Help file *archaeo_dating* Matlab tool v8 (March 2022).

The developed software contains a package of different routines in Matlab code. The programs package and related material are included as complementary files. It is also available online at **http://pc213fis.fis.ucm.es/archaeo_dating/index.html** and also at **http://earthref.org/erda/1134**. After downloading the compressed file archaeo_dating.rar, the decompressed folder must be put into the Matlab working folder: work (usually in C:\Matlab\RXXX\work).

To run the Matlab tool, write in the Command Window of Matlab:

>> archaeo_dating

and an interactive window will appear (Figure 1). Three different colour areas are shown in the interactive window.

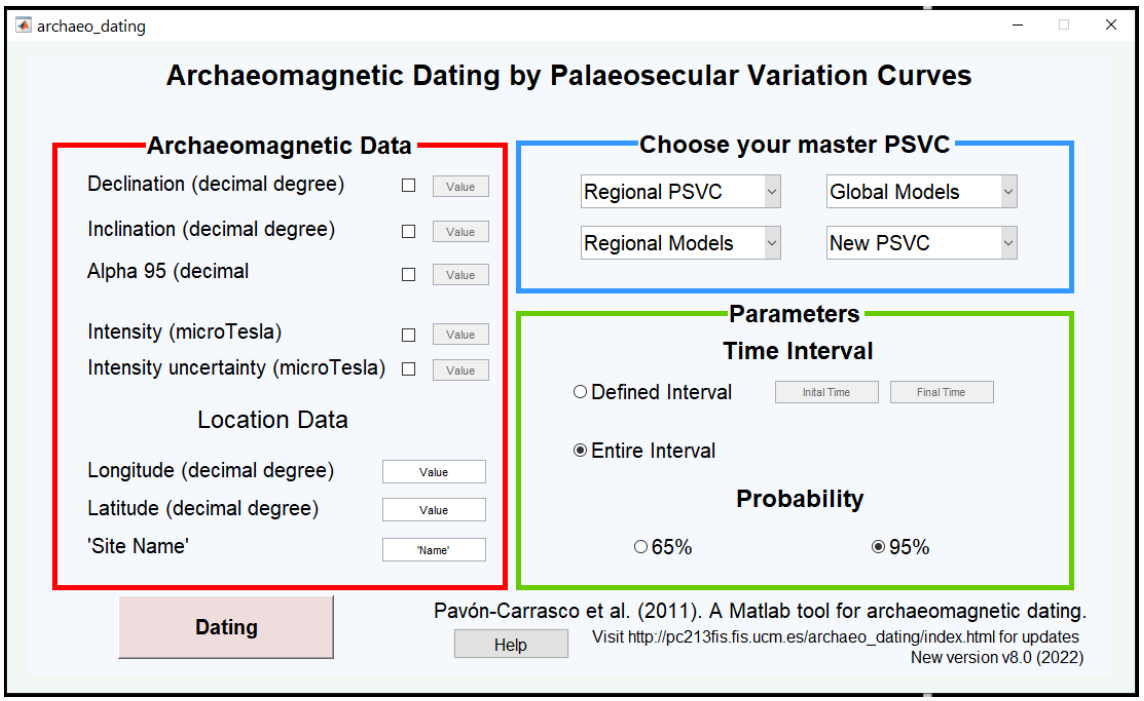

Figure 1. Matlab interactive window. Red area: archaeomagnetic data information. Blue area: buttons with the different PSVCs and regional/global models. Green area: the time interval and statistical probability. See text for details.

The **red area** should contain the archaeomagnetic information to the site to be dated. It is divided into two parts:

- The directional and intensity values with their respective uncertainties (declination, inclination, alpha 95, intensity and intensity uncertainty).
- The location information (the latitude, the longitude and the name of the archaeological site).

The user can then choose the archaeomagnetic elements to be used, and set their values. If an element is not available, as can be the case with intensity, the user must not select that element.

The master PSVC used for dating is selected in the **blue area**. Four buttons show the different sources of the PSVCs:

- The available local (for different regions and countries) PSVCs.
- Different global paleo-reconstructions.
- Different regional paleo-reconstructions.

- The last button gives the possibility to include a new master PSVC by the user.

After pressing a button, a new window will appear to select the different PSVCs or models described in the previous section. If the user uses a new PSVC (not included into the Matlab tool) the software asks for the new file. When a PSVC is selected, it is transferred from the reference location to the site location. This does not occur for the PSVCs given by the regional and global models, because they are calculated at the site location.

After including the archeomagnetic information and the master PSVC, the user can define the time interval used for dating and the statistical probability estimation. These parameters are input within the **green area**. Finally, the button Dating must be pressed to obtain the results.

Figure 2 is an example obtained with the Matlab tool. This example is taken from a kiln in Belgium studied by Spassov et al. (2008) which will be dated using the SCHA.DIF.3K regional model. The undated structure comes from the Corroy-le-Grand site, at 50.66ºN, 4.68ºE. Directional values are 15.0º for declination and 64.7º for inclination and its uncertainty (alpha 95) is 0.9º. The paleointensity is 69.4 ± 1.1 μT. Archaeological considerations suggest that the most probable age for the archaeological artefact is in the 11th century AD. Figure 2 is divided into 9 sections. On the top we plot the comparison between the different master PSVCs of the declination (left), inclination (centre) and intensity (right) with the non-dated archaeomagnetic data. In the middle, the PDFs of the declination (left), inclination (centre) and the intensity (right) are given with the most probable age for each archaeomagnetic element. On the bottom-left we plot a regional map showing the data and master PSVC locations.

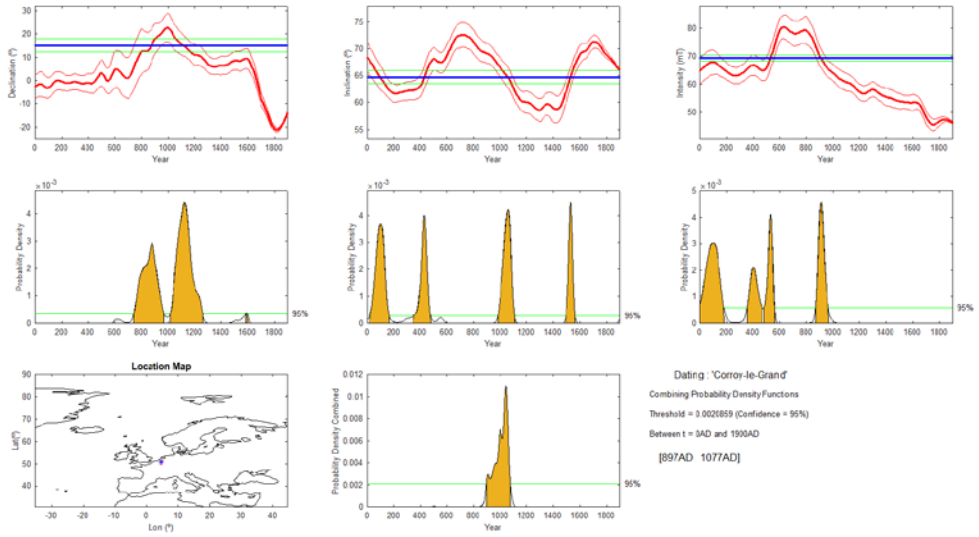

Figure 8. Dating results. Top: master PSVCs (red curves with red error bands) of the declination (left), inclination (centre) and intensity (right) and the undated archaeomagnetic data (blue line with green error bands). Middle: the individual PDFs for the declination (left), inclination (centre) and intensity (right). The green lines indicate the different thresholds for each element at the given level of probability chosen. Bottom: Regional map (left) of the data location (red point) and the master PSVC location (blue square); combined PDF marked with the green line of probability (centre); and archaeomagnetic dating information (right). See text for details.

The combined PDF (normalised multiplication of the three previous PDFs) showing the most probable age of the last use of the archaeological artefact is plotted at the centre. Finally, on the right, the archaeomagnetic dating information is shown. In this case, we have on interval for the last 2 millennia [897 AD – 1077 AD] which is in agreement with the archaeological date (Spassov et al., 2008).

List of programs.

Mean programs

archaeo_dating.p This program runs the interactive windows with the dating tool.

archaeo_dating_program.p It is the mean program, calls the selected PSVC and uses it for dating. This program also plots the final figure with the archaeomagnetic dating.

psvc_selection.p Prepares the PSVC selected by users.

datingD.p Calculates the PDF of the declination component.

datingF.p Calculates the PDF of the inclination component.

datingI.p Calculates the PDF of the intensity component.

pb.p Calculates the relationship between probability and threshold in the PDF.

pb_h.p Calculates the threshold for 95% or 65% of probability and the final date.

Coordinates and Components

conversion.p Translate the directional and/or intensity data to a reference point.

cvp.p Calculates the conversion via polo for directional data.

vadm.p Translate the intensity data using the Virtual Axial Dipole Moment.

vdm.p Translate the intensity data using the Virtual Dipole Moment (it is necessary the inclination information).

coords.p Transform from Geodetic to Geocentric coordinates and vice versa.

coords_comp.p Transform from Geodetic to Geocentric the components of the Earth's magnetic field.

coords_comp_inv.p Transform from Geocentric to Geodetic the components of the Earth's magnetic field.

sphnewf.p Rotates the coordinates and the components from geocentric coordinates to the reference frame of the spherical cap.

sphnewf_inv.p Rotates the coordinates and the components from the reference frame of the spherical cap to geocentric coordinates.

coast.mat World linecoast (original file of Matlab).

Classical Palaeosecular Variation Curves

Regional_psvc.p Selects the local PSVCs.

Regional models

olver_smith.p Calculates de associated Legendre functions with real degree n and its derivative for the SCHA and R-SCHA2D techniques.

meler.p Calculates de conical Mehler functions. The original function in which this routine is based **MFunNorm.mexw32** was provided by Erwan Thèbault (Thanks Erwan!).

parc_dif.p Creates the sch matrix using olver_smith and meler functions.

scha_dif_4k.p Calculates the SCHA.DIF.4k (Pavón-Carrasco et al., 2021) model prediction.

schadif8k.p & sch_8k.p Calculate the SCHA.DIF.8k (Pavón-Carrasco et al., 2010) model prediction.

schafrica_dif_4k.p Calculates the SCHAFRICA.DIF.4k (Di Chiara & Pavón-Carrasco, 2022) model prediction.

Global models

plmbar.p Calculates de associated Legendre functions with entire degree n and its derivative for the SHA technique.

sh.p Obtains the Gauss coefficients from the CALS family models.

psvc_shawq2k.p Calculates the SHAWQ2k (Campuzano et al., 2019) model prediction.

psvc_shawq_iron_age.p Calculates the SHAWQ_iron_age (Osete et al., 2020) model prediction.

shadif14k.p Calculates the SHA.DIF.14k (Pavón-Carrasco et al., 2014) model prediction.

arch3k1.p Calculates the ARCH3k.1 (Korte et al., 2009) model prediction.

cals3k4.p Calculates the CALS3k.4 (Korte & Constable, 2011) model prediction.

cals10k1b.p Calculates the CALS10k.1b (Korte et al., 2011) model prediction.

All programs have been encrypted using Matlab. If you need help, please, send an e-mail to fjpavon@ucm.es.

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