

**Electronic Supplementary Information (ESI)**

**U-Pb Geochronology of Wolframite by Laser Ablation  
Inductively Coupled Plasma Mass Spectrometry**

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*Submitted to Journal of Analytical Atomic Spectrometry*

**Table S-1.** Detailed mathematical equation for U-Pb data correction between calibration standards and samples.

$$R_{cor}^{sam} = R_{mea}^{sam} * R_{ref}^{std} * \left( \frac{1}{R_{mea1}^{std}} * \left( 1 - \frac{t^{sam} - t_{mea1}^{std}}{t_{mea2}^{std} - t_{mea1}^{std}} \right) + \frac{1}{R_{mea2}^{std}} * \frac{t^{sam} - t_{mea1}^{std}}{t_{mea2}^{std} - t_{mea1}^{std}} \right)$$

:Where  $R_{mea}^{sam}$  is the measured isotopic ratio of sample at time  $t^{sam}$ ,  $t^{sam}$  is the corrected isotopic ratio of the sample,  $R_{ref}^{std}$  is the reference isotopic ratio of the the zircon 91500,  $R_{mea1}^{std}$  and  $R_{mea2}^{std}$  are the measured isotopic ratios of 91500 at time  $t_{mea1}^{std}$  and  $t_{mea2}^{std}$ .

In this study, U-Pb isotopic ratios and downhole fractionation are corrected with standard-sample bracketing method. Zircon 91500 was used as external standard, which was analyzed twice every 6 analyses of wolframite samples (i.e. two 91500 + six wolframite samples + two 91500). The identical integrating time of external standard and samples were selected to correct the Pb/U fractionation and instrumental mass discrimination using ICPMSDataCal software. The U-Pb isotopic ratios of wolframite samples were calculated using a linear interpolation (with time) for every six analyses according to the variations of zircon 91500.

Table S-2. U-Pb analytical results of wolframite samples LB and MTM with ns-LA-ICP-MS in different ablation mode.

| Sample(LB) | Concentrations |     |      | Measured ratios                   |                                   |                                  |                                  |                                  |                                  |
|------------|----------------|-----|------|-----------------------------------|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|            | Pb             | Th  | U    | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ |
|            | ppm            | ppm | ppm  | Ratio                             | 1sigma                            | Ratio                            | 1sigma                           | Ratio                            | 1sigma                           |
|            | 34.2           | 0.4 | 6.7  | 0.0743                            | 0.0026                            | 0.4797                           | 0.0163                           | 0.0477                           | 0.0005                           |
|            | 34.1           | 0.4 | 5.9  | 0.0702                            | 0.0027                            | 0.4465                           | 0.0159                           | 0.0481                           | 0.0006                           |
|            | 34.9           | 0.4 | 11.5 | 0.0665                            | 0.0019                            | 0.4304                           | 0.0123                           | 0.0478                           | 0.0004                           |
|            | 33.9           | 0.4 | 5.1  | 0.0814                            | 0.0032                            | 0.5370                           | 0.0203                           | 0.0490                           | 0.0006                           |
|            | 31.6           | 0.5 | 7.8  | 0.0763                            | 0.0028                            | 0.5065                           | 0.0171                           | 0.0496                           | 0.0005                           |
|            | 30.1           | 0.5 | 8.8  | 0.0664                            | 0.0027                            | 0.4113                           | 0.0156                           | 0.0465                           | 0.0005                           |
|            | 28.8           | 0.5 | 13.1 | 0.0639                            | 0.0020                            | 0.4058                           | 0.0115                           | 0.0469                           | 0.0004                           |
|            | 30.2           | 0.5 | 6.4  | 0.0701                            | 0.0024                            | 0.4523                           | 0.0152                           | 0.0480                           | 0.0005                           |
|            | 28.1           | 0.5 | 10.8 | 0.0697                            | 0.0024                            | 0.4541                           | 0.0149                           | 0.0484                           | 0.0004                           |
|            | 27.4           | 0.5 | 15.5 | 0.0596                            | 0.0017                            | 0.3750                           | 0.0110                           | 0.0462                           | 0.0003                           |
|            | 26.8           | 0.5 | 7.0  | 0.0714                            | 0.0028                            | 0.4507                           | 0.0174                           | 0.0468                           | 0.0006                           |
|            | 25.7           | 0.4 | 6.7  | 0.0690                            | 0.0024                            | 0.4351                           | 0.0147                           | 0.0470                           | 0.0005                           |
|            | 24.6           | 0.4 | 4.7  | 0.0759                            | 0.0033                            | 0.4781                           | 0.0195                           | 0.0477                           | 0.0006                           |
|            | 25.9           | 0.4 | 7.5  | 0.0624                            | 0.0025                            | 0.3842                           | 0.0136                           | 0.0467                           | 0.0005                           |
|            | 25.3           | 0.4 | 6.1  | 0.0722                            | 0.0029                            | 0.4636                           | 0.0176                           | 0.0483                           | 0.0005                           |
|            | 23.0           | 0.4 | 8.6  | 0.0588                            | 0.0024                            | 0.3679                           | 0.0141                           | 0.0464                           | 0.0005                           |
|            | 24.4           | 0.4 | 9.8  | 0.0582                            | 0.0022                            | 0.3723                           | 0.0133                           | 0.0469                           | 0.0004                           |
|            | 23.1           | 0.4 | 8.1  | 0.0635                            | 0.0028                            | 0.4012                           | 0.0167                           | 0.0467                           | 0.0006                           |
|            | 22.2           | 0.4 | 4.4  | 0.0775                            | 0.0036                            | 0.4968                           | 0.0226                           | 0.0478                           | 0.0009                           |
|            | 22.2           | 0.4 | 3.9  | 0.0869                            | 0.0046                            | 0.5378                           | 0.0250                           | 0.0474                           | 0.0007                           |
|            | 22.8           | 0.4 | 6.7  | 0.0663                            | 0.0025                            | 0.4140                           | 0.0152                           | 0.0468                           | 0.0005                           |
|            | 23.5           | 0.4 | 4.5  | 0.0744                            | 0.0038                            | 0.4778                           | 0.0249                           | 0.0480                           | 0.0007                           |
|            | 23.2           | 0.3 | 8.6  | 0.0611                            | 0.0019                            | 0.3811                           | 0.0112                           | 0.0468                           | 0.0004                           |
|            | 23.3           | 0.6 | 7.3  | 0.0643                            | 0.0024                            | 0.4086                           | 0.0138                           | 0.0472                           | 0.0005                           |
|            | 22.6           | 0.5 | 5.3  | 0.0792                            | 0.0039                            | 0.5018                           | 0.0232                           | 0.0481                           | 0.0007                           |
|            | 19.1           | 0.3 | 6.6  | 0.0910                            | 0.0030                            | 0.5955                           | 0.0187                           | 0.0488                           | 0.0005                           |
|            | 21.1           | 0.3 | 8.4  | 0.0926                            | 0.0026                            | 0.6296                           | 0.0170                           | 0.0505                           | 0.0005                           |
|            | 20.5           | 0.3 | 5.4  | 0.0779                            | 0.0032                            | 0.4995                           | 0.0199                           | 0.0489                           | 0.0006                           |
|            | 18.8           | 0.3 | 8.4  | 0.0577                            | 0.0023                            | 0.3627                           | 0.0140                           | 0.0465                           | 0.0005                           |
|            | 20.6           | 0.3 | 9.8  | 0.0558                            | 0.0020                            | 0.3490                           | 0.0126                           | 0.0463                           | 0.0005                           |
|            | 18.6           | 0.3 | 11.7 | 0.0605                            | 0.0019                            | 0.3822                           | 0.0118                           | 0.0467                           | 0.0004                           |
|            | 25.1           | 0.3 | 11.2 | 0.0824                            | 0.0023                            | 0.5406                           | 0.0137                           | 0.0485                           | 0.0005                           |

Continued Table S-1. U-Pb analytical results of wolframite samples LB and MTM with ns-LA-ICP-MS in different ablation mode.

| Sample(MTM)                     | Concentrations |     |      | Measured ratios                   |                                   |                                  |                                  |                                  |                                  |
|---------------------------------|----------------|-----|------|-----------------------------------|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|                                 | Pb             | Th  | U    | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ |
|                                 | ppm            | ppm | ppm  | Ratio                             | 1sigma                            | Ratio                            | 1sigma                           | Ratio                            | 1sigma                           |
|                                 | 10.3           | -   | 56.2 | 0.0515                            | 0.0010                            | 0.3300                           | 0.0062                           | 0.0467                           | 0.0003                           |
|                                 | 4.2            | 0.1 | 63.1 | 0.0524                            | 0.0007                            | 0.3366                           | 0.0047                           | 0.0467                           | 0.0003                           |
|                                 | 10.9           | 0.1 | 73.7 | 0.0536                            | 0.0009                            | 0.3436                           | 0.0054                           | 0.0466                           | 0.0003                           |
|                                 | 12.1           | 0.1 | 54.7 | 0.0550                            | 0.0008                            | 0.3551                           | 0.0053                           | 0.0469                           | 0.0002                           |
|                                 | 9.0            | -   | 6.2  | 0.0726                            | 0.0025                            | 0.4716                           | 0.0160                           | 0.0486                           | 0.0006                           |
|                                 | 10.7           | 0.1 | 13.2 | 0.0577                            | 0.0018                            | 0.3691                           | 0.0109                           | 0.0472                           | 0.0004                           |
|                                 | 9.7            | 0.1 | 7.2  | 0.0753                            | 0.0026                            | 0.4949                           | 0.0160                           | 0.0493                           | 0.0005                           |
|                                 | 9.4            | -   | 6.6  | 0.0792                            | 0.0025                            | 0.5378                           | 0.0169                           | 0.0500                           | 0.0005                           |
|                                 | 9.5            | -   | 14.3 | 0.0622                            | 0.0018                            | 0.4034                           | 0.0116                           | 0.0478                           | 0.0003                           |
|                                 | 7.0            | -   | 11.4 | 0.0643                            | 0.0023                            | 0.4232                           | 0.0152                           | 0.0481                           | 0.0005                           |
|                                 | 8.5            | -   | 10.7 | 0.0726                            | 0.0027                            | 0.4808                           | 0.0168                           | 0.0491                           | 0.0005                           |
| Normal ablation                 | 10.1           | 0.1 | 10.6 | 0.0585                            | 0.0020                            | 0.3761                           | 0.0122                           | 0.0477                           | 0.0004                           |
| (spot size: 160 $\mu\text{m}$ ) | 10.3           | 0.1 | 21.8 | 0.0629                            | 0.0013                            | 0.4116                           | 0.0081                           | 0.0478                           | 0.0003                           |
|                                 | 9.7            | 0.1 | 12.6 | 0.0592                            | 0.0017                            | 0.3777                           | 0.0103                           | 0.0472                           | 0.0004                           |
|                                 | 9.3            | 0.1 | 19.7 | 0.0588                            | 0.0013                            | 0.3823                           | 0.0087                           | 0.0474                           | 0.0003                           |
|                                 | 8.2            | -   | 16.6 | 0.0561                            | 0.0014                            | 0.3582                           | 0.0090                           | 0.0468                           | 0.0003                           |
|                                 | 7.7            | -   | 10.8 | 0.0629                            | 0.0019                            | 0.4105                           | 0.0118                           | 0.0480                           | 0.0004                           |
|                                 | 8.5            | 0.1 | 16.4 | 0.0563                            | 0.0014                            | 0.3630                           | 0.0090                           | 0.0471                           | 0.0003                           |
|                                 | 9.2            | 0.1 | 36.9 | 0.0538                            | 0.0012                            | 0.3427                           | 0.0070                           | 0.0466                           | 0.0003                           |
|                                 | 10.6           | 0.1 | 54.3 | 0.0587                            | 0.0016                            | 0.3849                           | 0.0109                           | 0.0475                           | 0.0004                           |
|                                 | 11.0           | 0.1 | 51.0 | 0.0653                            | 0.0014                            | 0.4332                           | 0.0088                           | 0.0483                           | 0.0003                           |
|                                 | 6.9            | 0.1 | 61.0 | 0.0715                            | 0.0014                            | 0.4782                           | 0.0093                           | 0.0488                           | 0.0005                           |
|                                 | 8.3            | -   | 9.6  | 0.0551                            | 0.0017                            | 0.3513                           | 0.0110                           | 0.0468                           | 0.0004                           |
|                                 | 9.0            | 0.1 | 21.5 | 0.0511                            | 0.0011                            | 0.3274                           | 0.0069                           | 0.0467                           | 0.0003                           |
|                                 | 8.2            | 0.1 | 11.5 | 0.0587                            | 0.0018                            | 0.3763                           | 0.0114                           | 0.0471                           | 0.0004                           |

Continued Table S-1. U-Pb analytical results of wolframite samples LB and MTM with ns-LA-ICP-MS in different ablation mode.

| Sample(LB)           | Concentrations |     |      | Measured ratios                      |                                      |                                     |                                     |                                     |                                     |
|----------------------|----------------|-----|------|--------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
|                      | Pb             | Th  | U    | <sup>207</sup> Pb/ <sup>206</sup> Pb | <sup>207</sup> Pb/ <sup>206</sup> Pb | <sup>207</sup> Pb/ <sup>235</sup> U | <sup>207</sup> Pb/ <sup>235</sup> U | <sup>206</sup> Pb/ <sup>238</sup> U | <sup>206</sup> Pb/ <sup>238</sup> U |
|                      | ppm            | ppm | ppm  | Ratio                                | 1sigma                               | Ratio                               | 1sigma                              | Ratio                               | 1sigma                              |
|                      | 22.8           | 4.0 | 5.0  | 0.0924                               | 0.0027                               | 0.6982                              | 0.0195                              | 0.0562                              | 0.0005                              |
|                      | 21.4           | 3.7 | 9.8  | 0.0731                               | 0.0019                               | 0.5408                              | 0.0129                              | 0.0547                              | 0.0004                              |
|                      | 21.6           | 3.5 | 10.7 | 0.0833                               | 0.0017                               | 0.6293                              | 0.0125                              | 0.0552                              | 0.0003                              |
|                      | 22.7           | 3.2 | 7.2  | 0.0894                               | 0.0023                               | 0.6751                              | 0.0155                              | 0.0559                              | 0.0004                              |
|                      | 22.4           | 3.1 | 4.9  | 0.0940                               | 0.0026                               | 0.7121                              | 0.0179                              | 0.0561                              | 0.0004                              |
|                      | 20.0           | 2.9 | 7.6  | 0.0689                               | 0.0017                               | 0.5130                              | 0.0123                              | 0.0545                              | 0.0004                              |
|                      | 21.6           | 2.7 | 8.2  | 0.0705                               | 0.0017                               | 0.5264                              | 0.0122                              | 0.0546                              | 0.0004                              |
|                      | 23.7           | 1.7 | 3.5  | 0.0881                               | 0.0030                               | 0.6711                              | 0.0225                              | 0.0558                              | 0.0006                              |
|                      | 22.2           | 1.6 | 3.7  | 0.0738                               | 0.0017                               | 0.5549                              | 0.0129                              | 0.0550                              | 0.0004                              |
|                      | 21.0           | 1.4 | 3.6  | 0.0775                               | 0.0021                               | 0.5849                              | 0.0158                              | 0.0551                              | 0.0005                              |
|                      | 21.5           | 1.2 | 3.0  | 0.0886                               | 0.0031                               | 0.6772                              | 0.0226                              | 0.0559                              | 0.0006                              |
|                      | 19.9           | 0.6 | 1.3  | 0.0664                               | 0.0018                               | 0.4892                              | 0.0125                              | 0.0540                              | 0.0004                              |
|                      | 21.2           | 0.3 | 1.3  | 0.0724                               | 0.0013                               | 0.5408                              | 0.0088                              | 0.0547                              | 0.0003                              |
|                      | 19.1           | 1.8 | 9.0  | 0.0622                               | 0.0012                               | 0.4595                              | 0.0091                              | 0.0538                              | 0.0003                              |
| Water-vapor assisted | 18.9           | 4.3 | 12.8 | 0.0811                               | 0.0022                               | 0.6148                              | 0.0158                              | 0.0556                              | 0.0005                              |
| ablation             | 20.7           | 3.9 | 9.8  | 0.0904                               | 0.0020                               | 0.6874                              | 0.0144                              | 0.0559                              | 0.0004                              |
| (spot size: 160 μm)  | 18.6           | 4.0 | 13.7 | 0.0720                               | 0.0014                               | 0.5400                              | 0.0100                              | 0.0551                              | 0.0003                              |
|                      | 36.9           | 2.0 | 4.4  | 0.0772                               | 0.0019                               | 0.5863                              | 0.0137                              | 0.0560                              | 0.0004                              |
|                      | 36.9           | 2.1 | 4.7  | 0.0674                               | 0.0022                               | 0.5018                              | 0.0154                              | 0.0549                              | 0.0005                              |
|                      | 35.8           | 2.1 | 5.3  | 0.1003                               | 0.0023                               | 0.7914                              | 0.0168                              | 0.0581                              | 0.0004                              |
|                      | 36.5           | 2.0 | 5.7  | 0.0859                               | 0.0024                               | 0.6527                              | 0.0179                              | 0.0561                              | 0.0007                              |
|                      | 36.8           | 2.0 | 6.0  | 0.0750                               | 0.0023                               | 0.5660                              | 0.0169                              | 0.0554                              | 0.0005                              |
|                      | 34.6           | 2.0 | 4.1  | 0.1091                               | 0.0030                               | 0.8657                              | 0.0226                              | 0.0586                              | 0.0006                              |
|                      | 34.0           | 2.0 | 6.5  | 0.0733                               | 0.0016                               | 0.5552                              | 0.0117                              | 0.0553                              | 0.0004                              |
|                      | 34.1           | 2.0 | 5.3  | 0.0721                               | 0.0020                               | 0.5426                              | 0.0146                              | 0.0552                              | 0.0004                              |
|                      | 33.7           | 2.0 | 8.9  | 0.0939                               | 0.0016                               | 0.7378                              | 0.0123                              | 0.0573                              | 0.0003                              |
|                      | 33.3           | 2.0 | 5.8  | 0.0679                               | 0.0018                               | 0.5083                              | 0.0137                              | 0.0549                              | 0.0004                              |
|                      | 32.4           | 2.0 | 5.0  | 0.1009                               | 0.0022                               | 0.7921                              | 0.0165                              | 0.0575                              | 0.0004                              |
|                      | 31.3           | 1.9 | 3.0  | 0.0792                               | 0.0023                               | 0.5944                              | 0.0167                              | 0.0555                              | 0.0005                              |
|                      | 31.2           | 2.0 | 5.8  | 0.0889                               | 0.0019                               | 0.6806                              | 0.0138                              | 0.0563                              | 0.0004                              |
|                      | 31.0           | 1.8 | 2.9  | 0.1097                               | 0.0031                               | 0.8646                              | 0.0231                              | 0.0586                              | 0.0005                              |
|                      | 30.6           | 1.8 | 3.7  | 0.0711                               | 0.0020                               | 0.5347                              | 0.0147                              | 0.0556                              | 0.0004                              |

Continued Table S-1. U-Pb analytical results of wolframite samples LB and MTM with ns-LA-ICP-MS in different ablation mode.

| Sample(MTM)   | Concentrations |     |      | Measured ratios                   |                                   |                                  |                                  |                                  |                                  |
|---|----------------|-----|------|-----------------------------------|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|   | Pb             | Th  | U    | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ |
|   | ppm            | ppm | ppm  | Ratio                             | 1sigma                            | Ratio                            | 1sigma                           | Ratio                            | 1sigma                           |
|   | 11.6           | 1.7 | 5.2  | 0.0815                            | 0.0024                            | 0.6124                           | 0.0177                           | 0.0552                           | 0.0005                           |
|   | 12.0           | 1.6 | 8.3  | 0.0614                            | 0.0016                            | 0.4465                           | 0.0111                           | 0.0535                           | 0.0004                           |
|   | 12.0           | 1.4 | 28.5 | 0.0620                            | 0.0007                            | 0.4534                           | 0.0055                           | 0.0532                           | 0.0002                           |
|   | 11.9           | 2.2 | 7.5  | 0.0598                            | 0.0017                            | 0.4381                           | 0.0127                           | 0.0536                           | 0.0004                           |
|   | 11.9           | 1.4 | 3.4  | 0.0727                            | 0.0028                            | 0.5215                           | 0.0188                           | 0.0541                           | 0.0006                           |
|   | 11.8           | 1.3 | 3.8  | 0.0667                            | 0.0020                            | 0.4829                           | 0.0141                           | 0.0536                           | 0.0005                           |
|   | 11.5           | 1.4 | 10.9 | 0.0689                            | 0.0013                            | 0.5104                           | 0.0094                           | 0.0542                           | 0.0003                           |
|   | 11.0           | 1.5 | 19.5 | 0.0611                            | 0.0010                            | 0.4495                           | 0.0069                           | 0.0536                           | 0.0003                           |
|   | 11.5           | 1.4 | 6.7  | 0.0711                            | 0.0020                            | 0.5270                           | 0.0141                           | 0.0545                           | 0.0004                           |
|   | 10.1           | 1.2 | 7.0  | 0.0544                            | 0.0013                            | 0.3907                           | 0.0095                           | 0.0527                           | 0.0003                           |
|   | 11.0           | 1.3 | 4.3  | 0.0676                            | 0.0024                            | 0.4960                           | 0.0171                           | 0.0539                           | 0.0005                           |
|   | 11.0           | 1.3 | 3.7  | 0.0606                            | 0.0021                            | 0.4383                           | 0.0151                           | 0.0534                           | 0.0005                           |
| Water-vapor assisted<br>ablation<br>(spot size: 160 $\mu\text{m}$ ) | 9.7            | 1.3 | 5.6  | 0.0616                            | 0.0019                            | 0.4502                           | 0.0140                           | 0.0534                           | 0.0004                           |
|   | 11.2           | 1.2 | 43.4 | 0.0505                            | 0.0007                            | 0.3696                           | 0.0051                           | 0.0532                           | 0.0002                           |
|   | 11.5           | 1.1 | 71.1 | 0.0525                            | 0.0005                            | 0.3856                           | 0.0035                           | 0.0533                           | 0.0002                           |
|   | 11.7           | 1.1 | 71.3 | 0.0591                            | 0.0007                            | 0.4353                           | 0.0049                           | 0.0535                           | 0.0002                           |
|   | 11.2           | 1.1 | 76.5 | 0.0648                            | 0.0009                            | 0.4815                           | 0.0074                           | 0.0537                           | 0.0002                           |
|   | 10.7           | 1.2 | 29.7 | 0.0528                            | 0.0008                            | 0.3856                           | 0.0056                           | 0.0531                           | 0.0002                           |
|   | 10.9           | 1.2 | 5.5  | 0.0788                            | 0.0020                            | 0.5917                           | 0.0143                           | 0.0553                           | 0.0005                           |
|   | 10.6           | 1.1 | 9.6  | 0.0610                            | 0.0013                            | 0.4484                           | 0.0093                           | 0.0537                           | 0.0003                           |
|   | 10.2           | 1.1 | 5.8  | 0.0639                            | 0.0020                            | 0.4678                           | 0.0144                           | 0.0535                           | 0.0005                           |
|   | 10.5           | 1.1 | 16.4 | 0.0547                            | 0.0011                            | 0.3966                           | 0.0077                           | 0.0530                           | 0.0003                           |
|   | 10.4           | 1.1 | 7.5  | 0.0657                            | 0.0017                            | 0.4833                           | 0.0123                           | 0.0540                           | 0.0004                           |
|   | 11.6           | 1.4 | 18.3 | 0.0531                            | 0.0008                            | 0.3884                           | 0.0058                           | 0.0531                           | 0.0002                           |
|   | 10.3           | 1.1 | 5.5  | 0.0539                            | 0.0017                            | 0.3903                           | 0.0126                           | 0.0532                           | 0.0004                           |
|   | 9.9            | 1.3 | 9.4  | 0.0672                            | 0.0015                            | 0.4918                           | 0.0103                           | 0.0538                           | 0.0004                           |
|   | 10.5           | 1.4 | 8.5  | 0.0625                            | 0.0016                            | 0.4595                           | 0.0114                           | 0.0538                           | 0.0004                           |

Continued Table S-1. U-Pb analytical results of wolframite samples LB and MTM with ns-LA-ICP-MS in different ablation mode.

| Sample(LB)                     | Concentrations |     |      | Measured ratios                   |                                   |                                  |                                  |                                  |                                  |
|--------------------------------|----------------|-----|------|-----------------------------------|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|                                | Pb             | Th  | U    | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ |
|                                | ppm            | ppm | ppm  | Ratio                             | 1sigma                            | Ratio                            | 1sigma                           | Ratio                            | 1sigma                           |
|                                | 22.2           | 1.0 | 28.8 | 0.0638                            | 0.0012                            | 0.4738                           | 0.0088                           | 0.0541                           | 0.0003                           |
|                                | 22.3           | 1.3 | 16.1 | 0.1040                            | 0.0018                            | 0.8192                           | 0.0136                           | 0.0573                           | 0.0003                           |
|                                | 22.2           | 1.4 | 21.5 | 0.0914                            | 0.0015                            | 0.7032                           | 0.0113                           | 0.0559                           | 0.0003                           |
|                                | 21.5           | 1.3 | 14.7 | 0.0667                            | 0.0015                            | 0.4932                           | 0.0105                           | 0.0540                           | 0.0004                           |
|                                | 25.4           | 0.8 | 7.1  | 0.0838                            | 0.0033                            | 0.6344                           | 0.0229                           | 0.0561                           | 0.0006                           |
|                                | 24.8           | 1.3 | 7.6  | 0.1096                            | 0.0028                            | 0.8697                           | 0.0220                           | 0.0582                           | 0.0005                           |
|                                | 23.9           | 1.2 | 8.2  | 0.1166                            | 0.0029                            | 0.9309                           | 0.0217                           | 0.0589                           | 0.0005                           |
|                                | 24.0           | 1.2 | 4.3  | 0.0895                            | 0.0031                            | 0.6779                           | 0.0223                           | 0.0562                           | 0.0006                           |
|                                | 24.2           | 1.2 | 5.4  | 0.0829                            | 0.0028                            | 0.6077                           | 0.0191                           | 0.0546                           | 0.0005                           |
|                                | 24.3           | 1.2 | 6.4  | 0.0757                            | 0.0028                            | 0.5627                           | 0.0194                           | 0.0553                           | 0.0005                           |
|                                | 24.0           | 1.2 | 6.6  | 0.0776                            | 0.0026                            | 0.5872                           | 0.0194                           | 0.0556                           | 0.0005                           |
|                                | 24.7           | 1.2 | 7.5  | 0.0777                            | 0.0031                            | 0.5880                           | 0.0224                           | 0.0558                           | 0.0006                           |
|                                | 23.6           | 0.8 | 5.8  | 0.0863                            | 0.0034                            | 0.6547                           | 0.0238                           | 0.0570                           | 0.0007                           |
|                                | 25.2           | 1.1 | 4.4  | 0.0989                            | 0.0038                            | 0.7612                           | 0.0285                           | 0.0572                           | 0.0008                           |
| Water-vapor assisted           | 27.3           | 1.0 | 5.0  | 0.0805                            | 0.0038                            | 0.5946                           | 0.0256                           | 0.0557                           | 0.0008                           |
| ablation                       | 26.3           | 1.1 | 8.8  | 0.0666                            | 0.0020                            | 0.4934                           | 0.0139                           | 0.0550                           | 0.0005                           |
| (spot size: 90 $\mu\text{m}$ ) | 26.1           | 1.1 | 8.8  | 0.0752                            | 0.0023                            | 0.5586                           | 0.0161                           | 0.0547                           | 0.0005                           |
|                                | 26.2           | 1.0 | 5.6  | 0.0787                            | 0.0029                            | 0.5862                           | 0.0201                           | 0.0558                           | 0.0006                           |
|                                | 27.1           | 1.1 | 5.4  | 0.0791                            | 0.0030                            | 0.5815                           | 0.0205                           | 0.0548                           | 0.0006                           |
|                                | 28.3           | 1.0 | 4.9  | 0.0782                            | 0.0031                            | 0.5708                           | 0.0220                           | 0.0543                           | 0.0006                           |
|                                | 26.6           | 0.9 | 6.0  | 0.0796                            | 0.0046                            | 0.5967                           | 0.0335                           | 0.0556                           | 0.0008                           |
|                                | 26.6           | 1.0 | 4.7  | 0.0816                            | 0.0029                            | 0.6076                           | 0.0208                           | 0.0555                           | 0.0006                           |
|                                | 26.0           | 1.0 | 4.6  | 0.0860                            | 0.0031                            | 0.6400                           | 0.0220                           | 0.0552                           | 0.0006                           |
|                                | 24.4           | 1.0 | 3.9  | 0.1080                            | 0.0041                            | 0.8221                           | 0.0294                           | 0.0573                           | 0.0007                           |
|                                | 25.3           | 0.9 | 6.2  | 0.0659                            | 0.0032                            | 0.4797                           | 0.0221                           | 0.0543                           | 0.0007                           |
|                                | 24.8           | 1.0 | 3.8  | 0.0937                            | 0.0039                            | 0.6998                           | 0.0275                           | 0.0556                           | 0.0007                           |

Continued Table S-1. U-Pb analytical results of wolframite samples LB and MTM with ns-LA-ICP-MS in different ablation mode.

| Sample(MTM)                    | Concentrations |     |      | Measured ratios                   |                                   |                                  |                                  |                                  |                                  |
|--------------------------------|----------------|-----|------|-----------------------------------|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|                                | Pb             | Th  | U    | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{206}\text{Pb}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{207}\text{Pb}/^{235}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ | $^{206}\text{Pb}/^{238}\text{U}$ |
|                                | ppm            | ppm | ppm  | Ratio                             | 1sigma                            | Ratio                            | 1sigma                           | Ratio                            | 1sigma                           |
|                                | 5.8            | 0.4 | 25.8 | 0.0589                            | 0.0010                            | 0.4341                           | 0.0072                           | 0.0536                           | 0.0003                           |
|                                | 6.5            | 0.5 | 15.1 | 0.0644                            | 0.0011                            | 0.4775                           | 0.0082                           | 0.0541                           | 0.0003                           |
|                                | 6.9            | 0.5 | 20.9 | 0.0526                            | 0.0012                            | 0.3867                           | 0.0087                           | 0.0534                           | 0.0003                           |
|                                | 6.5            | 0.5 | 5.9  | 0.0707                            | 0.0024                            | 0.5204                           | 0.0165                           | 0.0546                           | 0.0005                           |
|                                | 6.7            | 0.5 | 13.3 | 0.0663                            | 0.0016                            | 0.4964                           | 0.0116                           | 0.0547                           | 0.0004                           |
|                                | 6.4            | 0.4 | 12.1 | 0.0616                            | 0.0014                            | 0.4557                           | 0.0104                           | 0.0540                           | 0.0004                           |
|                                | 6.4            | 0.5 | 9.8  | 0.0786                            | 0.0018                            | 0.5902                           | 0.0127                           | 0.0553                           | 0.0004                           |
|                                | 6.5            | 0.4 | 6.8  | 0.0702                            | 0.0026                            | 0.5196                           | 0.0190                           | 0.0549                           | 0.0007                           |
|                                | 6.4            | 0.4 | 17.1 | 0.0592                            | 0.0011                            | 0.4369                           | 0.0079                           | 0.0539                           | 0.0003                           |
|                                | 6.4            | 0.4 | 9.8  | 0.0621                            | 0.0013                            | 0.4586                           | 0.0099                           | 0.0539                           | 0.0003                           |
|                                | 6.5            | 0.4 | 11.4 | 0.0645                            | 0.0014                            | 0.4840                           | 0.0098                           | 0.0549                           | 0.0003                           |
| Water-vapor assisted           | 6.6            | 0.5 | 22.1 | 0.0614                            | 0.0012                            | 0.4484                           | 0.0083                           | 0.0535                           | 0.0004                           |
| ablation                       | 6.9            | 0.5 | 4.3  | 0.0713                            | 0.0025                            | 0.5238                           | 0.0173                           | 0.0548                           | 0.0005                           |
| (spot size: 90 $\mu\text{m}$ ) | 6.7            | 0.5 | 12.2 | 0.0622                            | 0.0013                            | 0.4613                           | 0.0098                           | 0.0545                           | 0.0003                           |
|                                | 6.7            | 0.5 | 24.2 | 0.0542                            | 0.0010                            | 0.3953                           | 0.0077                           | 0.0533                           | 0.0003                           |
|                                | 6.5            | 0.4 | 9.3  | 0.0586                            | 0.0017                            | 0.4271                           | 0.0127                           | 0.0536                           | 0.0004                           |
|                                | 6.8            | 0.5 | 8.2  | 0.0713                            | 0.0023                            | 0.5259                           | 0.0160                           | 0.0543                           | 0.0004                           |
|                                | 6.7            | 0.5 | 4.7  | 0.0670                            | 0.0021                            | 0.4862                           | 0.0144                           | 0.0540                           | 0.0005                           |
|                                | 6.9            | 0.5 | 5.1  | 0.0656                            | 0.0027                            | 0.4780                           | 0.0191                           | 0.0539                           | 0.0007                           |
|                                | 6.9            | 0.4 | 5.8  | 0.0695                            | 0.0029                            | 0.5117                           | 0.0210                           | 0.0542                           | 0.0006                           |
|                                | 7.0            | 0.4 | 10.4 | 0.0671                            | 0.0030                            | 0.4994                           | 0.0210                           | 0.0549                           | 0.0006                           |
|                                | 6.9            | 0.4 | 11.9 | 0.0604                            | 0.0024                            | 0.4524                           | 0.0187                           | 0.0545                           | 0.0005                           |
|                                | 6.6            | 0.4 | 8.5  | 0.0673                            | 0.0022                            | 0.4951                           | 0.0157                           | 0.0540                           | 0.0005                           |
|                                | 6.7            | 0.4 | 6.8  | 0.0682                            | 0.0020                            | 0.5038                           | 0.0138                           | 0.0549                           | 0.0004                           |
|                                | 6.6            | 0.5 | 5.9  | 0.0716                            | 0.0023                            | 0.5328                           | 0.0157                           | 0.0552                           | 0.0004                           |
|                                | 6.6            | 0.4 | 8.6  | 0.0717                            | 0.0020                            | 0.5380                           | 0.0141                           | 0.0551                           | 0.0005                           |