gates for OREAS 554b.**

| Constituent | Certified Value | Absolute Standard Deviations | | | | | Relative Standard Deviations | | | 5% window | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1SD | 2SD Low | 2SD High | 3SD Low | 3SD High | 1RSD | 2RSD | 3RSD | Low | High |
| **Borate Fusion XRF** | | | | | | | | | | | |
| $Al_2O_3$, wt.% | 12.54 | 0.196 | 12.15 | 12.94 | 11.96 | 13.13 | 1.56% | 3.13% | 4.69% | 11.92 | 13.17 |
| BaO, ppm | 707 | 93 | 522 | 893 | 429 | 985 | 13.11% | 26.21% | 39.32% | 672 | 743 |
| CaO, wt.% | 0.158 | 0.005 | 0.148 | 0.168 | 0.143 | 0.173 | 3.10% | 6.21% | 9.31% | 0.150 | 0.166 |
| Co, wt.% | 0.794 | 0.041 | 0.711 | 0.876 | 0.670 | 0.918 | 5.21% | 10.41% | 15.62% | 0.754 | 0.833 |
| Cu, wt.% | 3.67 | 0.110 | 3.45 | 3.89 | 3.34 | 4.00 | 3.01% | 6.01% | 9.02% | 3.49 | 3.86 |
| $Fe_2O_3$, wt.% | 5.30 | 0.125 | 5.05 | 5.55 | 4.93 | 5.68 | 2.36% | 4.72% | 7.08% | 5.04 | 5.57 |
| $K_2O$, wt.% | 3.13 | 0.121 | 2.89 | 3.37 | 2.77 | 3.49 | 3.85% | 7.70% | 11.55% | 2.97 | 3.29 |
| MgO, wt.% | 4.15 | 0.078 | 4.00 | 4.31 | 3.92 | 4.38 | 1.87% | 3.74% | 5.62% | 3.94 | 4.36 |
| MnO, wt.% | 0.085 | 0.006 | 0.074 | 0.096 | 0.068 | 0.101 | 6.48% | 12.97% | 19.45% | 0.081 | 0.089 |
| Ni, ppm | 159 | 17 | 124 | 194 | 106 | 211 | 11.00% | 22.01% | 33.01% | 151 | 167 |
| $P_2O_5$, wt.% | 0.079 | 0.006 | 0.067 | 0.092 | 0.061 | 0.098 | 7.74% | 15.49% | 23.23% | 0.075 | 0.083 |
| $SiO_2$, wt.% | 56.28 | 0.485 | 55.31 | 57.25 | 54.83 | 57.74 | 0.86% | 1.72% | 2.58% | 53.47 | 59.10 |
| $SO_3$, wt.% | 8.91 | 0.430 | 8.05 | 9.77 | 7.62 | 10.20 | 4.83% | 9.66% | 14.49% | 8.47 | 9.36 |
| Sr, ppm | 66 | 15 | 35 | 96 | 20 | 111 | 23.00% | 46.00% | 68.99% | 62 | 69 |
| $TiO_2$, wt.% | 0.747 | 0.024 | 0.700 | 0.795 | 0.676 | 0.819 | 3.19% | 6.38% | 9.58% | 0.710 | 0.785 |
| $V_2O_5$, ppm | 558 | 88 | 383 | 733 | 296 | 821 | 15.68% | 31.36% | 47.04% | 530 | 586 |
| Zr, ppm | 207 | 8 | 191 | 224 | 182 | 232 | 3.98% | 7.97% | 11.95% | 197 | 217 |
| **Thermogravimetry** | | | | | | | | | | | |
| $LOI^{1000}$, wt.% | 10.98 | 0.352 | 10.28 | 11.69 | 9.93 | 12.04 | 3.20% | 6.41% | 9.61% | 10.44 | 11.53 |
| **Infrared Combustion** | | | | | | | | | | | |
| C, wt.% | 3.77 | 0.114 | 3.54 | 4.00 | 3.43 | 4.11 | 3.02% | 6.03% | 9.05% | 3.58 | 3.96 |
| S, wt.% | 3.60 | 0.076 | 3.44 | 3.75 | 3.37 | 3.82 | 2.11% | 4.22% | 6.32% | 3.42 | 3.78 |
| **Sulphuric Acid 5% Leach** | | | | | | | | | | | |
| Co, wt.% | 0.269 | 0.025 | 0.219 | 0.319 | 0.194 | 0.344 | 9.32% | 18.64% | 27.97% | 0.255 | 0.282 |
| Cu, wt.% | 0.948 | 0.048 | 0.853 | 1.044 | 0.806 | 1.091 | 5.01% | 10.02% | 15.04% | 0.901 | 0.996 |
| **Peroxide Fusion ICP** | | | | | | | | | | | |
| Al, wt.% | 6.54 | 0.149 | 6.24 | 6.84 | 6.09 | 6.99 | 2.28% | 4.56% | 6.84% | 6.21 | 6.87 |
| As, ppm | 75 | 7.0 | 62 | 89 | 55 | 96 | 9.24% | 18.48% | 27.71% | 72 | 79 |
| B, ppm | 209 | 35 | 140 | 279 | 105 | 314 | 16.66% | 33.32% | 49.99% | 199 | 220 |
| Ba, ppm | 650 | 37 | 575 | 725 | 537 | 762 | 5.76% | 11.52% | 17.28% | 617 | 682 |
| Be, ppm | 4.79 | 0.334 | 4.12 | 5.46 | 3.78 | 5.79 | 6.98% | 13.96% | 20.94% | 4.55 | 5.03 |
| Bi, ppm | 1.41 | 0.084 | 1.24 | 1.57 | 1.15 | 1.66 | 5.96% | 11.92% | 17.88% | 1.34 | 1.48 |
| Ca, wt.% | 0.115 | 0.027 | 0.062 | 0.169 | 0.035 | 0.196 | 23.31% | 46.62% | 69.93% | 0.110 | 0.121 |
| Ce, ppm | 148 | 4 | 141 | 155 | 137 | 158 | 2.38% | 4.75% | 7.13% | 140 | 155 |
| Co, wt.% | 0.795 | 0.022 | 0.751 | 0.839 | 0.729 | 0.861 | 2.77% | 5.54% | 8.31% | 0.755 | 0.834 |
| Cr, ppm | 112 | 22 | 69 | 155 | 47 | 177 | 19.39% | 38.78% | 58.16% | 106 | 118 |
| Cs, ppm | 2.62 | 0.159 | 2.31 | 2.94 | 2.15 | 3.10 | 6.04% | 12.09% | 18.13% | 2.49 | 2.76 |
| Cu, wt.% | 3.73 | 0.092 | 3.54 | 3.91 | 3.45 | 4.00 | 2.47% | 4.94% | 7.42% | 3.54 | 3.91 |
| Dy, ppm | 6.54 | 0.390 | 5.76 | 7.32 | 5.37 | 7.71 | 5.97% | 11.94% | 17.90% | 6.21 | 6.87 |
| Er, ppm | 3.73 | 0.174 | 3.38 | 4.08 | 3.21 | 4.26 | 4.67% | 9.35% | 14.02% | 3.55 | 3.92 |
| Eu, ppm | 1.10 | 0.082 | 0.93 | 1.26 | 0.85 | 1.35 | 7.49% | 14.97% | 22.46% | 1.04 | 1.15 |
| Fe, wt.% | 3.69 | 0.135 | 3.42 | 3.96 | 3.29 | 4.10 | 3.66% | 7.31% | 10.97% | 3.51 | 3.88 |
| Ga, ppm | 27.0 | 1.52 | 24.0 | 30.1 | 22.5 | 31.6 | 5.62% | 11.25% | 16.87% | 25.7 | 28.4 |
| Gd, ppm | 7.06 | 0.450 | 6.16 | 7.96 | 5.72 | 8.41 | 6.36% | 12.73% | 19.09% | 6.71 | 7.42 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note 1: intervals may appear asymmetric due to rounding.

Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

**Table 6 continued.**

| Constituent | Certified Value | Absolute Standard Deviations | | | | | Relative Standard Deviations | | | 5% window | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1SD | 2SD Low | 2SD High | 3SD Low | 3SD High | 1RSD | 2RSD | 3RSD | Low | High |
| **Peroxide Fusion ICP continued** | | | | | | | | | | | |
| Ge, ppm | 2.28 | 0.32 | 1.64 | 2.92 | 1.32 | 3.24 | 14.05% | 28.09% | 42.14% | 2.17 | 2.40 |
| Ho, ppm | 1.28 | 0.058 | 1.17 | 1.40 | 1.11 | 1.45 | 4.51% | 9.02% | 13.53% | 1.22 | 1.35 |
| In, ppm | 2.04 | 0.090 | 1.86 | 2.22 | 1.77 | 2.31 | 4.38% | 8.77% | 13.15% | 1.94 | 2.15 |
| K, wt.% | 2.58 | 0.106 | 2.37 | 2.79 | 2.26 | 2.89 | 4.10% | 8.19% | 12.29% | 2.45 | 2.71 |
| La, ppm | 73 | 3.8 | 66 | 81 | 62 | 84 | 5.18% | 10.35% | 15.53% | 69 | 77 |
| Li, ppm | 54 | 4.4 | 45 | 62 | 40 | 67 | 8.27% | 16.54% | 24.80% | 51 | 56 |
| Lu, ppm | 0.55 | 0.09 | 0.37 | 0.72 | 0.28 | 0.81 | 16.32% | 32.63% | 48.95% | 0.52 | 0.57 |
| Mg, wt.% | 2.50 | 0.099 | 2.30 | 2.70 | 2.20 | 2.79 | 3.95% | 7.91% | 11.86% | 2.37 | 2.62 |
| Mn, wt.% | 0.067 | 0.003 | 0.061 | 0.073 | 0.058 | 0.076 | 4.60% | 9.19% | 13.79% | 0.064 | 0.070 |
| Mo, ppm | 15.0 | 1.02 | 13.0 | 17.1 | 11.9 | 18.1 | 6.82% | 13.63% | 20.45% | 14.3 | 15.8 |
| Nb, ppm | 22.9 | 1.78 | 19.3 | 26.4 | 17.5 | 28.2 | 7.79% | 15.57% | 23.36% | 21.7 | 24.0 |
| Nd, ppm | 61 | 4.2 | 53 | 69 | 48 | 74 | 6.90% | 13.80% | 20.70% | 58 | 64 |
| Ni, ppm | 157 | 14 | 130 | 184 | 116 | 198 | 8.61% | 17.23% | 25.84% | 149 | 165 |
| P, wt.% | 0.032 | 0.005 | 0.023 | 0.042 | 0.018 | 0.047 | 14.41% | 28.82% | 43.23% | 0.031 | 0.034 |
| Pb, ppm | 21.0 | 3.6 | 13.9 | 28.1 | 10.4 | 31.7 | 16.91% | 33.82% | 50.73% | 20.0 | 22.1 |
| Pr, ppm | 17.0 | 1.36 | 14.3 | 19.7 | 13.0 | 21.1 | 7.97% | 15.94% | 23.92% | 16.2 | 17.9 |
| Rb, ppm | 107 | 6 | 94 | 120 | 88 | 126 | 5.88% | 11.76% | 17.64% | 102 | 112 |
| S, wt.% | 3.60 | 0.120 | 3.36 | 3.84 | 3.24 | 3.96 | 3.33% | 6.66% | 9.98% | 3.42 | 3.78 |
| Sb, ppm | 3.96 | 0.292 | 3.38 | 4.55 | 3.09 | 4.84 | 7.38% | 14.76% | 22.14% | 3.76 | 4.16 |
| Sc, ppm | 11.4 | 0.92 | 9.5 | 13.2 | 8.6 | 14.1 | 8.09% | 16.17% | 24.26% | 10.8 | 11.9 |
| Si, wt.% | 26.68 | 0.548 | 25.58 | 27.77 | 25.04 | 28.32 | 2.05% | 4.11% | 6.16% | 25.35 | 28.01 |
| Sm, ppm | 8.83 | 0.587 | 7.66 | 10.00 | 7.07 | 10.59 | 6.64% | 13.28% | 19.93% | 8.39 | 9.27 |
| Sn, ppm | 3.10 | 0.58 | 1.93 | 4.26 | 1.35 | 4.85 | 18.84% | 37.68% | 56.52% | 2.94 | 3.25 |
| Sr, ppm | 73 | 7 | 58 | 88 | 50 | 95 | 10.24% | 20.49% | 30.73% | 69 | 76 |
| Ta, ppm | 1.77 | 0.118 | 1.53 | 2.00 | 1.41 | 2.12 | 6.65% | 13.31% | 19.96% | 1.68 | 1.86 |
| Tb, ppm | 1.14 | 0.070 | 1.00 | 1.28 | 0.93 | 1.35 | 6.18% | 12.37% | 18.55% | 1.08 | 1.19 |
| Th, ppm | 15.6 | 0.38 | 14.8 | 16.3 | 14.4 | 16.7 | 2.47% | 4.94% | 7.41% | 14.8 | 16.3 |
| Ti, wt.% | 0.436 | 0.013 | 0.411 | 0.461 | 0.398 | 0.474 | 2.89% | 5.78% | 8.66% | 0.414 | 0.458 |
| Tl, ppm | 1.03 | 0.10 | 0.82 | 1.24 | 0.71 | 1.34 | 10.19% | 20.37% | 30.56% | 0.98 | 1.08 |
| Tm, ppm | 0.53 | 0.030 | 0.47 | 0.59 | 0.44 | 0.62 | 5.75% | 11.50% | 17.25% | 0.50 | 0.55 |
| U, ppm | 8.62 | 0.604 | 7.41 | 9.82 | 6.81 | 10.43 | 7.00% | 14.01% | 21.01% | 8.19 | 9.05 |
| V, ppm | 333 | 22 | 288 | 378 | 266 | 400 | 6.69% | 13.39% | 20.08% | 316 | 350 |
| W, ppm | 3.10 | 0.92 | 1.27 | 4.93 | 0.35 | 5.85 | 29.56% | 59.13% | 88.69% | 2.94 | 3.25 |
| Y, ppm | 34.8 | 1.92 | 30.9 | 38.6 | 29.0 | 40.5 | 5.52% | 11.04% | 16.57% | 33.0 | 36.5 |
| Yb, ppm | 3.51 | 0.273 | 2.97 | 4.06 | 2.69 | 4.33 | 7.77% | 15.53% | 23.30% | 3.34 | 3.69 |
| Zn, ppm | 33.5 | 4.7 | 24.2 | 42.9 | 19.5 | 47.5 | 13.94% | 27.87% | 41.81% | 31.8 | 35.2 |
| **4-Acid Digestion** | | | | | | | | | | | |
| Ag, ppm | 0.135 | 0.028 | 0.080 | 0.191 | 0.052 | 0.219 | 20.52% | 41.04% | 61.55% | 0.129 | 0.142 |
| Al, wt.% | 6.47 | 0.240 | 5.99 | 6.95 | 5.75 | 7.18 | 3.70% | 7.41% | 11.11% | 6.14 | 6.79 |
| As, ppm | 75 | 3.3 | 69 | 82 | 65 | 85 | 4.37% | 8.74% | 13.11% | 72 | 79 |
| Ba, ppm | 586 | 58 | 471 | 702 | 413 | 760 | 9.84% | 19.68% | 29.52% | 557 | 616 |
| Be, ppm | 4.17 | 0.281 | 3.61 | 4.73 | 3.33 | 5.01 | 6.74% | 13.48% | 20.22% | 3.96 | 4.38 |
| Bi, ppm | 1.29 | 0.079 | 1.13 | 1.44 | 1.05 | 1.52 | 6.12% | 12.23% | 18.35% | 1.22 | 1.35 |
| Ca, wt.% | 0.114 | 0.010 | 0.094 | 0.134 | 0.085 | 0.144 | 8.63% | 17.25% | 25.88% | 0.108 | 0.120 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note 1: intervals may appear asymmetric due to rounding; IND = indeterminate.

Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

**Table 6 continued.**

| Constituent | Certified Value | Absolute Standard Deviations | | | | | Relative Standard Deviations | | | 5% window | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1SD | 2SD Low | 2SD High | 3SD Low | 3SD High | 1RSD | 2RSD | 3RSD | Low | High |
| **4-Acid Digestion continued** | | | | | | | | | | | |
| Cd, ppm | 0.38 | 0.035 | 0.31 | 0.45 | 0.28 | 0.49 | 9.16% | 18.31% | 27.47% | 0.36 | 0.40 |
| Ce, ppm | 134 | 6 | 122 | 146 | 116 | 152 | 4.50% | 9.00% | 13.49% | 127 | 141 |
| Co, wt.% | 0.788 | 0.036 | 0.716 | 0.860 | 0.680 | 0.896 | 4.57% | 9.15% | 13.72% | 0.749 | 0.827 |
| Cr, ppm | 93 | 8.8 | 76 | 111 | 67 | 120 | 9.44% | 18.89% | 28.33% | 89 | 98 |
| Cs, ppm | 2.44 | 0.106 | 2.23 | 2.66 | 2.13 | 2.76 | 4.33% | 8.66% | 12.99% | 2.32 | 2.57 |
| Cu, wt.% | 3.70 | 0.121 | 3.46 | 3.94 | 3.34 | 4.06 | 3.27% | 6.54% | 9.81% | 3.51 | 3.88 |
| Dy, ppm | 4.48 | 0.67 | 3.14 | 5.82 | 2.48 | 6.48 | 14.92% | 29.83% | 44.75% | 4.26 | 4.70 |
| Er, ppm | 2.69 | 0.41 | 1.87 | 3.51 | 1.46 | 3.92 | 15.21% | 30.43% | 45.64% | 2.55 | 2.82 |
| Eu, ppm | 0.97 | 0.059 | 0.85 | 1.09 | 0.79 | 1.15 | 6.05% | 12.10% | 18.15% | 0.92 | 1.02 |
| Fe, wt.% | 3.66 | 0.131 | 3.40 | 3.92 | 3.27 | 4.05 | 3.59% | 7.18% | 10.77% | 3.48 | 3.84 |
| Ga, ppm | 26.5 | 1.18 | 24.2 | 28.9 | 23.0 | 30.1 | 4.46% | 8.91% | 13.37% | 25.2 | 27.9 |
| Gd, ppm | 5.08 | 0.80 | 3.47 | 6.69 | 2.66 | 7.49 | 15.86% | 31.71% | 47.57% | 4.82 | 5.33 |
| Ge, ppm | 0.18 | 0.05 | 0.09 | 0.28 | 0.04 | 0.33 | 26.61% | 53.22% | 79.83% | 0.17 | 0.19 |
| Hf, ppm | 4.75 | 0.178 | 4.39 | 5.10 | 4.21 | 5.28 | 3.75% | 7.49% | 11.24% | 4.51 | 4.98 |
| Ho, ppm | 0.88 | 0.080 | 0.72 | 1.05 | 0.64 | 1.13 | 9.07% | 18.13% | 27.20% | 0.84 | 0.93 |
| In, ppm | 2.08 | 0.097 | 1.88 | 2.27 | 1.79 | 2.37 | 4.66% | 9.32% | 13.98% | 1.97 | 2.18 |
| K, wt.% | 2.57 | 0.092 | 2.38 | 2.75 | 2.29 | 2.84 | 3.57% | 7.13% | 10.70% | 2.44 | 2.70 |
| La, ppm | 64 | 4.1 | 56 | 72 | 52 | 76 | 6.43% | 12.85% | 19.28% | 61 | 67 |
| Li, ppm | 52 | 2.4 | 47 | 57 | 45 | 59 | 4.59% | 9.18% | 13.76% | 49 | 55 |
| Lu, ppm | 0.41 | 0.015 | 0.38 | 0.44 | 0.36 | 0.45 | 3.68% | 7.36% | 11.03% | 0.39 | 0.43 |
| Mg, wt.% | 2.46 | 0.100 | 2.26 | 2.66 | 2.16 | 2.76 | 4.04% | 8.09% | 12.13% | 2.34 | 2.59 |
| Mn, wt.% | 0.065 | 0.003 | 0.059 | 0.070 | 0.057 | 0.072 | 4.05% | 8.11% | 12.16% | 0.061 | 0.068 |
| Mo, ppm | 14.7 | 0.93 | 12.9 | 16.6 | 11.9 | 17.5 | 6.32% | 12.64% | 18.95% | 14.0 | 15.4 |
| Na, wt.% | 0.063 | 0.011 | 0.042 | 0.084 | 0.031 | 0.095 | 16.92% | 33.84% | 50.76% | 0.060 | 0.066 |
| Nb, ppm | 15.0 | 2.5 | 9.9 | 20.0 | 7.4 | 22.5 | 16.75% | 33.50% | 50.25% | 14.2 | 15.7 |
| Nd, ppm | 58 | 4.4 | 49 | 67 | 45 | 71 | 7.53% | 15.07% | 22.60% | 55 | 61 |
| Ni, ppm | 151 | 8 | 135 | 167 | 128 | 175 | 5.21% | 10.43% | 15.64% | 144 | 159 |
| P, wt.% | 0.033 | 0.002 | 0.028 | 0.038 | 0.026 | 0.040 | 7.09% | 14.17% | 21.26% | 0.031 | 0.035 |
| Pb, ppm | 15.9 | 0.75 | 14.4 | 17.4 | 13.6 | 18.1 | 4.75% | 9.50% | 14.26% | 15.1 | 16.7 |
| Pr, ppm | 15.5 | 1.6 | 12.2 | 18.7 | 10.6 | 20.3 | 10.46% | 20.91% | 31.37% | 14.7 | 16.2 |
| Rb, ppm | 106 | 8 | 90 | 123 | 82 | 131 | 7.62% | 15.24% | 22.86% | 101 | 112 |
| Re, ppm | 0.024 | 0.003 | 0.018 | 0.030 | 0.016 | 0.032 | 11.62% | 23.25% | 34.87% | 0.023 | 0.025 |
| S, wt.% | 3.57 | 0.134 | 3.30 | 3.83 | 3.17 | 3.97 | 3.75% | 7.51% | 11.26% | 3.39 | 3.75 |
| Sb, ppm | 3.79 | 0.309 | 3.17 | 4.41 | 2.86 | 4.71 | 8.16% | 16.33% | 24.49% | 3.60 | 3.98 |
| Sc, ppm | 12.4 | 0.68 | 11.0 | 13.7 | 10.3 | 14.4 | 5.49% | 10.97% | 16.46% | 11.7 | 13.0 |
| Se, ppm | 5.99 | 0.527 | 4.94 | 7.05 | 4.41 | 7.57 | 8.79% | 17.57% | 26.36% | 5.69 | 6.29 |
| Sm, ppm | 8.29 | 0.484 | 7.32 | 9.26 | 6.83 | 9.74 | 5.84% | 11.68% | 17.52% | 7.87 | 8.70 |
| Sn, ppm | 3.21 | 0.214 | 2.79 | 3.64 | 2.57 | 3.85 | 6.65% | 13.30% | 19.95% | 3.05 | 3.37 |
| Sr, ppm | 66 | 3.6 | 59 | 73 | 55 | 77 | 5.46% | 10.92% | 16.38% | 63 | 69 |
| Ta, ppm | 1.05 | 0.21 | 0.62 | 1.47 | 0.40 | 1.69 | 20.45% | 40.90% | 61.36% | 0.99 | 1.10 |
| Tb, ppm | 0.77 | 0.12 | 0.54 | 1.01 | 0.42 | 1.13 | 15.28% | 30.55% | 45.83% | 0.73 | 0.81 |
| Te, ppm | 0.078 | 0.021 | 0.036 | 0.120 | 0.015 | 0.141 | 27.03% | 54.05% | 81.08% | 0.074 | 0.082 |
| Th, ppm | 15.4 | 0.95 | 13.5 | 17.3 | 12.6 | 18.3 | 6.16% | 12.33% | 18.49% | 14.6 | 16.2 |
| Ti, wt.% | 0.275 | 0.073 | 0.130 | 0.421 | 0.057 | 0.493 | 26.38% | 52.75% | 79.13% | 0.262 | 0.289 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note 1: intervals may appear asymmetric due to rounding.

Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

**Table 6 continued.**

| Constituent | Certified Value | Absolute Standard Deviations | | | | | Relative Standard Deviations | | | 5% window | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1SD | 2SD Low | 2SD High | 3SD Low | 3SD High | 1RSD | 2RSD | 3RSD | Low | High |
| **4-Acid Digestion continued** | | | | | | | | | | | |
| Tm, ppm | 0.39 | 0.06 | 0.27 | 0.50 | 0.21 | 0.56 | 14.87% | 29.74% | 44.61% | 0.37 | 0.41 |
| U, ppm | 8.26 | 0.581 | 7.10 | 9.42 | 6.52 | 10.00 | 7.03% | 14.07% | 21.10% | 7.85 | 8.67 |
| V, ppm | 316 | 15 | 286 | 345 | 272 | 359 | 4.62% | 9.25% | 13.87% | 300 | 331 |
| W, ppm | 2.63 | 0.187 | 2.26 | 3.01 | 2.07 | 3.19 | 7.11% | 14.21% | 21.32% | 2.50 | 2.76 |
| Y, ppm | 22.8 | 1.14 | 20.5 | 25.1 | 19.4 | 26.2 | 5.00% | 10.00% | 15.00% | 21.7 | 23.9 |
| Yb, ppm | 2.70 | 0.35 | 2.00 | 3.40 | 1.65 | 3.75 | 12.99% | 25.98% | 38.97% | 2.56 | 2.83 |
| Zn, ppm | 31.6 | 1.77 | 28.1 | 35.2 | 26.3 | 36.9 | 5.60% | 11.20% | 16.80% | 30.0 | 33.2 |
| Zr, ppm | 165 | 5 | 155 | 176 | 149 | 182 | 3.25% | 6.50% | 9.76% | 157 | 174 |
| **Aqua Regia Digestion** | | | | | | | | | | | |
| Ag, ppm | 0.088 | 0.011 | 0.067 | 0.110 | 0.057 | 0.120 | 11.93% | 23.85% | 35.78% | 0.084 | 0.093 |
| Al, wt.% | 0.868 | 0.185 | 0.498 | 1.238 | 0.313 | 1.423 | 21.31% | 42.62% | 63.93% | 0.824 | 0.911 |
| As, ppm | 72 | 3.8 | 65 | 80 | 61 | 84 | 5.24% | 10.49% | 15.73% | 69 | 76 |
| Au, ppm | < 0.02 | IND | IND | IND | IND | IND | IND | IND | IND | IND | IND |
| B, ppm | < 10 | IND | IND | IND | IND | IND | IND | IND | IND | IND | IND |
| Ba, ppm | 81 | 14 | 53 | 109 | 38 | 123 | 17.50% | 34.99% | 52.49% | 77 | 85 |
| Be, ppm | 1.84 | 0.22 | 1.39 | 2.28 | 1.17 | 2.50 | 12.07% | 24.13% | 36.20% | 1.75 | 1.93 |
| Bi, ppm | 1.19 | 0.065 | 1.06 | 1.32 | 0.99 | 1.38 | 5.50% | 11.00% | 16.50% | 1.13 | 1.25 |
| Ca, wt.% | 0.108 | 0.004 | 0.099 | 0.117 | 0.094 | 0.121 | 4.15% | 8.29% | 12.44% | 0.102 | 0.113 |
| Cd, ppm | 0.38 | 0.028 | 0.33 | 0.44 | 0.30 | 0.46 | 7.24% | 14.47% | 21.71% | 0.36 | 0.40 |
| Ce, ppm | 46.3 | 7.6 | 31.0 | 61.5 | 23.3 | 69.2 | 16.51% | 33.03% | 49.54% | 43.9 | 48.6 |
| Co, wt.% | 0.759 | 0.054 | 0.650 | 0.868 | 0.596 | 0.922 | 7.17% | 14.34% | 21.51% | 0.721 | 0.797 |
| Cr, ppm | 33.3 | 4.2 | 24.9 | 41.6 | 20.8 | 45.7 | 12.48% | 24.97% | 37.45% | 31.6 | 34.9 |
| Cs, ppm | 0.43 | 0.12 | 0.18 | 0.68 | 0.06 | 0.81 | 28.73% | 57.45% | 86.18% | 0.41 | 0.46 |
| Cu, wt.% | 3.74 | 0.087 | 3.56 | 3.91 | 3.47 | 4.00 | 2.33% | 4.66% | 7.00% | 3.55 | 3.92 |
| Dy, ppm | 1.10 | 0.19 | 0.71 | 1.48 | 0.52 | 1.67 | 17.55% | 35.09% | 52.64% | 1.04 | 1.15 |
| Er, ppm | 0.46 | 0.09 | 0.28 | 0.63 | 0.20 | 0.72 | 19.05% | 38.11% | 57.16% | 0.44 | 0.48 |
| Eu, ppm | 0.43 | 0.10 | 0.23 | 0.62 | 0.13 | 0.72 | 22.91% | 45.81% | 68.72% | 0.41 | 0.45 |
| Fe, wt.% | 3.51 | 0.177 | 3.16 | 3.87 | 2.98 | 4.05 | 5.03% | 10.06% | 15.10% | 3.34 | 3.69 |
| Ga, ppm | 7.13 | 1.22 | 4.70 | 9.57 | 3.48 | 10.79 | 17.08% | 34.15% | 51.23% | 6.78 | 7.49 |
| Gd, ppm | 2.31 | 0.159 | 1.99 | 2.63 | 1.83 | 2.79 | 6.90% | 13.80% | 20.70% | 2.19 | 2.42 |
| Ge, ppm | 0.093 | 0.027 | 0.040 | 0.147 | 0.013 | 0.174 | 28.84% | 57.67% | 86.51% | 0.089 | 0.098 |
| Hf, ppm | 0.33 | 0.05 | 0.24 | 0.42 | 0.19 | 0.47 | 13.84% | 27.68% | 41.52% | 0.31 | 0.35 |
| Hg, ppm | 0.054 | 0.010 | 0.035 | 0.073 | 0.025 | 0.083 | 17.64% | 35.29% | 52.93% | 0.051 | 0.057 |
| Ho, ppm | 0.18 | 0.03 | 0.12 | 0.24 | 0.09 | 0.27 | 16.53% | 33.06% | 49.59% | 0.17 | 0.19 |
| In, ppm | 1.47 | 0.062 | 1.35 | 1.60 | 1.29 | 1.66 | 4.21% | 8.42% | 12.62% | 1.40 | 1.55 |
| K, wt.% | 0.203 | 0.030 | 0.144 | 0.262 | 0.115 | 0.292 | 14.54% | 29.09% | 43.63% | 0.193 | 0.213 |
| La, ppm | 20.9 | 3.2 | 14.6 | 27.3 | 11.4 | 30.4 | 15.11% | 30.23% | 45.34% | 19.9 | 22.0 |
| Li, ppm | 27.7 | 6.1 | 15.5 | 39.9 | 9.3 | 46.1 | 22.10% | 44.20% | 66.31% | 26.3 | 29.1 |
| Mg, wt.% | 1.88 | 0.20 | 1.48 | 2.27 | 1.29 | 2.47 | 10.50% | 21.01% | 31.51% | 1.78 | 1.97 |
| Mn, wt.% | 0.064 | 0.003 | 0.057 | 0.070 | 0.054 | 0.073 | 5.03% | 10.06% | 15.09% | 0.061 | 0.067 |
| Mo, ppm | 14.0 | 0.69 | 12.6 | 15.3 | 11.9 | 16.0 | 4.97% | 9.94% | 14.92% | 13.3 | 14.7 |
| Na, wt.% | 0.010 | 0.002 | 0.006 | 0.014 | 0.005 | 0.016 | 18.99% | 37.98% | 56.98% | 0.010 | 0.011 |
| Nb, ppm | 0.083 | 0.016 | 0.051 | 0.115 | 0.035 | 0.131 | 19.11% | 38.21% | 57.32% | 0.079 | 0.087 |
| Nd, ppm | 21.1 | 5.4 | 10.3 | 32.0 | 4.8 | 37.5 | 25.72% | 51.45% | 77.17% | 20.1 | 22.2 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note 1: intervals may appear asymmetric due to rounding; IND = indeterminate.

Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

**Table 6 continued.**

| Constituent | Certified Value | Absolute Standard Deviations | | | | | Relative Standard Deviations | | | 5% window | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1SD | 2SD Low | 2SD High | 3SD Low | 3SD High | 1RSD | 2RSD | 3RSD | Low | High |
| **Aqua Regia Digestion continued** | | | | | | | | | | | |
| Ni, ppm | 147 | 7 | 133 | 161 | 126 | 168 | 4.76% | 9.53% | 14.29% | 140 | 154 |
| P, wt.% | 0.020 | 0.001 | 0.018 | 0.023 | 0.017 | 0.024 | 5.16% | 10.31% | 15.47% | 0.019 | 0.021 |
| Pb, ppm | 11.8 | 1.7 | 8.5 | 15.1 | 6.9 | 16.8 | 14.01% | 28.01% | 42.02% | 11.2 | 12.4 |
| Pr, ppm | 5.46 | 1.42 | 2.62 | 8.30 | 1.20 | 9.72 | 26.01% | 52.03% | 78.04% | 5.18 | 5.73 |
| Rb, ppm | 8.01 | 1.29 | 5.44 | 10.58 | 4.15 | 11.87 | 16.06% | 32.12% | 48.19% | 7.61 | 8.41 |
| Re, ppm | 0.021 | 0.002 | 0.017 | 0.026 | 0.015 | 0.028 | 10.32% | 20.65% | 30.97% | 0.020 | 0.023 |
| S, wt.% | 3.48 | 0.144 | 3.19 | 3.77 | 3.05 | 3.91 | 4.14% | 8.28% | 12.43% | 3.31 | 3.66 |
| Sb, ppm | 2.22 | 0.30 | 1.61 | 2.82 | 1.31 | 3.12 | 13.57% | 27.13% | 40.70% | 2.10 | 2.33 |
| Sc, ppm | 2.91 | 0.32 | 2.27 | 3.54 | 1.96 | 3.86 | 10.88% | 21.76% | 32.65% | 2.76 | 3.05 |
| Se, ppm | 5.95 | 0.550 | 4.85 | 7.05 | 4.30 | 7.60 | 9.25% | 18.49% | 27.74% | 5.65 | 6.25 |
| Sm, ppm | 3.72 | 0.59 | 2.54 | 4.90 | 1.94 | 5.50 | 15.91% | 31.83% | 47.74% | 3.53 | 3.91 |
| Sn, ppm | 1.31 | 0.126 | 1.06 | 1.56 | 0.93 | 1.69 | 9.63% | 19.27% | 28.90% | 1.24 | 1.38 |
| Sr, ppm | 15.8 | 3.7 | 8.4 | 23.2 | 4.7 | 27.0 | 23.42% | 46.85% | 70.27% | 15.0 | 16.6 |
| Ta, ppm | < 0.01 | IND | IND | IND | IND | IND | IND | IND | IND | IND | IND |
| Tb, ppm | 0.26 | 0.03 | 0.19 | 0.32 | 0.16 | 0.35 | 12.21% | 24.41% | 36.62% | 0.24 | 0.27 |
| Te, ppm | 0.057 | 0.012 | 0.034 | 0.081 | 0.022 | 0.093 | 20.48% | 40.97% | 61.45% | 0.054 | 0.060 |
| Th, ppm | 6.93 | 1.06 | 4.82 | 9.05 | 3.77 | 10.10 | 15.22% | 30.44% | 45.66% | 6.59 | 7.28 |
| U, ppm | 3.22 | 0.259 | 2.70 | 3.73 | 2.44 | 3.99 | 8.04% | 16.09% | 24.13% | 3.05 | 3.38 |
| V, ppm | 52 | 7 | 38 | 66 | 32 | 73 | 13.09% | 26.19% | 39.28% | 49 | 55 |
| W, ppm | 0.91 | 0.11 | 0.70 | 1.13 | 0.59 | 1.23 | 11.73% | 23.45% | 35.18% | 0.87 | 0.96 |
| Y, ppm | 4.37 | 0.56 | 3.25 | 5.49 | 2.69 | 6.04 | 12.78% | 25.56% | 38.34% | 4.15 | 4.59 |
| Yb, ppm | 0.37 | 0.08 | 0.20 | 0.54 | 0.12 | 0.62 | 22.73% | 45.46% | 68.19% | 0.35 | 0.39 |
| Zn, ppm | 28.2 | 1.61 | 25.0 | 31.4 | 23.4 | 33.0 | 5.71% | 11.42% | 17.13% | 26.8 | 29.6 |
| Zr, ppm | 10.4 | 1.5 | 7.4 | 13.5 | 5.9 | 15.0 | 14.57% | 29.13% | 43.70% | 9.9 | 10.9 |

SI unit equivalents: ppm (parts per million; 1 x $10^{-6}$) ≡ mg/kg; wt.% (weight per cent) ≡ % (mass fraction).

Note 1: intervals may appear asymmetric due to rounding; IND = indeterminate.

Note 2: the number of decimal places quoted does not imply accuracy of the certified value to this level but are given to minimise rounding errors when calculating 2SD and 3SD windows.

## PARTICIPATING LABORATORIES

1. Actlabs, Ancaster, Ontario, Canada
2. African Natural Resources & Mines Ltd, Suleja, Niger State, Nigeria
3. AGAT Laboratories, Calgary, Alberta, Canada
4. ALS, Brisbane, QLD, Australia
5. ALS, Lima, Peru
6. ALS, Loughrea, Galway, Ireland
7. ALS, Malaga, WA, Australia
8. ALS, Vancouver, BC, Canada
9. American Assay Laboratories, Sparks, Nevada, USA
10. ARGETEST Mineral Processing, Ankara, Central Anatolia, Turkey
11. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
12. CERTIMIN, Lima, Peru
13. ESAN Istanbul, Istanbul, Turkey
14. Inspectorate (BV), Lima, Peru
15. Intertek Genalysis, Perth, WA, Australia
16. Intertek Testing Services, Townsville, QLD, Australia
17. Intertek Testing Services Philippines, Cupang, Muntinlupa, Philippines
18. Labwest Minerals Analysis, Perth, WA, Australia
19. MSALABS, Vancouver, BC, Canada
20. Ontario Geological Survey, Sudbury, Ontario, Canada
21. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
22. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
23. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada
24. SGS, Randfontein, Gauteng, South Africa
25. SGS del Peru, Lima, Peru
26. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
27. Skyline Assayers & Laboratories, Tucson, Arizona, USA
28. Stewart Assay & Environmental Laboratories LLC, Kara-Balta, Chüy, Kyrgyzstan

***Please note: To preserve anonymity, the above numbered alphabetical list of participating laboratories <u>does not</u> correspond with the Lab ID numbering on the scatter plots below.***

## PREPARER AND SUPPLIER

Certified reference material OREAS 554b is prepared, certified and supplied by:

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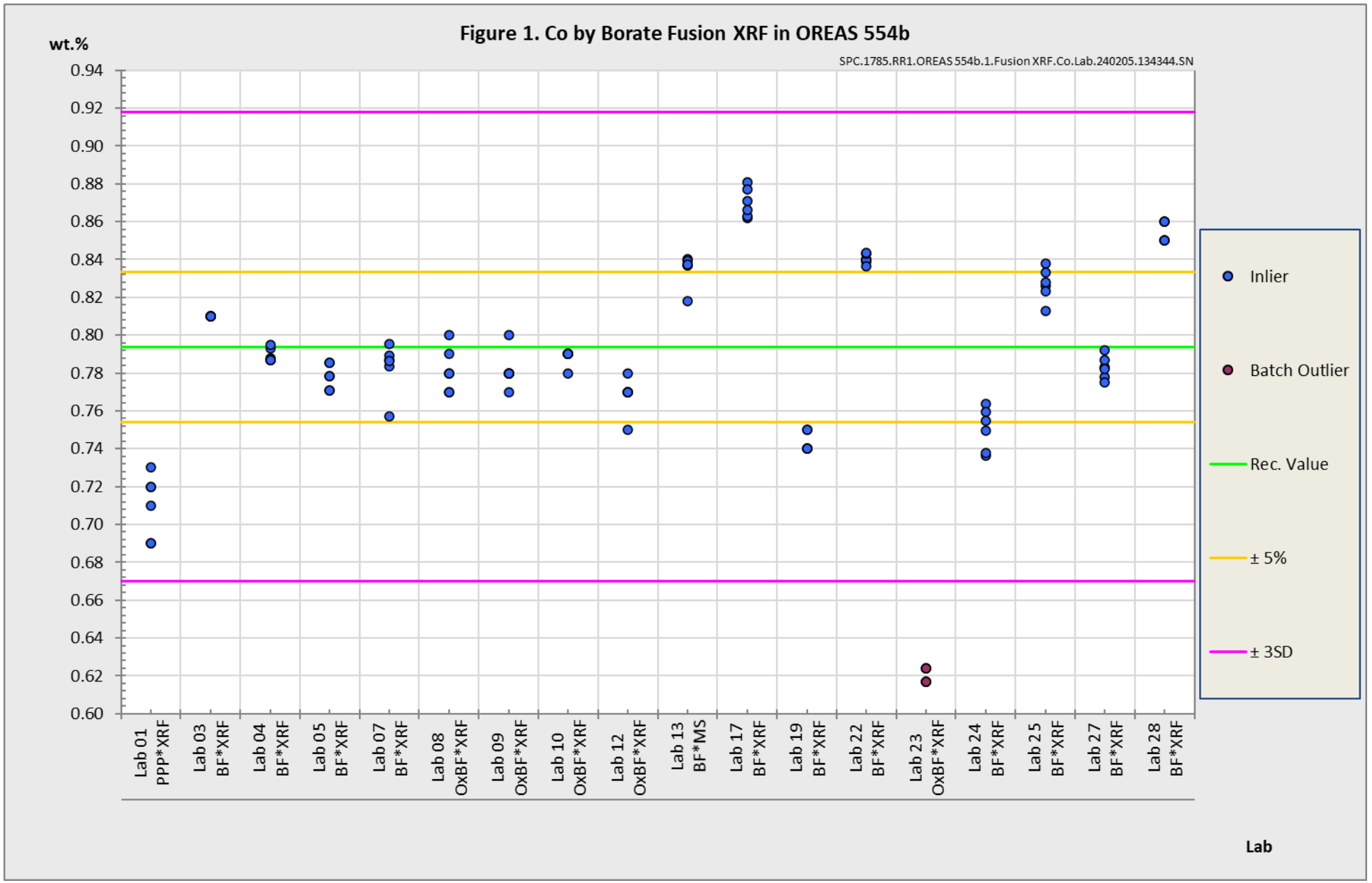
Figure 1. Co by Borate Fusion XRF in OREAS 554b
wt.%
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0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0.70
0.68
0.66
0.64
0.62
0.60
Lab 01 PPP*XRF
Lab 03 BF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 07 BF*XRF
Lab 08 OxBF*XRF
Lab 09 OxBF*XRF
Lab 10 OxBF*XRF
Lab 12 OxBF*XRF
Lab 13 BF*MS
Lab 17 BF*XRF
Lab 19 BF*XRF
Lab 22 BF*XRF
Lab 23 OxBF*XRF
Lab 24 BF*XRF
Lab 25 BF*XRF
Lab 27 BF*XRF
Lab 28 BF*XRF
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

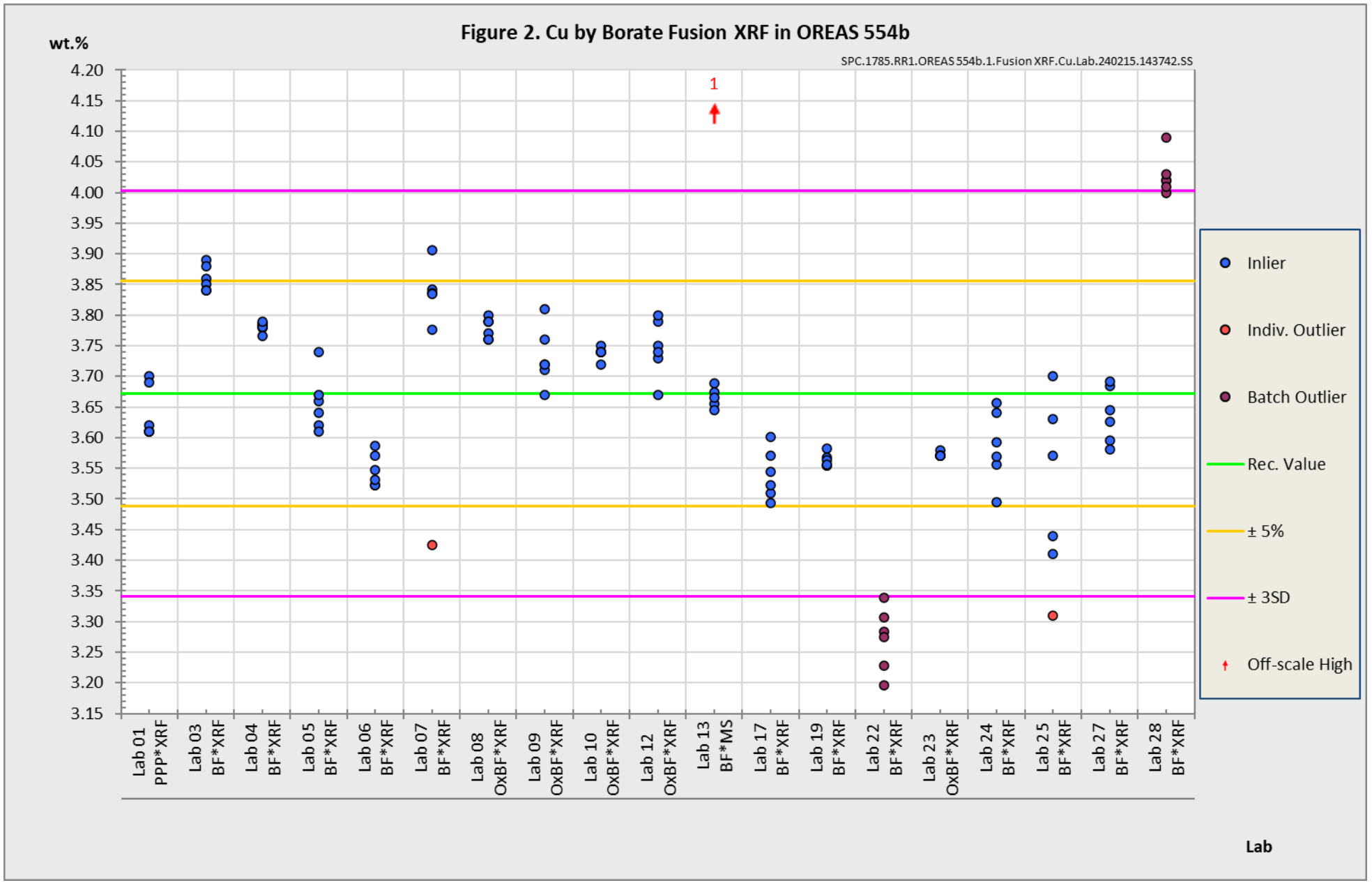
Figure 2. Cu by Borate Fusion XRF in OREAS 554b
wt.%
SPC.1785.RR1.OREAS 554b.1.Fusion XRF.Cu.Lab.240215.143742.SS
4.20
4.15
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.60
3.55
3.50
3.45
3.40
3.35
3.30
3.25
3.20
3.15
1
Lab 01 PPP*XRF
Lab 03 BF*XRF
Lab 04 BF*XRF
Lab 05 BF*XRF
Lab 06 BF*XRF
Lab 07 BF*XRF
Lab 08 OxBF*XRF
Lab 09 OxBF*XRF
Lab 10 OxBF*XRF
Lab 12 OxBF*XRF
Lab 13 BF*MS
Lab 17 BF*XRF
Lab 19 BF*XRF
Lab 22 BF*XRF
Lab 23 OxBF*XRF
Lab 24 BF*XRF
Lab 25 BF*XRF
Lab 27 BF*XRF
Lab 28 BF*XRF
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale High

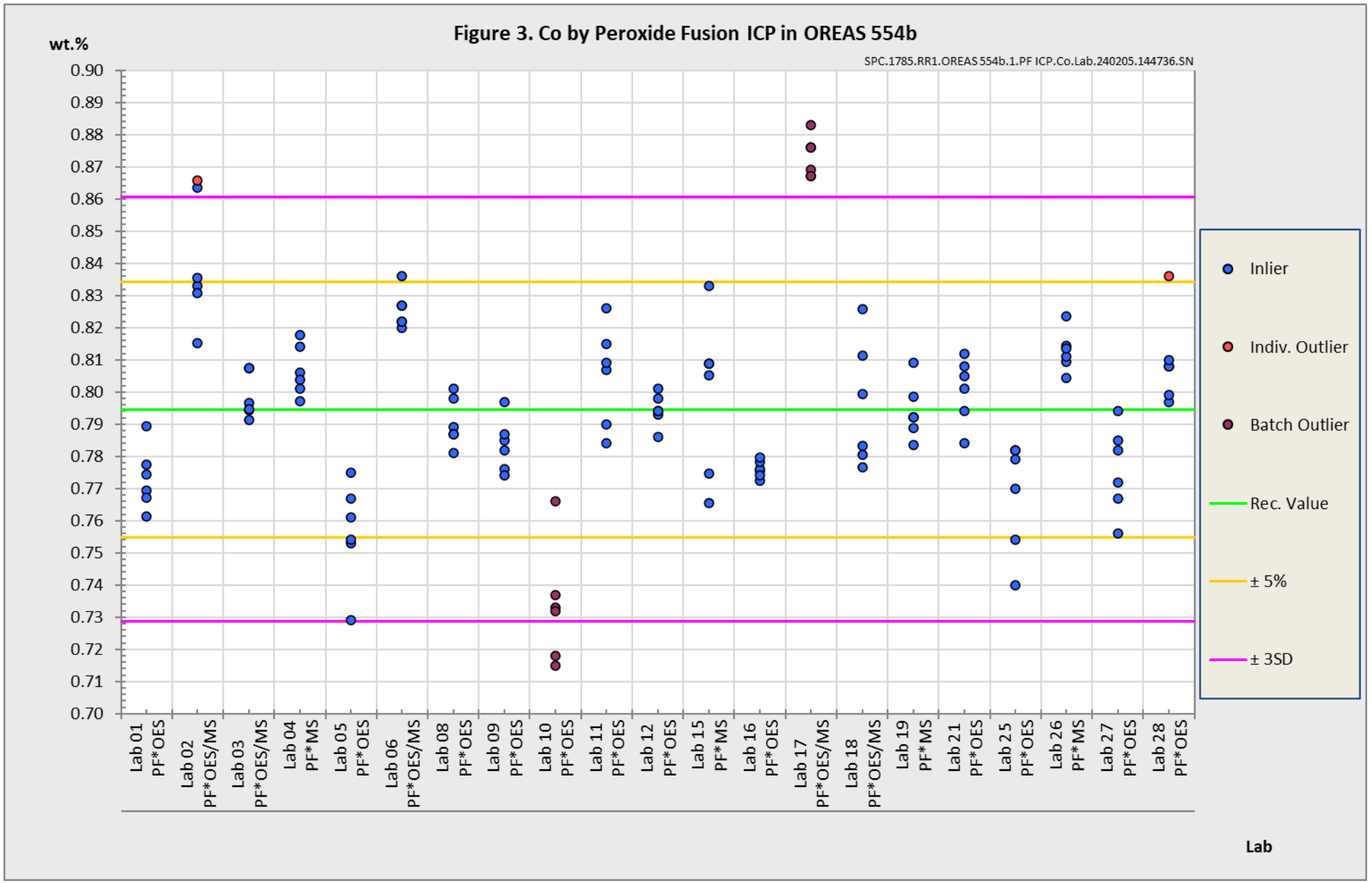
Figure 3. Co by Peroxide Fusion ICP in OREAS 554b
wt.%
SPC.1785.RR1.OREAS 554b.1.PF ICP.Co.Lab.240205.144736.SN
0.90
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.81
0.80
0.79
0.78
0.77
0.76
0.75
0.74
0.73
0.72
0.71
0.70
Lab 01 PF*OES
Lab 02 PF*OES/MS
Lab 03 PF*OES/MS
Lab 04 PF*MS
Lab 05 PF*OES
Lab 06 PF*OES/MS
Lab 08 PF*OES
Lab 09 PF*OES
Lab 10 PF*OES
Lab 11 PF*OES
Lab 12 PF*OES
Lab 15 PF*MS
Lab 16 PF*OES
Lab 17 PF*OES/MS
Lab 18 PF*OES/MS
Lab 19 PF*MS
Lab 21 PF*OES
Lab 25 PF*OES
Lab 26 PF*MS
Lab 27 PF*OES
Lab 28 PF*OES
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

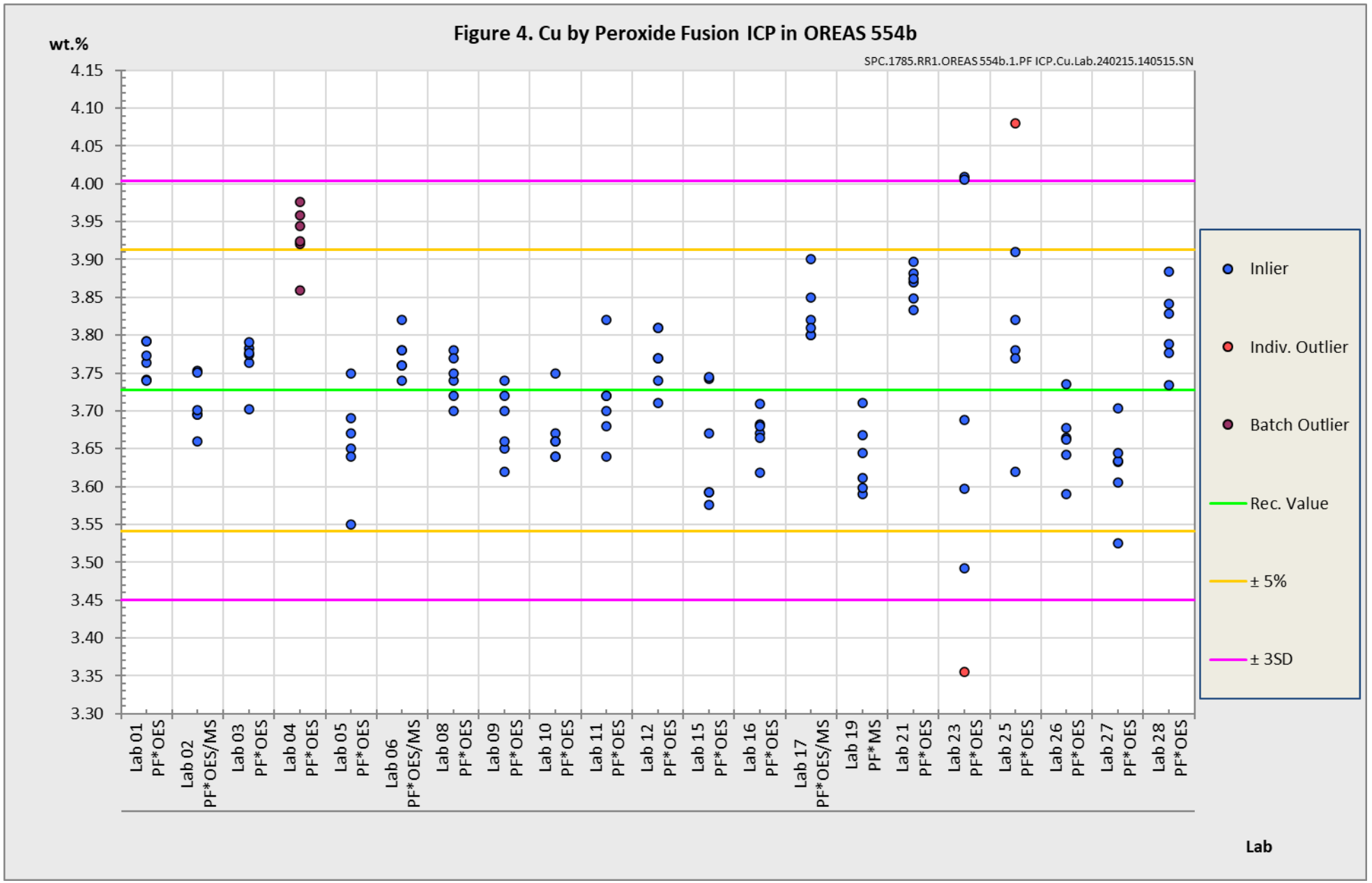
Figure 4. Cu by Peroxide Fusion ICP in OREAS 554b
wt.%
SPC.1785.RR1.OREAS 554b.1.PF ICP.Cu.Lab.240215.140515.SN
4.15
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.60
3.55
3.50
3.45
3.40
3.35
3.30
Lab 01 PF*OES
Lab 02 PF*OES/MS
Lab 03 PF*OES
Lab 04 PF*OES
Lab 05 PF*OES
Lab 06 PF*OES/MS
Lab 08 PF*OES
Lab 09 PF*OES
Lab 10 PF*OES
Lab 11 PF*OES
Lab 12 PF*OES
Lab 15 PF*OES
Lab 16 PF*OES
Lab 17 PF*OES/MS
Lab 19 PF*MS
Lab 21 PF*OES
Lab 23 PF*OES
Lab 25 PF*OES
Lab 26 PF*OES
Lab 27 PF*OES
Lab 28 PF*OES
Lab
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD

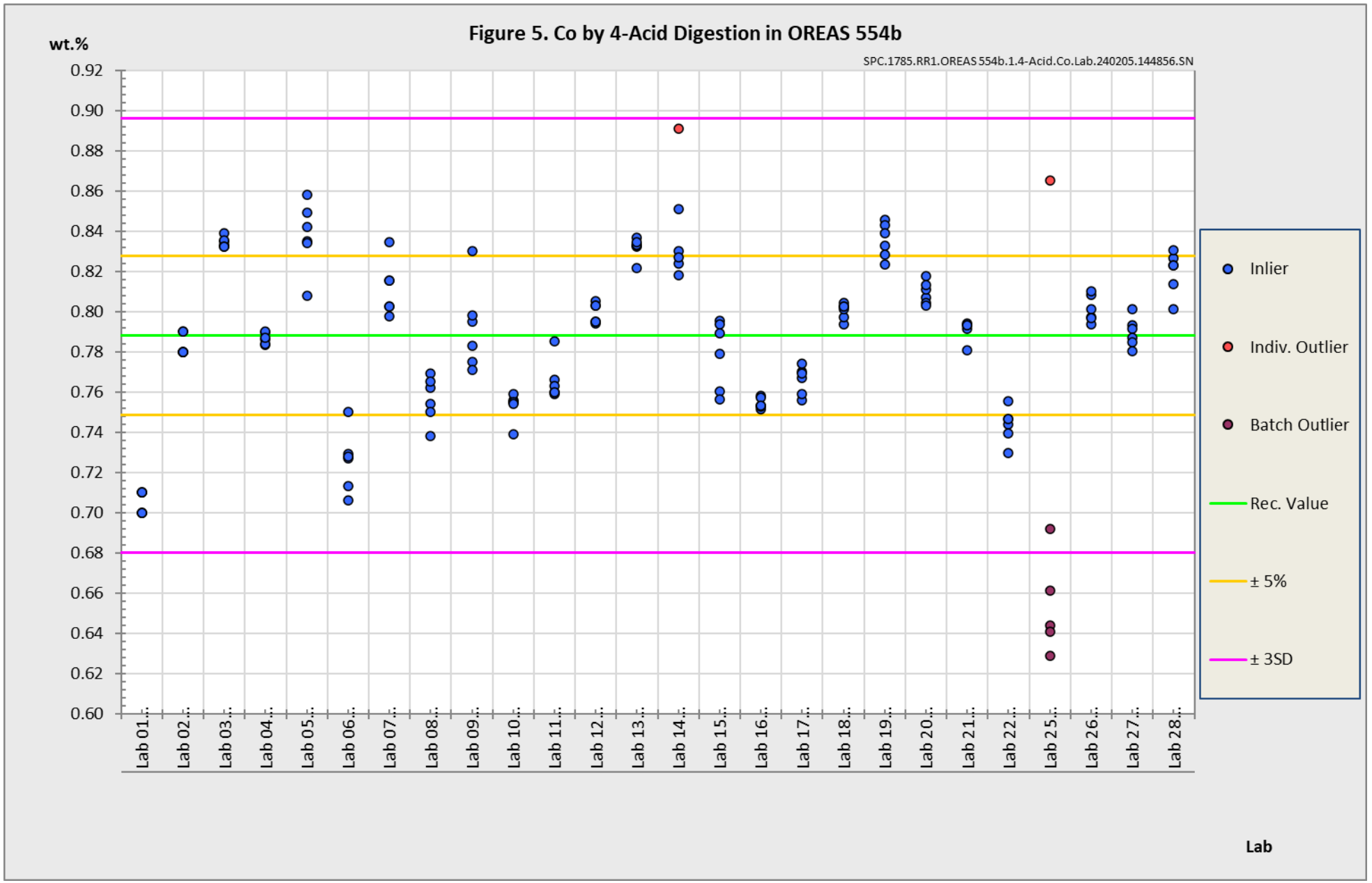
Figure 5. Co by 4-Acid Digestion in OREAS 554b
wt.%
SPC.1785.RR1.OREAS 554b.1.4-Acid.Co.Lab.240205.144856.SN
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0.70
0.68
0.66
0.64
0.62
0.60
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 25...
Lab 26...
Lab 27...
Lab 28...
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Lab

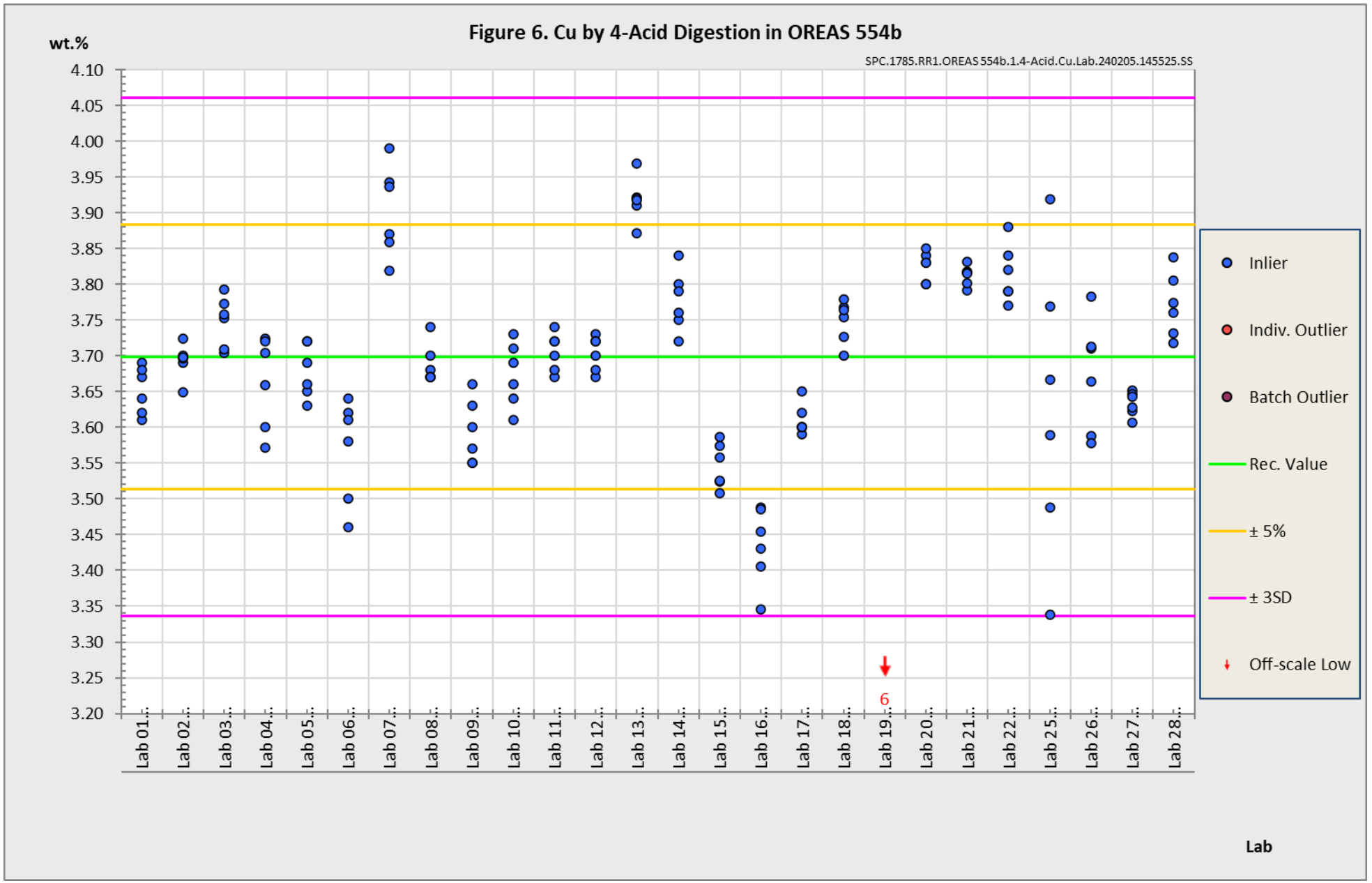
Figure 6. Cu by 4-Acid Digestion in OREAS 554b
wt.%
SPC.1785.RR1.OREAS 554b.1.4-Acid.Cu.Lab.240205.145525.SS
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.60
3.55
3.50
3.45
3.40
3.35
3.30
3.25
3.20
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 16...
Lab 17...
Lab 18...
Lab 19...
6
Lab 20...
Lab 21...
Lab 22...
Lab 25...
Lab 26...
Lab 27...
Lab 28...
Inlier
Indiv. Outlier
Batch Outlier
Rec. Value
± 5%
± 3SD
Off-scale Low
Lab

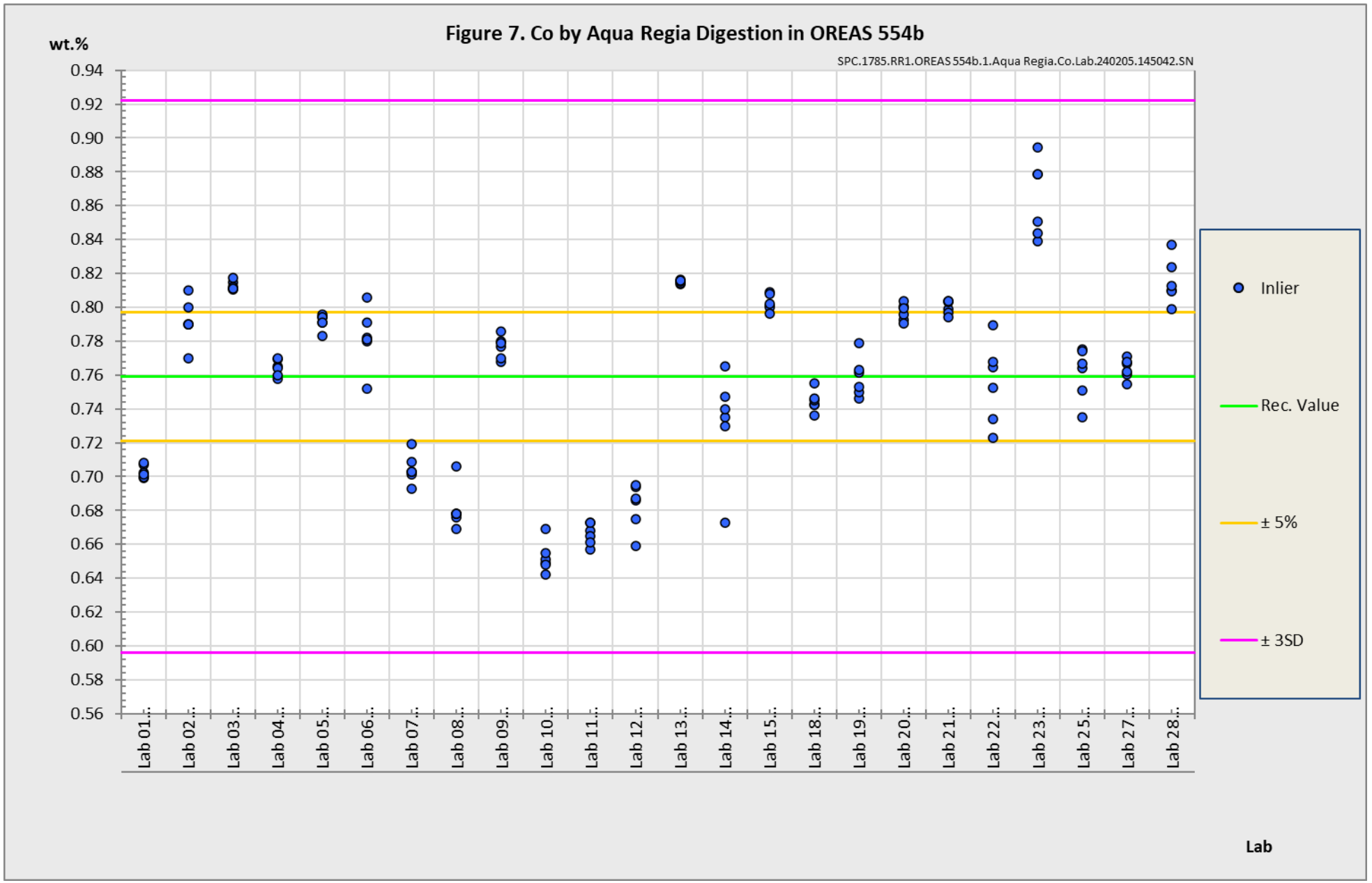
Figure 7. Co by Aqua Regia Digestion in OREAS 554b
wt.%
SPC.1785.RR1.OREAS 554b.1.Aqua Regia.Co.Lab.240205.145042.SN
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0.70
0.68
0.66
0.64
0.62
0.60
0.58
0.56
Lab 01...
Lab 02...
Lab 03...
Lab 04...
Lab 05...
Lab 06...
Lab 07...
Lab 08...
Lab 09...
Lab 10...
Lab 11...
Lab 12...
Lab 13...
Lab 14...
Lab 15...
Lab 18...
Lab 19...
Lab 20...
Lab 21...
Lab 22...
Lab 23...
Lab 25...
Lab 27...
Lab 28...
Inlier
Rec. Value
± 5%
± 3SD
Lab

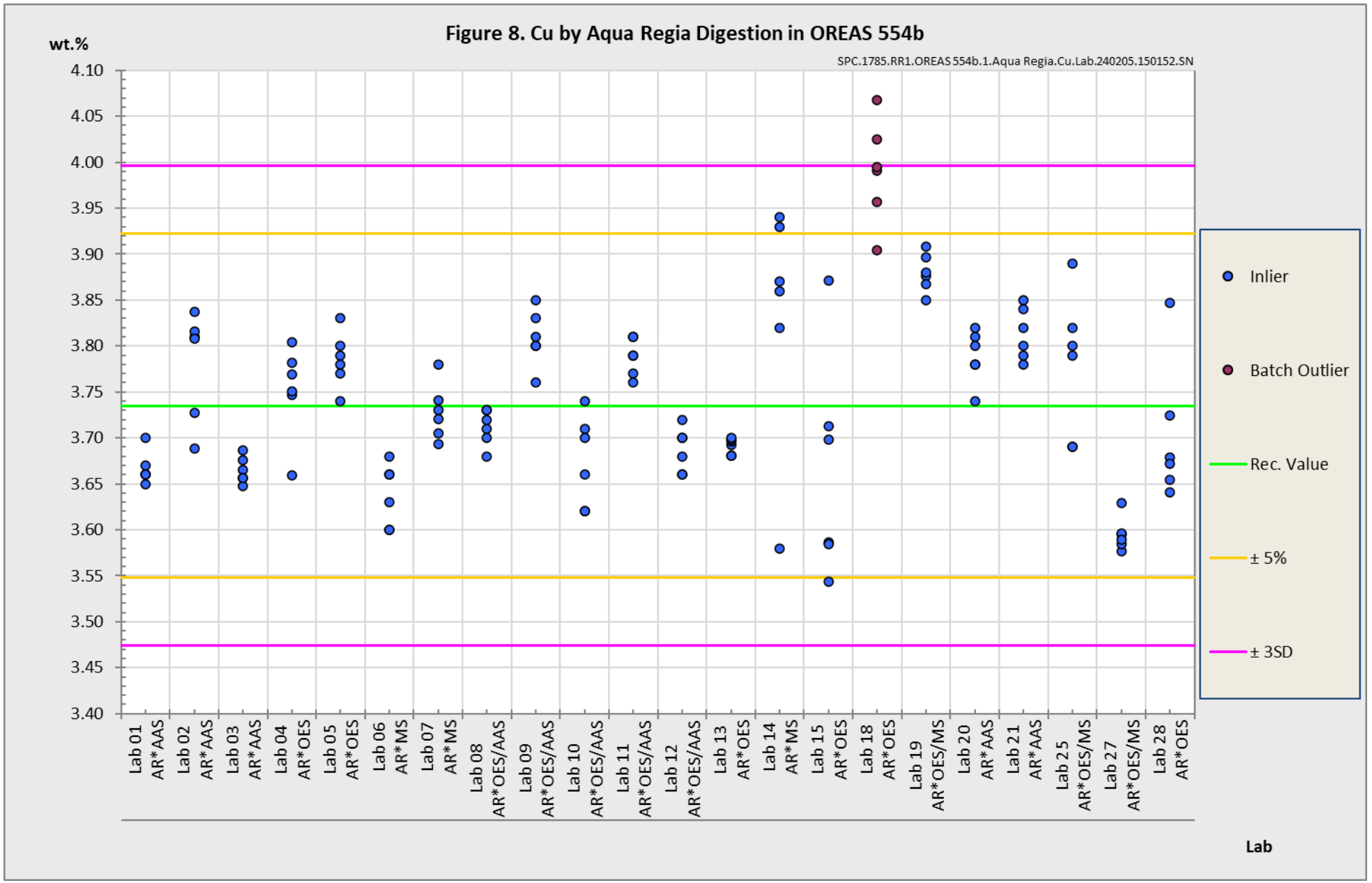
Figure 8. Cu by Aqua Regia Digestion in OREAS 554b
wt.%
SPC.1785.RR1.OREAS 554b.1.Aqua Regia.Cu.Lab.240205.150152.SN
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.60
3.55
3.50
3.45
3.40
Lab 01 AR*AAS
Lab 02 AR*AAS
Lab 03 AR*AAS
Lab 04 AR*OES
Lab 05 AR*OES
Lab 06 AR*MS
Lab 07 AR*MS
Lab 08 AR*OES/AAS
Lab 09 AR*OES/AAS
Lab 10 AR*OES/AAS
Lab 11 AR*OES/AAS
Lab 12 AR*OES/AAS
Lab 13 AR*OES
Lab 14 AR*MS
Lab 15 AR*OES
Lab 18 AR*OES
Lab 19 AR*OES/MS
Lab 20 AR*AAS
Lab 21 AR*AAS
Lab 25 AR*OES/MS
Lab 27 AR*OES/MS
Lab 28 AR*OES
Lab
Inlier
Batch Outlier
Rec. Value
± 5%
± 3SD

## METROLOGICAL TRACEABILITY

The interlaboratory results that underpin the certified values are metrologically traceable to the international measurement scale (SI) of mass (either as a % mass fraction or as milligrams per kilogram (mg/kg)). In line with popular use, all data within tables in this certificate are expressed as the mass fraction in either weight percent (wt.%) or parts per million (ppm).

The analytical samples sent to participating laboratories were selected in a manner to be representative of the entire prepared batch of CRM. This 'representivity' was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results. The systematic sampling method was chosen due to the low risk of overlooking repetitive effects or trends in the batch due to the way the CRM was processed. In line with ISO 17025 [8], each analytical data set received from the participating laboratories has been validated by its assayer through the inclusion of internal reference materials and QC checks during and post analysis.

The participating laboratories were chosen on the basis of their competence (from past performance in interlaboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite and sample matrix. These laboratories are accredited to ISO 17025 for 4-acid digestion and aqua regia digestion methods (Table 1). The other operationally defined measurands characterised in this certificate (Table 2) are derived from data procured mostly from ISO 17025 accredited laboratories. The certified values presented in this report are calculated from the means of accepted data following robust technical and statistical analysis as detailed in this report.

Guide ISO/TR 16476:2016, section 5.3.1 describes metrological traceability in reference materials as it pertains to the transformation of the measurand. In this section it states, *"Although the determination of the property value itself can be made traceable to appropriate units through, for example, calibration of the measurement equipment used, steps like the transformation of the sample from one physical (chemical) state to another cannot. Such transformations may only be compared with a reference (when available), or among themselves. For some transformations, reference methods have been defined and may be used in certification projects to evaluate the uncertainty associated with such a transformation.* ***In other cases, only a comparison among different laboratories using the same procedure is possible. In this case, it is impossible to demonstrate absence of method bias; therefore, the result is an operationally defined measurand*** *(ISO Guide 35:2017, 9.2.4c)."* Certification takes place on the basis of agreement among operationally defined, independent measurement results.

## COMMUTABILITY

The measurements of the results that underlie the certified values contained in this report were undertaken by methods involving pre-treatment (fusion/digestion) of the sample. This served to reduce the sample to a simple and well understood form permitting calibration using simple solutions of the CRM. Due to these methods being well understood and highly effective, commutability is not an issue for this CRM. All OREAS CRMs are sourced from natural ore minerals meaning they will display similar behaviour as routine 'field' samples in the relevant measurement process. Care should be taken to ensure 'matrix matching' as close as practically achievable. The matrix and mineralisation style of the CRM is described in the 'Source Material' section and users should select appropriate CRMs matching these attributes to the field samples being analysed.

## INTENDED USE

OREAS 554b is intended to cover all activities needed to produce a measurement result. This includes extraction, possible separation steps and the actual measurement process (the signal producing step). OREAS 554b may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 554b is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Tables 1 and 2 in geological samples;
- For the verification of analytical methods for analytes reported in Tables 1 and 2;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Tables 1 and 2. When a value provided in this certificate is used to calibrate a measurement process, the uncertainty associated with that value should be appropriately propagated into the user's uncertainty calculation. Users can determine an approximation of the standard uncertainty by calculating one fourth of the width of the Expanded Uncertainty interval given in this certificate (Expanded Uncertainty intervals are provided in Tables 1 and 2).

## MINIMUM SAMPLE SIZE

To relate analytical determinations to the values in this certificate, the minimum mass of sample used should match the typical mass that the laboratories used in the interlaboratory (round robin) certification program. This means that different minimum sample masses should be used depending on the operationally defined methodology as follows:

- Lithium borate fusion with X-ray fluorescence finish: ≥0.2g;
- Loss on Ignition (LOI) at 1000°C: ≥1g;
- C and S by infrared combustion furnace/CS analyser: ≥0.1g;
- Cu and Co by 5% sulphuric acid leach with ICP or AAS finish: 0.5g;
- Sodium peroxide fusion with ICP-OES and/or MS finish: ≥0.2g;
- 4-acid digestion with ICP-OES and/or MS finish: ≥0.25g;
- Aqua regia digestion with ICP-OES and/or MS finish: ≥0.5g.

## PERIOD OF VALIDITY & STORAGE INSTRUCTIONS

The certification of OREAS 554b remains valid, within the specified measurement uncertainties, until September 2033, provided the CRM is handled and stored in accordance with the instructions given below. This certification is nullified if the CRM is any way changed or contaminated.

Store in a clean and cool dry place away from direct sunlight.

Long-term stability will be monitored at appropriate intervals and purchasers notified if any changes are observed. The period of validity may well be indefinite and will be reassessed prior to expiry with the aim of extending the validity if possible.

**Single-use sachets (e.g., 10g units)**

Following analysis of the CRM subsample it is the manufacturers' expectation that any remaining material is discarded. The stability of the material after opening the sachet is not within the scope of proper use. However, if opened sachets are resealed after opening, then under ordinary* storage conditions the CRM will have a shelf-life beyond ten years.

**Ordinary storage conditions: means storage not in direct sunlight in a dry, clean, well ventilated area at temperatures between -5° and 50°C.*

## INSTRUCTIONS FOR HANDLING & CORRECT USE

Pre-homogenisation of the CRM prior to subsampling and analysis is not necessary as there is no particle segregation under transport [12].

Fine powders pose a risk to eyes and lungs and therefore standard precautions including the use of safety glasses and dust masks are advised.

**QC monitoring using multiples of the Standard Deviation (SD)**

In the application of SD's in monitoring performance it is important to note that not all laboratories function at the same level of proficiency and that different methods in use at a particular laboratory have differing levels of precision. Each laboratory has its own inherent SD (for a specific concentration level and analyte-method pair) based on the analytical process and this SD is not directly related to the round robin program.
The majority of data generated in the round robin program was produced by a selection of world class laboratories. The SD's thus generated are more constrained than those that would be produced across a randomly selected group of laboratories. To produce more generally achievable SD's the 'pooled' SD's provided in this report include interlaboratory bias. This 'one size fits all' approach may require revision at the discretion of the QC manager concerned following careful scrutiny of QC control charts.

The performance gates shown in Table 6 are intended only to be used as a preliminary guide as to what a laboratory may be able to achieve. Over a period of time monitoring your own laboratory's data for this CRM, SD's should be calculated directly from your own laboratory's process. This will enable you to establish more specific performance gates that are fit for purpose for your application as well as the ability to monitor bias. If your long-term trend analysis shows an average value that is within the 95% expanded uncertainty then generally there is no cause for concern in regard to bias.

**For use with the aqua regia digestion method**

It is important to note that in the analytical industry there is no standardisation of the aqua regia digestion process. This method is a partial empirical digest and differences in recoveries for various analytes are commonplace. These are caused by variations in the digest conditions and can include the ratio of nitric to hydrochloric acids, acid strength, temperatures, leach times and secondary digestions. Recoveries for sulphide-hosted base metal sulphides approach total values, however, other analytes, in particular the lithophile elements, show greater sensitivity to method parameters. This can result in lack of consensus in an inter-laboratory certification program for these elements.

The approach applied here is to report certified values in those instances where reasonable agreement exists amongst a majority of participating laboratories. The results of specific laboratories may differ significantly from the certified values, but will, nonetheless, be valid

and reproducible in the context of the specifics of the aqua regia method in use. Users of this reference material should, therefore, be mindful of this limitation when applying the certified values in a quality control program.

## LEGAL NOTICE

Ore Research & Exploration Pty Ltd has prepared and statistically evaluated the property values of this reference material to the best of its ability. The Purchaser by receipt hereof releases and indemnifies Ore Research & Exploration Pty Ltd from and against all liability and costs arising from the use of this material and information.



## DOCUMENT HISTORY

| Revision No. | Date | Changes applied |
|---|---|---|
| 0 | 6th March, 2024 | First publication. |

## CERTIFYING OFFICER

6th March, 2024

Craig Hamlyn (B.Sc. Hons - Geology), Technical Manager - ORE P/L

## QMS CERTIFICATION

ORE Pty Ltd is accredited for compliance with ISO 17034:2016.

ORE Pty Ltd is ISO 9001:2015 certified by Lloyd's Register Quality Assurance Ltd for its quality management system including development, manufacturing, certification and supply of CRMs.

# REFERENCES


[1] Govett, G.J.S. (1983). Handbook of Exploration Geochemistry, Volume 2: Statistics and Data Analysis in Geochemical Prospecting (Variations of accuracy and precision).

[2] ISO Guide 30:2015. Terms and definitions used in connection with reference materials.

[3] ISO Guide 31:2015. Reference materials – Contents of certificates and labels.

[4] ISO Guide 35:2017. Certification of reference materials - General and statistical principals.

[5] ISO Guide 98-3:2008. Guide to the expression of uncertainty in measurement (GUM:1995).

[6] ISO 16269:2014. Statistical interpretation of data – Part 6: Determination of statistical tolerance intervals.

[7] ISO/TR 16476:2016, Reference Materials – Establishing and expressing metrological traceability of quantity values assigned to reference materials.

[8] ISO 17025:2017, General requirements for the competence of testing and calibration laboratories.

[9] ISO 17034:2016. General requirements for the competence of reference material producers.

[10] Munsell Rock Color Book (2014). Rock-Color Chart Committee, Geological Society of America (GSA), Minnesota (USA).

[11] OREAS-BUP-70-09-11: Statistical Analysis - OREAS Evaluation Method.

[12] OREAS-TN-04-1498: Stability under transport; an experimental study of OREAS CRMs.

[13] OREAS-TN-05-1674: Long-term storage stability; an experimental study of OREAS CRMs.

[14] Thompson, A.; Taylor, B.N.; Guide for the Use of the International System of Units (SI); NIST Special Publication 811; U.S. Government Printing Office: Washington, DC (2008); available at: https://physics.nist.gov/cuu/pdf/sp811.pdf (accessed Jan 2024).

[15] Van der Veen AMH and Pauwels, J. (2001). Uncertainty calculations in the certification of reference materials, Accred Qual Assur 6: 290-294.


# APPENDIX

For Cu and Co by the two sulphuric acid leaches, specific methodologies were detailed for the participating laboratories to follow:

**5% sulphuric acid leach**

1. Weigh 0.500 ± 0.002g of sample pulp into a clean 250 ml flask.
2. Add to the flask 0.5g of Sodium Sulphite (AR Grade).
3. Add 50 ml of approximately 55 g/l Sulphuric acid solution (prepared from a 98% pure concentrated sulphuric acid).
4. Put the cap on the flask and start automatic shaking. Leave the sample on continuous shaking to leach for four (4) hours.
5. Remove the cap and add 25 ml of hydrochloric acid.
6. Dilute to a final volume of 250 ml with distilled/deionised water up to the mark and mix again by inverting at least 10 times. Allow the solution to settle for 30 minutes.
7. The solution is now ready to be analysed by ICP or AAS.