

TACtool: A targeting and co-ordination tool for spatial sampling and data traceability applied to scanning electron microscopy and laser ablation ICP-MS

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Software

- Review
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Summary

The precise analysis of geological samples is crucial for understanding the history of Earths formation, identification of mineral deposits, age dating, paleoclimatology and more (Chew et al., 2021). Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) has become one of the most common analytical techniques for the chemical analysis of such geological samples by measuring elemental composition upon ablation of target areas, often performed on mineral grains at the micron scale (Astbury et al., 2018; George et al., 2018; Yao et al., 2017). Accurate recording of laser ablation targets is important for traceability, ensuring that collected data can be matched to its target location and any other related data. Annotation of laser ablation targets or Regions Of Interest (ROI) for laser ablated samples can be mapped onto high resolution Scanning Electron Microscope (SEM) images, which are often used for mineral characterisation (Astbury et al., 2018; Bonnetti et al., 2020). Historically, this has been a manual process for many laboratories, thus could lead to inaccurate labelling which impedes traceability, verification of conclusions, and compromises important studies.

Existing Solutions

There exists tools for the annotation of geological samples and integration with laser ablation systems, however they all have varying functionality, accessibility and ease of use (Table 1).

Table 1

Software	Description	Access
GeoStar µGIS TM (GeoStar µGIS TM Software, n.d.)	Manual and automatic sample point selection. Image importation from any source such as SEM. Integration with ICP-MS systems and automatic instrument control.	Proprietary software package written for use in RESolution instruments and requires a paid license.
ImageJ (FIJI) (ImageJ Docs Fiji, n.d.)	Many available plugins and features allow customization of the software to perform a variety of tasks.	Free and open source.

Software	Description	Access
Quartz PCI (QUARTZ PCI, n.d.)	PCI allows for SEM image annotation and measurement of features.	Requires a paid license.
uScope Navigator (Microscopes International, n.d.)	Capable of image processing such as gamma, contrast and bilateral smoothing filters in addition to ROI annotation. May not be compatible with all laser ablation systems.	Requires a paid license/ comes with their microscope systems.
MIPAR (MIPAR, n.d.)	Capable of analysing SEM images and creating annotations with locations recorded.	Requires a paid license.
PIBC (PIBC, n.d.)	A plugin for QGIS which provides tools to import SEM images and associated metadata.	Free and open source.

Many of the existing paid software solutions are efficient, but the fact that they are paid for restricts their use within the community, both financially and through dependency on manufacturer systems in the case of proprietary software. Moreover, ImageJ and PIBC are free and provide a range of customization options, but the complexity of this customization requires specialist time investment, making it difficult for those with less computational experience. This leaves a niche for a simple, accessible, and free to use solution, which enables efficient laser ablation workflows. In this body of work, we introduce our software, TACtool, as a contribution to this niche.

Statement of Need

The primary purpose for which TACtool (Targeting And Coordination tool) was designed, was to enable users to annotate laser ablation analysis locations onto high resolution SEM images. TACtool automatically calculates coordinates of annotations which can be uploaded to laser ablation systems, ensuring efficient and accurate re-coordination of target locations relative to the spatial context resolved in the SEM image. In the latest version, TACtool can also import an SEM image and identify point coordinates and plot these existing positions onto the imported image. These can then be used or added to ready for export. This automatic process additionally saves time, lab resources, and therefore money, when identifying ROI. TACtool also provides optional metadata recording for every ROI which further improves reproducibility and traceability throughout a lab's workflow.

The intuitive and accessible front-end design of TACtool allows users with a lack of computational experience to easily record their annotations. The software can be downloaded as a compiled program, mitigating the need to setup complex development environments. This simplicity continues throughout the workflow within TACtool. Users can import an image file onto a canvas, before clicking directly onto that image to add their ROI and respective annotations. The coordinates and metadata for each ROI can be exported to a plain text Comma-Separated Values (CSV) file, ready to be uploaded directly to a laser ablation system.

The community surrounding TACtool has been growing since it's initial release, as shown by the download metrics from GitHub ([Figure 1](#)). Many recent changes to the software originate from community feedback, including bug fixes, the addition of the transparent ghost point for easier ROI identification (v1.3.0), and a MacOS version of the software to accommodate a new

55 user base (v1.2.0). This feedback came from GitHub issues and discussions at LA-ICP-MS
56 conferences.

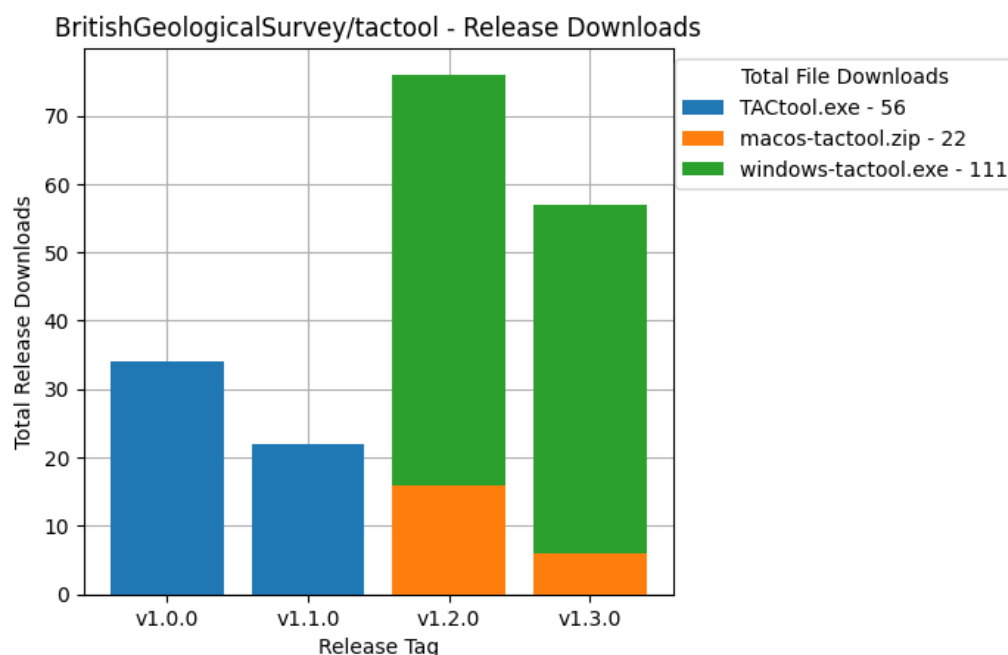


Figure 1: TACTool download metrics as of 2025/09/05. Executable downloads are provided by GitHub releases and their statistics via the GitHub API.

57 Although TACTool was initially created for geological samples, it has possible applications
58 for many other fields requiring spatial coordination and re-ordination of disparate, spatially
59 correlated data sets. The use cases of TACTool are scale independent and as a standalone user
60 environment, TACTool is platform agnostic with outputs that can be used with any downstream
61 instrumentation able to use the output information. This wider use is promoted by the fact
62 that TACTool is open source and free to use, making it excellent for any community requiring
63 its use, and enabling individuals to contribute to further features and adapting it for their own
64 specific needs.

65 TACTool offers a laser ablation annotation and coordinate system solution to any community
66 requiring use at no cost and with maximum accessibility in mind, increasing laboratory efficiency,
67 traceability of data and their interpretation, and therefore scientific reproducibility.

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70 the purpose of open access, the author has applied a Creative Commons Attribution (CC BY)
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72 References

73 Astbury, R. L., Petrelli, M., Ubide, T., Stock, M. J., Arienzo, I., D'Antonio, M., & Perugini,
74 D. (2018). Tracking plumbing system dynamics at the campi flegrei caldera, Italy: High-
75 resolution trace element mapping of the astroni crystal cargo. *Lithos*, 318–319, 464–477.
76 [https://doi.org/https://doi.org/10.1016/j.lithos.2018.08.033](https://doi.org/10.1016/j.lithos.2018.08.033)

- 77 Bonnetti, C., Zhou, L., Riegler, T., Brugger, J., & Fairclough, M. (2020). Large s iso-
78 tope and trace element fractionations in pyrite of uranium roll front systems result from
79 internally-driven biogeochemical cycle. *Geochimica Et Cosmochimica Acta*, 282, 113–132.
80 <https://doi.org/https://doi.org/10.1016/j.gca.2020.05.019>
- 81 Chew, D., Drost, K., Marsh, J., & Petrus, J. (2021). LA-ICP-MS imaging in the geosciences
82 and its applications to geochronology. *Chemical Geology*, 559, 119917. [https://doi.org/10.](https://doi.org/10.1016/j.chemgeo.2020.119917)
83 [1016/j.chemgeo.2020.119917](https://doi.org/10.1016/j.chemgeo.2020.119917)
- 84 George, F. R., Gaidies, F., & Boucher, B. (2018). Population-wide garnet growth zoning
85 revealed by LA-ICP-MS mapping: Implications for trace element equilibration and syn-
86 kinematic deformation during crystallisation. *Contributions to Mineralogy and Petrology*,
87 173(9), 74. <https://doi.org/10.1007/s00410-018-1503-0>
- 88 GeoStar μ GIS TM software. (n.d.). [https://appliedspectra.com/products/resolution/](https://appliedspectra.com/products/resolution/geostar-software.html)
89 [geostar-software.html](https://appliedspectra.com/products/resolution/geostar-software.html)
- 90 ImageJ docs fiji. (n.d.). <https://imagej.net/software/fiji/>
- 91 Microscopes international. (n.d.). <https://www.microscopesinternational.com/>
- 92 MIPAR. (n.d.). <https://www.mipar.us/products-microscope-software.html>
- 93 PIBC. (n.d.). <https://github.com/wiscsim/PIBC>
- 94 QUARTZ PCI: Microscope software. (n.d.). [https://www.quartzimaging.com/](https://www.quartzimaging.com/pci-microscope-imaging-software.html)
95 [pci-microscope-imaging-software.html](https://www.quartzimaging.com/pci-microscope-imaging-software.html)
- 96 Yao, M., Cao, Y., Liu, J., & Ren, Z. (2017). Magma mixing as a trigger for sulphide
97 saturation in the UG2 chromitite (bushveld): Evidence from the silicate and sulphide
98 melt inclusions in chromite. *Acta Geologica Sinica (English Edition)*, 91, 1704–1716.
99 <https://doi.org/10.1111/1755-6724.13406>