

## **Report of the meeting of Arcane Transversal Group TG03 Meeting Blaubeuren (Germany) 9-12 May 2010**

### **"From the data to their modeling: regional and inter-regional chronologies"**

**Prepared by Elisabetta Boaretto**

#### **Summary**

The meeting, held in Blaubeuren for two full days included the participation of part of the TG03 members and some of the ARCANE project organizers. Unfortunately some delays in the arrival of some participants occurred due to the Icelandic ash clouds over Germany.

This meeting has summarized the actual state of the inventories collection for the different regions and their possible modeling.

Only few regions have a large corpus of regions have a large number of dates that allow modeling. These regions are North and South Levant, Early Jezirah, Middle Euphrates and Eastern Anatolia. The regions have all together few hundred radiocarbon dates, but the very restricted context requirements have excluded about 50% of the dates.

The major aim of this meeting was to present the results of the modeling of these regions. The modeled chronological sequences have been presented by Johanna Regev (SL), Laurel Risvet (EJ), Jean-Paul Thalmann (NL) and Pascal Butterlin some preliminary chronological data from Mari.

The South Levant is one the regions with the highest number of sites with radiocarbon dates. In the SL there are 20 sites that have received ESL inventories. Of these 20 sites only 3 have more than one layer radiocarbon dated. The rest of the sites, although they might have more than one occupational layer, they have been dated with radiocarbon only in one layer.

The North Levant is still completing the collection and modeling of the dates. A very good and complete example of chronology and between sites connection including architecture, tools was proposed. A dendro study with  $^{14}\text{C}$  date from Arqa was given showing the great potential of this method. Unfortunately charred wood beams are not very often recovered in archaeological sites.

Early Jezirah has completed the  $^{14}\text{C}$  data collection and models were presented. Eight sites were considered for chronological model, but only three had Arcane inventories: Brak, Beydar and Leilan.

How the chronologies were build depended from the nature of the dates and the sites associated. For example if the sites were multilayers or single layer (in relation to radiocarbon dates). Single level radiocarbon dated sites are particularly present in the SL region and it has the effect to make the boundaries between the different ESL phases very complicate. Indeed several phases are overlapping and only by modeling and by imposing a sequential order it is possible to separate the phases and determine a boundary. But by imposing sequential order without possible overlap between the dates, many  $^{14}\text{C}$  data are identified as outliers.

Major questions were about dates that were inverted in relation to the stratigraphy, how to include periods of abandonment (gap) after for example a destruction event, how secure is the relation between context and radiocarbon date and which date should define the

end of a phase or stratum and therefore be the *terminus post quem* for the boundary between this and the next phase/stratum.

These questions requires to build an *a priori* model for the dates. Outliers therefore appear because the existing dates do not fit the *a priori* requirements. Outliers in the sequence are normally removed in order to have a better chronological frame. This step, the removal of the non-fitting dates, if not well justified can bias the results and produce wrong results.

A very detailed and clear presentation of the nature of radiocarbon measurements and modeling was given by Marian Scott. The Bayesian theory and its application for  $^{14}\text{C}$  based chronologies, its theoretical principles, possibilities and problems were shown. Bayesian theory is a formula, and a philosophy that integrates the observed C-14 dates with the additional knowledge about the archaeological context. The prior distribution is about this knowledge and the result is the posterior distribution of the data after modelling: posterior  $\sim$  prior  $\times$  likelihood (data).

The OxCal software package is commonly used to build the model and set up the prior and the likelihood and any constraints. The latter is carried out through incorporating some form of stratigraphic information. OxCal defines several such types: phases, sequences, boundaries, termini. Complex model can be build but this require a large corpus of dates. The goodness of the model, or of the posterior distribution is given by the model-data agreement (A statistic). Therefore general rules for good modelling is having many good (high precision and accuracy) dates and good information about relative relationships between samples or the events they relate to and expectations of the 'ages'. Outliers are then identified when agreement between the prior and the posterior is low. Three different problems can be identified:

- Problem 1: 'Poor' samples, not associated with the events of interest (dispute over archaeology/stratigraphy...);
- Problem 2: expectations are not well-founded ('poor' statistical model- poor archaeological model);
- Problem 3: measurements are insufficiently accurate or precise ('poor' measurements)

Different strategies can be adopted according to the type of problem.

One of the most challenging question/problem is related to the historical or written sources and the associated archaeological chronology. Walter Sallaberger presented the different chronological scenarios (High, Middle, Low and New Chronology) and what would be the precision required to sort between the proposed chronologies.

At the meeting the possibility to use radiocarbon and how to build the prior to model the dates were discussed and some attempts were made to see the effect of adding artificial gaps between the periods. These attempts have indicated how sensitive the dates might be priors e.g imposing a gap can move up and down the boundaries of the dates on both sides. It was important to note that as the chronological question is more and more detailed, so more and more dates are requested in order to justify or to build a solid model that would not change by the addition or the removal of single date.

The conclusion of the meeting point to the understanding that while  $^{14}\text{C}$  dates and model might be the key to sort between alternative chronologies or build time connection between sites and regions, it is necessary to understand the limits of  $^{14}\text{C}$  dates (e.g. precision of  $\pm 30$ -20 years) and to carefully use the Bayesian theory in modeling both the radiometric dates but also to describe the archaeological context by associating the priors.

## **MEETING PROGRAM**

### Day 1: Sunday 9 May

Arrival at Blaubeuren

### Day 2: Monday 10 May

**9:00 - 10:30** Welcome and presentation of the current state of chronological data collection in the different regions and the model so far performed (Boaretto)

**10:30 - 11:00** Coffee break

**11:00 - 12:30** Regional chronologies (North Levant, J-P. Thalmann) and Mari (P. Butterlin)

**12:30 - 14:30** Lunch

**14:30 - 15:30** Regional chronologies presentation (Jezirah, Rivset)

**15:30 - 16:30** Regional chronologies presentation ( South Levant, J. Regev)

**16:30 - 17:00** Coffee break

**17:00 - 18:30** Discussion

**18:30** Dinner

### Day 3 Tuesday 11 May

**9:00 - 10:30** Bayesian Theory: Modeling and outliers (M. Scott)

**10:30 - 11:00** Coffee break

**11:00 - 12:30** Written and historical chronologies (W. Sallarberger).

**12:30 - 14:30** Lunch

**14:30 - 15:30** Simulation and discussion of other models for the regional chronologies.

**15:30 - 16:30** Alternative modeling and effects of different prior

**16:30 - 17:00** Coffee break

**17:00 - 18:30** Discussion and conclusion

**18:30** Dinner

### Day 4 Wednesday 12 May

**9:00 - 10:00** Departure from Blaubeuren

## LIST OF PARTICIPANTS AND SPEAKERS

### TG Radiocarbon dating and other techniques

Elisabetta Boaretto (Israeli), Weizmann Institute of Science and Bar Ilan University  
Marian Scott (British), University of Glasgow  
Pierre de Miroschedji (French), Centre de Recherche Français de Jérusalem  
Jean-Paul Thalmann (French), Université de Paris I Panthéon-Sorbonne  
Walther Sallaberger (German) University of Munchen  
Johanna Regev (Israeli) Bar Ilan University  
Pascal Butterlin (France) Université Versailles Saint Quentin en Yvelines  
Laurel Ristvet (USA) University of Pennsylvania

### Absent

Jan Heinemeier, (Danish), Aarhus University  
Otto Cichocki (Austrian) Vienna Institute for Archaeological Science  
Katleen Deckers (German), Universität Tübingen  
Gian Maria di Nocera (Italian) University of Viterbo