High Precision Dating with ^{14}C/Wiggle-Matching by use of external information (year-rings, relative chronology by seriation or stratigraphy)

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A new methodology is suggested to further refine high-precision dating with ^{14}C/wiggle-matching by the inclusion of external information (tree-rings, relative chronology by seriation or stratigraphy).

For a single date the uncertainty in the calibrated date is in general completely dominated by the “wiggliness” of the calibration curve, and to a much lesser degree by the precision of the ^{14}C measurement.

Although the wiggles are really an obstacle for obtaining a precise absolute date with only a single ^{14}C date, one can take advantage of these wiggles if a series of radiocarbon dates is available.

If such a series is combined with external information together with Bayesian statistics, a considerable improvement of absolute dating can be reached. The method is also called wiggle matching. It is basically implemented in the Oxford calibration program Oxcal (currently version 1.5) by Christopher Ramsey Bronk.

So far, we envision four main applications in wiggle matching:

1) Floating dendrochronologies with a series of ^{14}C samples can be wiggle matched by using a known tree-ring distance (in years) between the different samples.

2) Seriation results are relative chronologies obtained by different methods of combination statistics. If one takes a series of ^{14}C samples one can see if the sequence (documented by sequence dates (SD)) from seriation correlates with the measured years BP. If there exists such a correlation one can determine the slope of the correlation in SD/year BP. With this information one can calculate a “year-ring distance” between the samples, including a sigma uncertainty for the year-ring distance. This information can be used in wiggle matching with Oxcal procedure V_Sequence.

3) In a similar way stratigraphies may be ^{14}C dated. One samples the different layers in a stratigraphy for ^{14}C and takes into account also depth information. If the sedimentation process was continuous one may get a correlation between depth and years BP. In most cases this may not be possible. If it does, however, one can calculate a sedimentation rate in cm/year BP. One may then proceed in the same way as described above.

4) If the stratigraphy provides only information about which layer is older and which is younger, and if the sedimentation process was not continuous, there is also a possibility of using Bayesian statistics to shorten the time span of a calibrated sample in a series of ^{14}C dates.

The validity and precision of the methods decreases from 1 to 4.

Here we will deal only with case 2. The example we will present is concernced with seration of Avar male graves from the Carpathian basin.

The seriation of more than **40000** Avar graves from the Carpathian basin yielded a useful relative chronological sequence. Evaluations were done with the program package WinSerion 1. which was already presented in a workshop before. In the mean time a new developed image database for archaeological typology "Montelius" helps with the data management. **Fig.1** presents how one can use publications from literature to set up an image database. **Fig. 2** shows how this image database can be used for different evaluations, seriation and spatial analysis. **Fig. 3** shows an example of image database "Montelius" within picturebrowser ACDSee 4.0, which is available commercially in the internet. In the browser can be shown the complexes, but also the typology. Typology view can be obtained from complexes by using a conventional database and the complexes view. Typology can easily be more elaborated only by "Drag 'n Drop" of the images and creration of new folders. This typology can be transferred to the convention database by "Montelius".

Fig. 4 shows the result of such a typology in form of a publication in the web. In this presentation of results also type mappings and other informations are available, see Fig. 5.

Fig. 6 displays the result of seriation (reciprocal averaging). The correctness of the sequence was confirmed with (only) 30 gold coins contained in these graves, but only for the Early Avar period, because later no gold coins were deposited in the graves (see **Fig. 7**) . More than that the sequence could also be calibrated with the help of these coins. The huge seriation was possible because of the use of picture database "Montelius", which has been specially designed for the task to obtain an archaeological typology.

In a large scaled project from these complexes about 150 samples were taken from human bone for ^{14}C dating. The main advantage of radiocarbon dates versus coins is, that the number of the first can be enlarged easily. About 99 dates are currently available, which can be used at first for a group calibration of the Avar time, male and female graves together (**Fig.8**).

For 49 radiocarbon dates from male graves, which can be sequenced by seriation, a correlation of the measured Years BP is given in Fig.9. The horizontal axe shows years BP, the vertical the sequence dates, a scale over the seriation from 0 to 1000.

With the help of this correlation it is possible to determine the year distance in years AD between sampled graves. With this information as a starting point, a wiggle matching will be carried out. Oxcal Procedure V_Sequence can be used for this evaluation. The necessary error for the year distance is calculated from the sigma of any complex in the seriation. Wiggle matching narrows down the dates for every radiocarbon analysis involved.

It is expected that these procedures may allow to date a series of ^{14}C samples **up to a precision of about ± 20 years on the 1σ level after calibration.**

Fig. 10 shows the most important objects from an early Avar male grave from Keckemet Sallai utca in Hungary, as it can be seen within “Montelius”.

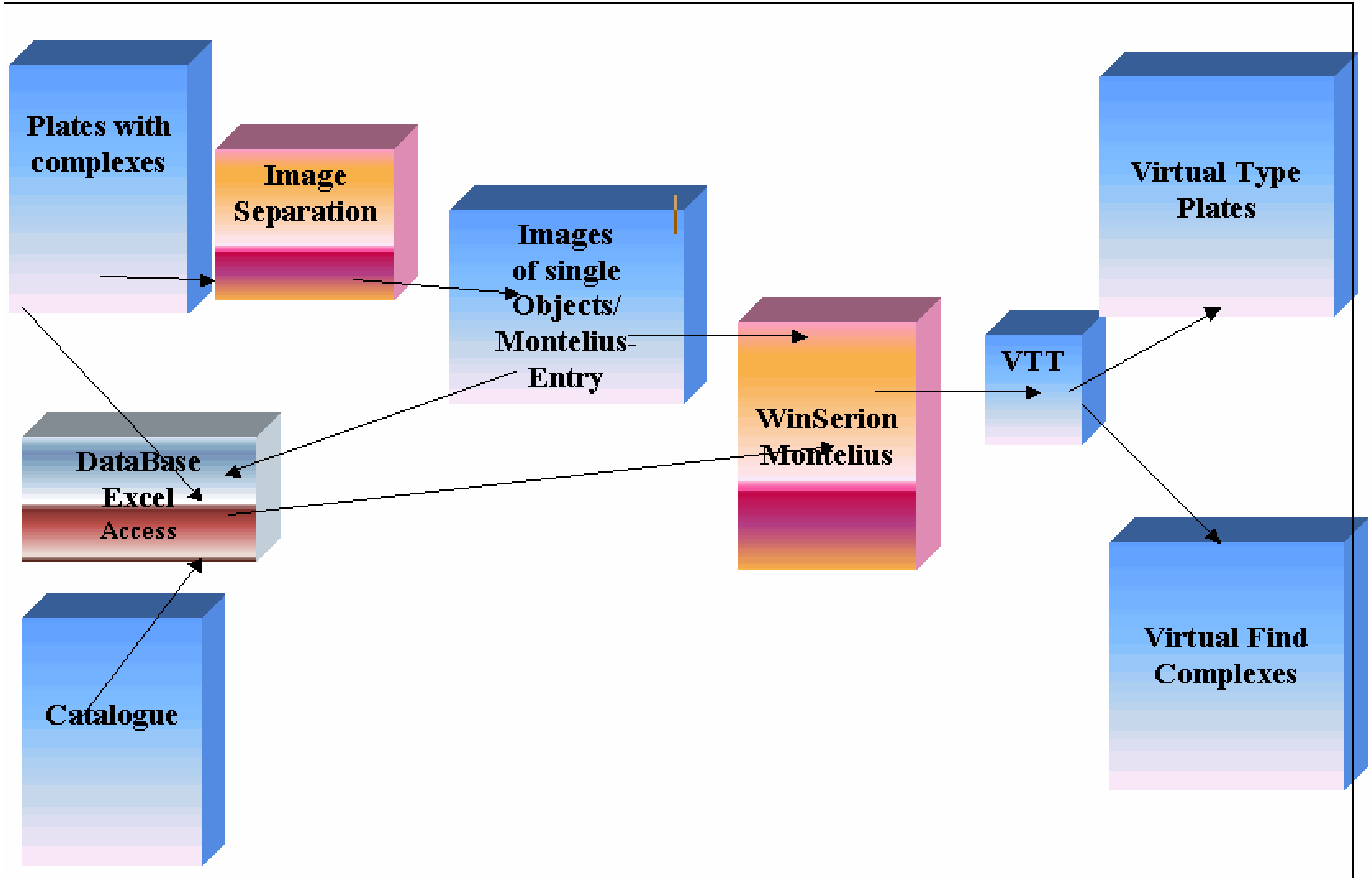
Fig. 11 gives an example without wiggle matching, the date for this grave on the 1 sigma level for the main solution will be from 595 to 660 AD (65years), with wiggle matching about from 596 to 624 (28 years), thus the dating intervall can be reduced notably, see **Fig.12**.

In **Fig. 13** the first page of Oxcal graphics for the first 17 samples is presented. It is quite good visible, that the reduced solution from wioggle matching (black area) fits very well under the white area, by obtaining an overall agreement for all 49 samples from about 90,8%. A value of mor than 60% would be necessary to be significant.

Fig. 14 shows the correlation of sequence dates and determined ages in years AD of all 49 samples. The resulting curve can be compared with the older coin-curve and is somewhat higher situated. This might correspond to the fact that coins are very often the youngest objects in avar grave complexes.

In Oxcal this combination of seriation with radiocarbon calibration can only be obtained by using external programmes at the moment, thus the realization is complicated. Therefore we will suggest improvements of Oxcal to Christopher Bronk Ramsey at Oxford University, or, alternatively implement these additions ourselves. The goal is to better combine the four different wiggle matching applications with archaeological methods.

Fig.01


Plates with complexes
Image Separation
Images of single Objects/ Montelius-Entry
WinSerion Montelius
VTT
Virtual Type Plates
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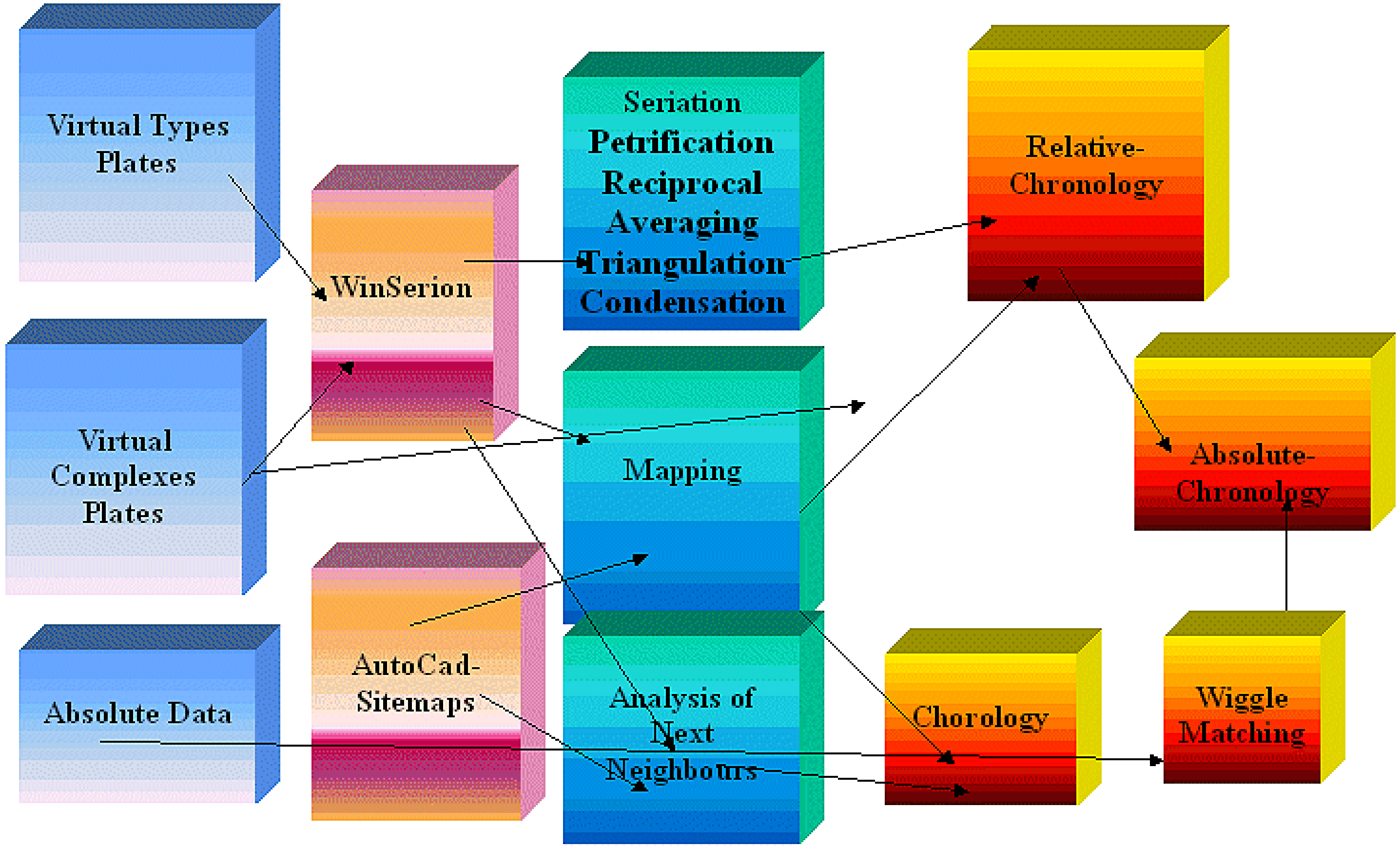
DataBase Excel
Access
Catalogue

Fig.02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Analysis of Next Neighbours
Chorology
Wiggle Matching

Fig.03

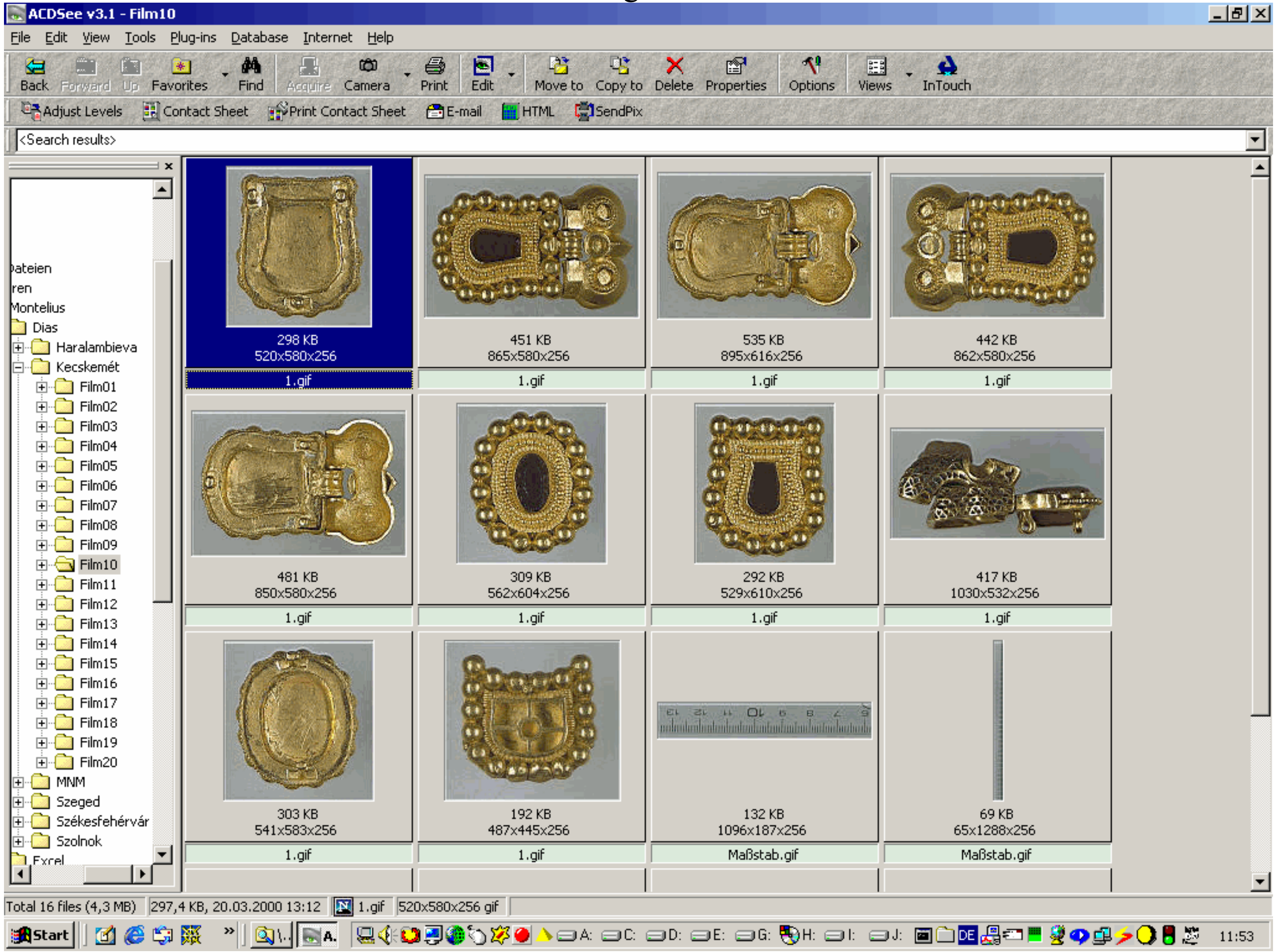
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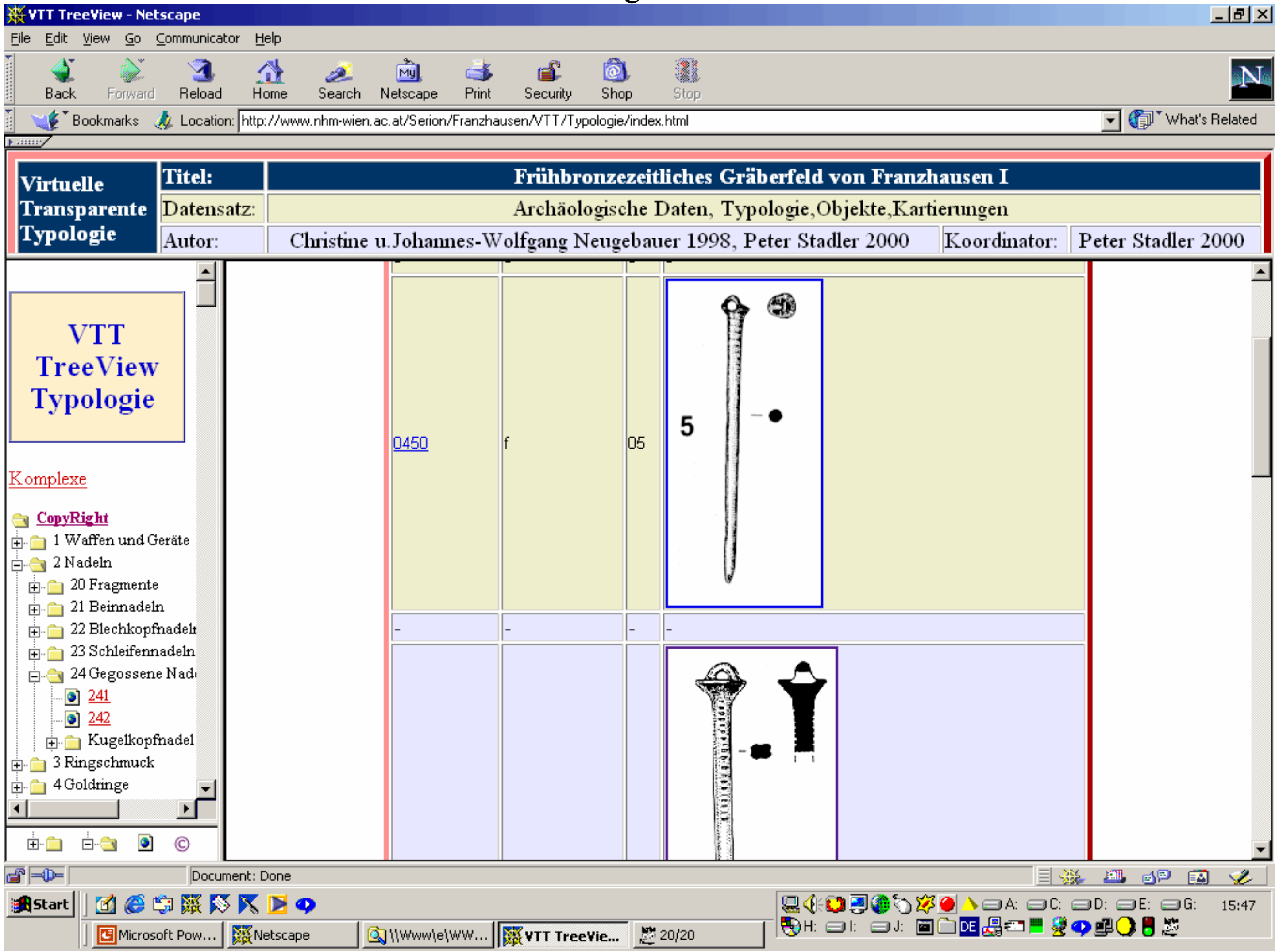
Fig.04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What's Related
Virtuelle Transparente Typologie
Titel: Frühbronzezeitliches Gräberfeld von Franzhausen I
Datensatz: Archäologische Daten, Typologie,Objekte,Kartierungen
Autor: Christine u.Johannes-Wolfgang Neugebauer 1998, Peter Stadler 2000
Koordinator: Peter Stadler 2000
VTT TreeView Typologie
Komplexe
CopyRight
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2 Nadeln
20 Fragmente
21 Beinnadeln
22 Blechkopfnadeln
23 Schleifennadeln
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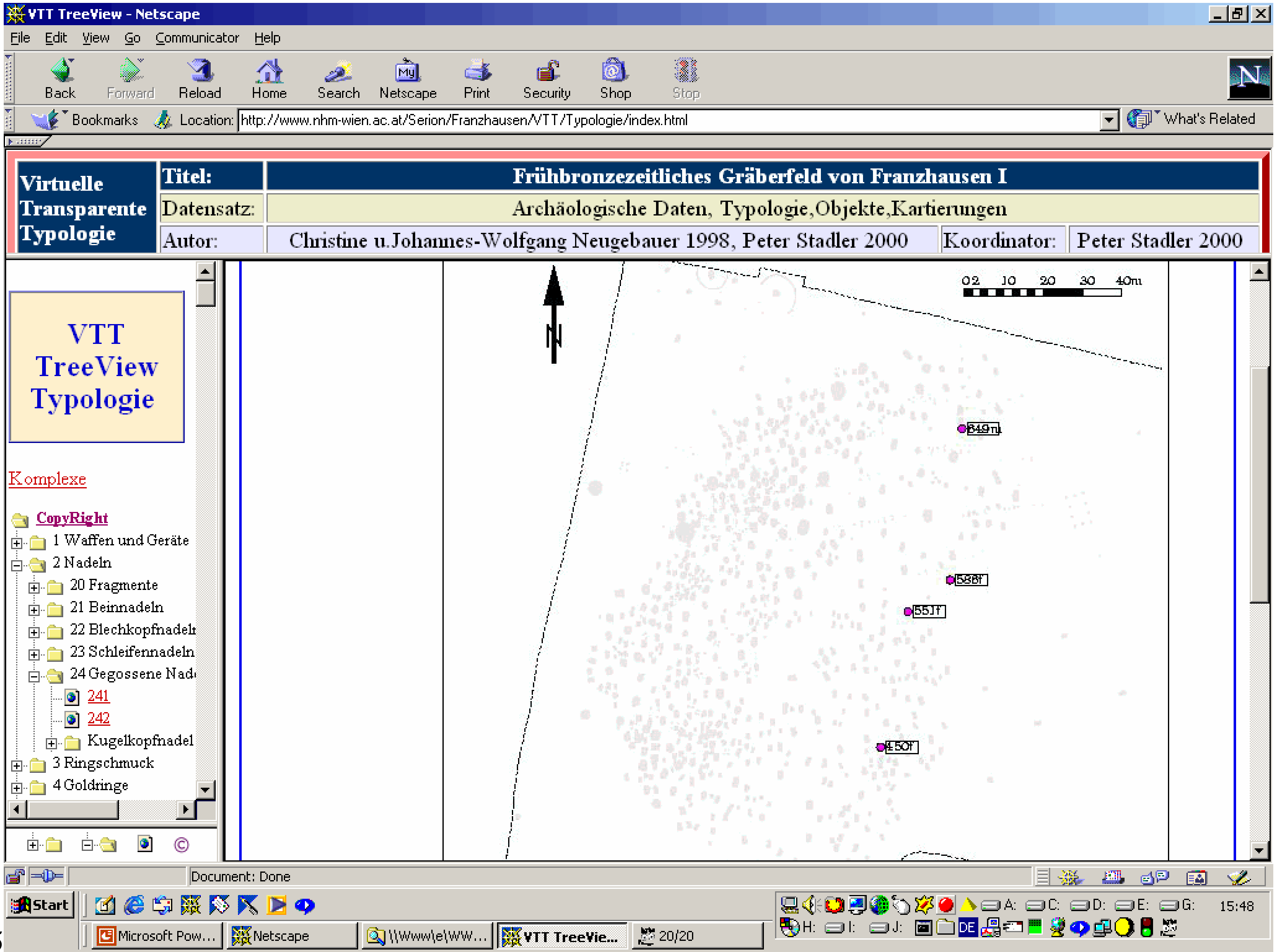
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What's Related
Virtuelle Transparente Typologie
Titel: Frühbronzezeitliches Gräberfeld von Franzhausen I
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VTT TreeView Typologie
Komplexe
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1 Waffen und Geräte
2 Nadeln
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Fig.05

Fig.06

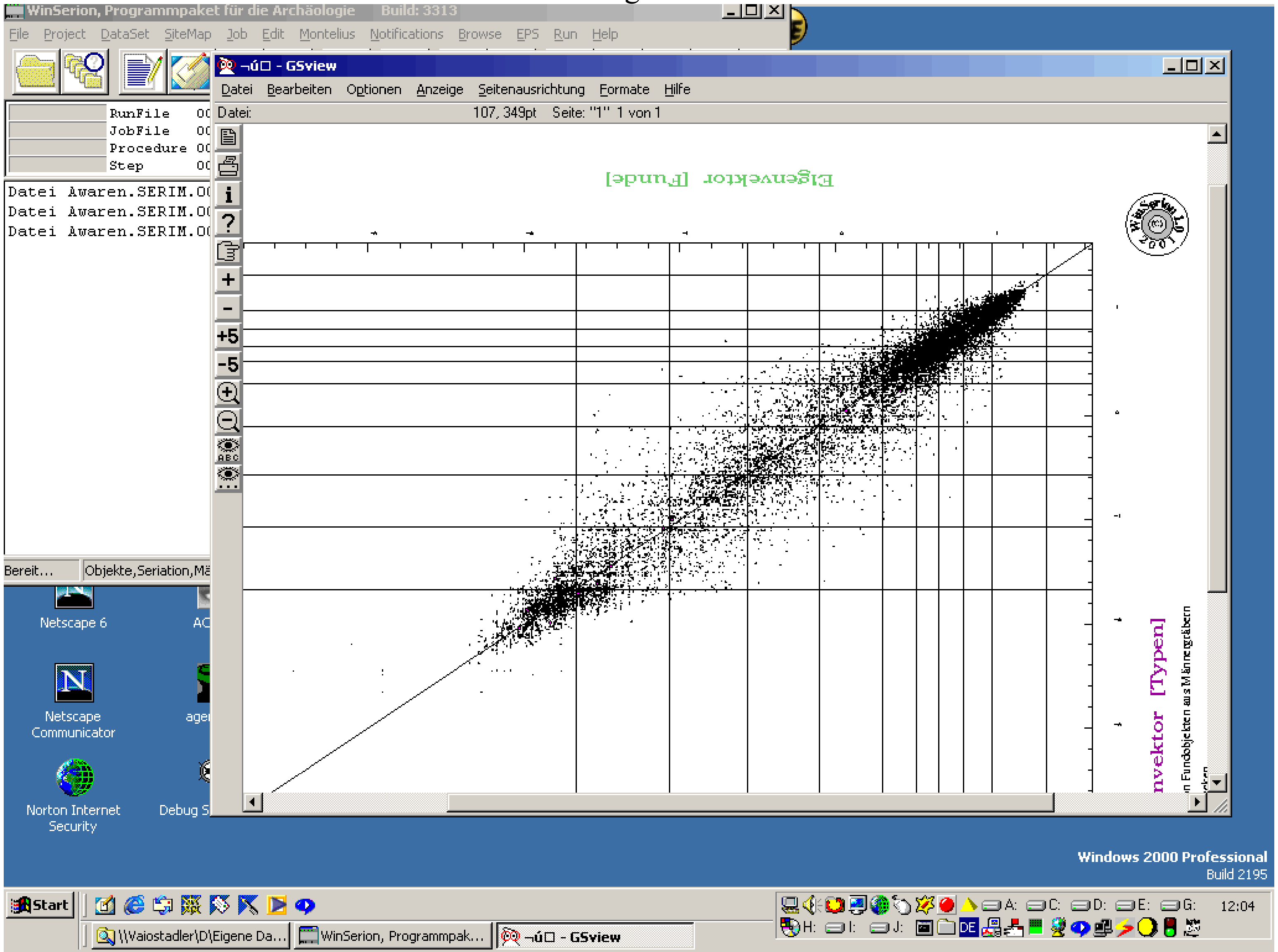
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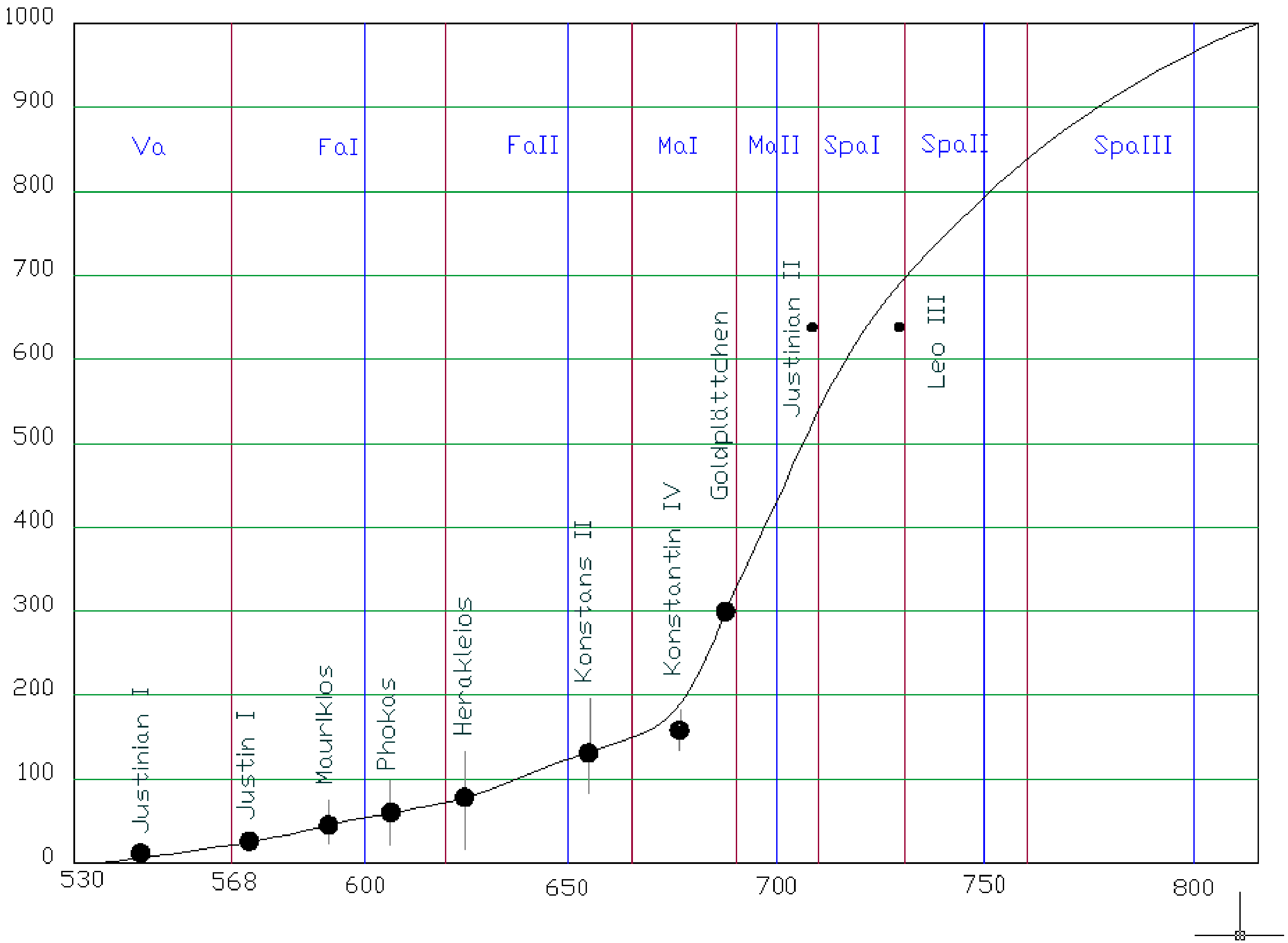
Fig.07



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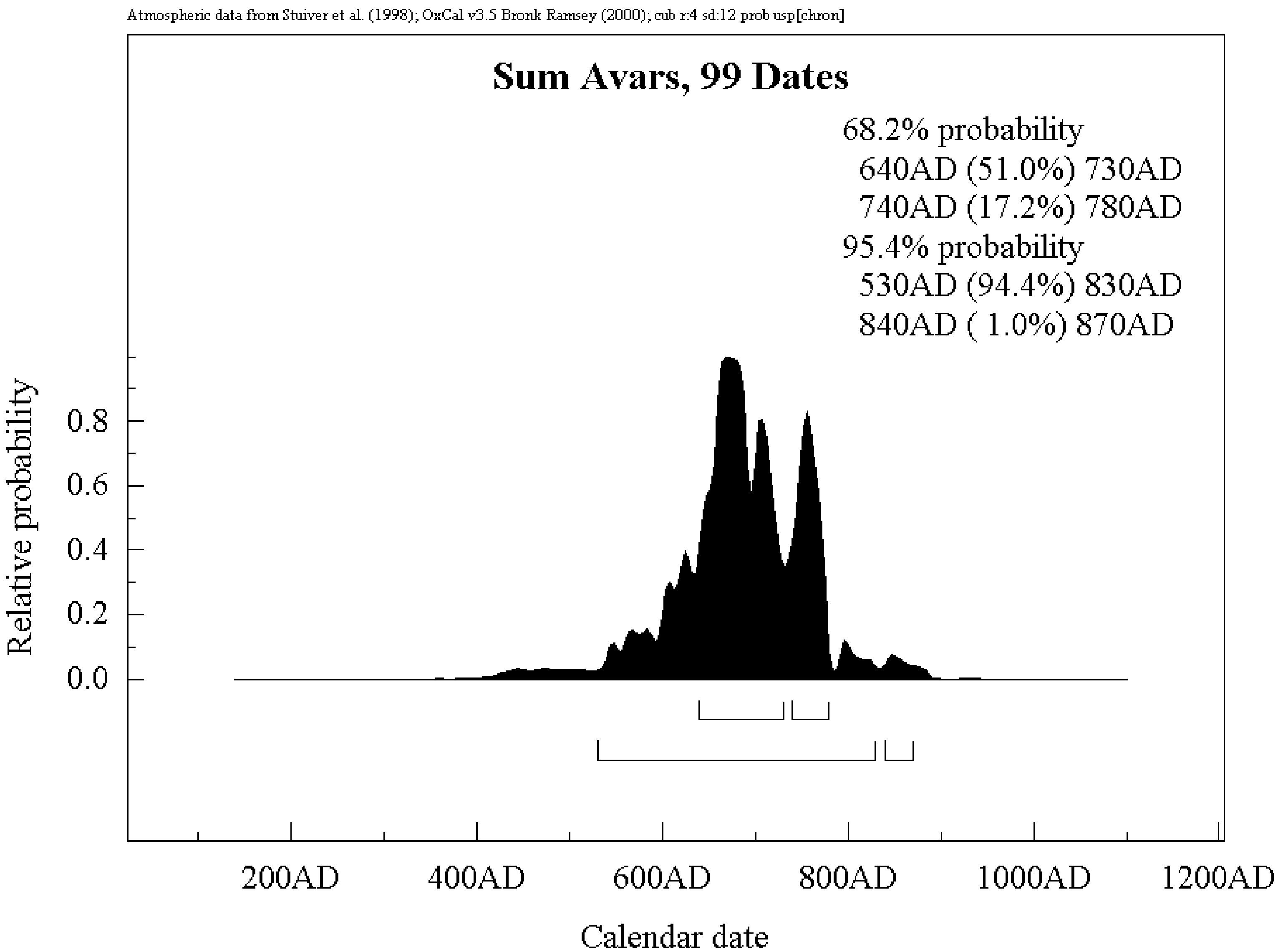
Leo III

Fig.08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740AD (17.2%) 780AD
95.4% probability
530AD (94.4%) 830AD
840AD (1.0%) 870AD
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Fig.09

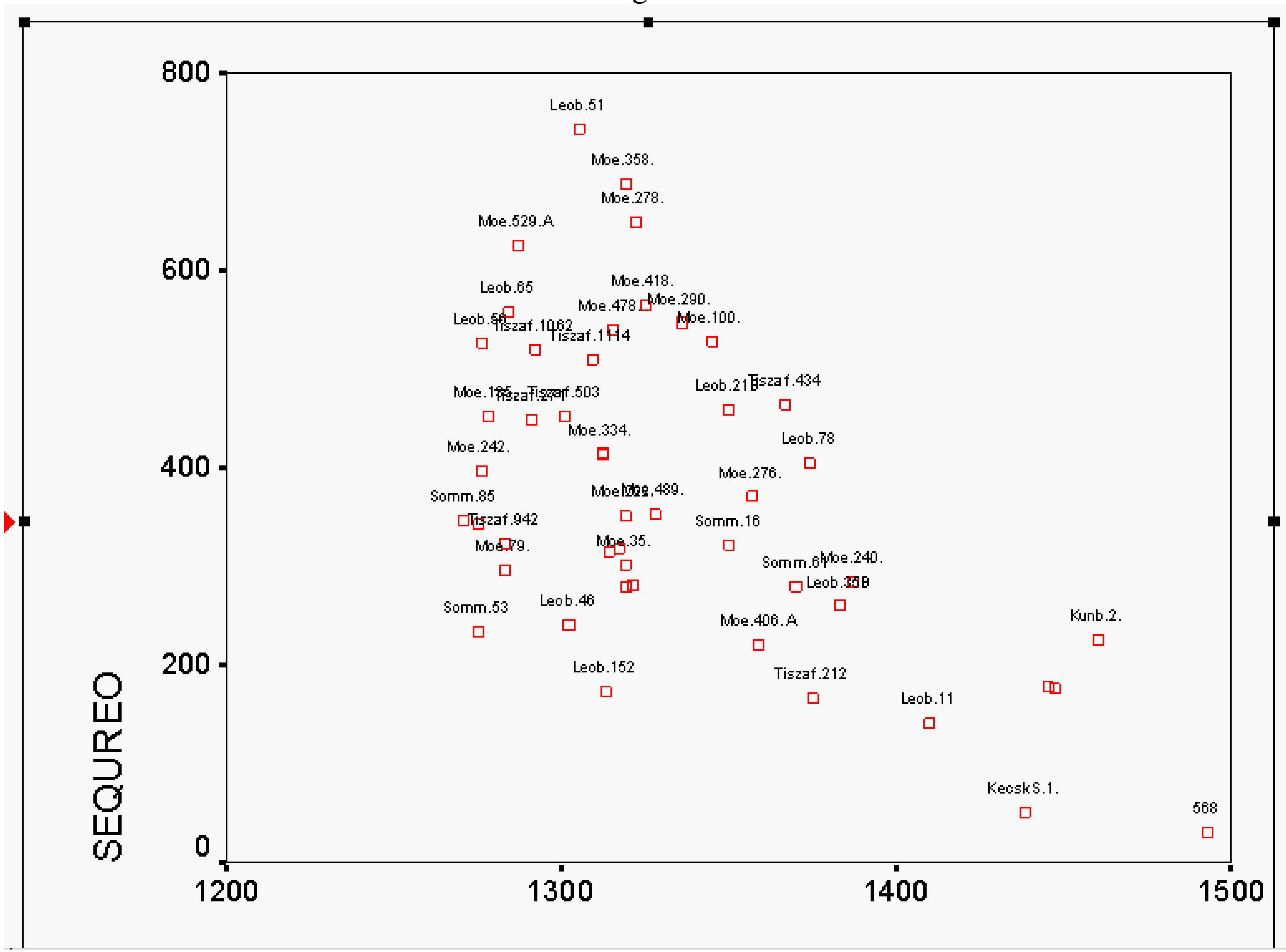
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Fig.10

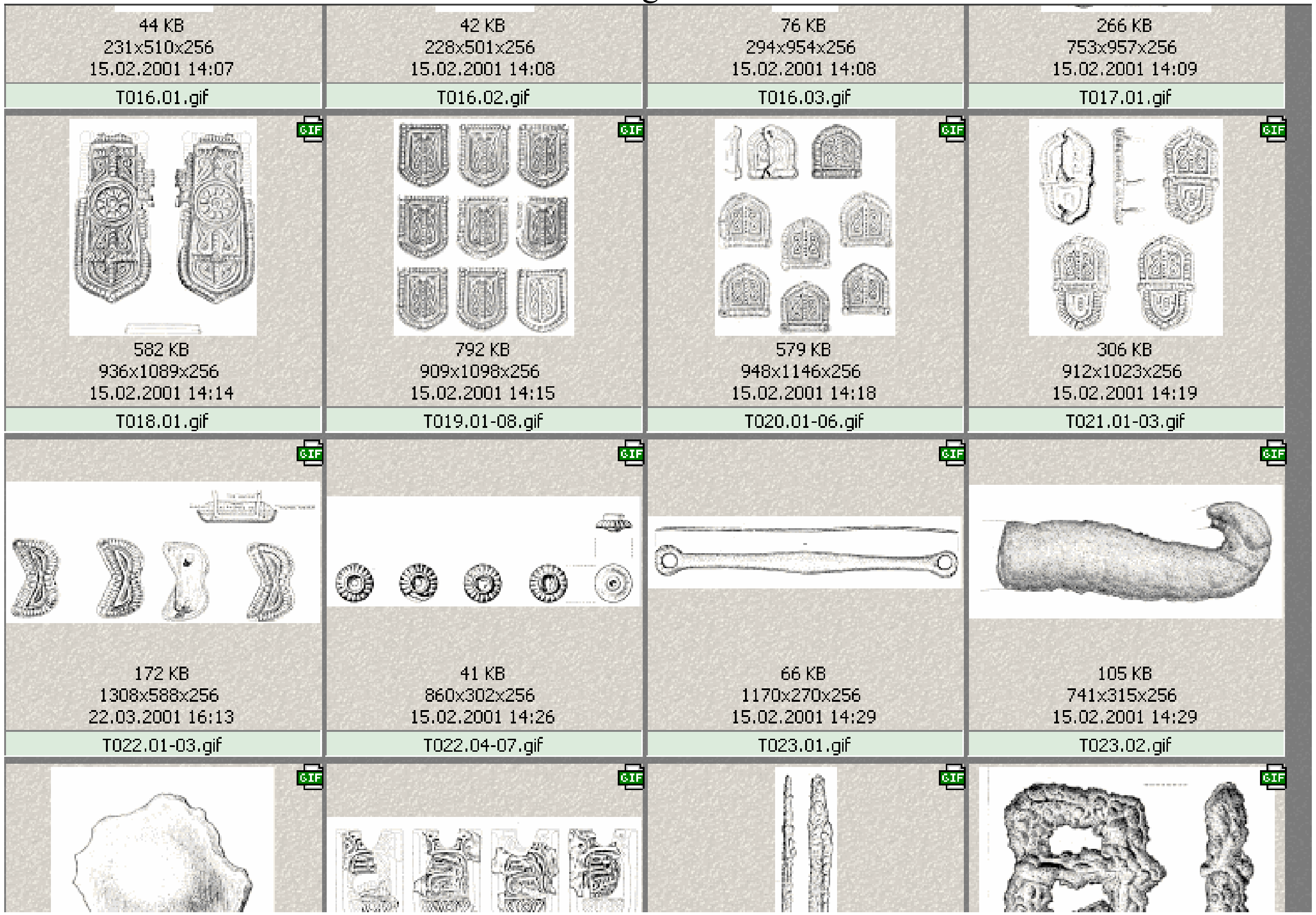
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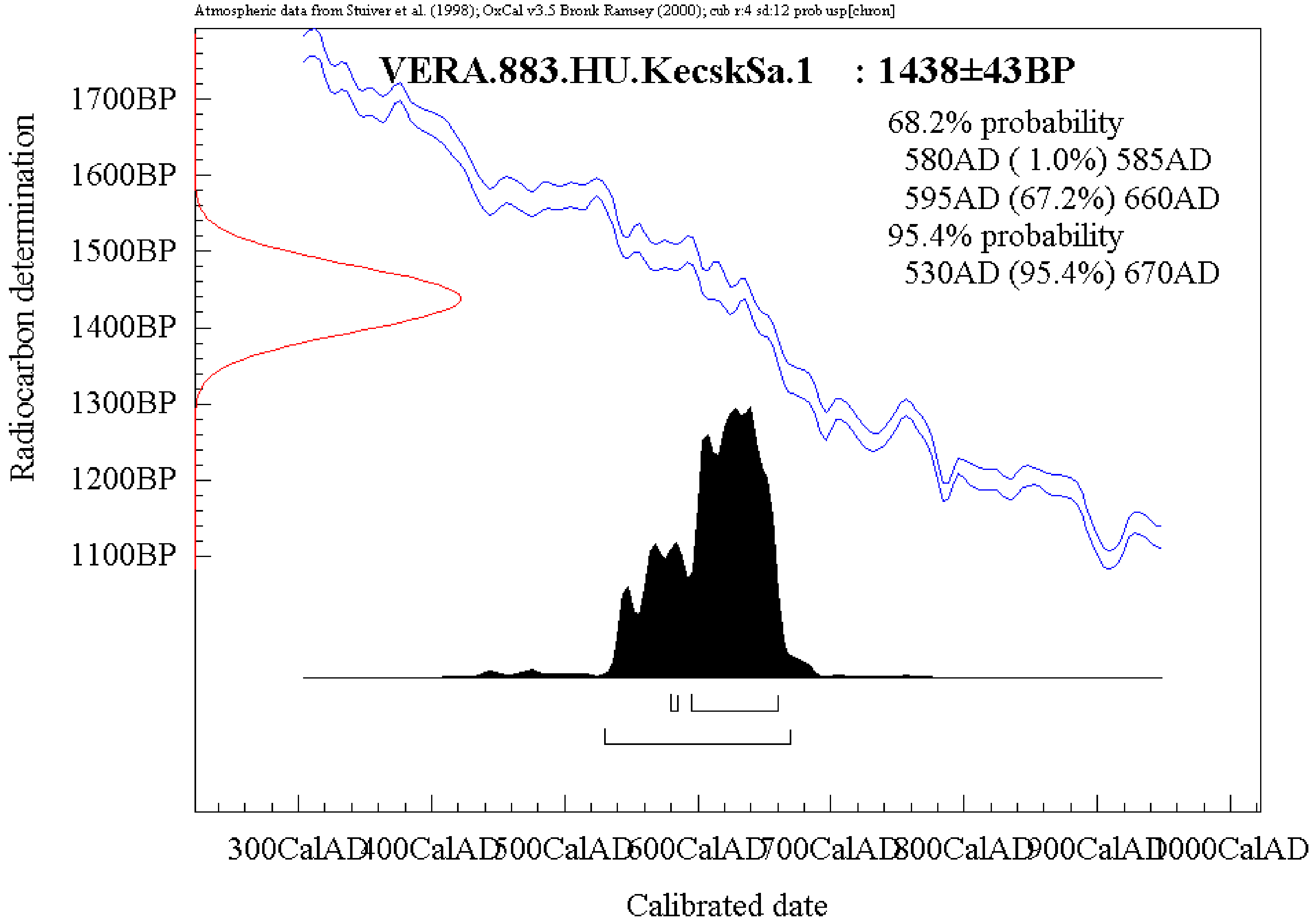
Fig.11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68.2% probability
580AD (1.0%) 585AD
595AD (67.2%) 660AD
95.4% probability
530AD (95.4%) 670AD
Radiocarbon determination
1700BP
1600BP
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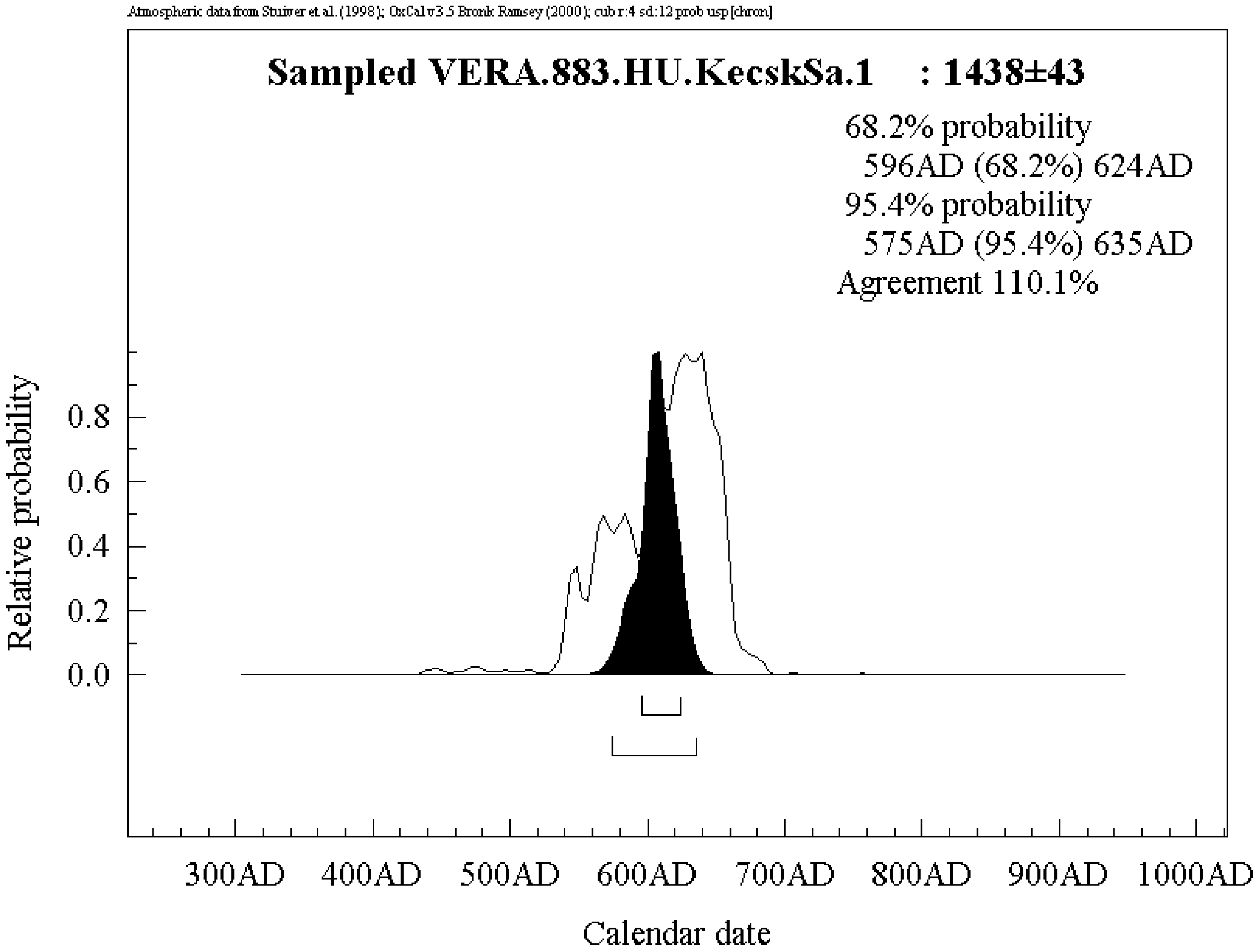
Calibrated date

Fig.12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Sampled VERA.883.HU.KecskSa.1 : 1438±43
68.2% probability
596AD (68.2%) 624AD
95.4% probability
575AD (95.4%) 635AD
Agreement 110.1%
Relative probability
0.0
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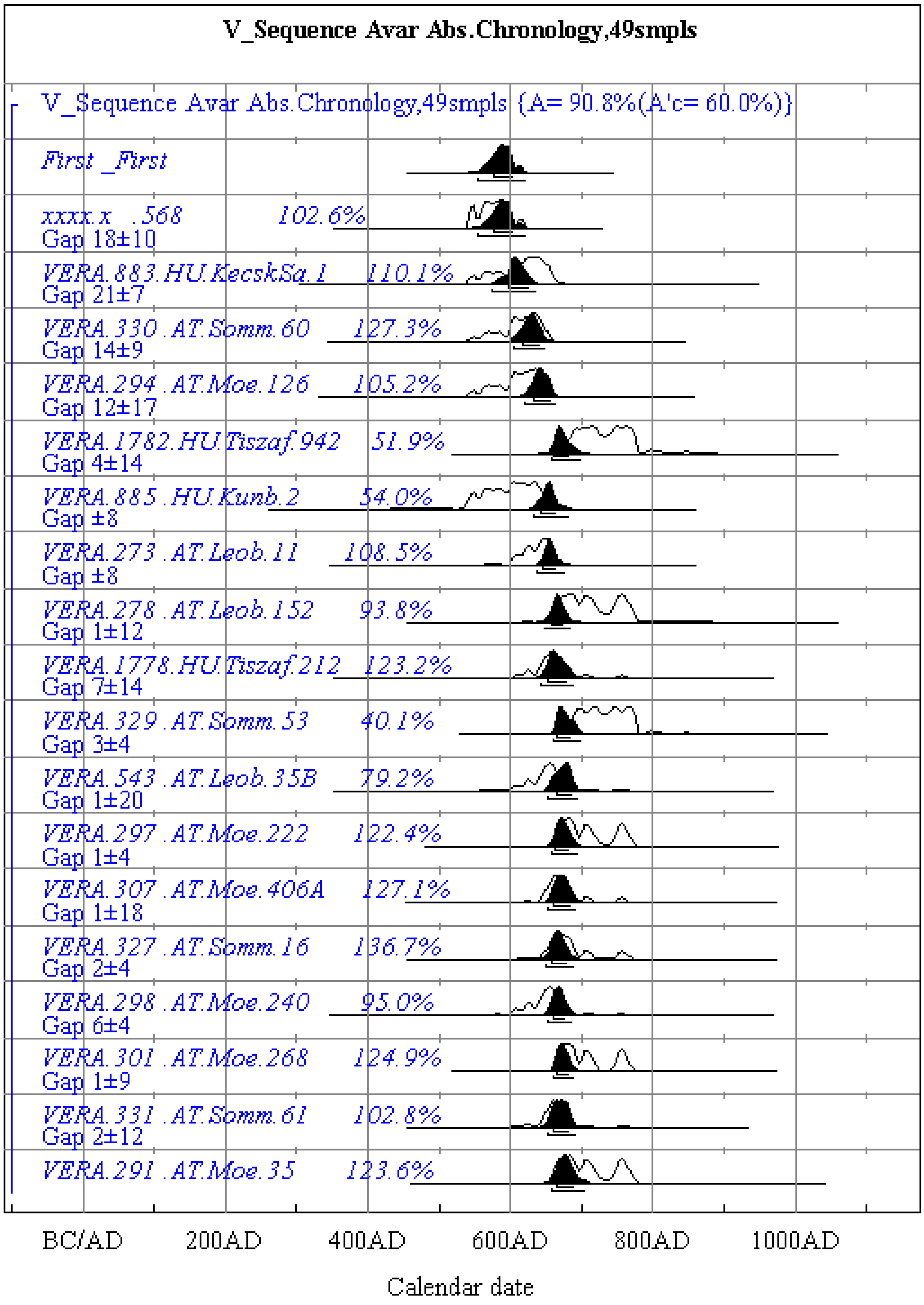
Fig.13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Gap 21±7
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Gap 14±9
VERA.294 .AT.Moe.126 105.2%
Gap 12±17
VERA.1782.HU.Tiszaf.942 51.9%
Gap 4±14
VERA.885 .HU.Kunb.2 54.0%
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VERA.273 .AT.Leob.11 108.5%
Gap ±8
VERA.278 .AT.Leob.152 93.8%
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VERA.329 .AT.Somm.53 40.1%
Gap 3±4
VERA.543 .AT.Leob.35B 79.2%
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VERA.297 .AT.Moe.222 122.4%
Gap 1±4
VERA.307 .AT.Moe.406A 127.1%
Gap 1±18
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Gap 2±4
VERA.298 .AT.Moe.240 95.0%
Gap 6±4
VERA.301 .AT.Moe.268 124.9%
Gap 1±9
VERA.331 .AT.Somm.61 102.8%
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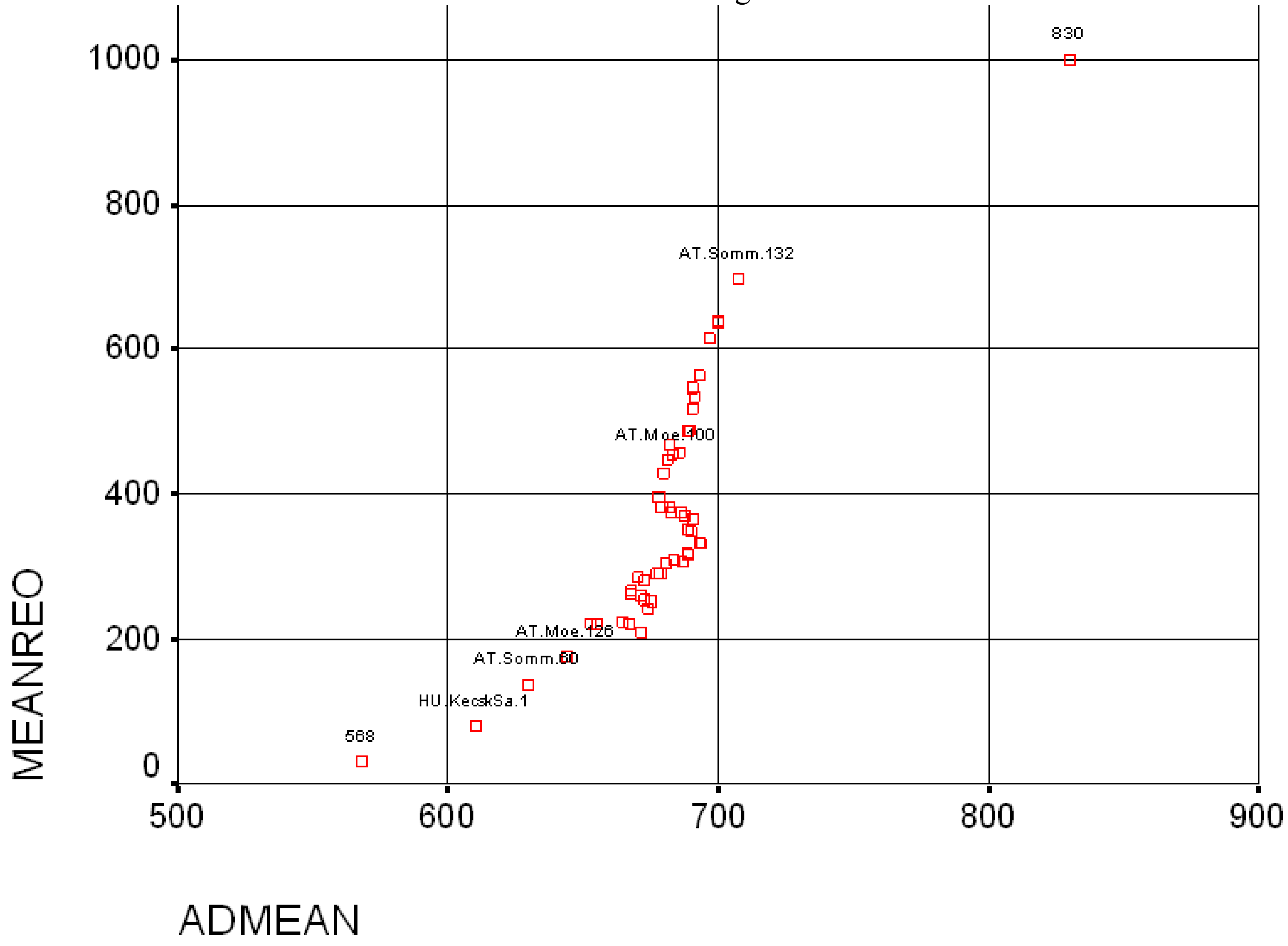
Fig.14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