# Additional file

## The layered structure model for winonaite parent asteroid implicated by textural and mineralogical diversity

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Figure A1. The image of six studied winonaite sections, which were carbon-coated.

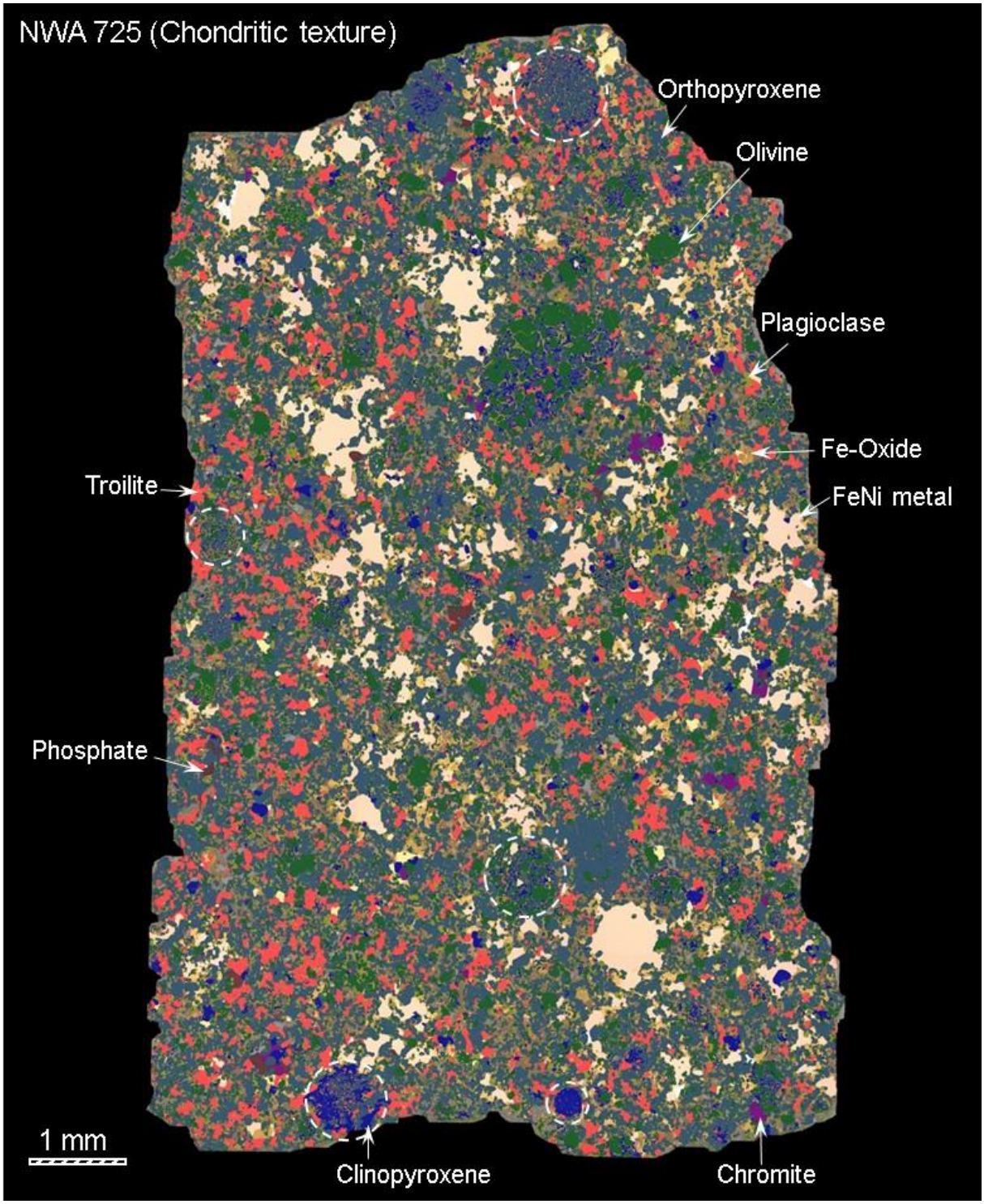


Figure A2. Elemental composite map of the NWA 725 contenting some relic chondrules (circles).

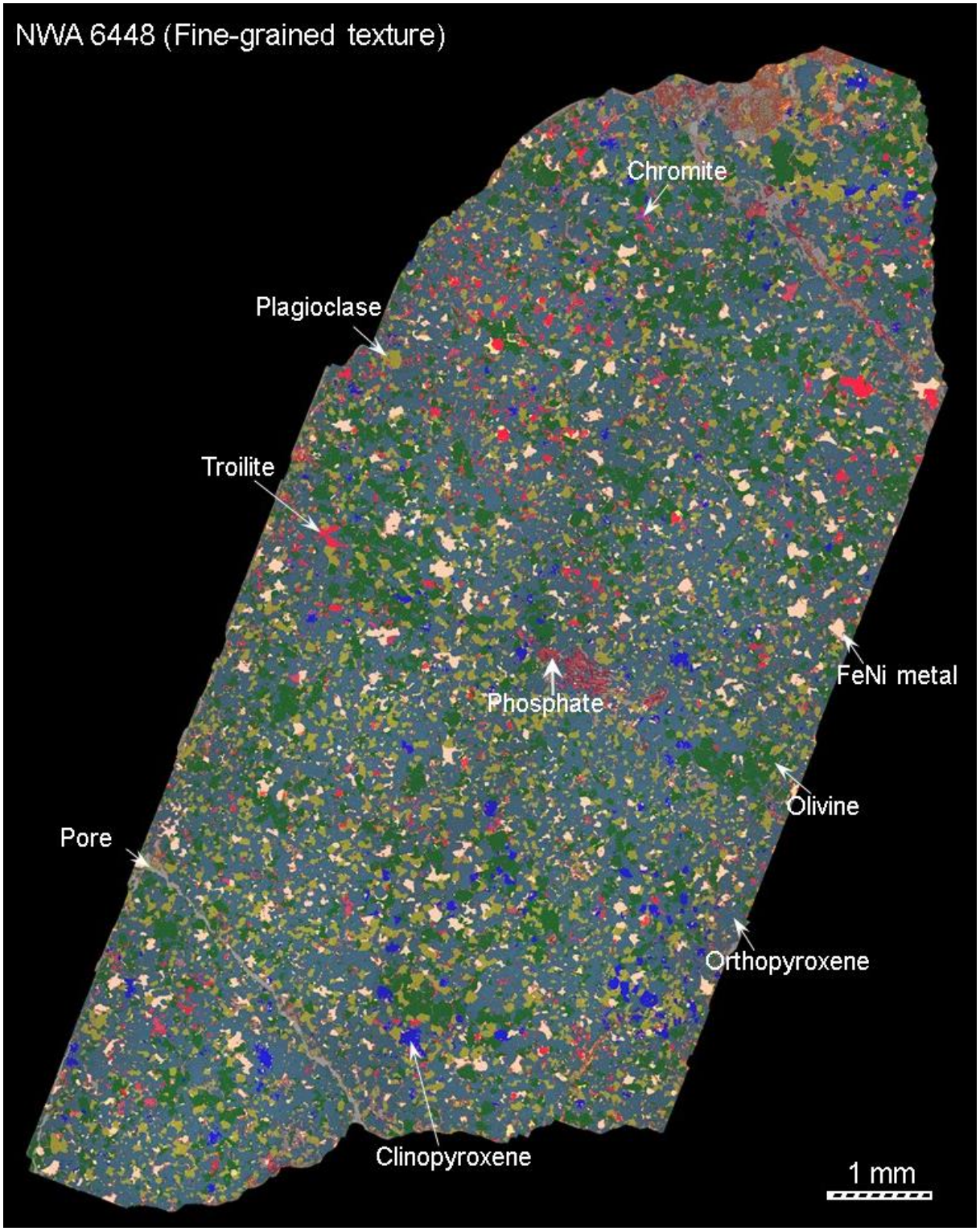


Figure A3. Elemental composite map of the fine-grained achondritic texture NWA 6448.

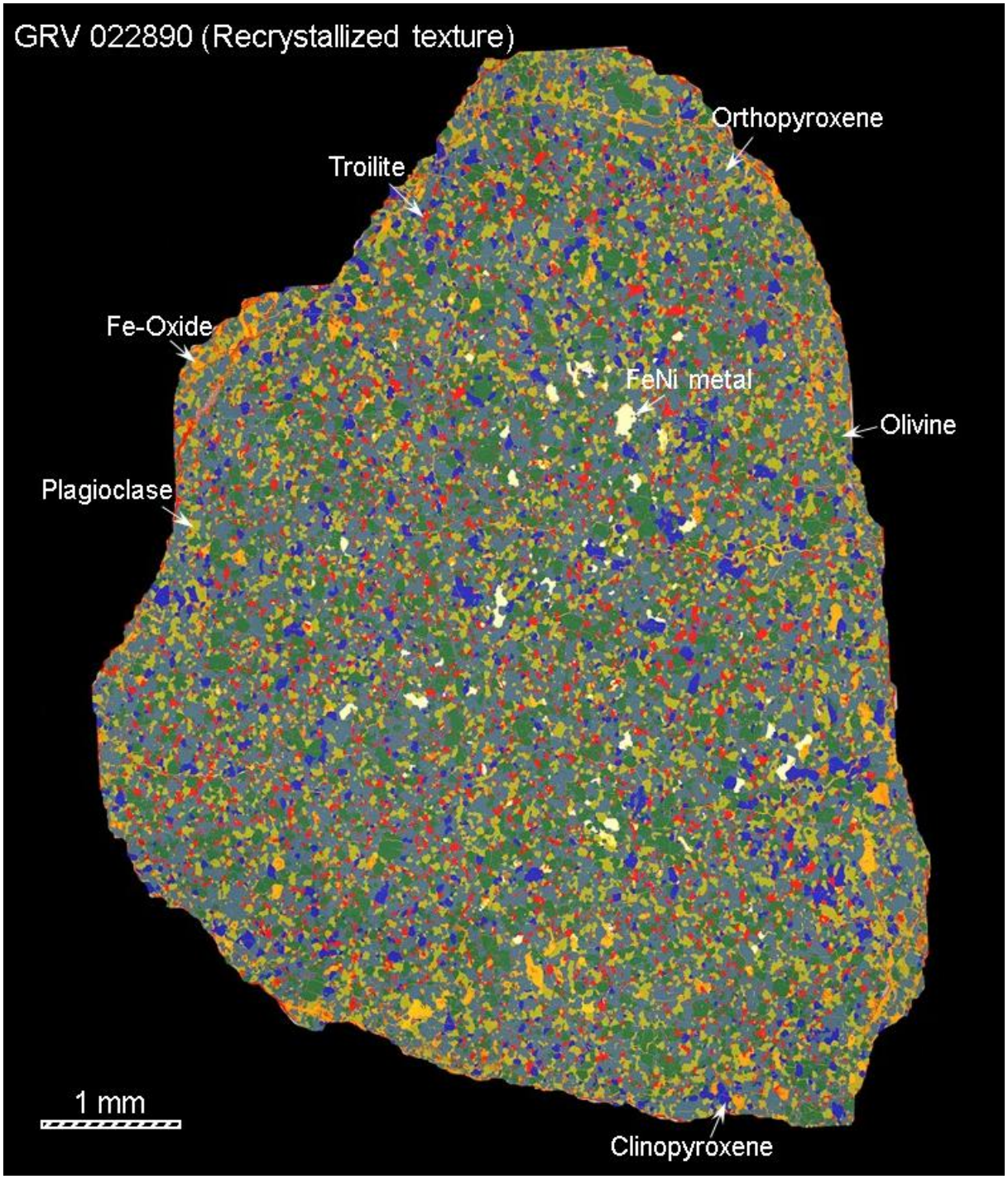


Figure A4. Elemental composite map of medium-grained recrystallized texture GRV 022890

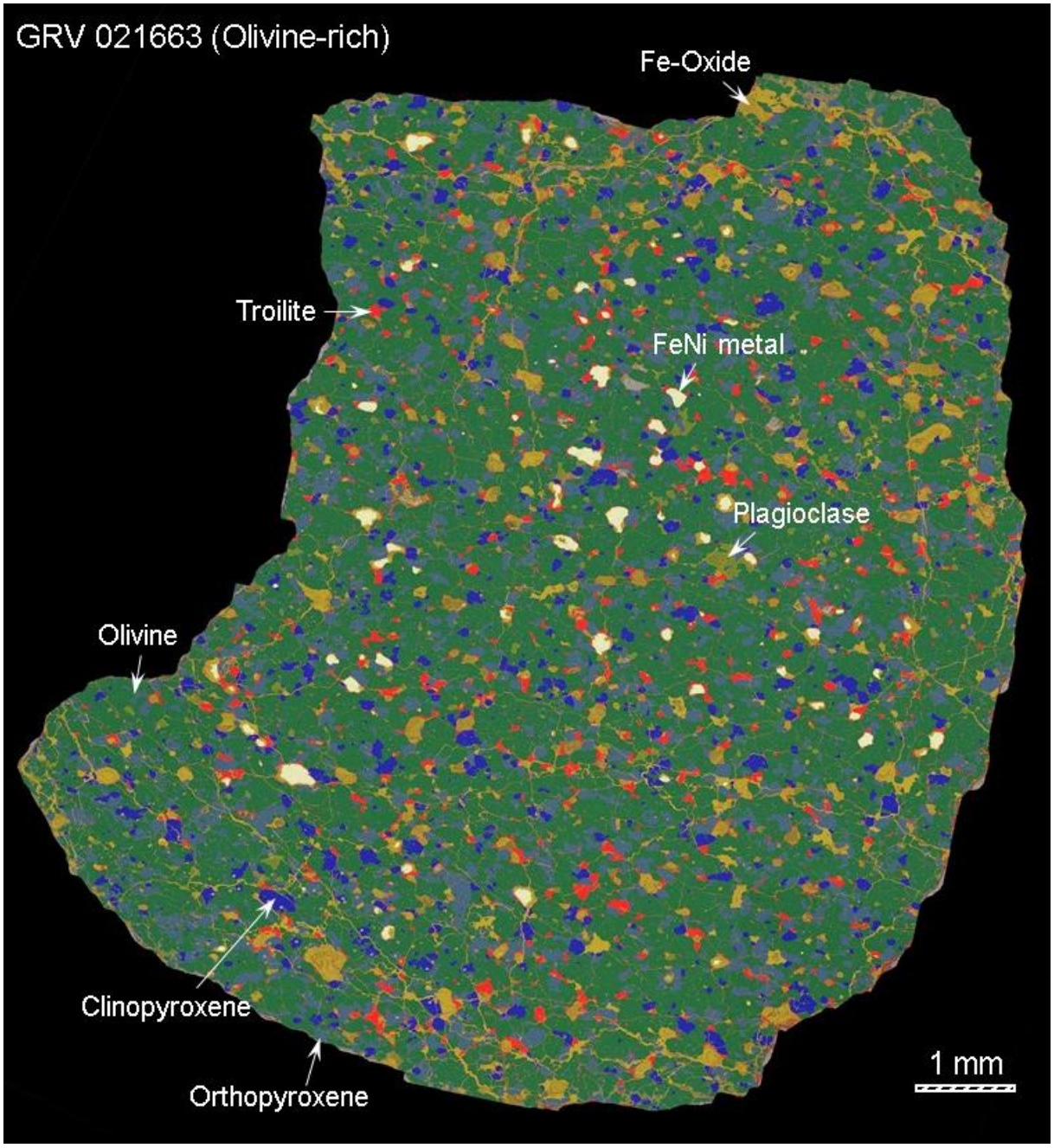


Figure A5. Elemental composite map of the coarse-grained olivine-rich texture GRV 021663

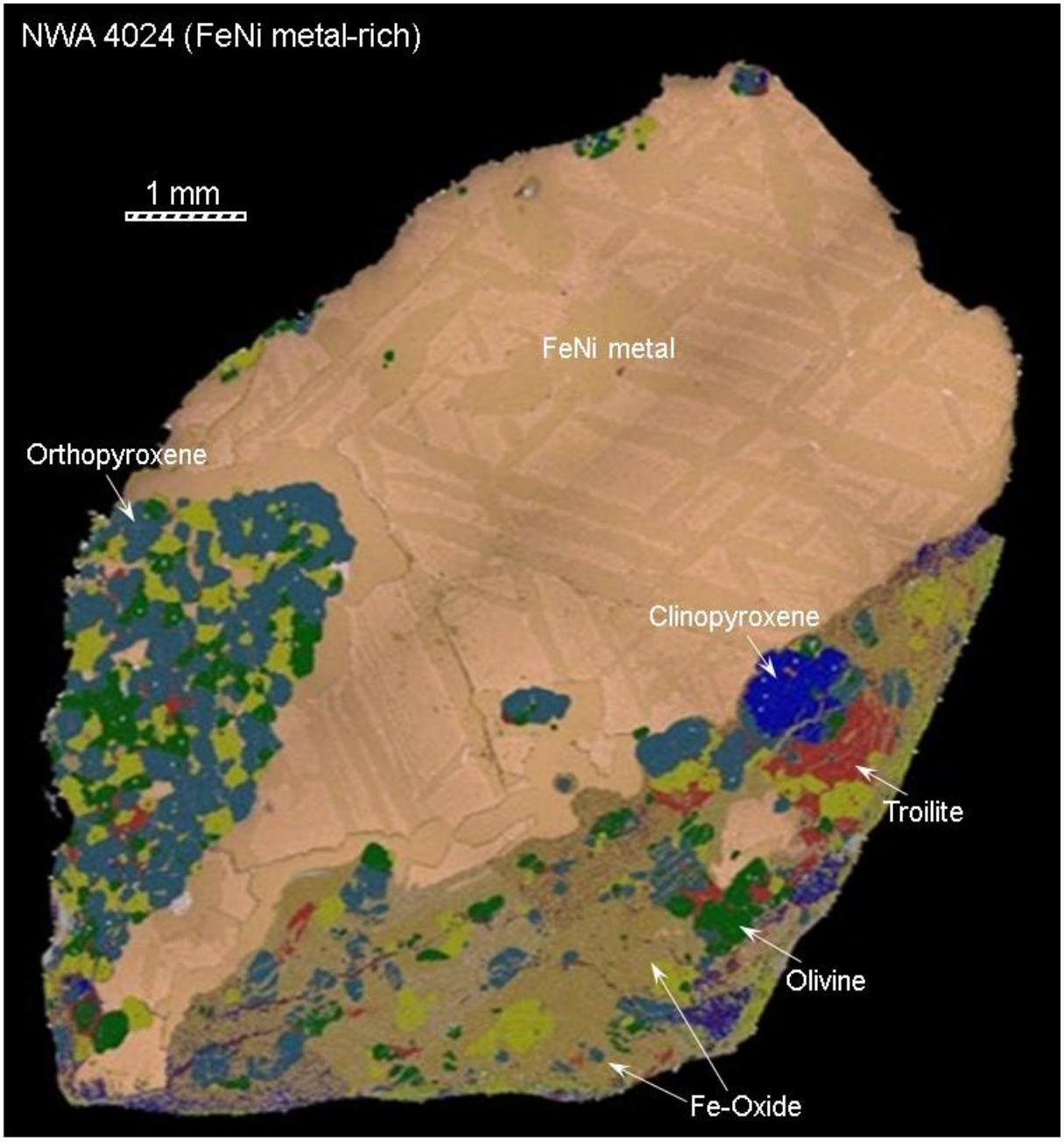


Figure A6. Elemental composite map of coarse-grained metal-rich texture NWA 4024

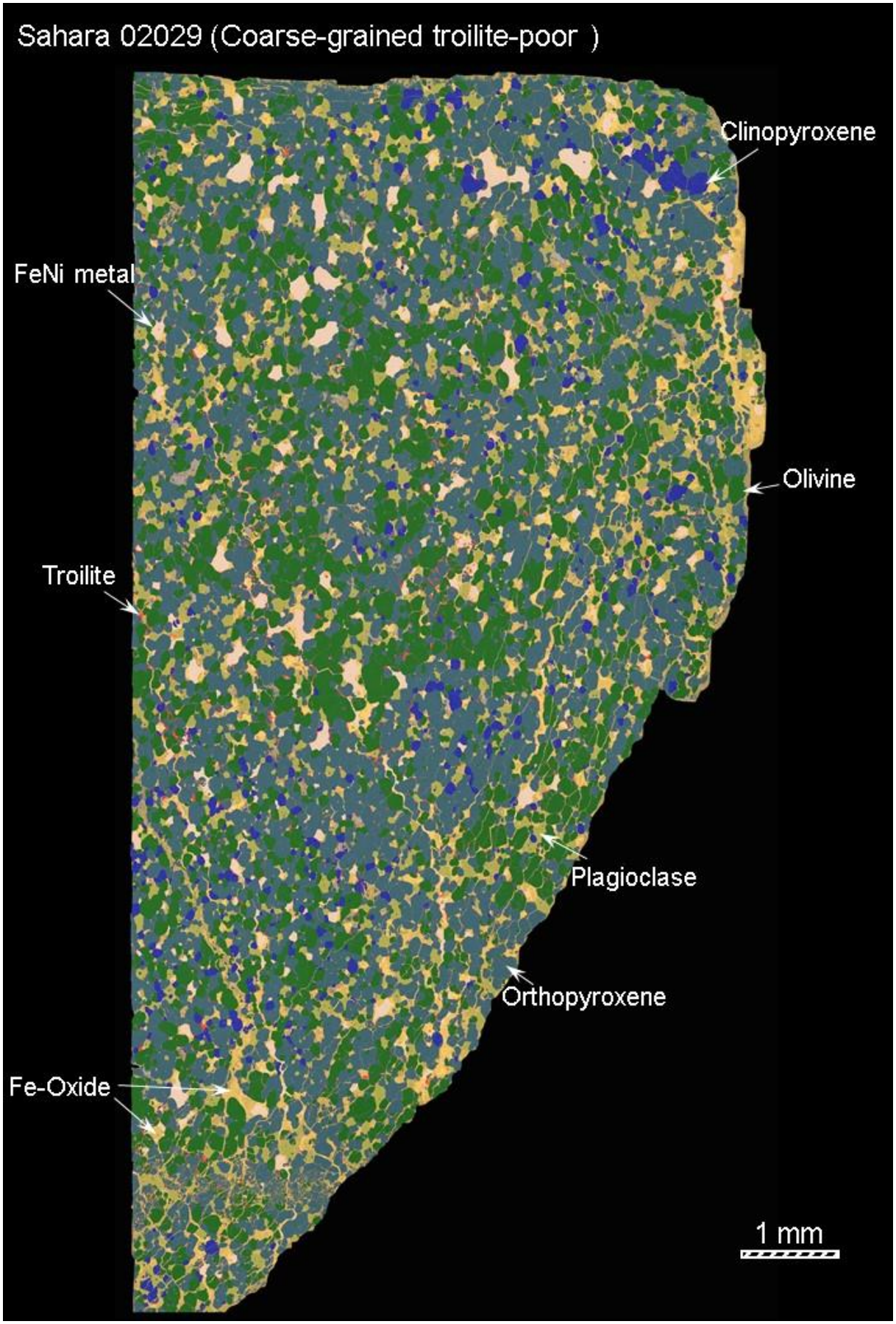


Figure A7. Elemental composite map of the coarse-grained troilite-poor texture SAH 02029.

Table A1. The rare earth elements composition for orthopyroxene (Opx), clinopyroxene (Cpx), and plagioclase (Pl) in the studied winonaites (ppm).

| | **NWA 725 Opx** | **NWA 6448 Opx** | **GRV 022890 Opx** | **GRV 021663 Opx [a]** | **NWA 4024 Opx** | **SAH 02029 Opx** | **Detection limits** |
|---|---|---|---|---|---|---|---|
| | N=7 (1SD) | N=3 (1SD) | N=8 (1SD) | N=12 | N=7 (1SD) | N=7 (1SD) | |
| La | b.d. | 0.010 ±0.005 | 0.038 ±0.037 | 0.062 | 0.015 ±0.014 | 0.024 ±0.021 | 0.011 |
| Ce | 0.021 ±0.019 | 0.011 ±0.009 | 0.108 ±0.096 | 0.095 | b.d. | 0.069 ±0.048 | 0.008 |
| Pr | b.d. | b.d. | 0.018 ±0.022 | 0.022 | b.d. | 0.013 ±0.009 | 0.007 |
| Nd | 0.044 ±0.040 | b.d. | 0.092 ±0.048 | 0.16 | 0.034 ±0.019 | 0.101 ±0.077 | 0.023 |
| Sm | 0.030 ±0.016 | 0.031 ±0.018 | 0.025 ±0.022 | 0.11 | 0.053 ±0.033 | 0.086 ±0.020 | 0.012 |
| Eu | b.d. | 0.015 ±0.017 | b.d. | 0.013 | 0.013 ±0.004 | 0.016 ±0.008 | 0.009 |
| Gd | 0.038 ±0.022 | b.d. | 0.058 ±0.031 | 0.16 | 0.146 ±0.238 | 0.155 ±0.053 | 0.021 |
| Tb | b.d. | b.d. | 0.012 ±0.007 | 0.029 | b.d. | 0.042 ±0.010 | 0.007 |
| Dy | 0.077 ±0.035 | 0.041 ±0.023 | 0.103 ±0.042 | 0.28 | 0.065 ±0.045 | 0.331 ±0.052 | 0.033 |
| Ho | 0.021 ±0.010 | 0.013 ±0.003 | 0.028 ±0.011 | 0.08 | 0.022 ±0.015 | 0.087 ±0.011 | 0.011 |
| Er | 0.093 ±0.027 | 0.043 ±0.020 | 0.115 ±0.033 | 0.28 | 0.093 ±0.048 | 0.293 ±0.055 | 0.031 |
| Tm | 0.014 ±0.006 | 0.011 ±0.007 | 0.024 ±0.011 | 0.047 | 0.017 ±0.007 | 0.042 ±0.008 | 0.010 |
| Yb | 0.126 ±0.065 | 0.148 ±0.027 | 0.212 ±0.078 | 0.35 | 0.165 ±0.107 | 0.310 ±0.053 | 0.064 |
| Lu | 0.031 ±0.010 | 0.022 ±0.006 | 0.038 ±0.009 | 0.059 | 0.034 ±0.019 | 0.051 ±0.015 | 0.010 |
| | **NWA 725 Cpx** | **NWA 6448 Cpx** | **GRV 022890 Cpx** | **GRV 021663 Cpx [a]** | **NWA 4024 Cpx** | **SAH 02029 Cpx** | |
| | N=8 (1SD) | N=6 (1SD) | N=8 (1SD) | N=12 (1SD) | N=5 | N=7 (1SD) | |
| La | 2.284 ±0.522 | 2.165 ±0.272 | 3.542 ±0.161 | 2.4 | 2.348 ±0.149 | 0.307 ±0.040 | 0.012 |
| Ce | 8.926 ±2.194 | 8.456 ±1.130 | 12.66 ±0.569 | 10 | 8.938 ±0.781 | 1.431 ±0.132 | 0.008 |
| Pr | 1.468 ±0.411 | 1.442 ±0.195 | 1.925 ±0.087 | 1.7 | 1.469 ±0.116 | 0.359 ±0.033 | 0.004 |
| Nd | 8.741 ±2.280 | 8.506 ±1.383 | 10.60 ±0.636 | 9.5 | 8.747 ±0.918 | 3.143 ±0.246 | 0.097 |
| Sm | 2.834 ±0.792 | 3.041 ±0.350 | 3.421 ±0.441 | 3 | 3.166 ±0.237 | 1.581 ±0.191 | 0.069 |
| Eu | 0.060 ±0.024 | 0.060 ±0.016 | 0.049 ±0.016 | 0.058 | 0.056 ±0.026 | 0.078 ±0.026 | 0.023 |
| Gd | 3.634 ±0.997 | 4.041 ±0.481 | 4.356 ±0.364 | 4.1 | 4.333 ±0.331 | 2.393 ±0.162 | 0.114 |
| Tb | 0.615 ±0.146 | 0.662 ±0.094 | 0.743 ±0.057 | 0.67 | 0.806 ±0.046 | 0.402 ±0.035 | 0.008 |
| Dy | 3.978 ±1.033 | 4.411 ±0.577 | 5.022 ±0.292 | 4.5 | 5.312 ±0.256 | 2.739 ±0.234 | 0.007 |
| Ho | 0.746 ±0.211 | 0.864 ±0.113 | 0.978 ±0.077 | 0.9 | 1.119 ±0.061 | 0.543 ±0.042 | 0.012 |
| Er | 2.095 ±0.431 | 2.459 ±0.242 | 2.725 ±0.189 | 2.4 | 2.767 ±0.176 | 1.489 ±0.085 | 0.012 |
| Tm | 0.269 ±0.074 | 0.322 ±0.052 | 0.349 ±0.022 | 0.31 | 0.352 ±0.016 | 0.174 ±0.017 | 0.016 |
| Yb | 1.577 ±0.458 | 2.061 ±0.278 | 2.160 ±0.158 | 1.9 | 2.284 ±0.308 | 1.203 ±0.097 | 0.036 |
| Lu | 0.222 ±0.063 | 0.260 ±0.022 | 0.285 ±0.026 | 0.26 | 0.343 ±0.046 | 0.160 ±0.017 | 0.009 |
| | **NWA 725 Pl** | **NWA 6448 Pl** | **GRV 022890 Pl** | **GRV 021663 Pl [a]** | **NWA 4024 Pl** | **SAH 02029 Pl** | |
| | N=3 (1SD) | N=6 (1SD) | N=5 (1SD) | N=3 | N=3 (1SD) | N=5 (1SD) | |
| La | 1.195 ±0.071 | 0.232 ±0.115 | 1.361 ±0.190 | 1.2 | 0.461 ±0.420 | 0.320 ±0.143 | 0.012 |
| Ce | 1.264 ±0.038 | 0.264 ±0.083 | 1.216 ±0.186 | 1.8 | 0.462 ±0.361 | 0.665 ±0.211 | 0.006 |
| Pr | 0.068 ±0.020 | 0.020 ±0.016 | 0.066 ±0.023 | 0.12 | 0.038 ±0.018 | 0.099 ±0.038 | 0.016 |
| Nd | 0.273 ±0.032 | 0.066 ±0.039 | 0.129 ±0.062 | 0.23 | 0.058 ±0.044 | 0.565 ±0.256 | 0.045 |
| Sm | 0.041 ±0.029 | 0.133 ±0.075 | 0.044 ±0.044 | 0.19 | 0.013 ±0.013 | 0.109 ±0.079 | 0.011 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Eu | 0.581 ±0.046 | 0.599 ±0.135 | 0.738 ±0.081 | 0.8 | 0.826 ±0.439 | 1.131 ±0.060 | 0.015 |
| Gd | b.d. | 0.063 ±0.035 | 0.096 ±0.031 | b.d. | 0.115 ±0.032 | 0.178 ±0.118 | 0.050 |
| Tb | b.d. | 0.007 ±0.006 | 0.006 ±0.004 | b.d. | b.d. | 0.015 ±0.013 | 0.009 |
| Dy | b.d. | 0.038 ±0.037 | 0.020 ±0.008 | b.d. | b.d. | 0.121 ±0.088 | 0.018 |
| Ho | b.d. | b.d. | 0.012 ±0.009 | b.d. | b.d. | 0.017 ±0.009 | 0.010 |
| Er | b.d. | b.d. | 0.019 ±0.013 | b.d. | b.d. | 0.062 ±0.045 | 0.015 |
| Tm | b.d. | b.d. | b.d. | b.d. | b.d. | b.d. | 0.014 |
| Yb | b.d. | b.d. | 0.060 ±0.023 | b.d. | b.d. | 0.089 ±0.067 | 0.049 |
| Lu | b.d. | b.d. | b.d. | b.d. | b.d. | b.d. | 0.015 |

b.d. = below detection.

[a]Data was taken from Li et al. (2011).