

Supplementary material

Copper isotope evidence for a Cu-rich mantle source of the world-class Jinchuan magmatic Ni–Cu deposit

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Table OM1

Chalcophile elements (PGE, Cu, and Ni) and S contents of whole-rock samples, and Cu isotopic compositions and Cu/Fe ratios of chalcopyrite separates from the Jinchuan deposit, NW China.

| Sample no. | Locations | Line No | Elevation (m) | Mineralization types | $\delta^{65}\text{Cu}$ (‰) | 2SD | Cu/Fe | Cu (ppm) | Ni (ppm) | S (wt. %) | Pt (ppm) | Pd (ppm) | Rh (ppm) | Ru (ppm) | Ir (ppm) | Os (ppm) |
|------------|------------|---------|---------------|----------------------|----------------------------|------|-------|----------|----------|-----------|----------|----------|----------|----------|----------|----------|
| 2j5-1 | Segment II | 5 | 1040 | Net-textured | 0.02 | 0.05 | 0.91 | 35260 | 26330 | 11.0 | 60.5 | 341.0 | 11.5 | 11.4 | 20.8 | 28.0 |
| 2j5-2 | Segment II | 5 | 1040 | Net-textured | -0.03 | 0.07 | 0.90 | 3596 | 29203 | 9.9 | 4450.0 | 137.0 | 25.1 | 25.5 | 39.3 | 66.3 |
| 2j4-4 | Segment II | 4 | 1040 | Net-textured | 0.60 | 0.05 | 0.94 | 5363 | 31970 | 9.7 | 16.4 | 372.0 | 14.7 | 11.3 | 21.8 | 26.3 |
| 2j4-3 | Segment II | 4 | 1040 | Disseminated | 0.29 | 0.05 | 0.93 | 4350 | 20780 | 3.5 | 10.3 | 243.5 | 11.2 | 10.5 | 16.5 | 12.3 |
| 2j4-2 | Segment II | 4 | 1040 | Net-textured | 0.57 | 0.09 | 0.98 | 27290 | 28567 | 9.4 | 121.0 | 802.0 | 1.5 | 0.6 | 1.4 | 2.5 |
| 2j3-7 | Segment II | 3 | 1040 | Country rocks | 0.23 | 0.05 | nd | 16 | 19 | 0.2 | nd | nd | nd | nd | nd | nd |
| 2j3-8 | Segment II | 3 | 1040 | Country rocks | 0.21 | 0.05 | nd | 27 | 16 | 0.2 | nd | nd | nd | nd | nd | nd |
| 2j3-10 | Segment II | 3 | 1040 | Country rocks | 0.22 | 0.05 | nd | 22 | 14 | 0.2 | nd | nd | nd | nd | nd | nd |
| 2j3-11 | Segment II | 3 | 1040 | Country rocks | 0.23 | 0.05 | nd | 25 | 15 | 0.3 | nd | nd | nd | nd | nd | nd |
| 2J1-1 | Segment II | 1 | 1040 | Net-textured | 0.39 | 0.09 | 0.96 | 15600 | 46131 | 9.7 | 15.4 | 486.0 | 20.4 | 24.0 | 34.4 | 46.7 |
| 2J1-2 | Segment II | 1 | 1040 | Net-textured | 0.57 | 0.05 | 0.90 | 43610 | 42411 | 10.3 | 54.7 | 320.0 | 15.7 | 9.9 | 17.5 | 22.6 |
| 2J1-4 | Segment II | 1 | 1040 | Disseminated | 0.69 | 0.05 | 0.93 | 6439 | 21825 | 5.9 | 367.0 | 131.0 | 2.4 | 0.9 | 2.0 | 3.6 |
| 2j1-1 | Segment II | 1.25 | 1040 | Net-textured | -0.21 | 0.08 | 0.92 | 70980 | 14056 | 11.1 | 342.0 | 337.0 | 10.8 | 8.2 | 18.1 | 12.9 |
| 2j1-2 | Segment II | 1.25 | 1040 | Net-textured | -0.47 | 0.05 | 0.95 | 2044 | 17225 | 9.8 | 695.0 | 82.8 | 12.3 | 6.9 | 13.2 | 5.5 |
| 2j1-3 | Segment II | 1.25 | 1040 | Net-textured | -0.27 | 0.10 | 0.92 | 70980 | 14056 | 9.6 | 29.3 | 367.0 | 1.2 | 1.0 | 1.1 | 2.6 |
| 2j1-4 | Segment II | 1.25 | 1040 | Net-textured | 0.15 | 0.05 | 0.90 | 72070 | 6777 | 9.2 | 555.0 | 371.0 | 0.7 | 0.7 | 1.0 | 1.5 |
| j1-1 | Segment I | 1 | 1040 | Net-textured | 0.00 | 0.06 | 0.95 | 50980 | 21189 | 9.9 | 54.5 | 151.0 | 1.4 | 2.5 | 2.6 | 5.1 |
| j1-2 | Segment I | 1 | 1040 | Net-textured | 0.62 | 0.05 | 0.92 | 21990 | 21741 | 7.7 | 269.0 | 505.0 | 1.7 | 2.6 | 4.6 | 3.7 |
| j3-1 | Segment I | 3 | 1040 | Disseminated | 0.32 | 0.05 | 0.93 | 4777 | 16854 | 6.0 | 260.0 | 205.0 | 12.9 | 17.8 | 33.1 | 23.8 |
| j3-4 | Segment I | 3 | 1040 | Disseminated | 0.41 | 0.05 | 0.92 | 5432 | 12773 | 5.3 | 17.5 | 79.8 | 9.7 | 9.5 | 13.8 | 20.2 |
| j3-6 | Segment I | 3 | 1040 | Net-textured | 0.19 | 0.05 | 0.94 | 3980 | 18200 | 6.6 | 477.0 | 265.0 | 9.2 | 9.7 | 15.0 | 10.3 |
| j5-1 | Segment I | 5 | 1040 | Disseminated | 0.58 | 0.05 | 0.95 | 6125 | 10435 | 3.9 | 157.0 | 114.0 | 7.6 | 15.8 | 25.4 | 23.9 |

Table OM1 (continued)

| Sample no. | Locations | Line No | Elevation (m) | Mineralization types | $\delta^{65}\text{Cu}$ (‰) | 2SD | Cu/Fe | Cu (ppm) | Ni (ppm) | S (wt. %) | Pt (ppm) | Pd (ppm) | Rh (ppm) | Ru (ppm) | Ir (ppm) | Os (ppm) |
|-------------------|-----------|---------|---------------|----------------------|----------------------------|------|-------|----------|----------|-----------|----------|----------|----------|----------|----------|----------|
| j5-3 | Segment I | 5 | 1040 | Disseminated | 0.44 | 0.05 | 0.97 | 6869 | 15328 | 5.0 | 76.2 | 86.4 | 8.5 | 17.4 | 22.6 | 36.8 |
| j5-4 | Segment I | 5 | 1040 | Disseminated | 0.57 | 0.05 | 0.91 | 7200 | 16700 | 5.0 | 36.5 | 28.5 | 5.3 | 13.5 | 32.2 | 24.2 |
| j5-5 | Segment I | 5 | 1040 | Disseminated | 0.53 | 0.06 | 0.90 | 1050 | 6248 | 1.6 | 16.0 | 31.6 | 4.2 | 13.8 | 21.3 | 26.3 |
| j5-6 | Segment I | 5 | 1040 | Disseminated | 0.38 | 0.05 | 0.89 | 2375 | 4914 | 1.2 | 32.5 | 43.6 | 3.0 | 6.9 | 7.8 | 12.8 |
| j5-9 | Segment I | 5 | 1040 | Net-textured | -0.47 | 0.05 | 0.91 | 47970 | 9533 | 7.4 | 265.0 | 158.0 | 13.8 | 24.3 | 54.0 | 101.0 |
| j5-9 (replicate) | Segment I | 5 | 1040 | Net-textured | -0.44 | 0.05 | 0.93 | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| j5-11 | Segment I | 5 | 1040 | Net-textured | 0.65 | 0.05 | 0.98 | 7360 | 32213 | 7.0 | 23.9 | 156.0 | 7.9 | 8.2 | 12.1 | 25.6 |
| j5-13 | Segment I | 5 | 1040 | Net-textured | 1.29 | 0.05 | 0.92 | 42840 | 17469 | 7.3 | 56.0 | 151.0 | 0.4 | 0.2 | 0.6 | 1.5 |
| j5-13 (replicate) | Segment I | 5 | 1040 | Net-textured | 1.18 | 0.08 | 0.92 | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| j5-14 | Segment I | 5 | 1040 | Net-textured | 0.56 | 0.05 | 0.96 | 42760 | 38902 | 9.3 | 24.9 | 345.0 | 11.3 | 4.9 | 10.6 | 13.3 |
| j6-1 | Segment I | 6 | 1040 | Disseminated | 0.96 | 0.05 | 0.93 | 43500 | 13200 | 2.5 | 534.0 | 76.0 | 17.0 | 22.0 | 35.9 | 37.3 |
| j6-2 | Segment I | 6 | 1040 | Net-textured | 0.15 | 0.05 | 0.90 | 16210 | 15510 | 10.6 | 769.0 | 88.1 | 25.7 | 35.6 | 46.9 | 34.9 |
| j6-3 | Segment I | 6 | 1040 | Net-textured | 0.37 | 0.05 | 0.98 | 58800 | 9800 | 9.5 | 266.0 | 89.0 | 6.5 | 2.4 | 18.2 | 9.9 |
| j6-5 | Segment I | 6 | 1040 | Net-textured | -0.2 | 0.05 | 0.90 | 5615 | 32044 | 9.2 | 20.1 | 476.0 | 14.2 | 20.9 | 27.9 | 38.0 |
| j6-5 (replicate) | Segment I | 6 | 1040 | Net-textured | -0.25 | 0.05 | 0.91 | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| j6-6 | Segment I | 6 | 1040 | Net-textured | 0.33 | 0.05 | 0.94 | 56670 | 17416 | 9.3 | 1219.0 | 453.0 | 2.1 | 2.6 | 3.1 | 4.2 |
| j6-7 | Segment I | 6 | 1040 | Net-textured | 0.67 | 0.05 | 1.02 | 73300 | 5030 | 9.4 | 238.0 | 164.0 | 37.8 | 1.4 | 1.2 | 0.7 |
| j6-9 | Segment I | 6 | 1040 | Net-textured | 1.05 | 0.13 | 1.08 | 57900 | 15434 | 8.6 | 302.0 | 231.0 | 1.2 | 1.6 | 2.4 | 3.8 |
| j6-10 | Segment I | 6 | 1040 | Net-textured | 0.86 | 0.05 | 0.98 | 49510 | 10366 | 8.6 | 391.0 | 125.0 | 0.9 | 2.0 | 1.1 | 2.5 |
| j6-11 | Segment I | 6 | 1040 | Net-textured | 0.51 | 0.05 | 0.99 | 62700 | 14522 | 9.4 | 1584.0 | 472.0 | 1.1 | 0.5 | 0.7 | 2.0 |
| j7-1 | Segment I | 7 | 1040 | Net-textured | 0.32 | 0.06 | 0.91 | 70530 | 15412 | 10.7 | 244.0 | 267.0 | 3.1 | 5.4 | 7.2 | 4.3 |
| j7-2 | Segment I | 7 | 1040 | Net-textured | 0.45 | 0.05 | 1.09 | 71500 | 10296 | 9.2 | 205.0 | 235.0 | 1.0 | 0.8 | 0.9 | 1.2 |
| j7-4 | Segment I | 7 | 1040 | Net-textured | 0.43 | 0.06 | 1.01 | 53300 | 8909 | 7.3 | 295.0 | 298.0 | 2.7 | 5.3 | 5.3 | 4.2 |
| j20-12-1 | Segment I | 20 | 1220 | Disseminated | 0.26 | 0.05 | 0.98 | 4480 | 3132 | 1.3 | 7.8 | 4.7 | 0.4 | 0.6 | 5.8 | 1.1 |

Table OM1 (continued)

| Sample no. | Locations | Line No | Elevation (m) | Mineralization types | $\delta^{65}\text{Cu}$ (‰) | 2SD | Cu/Fe | Cu (ppm) | Ni (ppm) | S (wt. %) | Pt (ppm) | Pd (ppm) | Rh (ppm) | Ru (ppm) | Ir (ppm) | Os (ppm) |
|-------------------|-----------|---------|---------------|----------------------|----------------------------|------|-------|----------|----------|-----------|----------|----------|----------|----------|----------|----------|
| j25-1 | Segment I | 25 | 1220 | Disseminated | 0.26 | 0.05 | 0.91 | 6717 | 10274 | 3.1 | 84.6 | 42.8 | 4.3 | 7.5 | 9.7 | 19.4 |
| j25-3 | Segment I | 25 | 1220 | Disseminated | 0.4 | 0.05 | 0.90 | 13100 | 12434 | 4.6 | 111.0 | 128.0 | 16.3 | 24.5 | 36.9 | 35.6 |
| j20-1 | Segment I | 20 | 1220 | Massive | -0.36 | 0.05 | 1.13 | 20440 | 72684 | 25.1 | 93.2 | 623.0 | 117.0 | 339.0 | 369.0 | 643.0 |
| j20-2 | Segment I | 20 | 1220 | Massive | 0.09 | 0.05 | 1.00 | 7844 | 87620 | 30.1 | 67.7 | 197.0 | 135.0 | 377.0 | 419.0 | 357.0 |
| j20-3 | Segment I | 20 | 1220 | Massive | -0.46 | 0.05 | 0.99 | 34000 | 71656 | 28.9 | 150.0 | 705.0 | 163.0 | 587.0 | 542.0 | 625.0 |
| j20-4 | Segment I | 20 | 1220 | Massive | -0.49 | 0.12 | 0.99 | 94990 | 42560 | 20.1 | 146.0 | 53.0 | 35.2 | 149.0 | 143.0 | 220.0 |
| j20-5 | Segment I | 20 | 1220 | Massive | -0.22 | 0.07 | 0.96 | 115900 | 34492 | 24.0 | 2049.0 | 412.0 | 50.9 | 463.0 | 402.0 | 551.0 |
| j20-5 (replicate) | Segment I | 20 | 1220 | Massive | -0.19 | 0.05 | 0.95 | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| j20-6 | Segment I | 20 | 1220 | Massive | -0.44 | 0.05 | 0.97 | 50470 | 49629 | 21.8 | 1089.0 | 697.0 | 63.3 | 217.0 | 344.0 | 228.0 |
| j20-7 | Segment I | 20 | 1220 | Massive | -0.83 | 0.05 | 0.97 | 38390 | 62943 | 26.8 | 38125.0 | 936.0 | 333.0 | 225.0 | 405.0 | 368.0 |
| j24-6 | Segment I | 24 | 1220 | Massive | -0.91 | 0.05 | 0.90 | 4229 | 89570 | 34.4 | 119.0 | 365.5 | 154.0 | 337.0 | 192.0 | 405.0 |
| j24-8 | Segment I | 24 | 1220 | Massive | -0.6 | 0.05 | 1.02 | 1485 | 77645 | 34.8 | 66.3 | 464.0 | 139.0 | 366.0 | 399.0 | 435.0 |
| j24-7 | Segment I | 24 | 1220 | Massive | -0.38 | 0.05 | 0.90 | 1767 | 72589 | 34.8 | 74.5 | 399.0 | 110.0 | 273.0 | 260.0 | 367.0 |

Notes: Copper isotope data are expressed in per mil relative to NIST 976. nd = not determined. Replicate = repeat sample dissolution, purified column chemistry and MC-ICPMS analysis.