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ANALYSIS OF CHARCOAL SAMPLES FROM EARLY BRONZE AGE STRATA AT TELL ARQA

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Abstract: Charred seeds and beams of burnt houses were found in Early Bronze Age IV strata at Tell Arqa, Lebanon. Wood species analysis indicated that most of the charcoals were of *Cedrus libani*; however, *Juniperus foetidissima, Olea europaea* , *Prunus mahaleb, Acer sp., Laurus nobilis, Quercus sp.* were also identified. Among the construction timbers of floors a yet unknown tissue with strange anatomic features occurred.
According to C14 data, the houses were built between 2470 and 2270 BC (+ up to 5 years), and the destruction event occurred between 2350 (2460!?) and 2130 BC.
For dendrochronological investigations, the single posts and planks were reconstructed and combined to a floating chronology of 122 years. This chronology has a good statistical fit GL 60, 2%, GLSIG 65, 4%, TBP 3, 52, THO 4, 14) (with a floating chronology of coffin 7512 from Giza (presently at the Kunsthistorisches Museum, Vienna, dated to the 5th Dynasty).

1. Introduction

In the course of a most interesting long term excavation at Tell Arqa (22 km north-east of Tripoli, J.-P. Thalmann, 1978, 1997, 2003), in 2002 and 2003 sub-constructions of burnt houses from the Early Bronze Age were found (J.-P. Thalmann, 2006). In two of these houses, carbonized remains of wooden columns, beams and planks were preserved. On the first floor, most of the charcoal was still *in situ,* and parts of the ceiling beams were found lying flat in their original parallel position. Several pieces of carbonized wood from the floor above were mixed with debris from the collapsed walls. Thanks to this collapse the wood did not burn to ashes, but due to lack of oxygen, was transformed to a certain extent into charcoal. This process also turned into charcoal large quantities of grain which had been stored in the cellars of these homes. These wood findings provided superb material, not only for wood species analysis and C14 dating, but also for dendrochronological investigation.

2. Results of the wood species analysis

To determine the wood species found in these houses at Arqa it was necessary to break the small pieces of charcoal to get the clear surface necessary for studying the numerous anatomical features of the cell structure still preserved even after charring. These surfaces were coated with gold and magnified with a REM microscope to obtain pictures as sharp as possible. Since the surfaces are never completely plain, a light microscope would have not reproduced a sharp image of adequate size. The anatomic features were compared with literature providing both microscope and REM micro-photos (F. H. Schweingruber, 1990; J. Ilic, 1991; R. Gerisch, 2004) and the growth areas of the species studied (G. Krüssmann 1976/77/78, 1983).

2.1. Cedar

Investigation of the wood species showed a very uniform spectrum. Approximately 95% of the samples originated from wood of *Cedrus libani*, a tree quite common during the Bronze Age in Lebanon. It was widely used as wood for construction and was extensively exported to Egypt as early as the Old Kingdom. These trees grew up to 40 m tall and had a very dense and long lasting wood due to resin and ethereal oils.
Today, the cedars are present only in few places on the slopes of Mount Lebanon, in areas located between 900 and 2100 m above sea level. In antiquity, these trees formed dense forests on all north- and west-facing

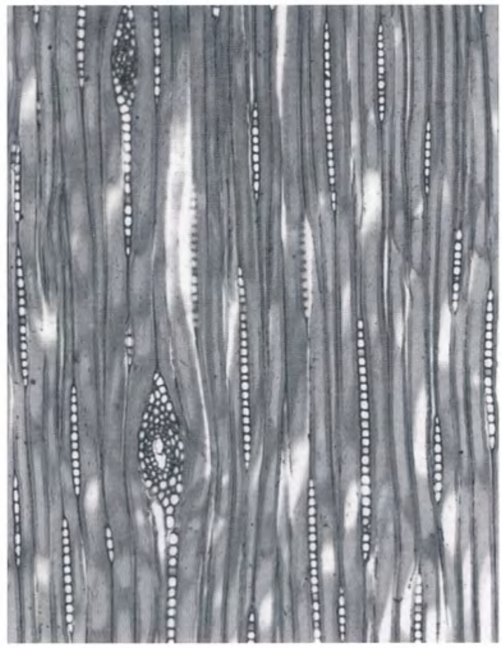
slopes between 1400 and 1800 m above sea level (R. Gerisch, 2004). Cedar samples can be detected by their lines of traumatic resin ducts (fig. 4) and the lobated tori of their pits (figs. 1-4).

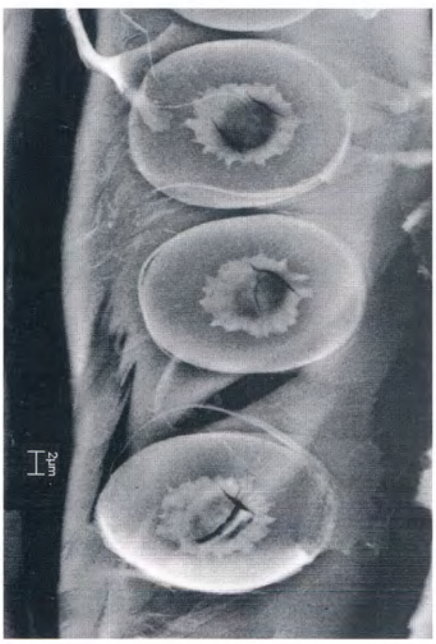
1 Cedrus libani, cross section, 15x, two bands of resin ducts along ring-borders

2 Cedrus libani, tangential section, 40x, uniseriate rays, one with a resin duct.

3 Cedrus libani, radial section, 600x , bordered pits with lobated tori in the centers

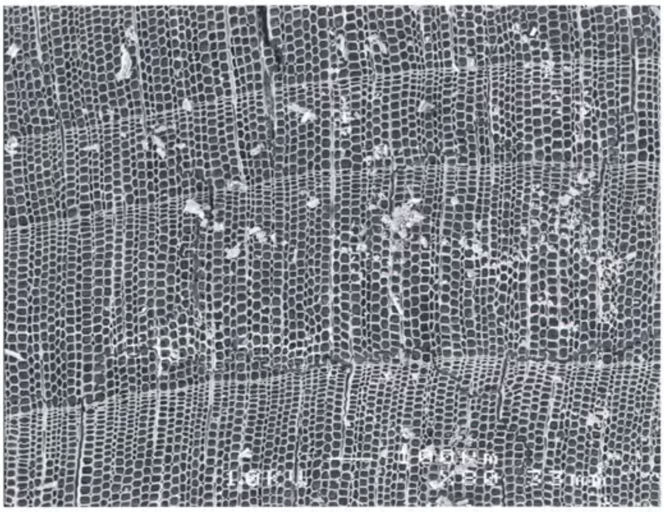
4 Cedrus libani, cross section, 30x, one band of resin ducts as false ring (arrow).

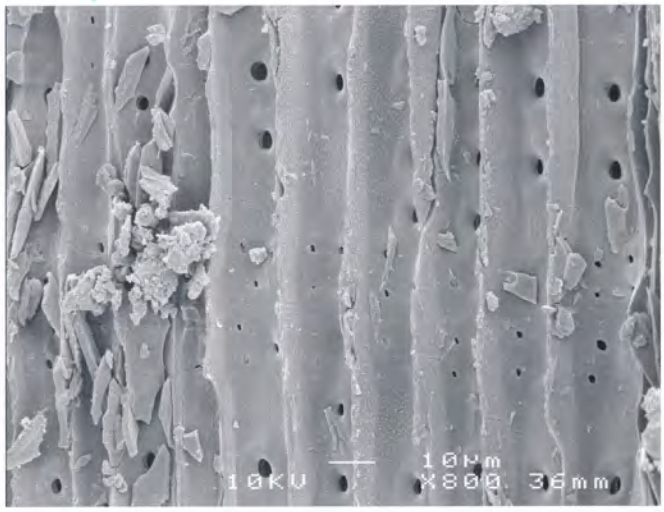




2.2. Juniper

Two samples (03/7 and 03/12) were charcoal of *Juniperus foetidissima*, a Gymnosperm tree growing to a maximum height of approximately 20 m. This tree lacks resin ducts and has 2-4 small pits in the crossing fields between the tracheids and ray cells (figs. 5, 6).





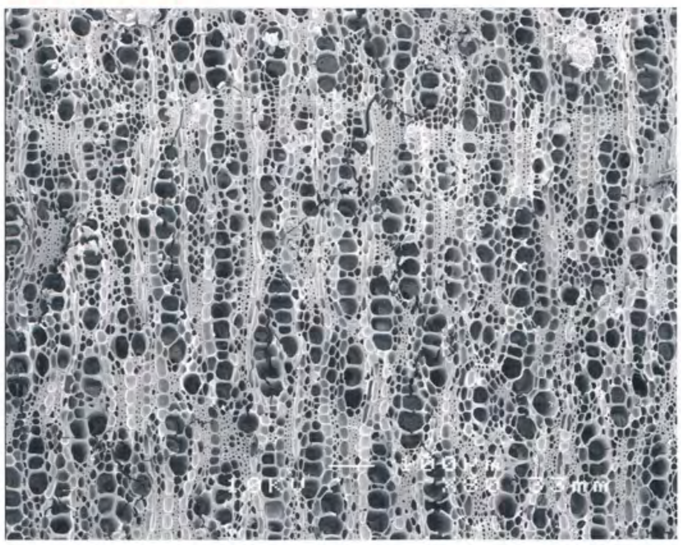
2.3. Olive tree

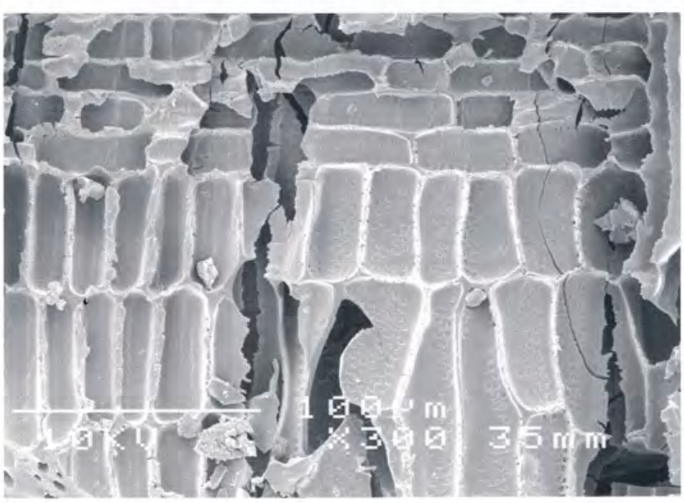
5 Juniperus foetidissima, cross section, 80x.

6 Juniperus foetidissima, radial section, 300x.

7 Olea europaea, cross section, 80x, radial groups of vessels.

8 Olea europaea, radial section, 300x, lying and standing ray cells with many small pits.

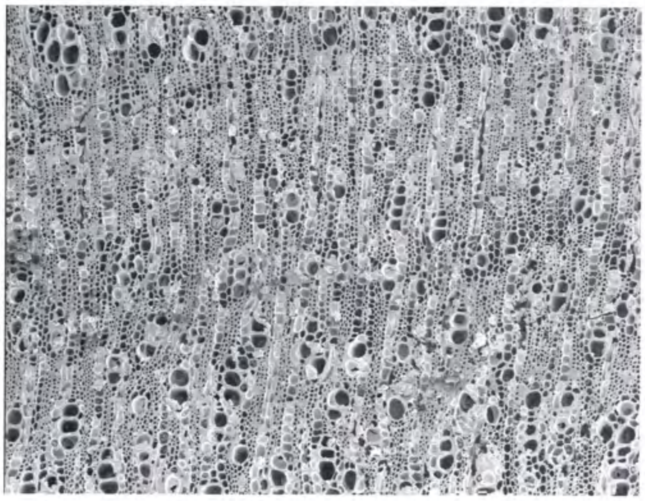


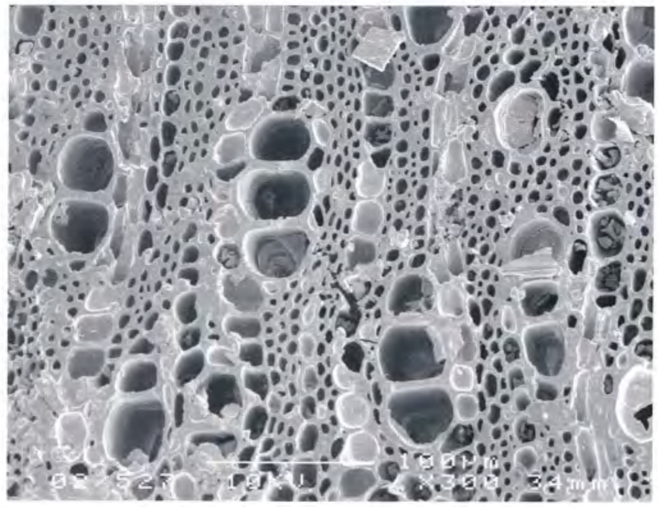


Four pieces (01/420, 02/527_4, 02/527_X, 02/575_4) were charcoals from olive trees, *Olea europaea* (figs. 7, 8). When grown wild it is called *Olea europaea* var. *oleaster*. However, this species has been cultivated since the 4th millennium BC, possibly first in Palestine (R. Gerisch, 2004), to produce edible fruits and oil (figs 7, 8).

2.4. Mahaleb cherry

A single sample of *Prunus mahaleb* (02/527) documents the occurrence of this tiny tree in the region. Even today, the inner edible part of the fruit stone is used by Lebanese pastry cooks to flavour certain cakes and delicacies. The wood shows vessels in radial rows and vasicentric parenchyma (figs. 9, 10).



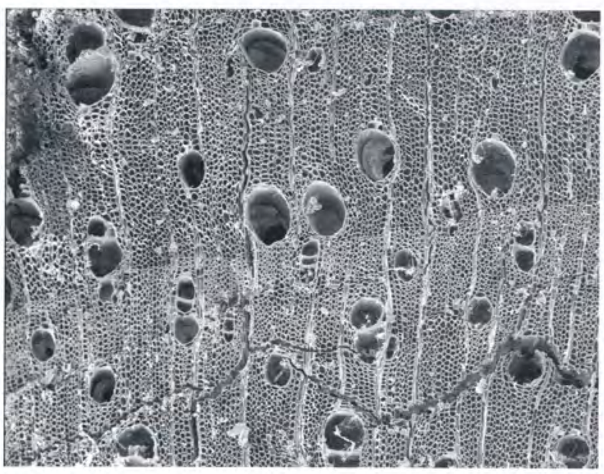


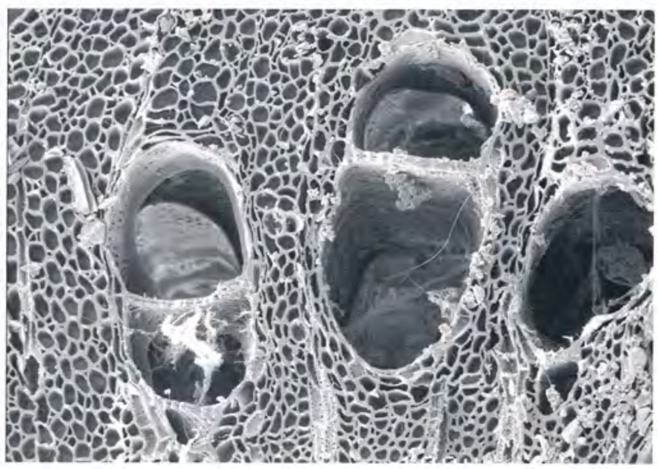
9 Prunus mahaleb, cross section, 80x.

10 Prunus mahaleb, cross section, 300x.

2.5. Evergreen Maple/Oriental Maple

One sample originated from *Acer* sp. as shown from the vessels with diffuse porous texture arranged in radial groups. The species might have been *A. sempervirens* or *A. orientale*, but since Acer samples are very difficult to separate, and because the samples were quite small, species determination was not possible (figs. 11, 12).



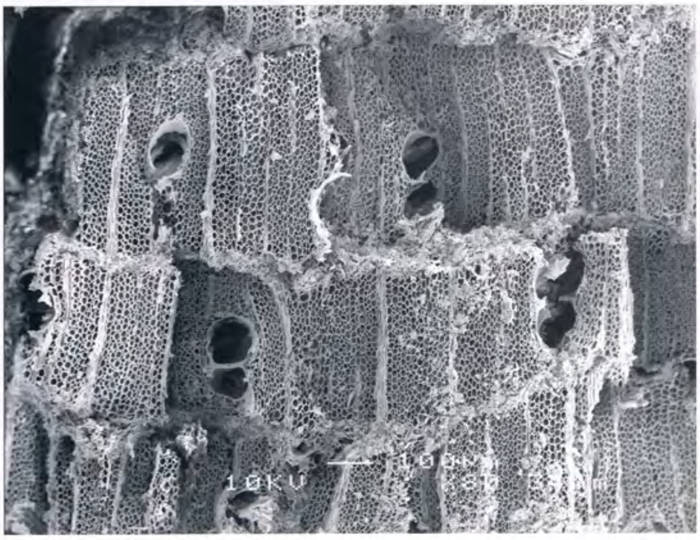


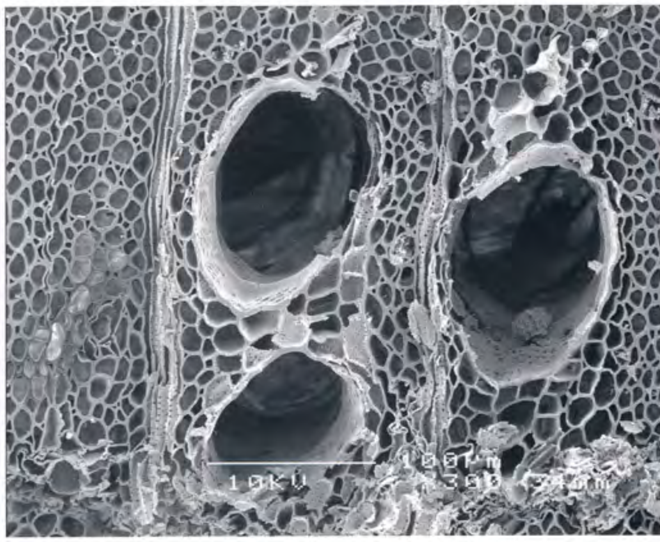
11 Acer sp., cross section, 30x, single and radial pairs of vessels.

12 Acer sp., cross section, 300x.

2.6. Sweet Bay

A highly degraded piece of charcoal might be *Laurus nobilis*. The vessels of this species are larger than in Acer wood, of the same diameter throughout the ring, and mostly arranged in pairs. But since all the wood samples were cracked, an exact identification is uncertain (figs. 13, 14).



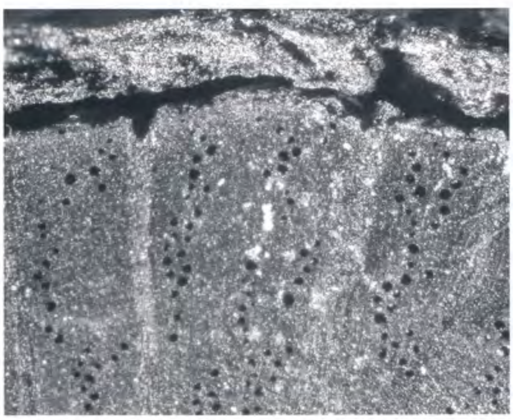


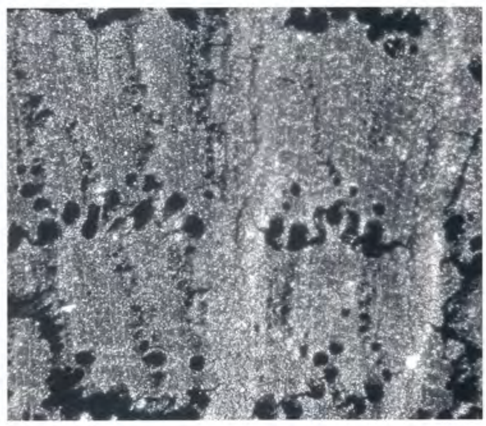
13 Laurus nobilis, cross section, 80x, pairs of big vessels, crashed late wood.

14 Laurus nobilis, cross section, 300x.

2.7. Oak

There were two samples of *Quercus* sp. with ring-porous vessels, maybe of *Quercus cerris*. The different species of this type cannot be separated by anatomic features (figs. 15, 16).



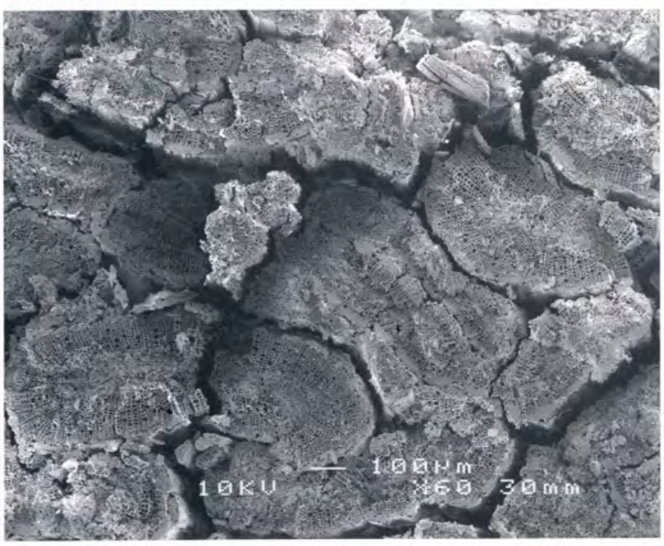


15 Quercus sp., cross section, 15x, thick radial rays, late wood vessels in radial groups.

16 Quercus sp., cross section, 100x, spring wood vessels along the ring border (=ring porous).

2.8. Unknown species

Finally, sample 02/575_7 is an enigma. The macroscopic impression was similar to palm wood (singular bundles of fibres embedded into parenchyma tissue), but microscopic examination showed singular stems (roots?) embedded into thick walled tissue (figs. 17,18). The secondary xylem shows radial cells, some of which are bigger than the others. Thus, it is difficult to say whether this tissue is the complex stem of a gymnosperm, an angiosperm (a creeper ?), (most unlikely a fern) or a package of very thin separated twigs or spears (figs 17, 18).



17 Unknown wood, cross section, 60x, oval groups of concentric xylem embedded in thick walled tissue.

18 Unknown wood, cross section, 500x, some larger cells among the smaller ones, sort of ray to the left, inner part crushed.

3. C14 Dating

The C14 data of construction wood samples from the burnt houses and charred seeds helps to date the various building phases and time of destruction:

*) 1?- error

**) Determined with the OxCal calibration program and the INTCAL04 calibration curve.

Labor-Nr.	sample name	13C*) [‰]	14C-age*) [BP]	calibrated age **)
VERA-4013HS	Tell Arqa_42 FundInvNr: 2005/1 humic acids corner post - EB IVa	-23.2 ± 0.6	3885±35	2470BC (92.7%) 2280BC 2250BC (2.7%) 2230BC
VERA-4015	Tell Arqa_44 FundInvNr: 2005/3 rafter- EB IVa	-22.1 ± 0.5	3935±30	2570BC (5.9%) 2530BC 2500BC (89.5%) 2300BC
VERA-4004HS	Tell Arqa_33 FundInvNr: 2005/4 humic acids ashes- EB IVa	-22.7 ± 0.7	3840±35	2460BC (95.4%) 2200BC
VERA-4005HS	Tell Arqa_34 FundInvNr: 5 humic acids charcoal- EB IVa	-20.4 ± 0.7	3870±35	2470BC (87.5%) 2270BC 2260BC (7.9%) 2200BC
VERA-4011HS	Tell Arqa_40 FundInvNr: 96/366 humic acids seeds (destr. layer) - EB IVa	-23.7 ± 0.6	3815±35	2460BC (6.9%) 2370BC 2350BC (88.5%) 2130BC
VERA-4012HS	Tell Arqa_41 FundInvNr: 712 humic acids seeds (destr. layer) - EB IVa	-23.5 ± 0.5	3825±40	2460BC (89.2%) 2190BC 2180BC (6.2%) 2140BC

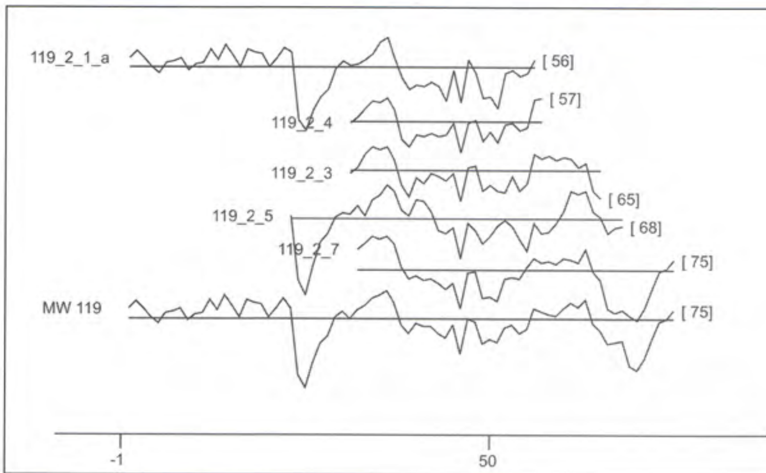
Values correspond to the 2 ?- confidence interval, probability for the respective time period in brackets.

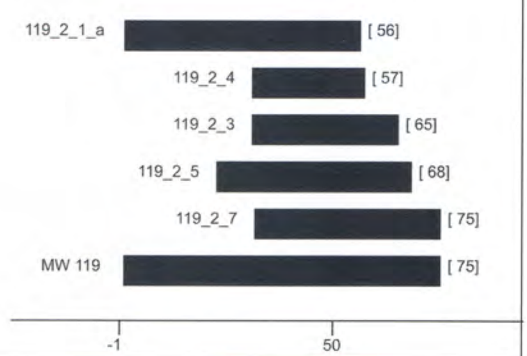
Measurements: Ao. Univ. Prof. Mag. Dr. Eva Wild, Mag. Dr. Peter Steier, Institut für Isotopenforschung und Kernphysik der Universität Wien, Vienna Environmental Research Accelerator VERA

Since the C14 samples from the wooden posts were taken from the outer rings, the data give a time span for when the trees were cut down namely between 2470 and 2270 BC. This is plus up to *ca.* 5 years for possible storing of the wood for the construction date of the houses. The destruction event (marked by the burnt seeds) took place between 2350 (2460!?) and 2130 BC.

19 Reconstruction of a single beam Nr. 119 by combining the different smaller pieces 2_1_a, 2_4, 2_3, 2_5, 2_7 to a sequence MW 119 with 75 rings.

4. Dendrochronology

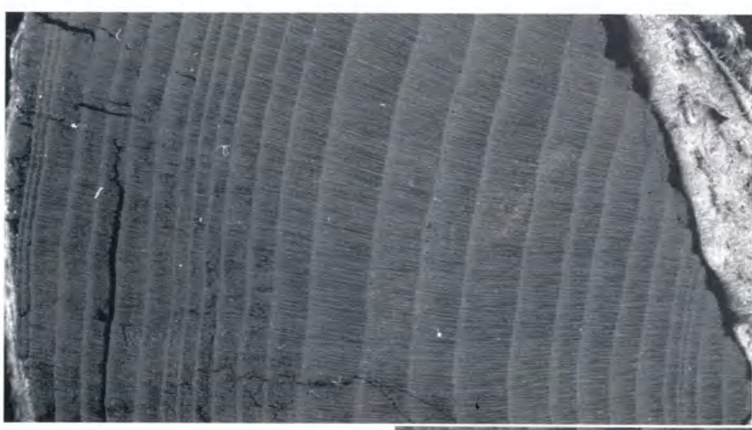




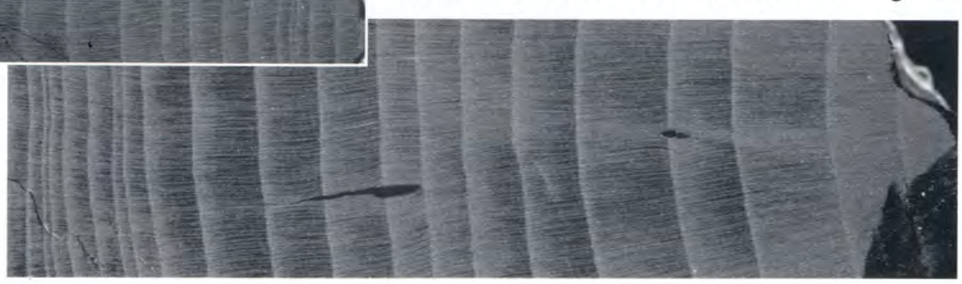
20 Block diagram of fig. 19 showing position of single pieces to each other.

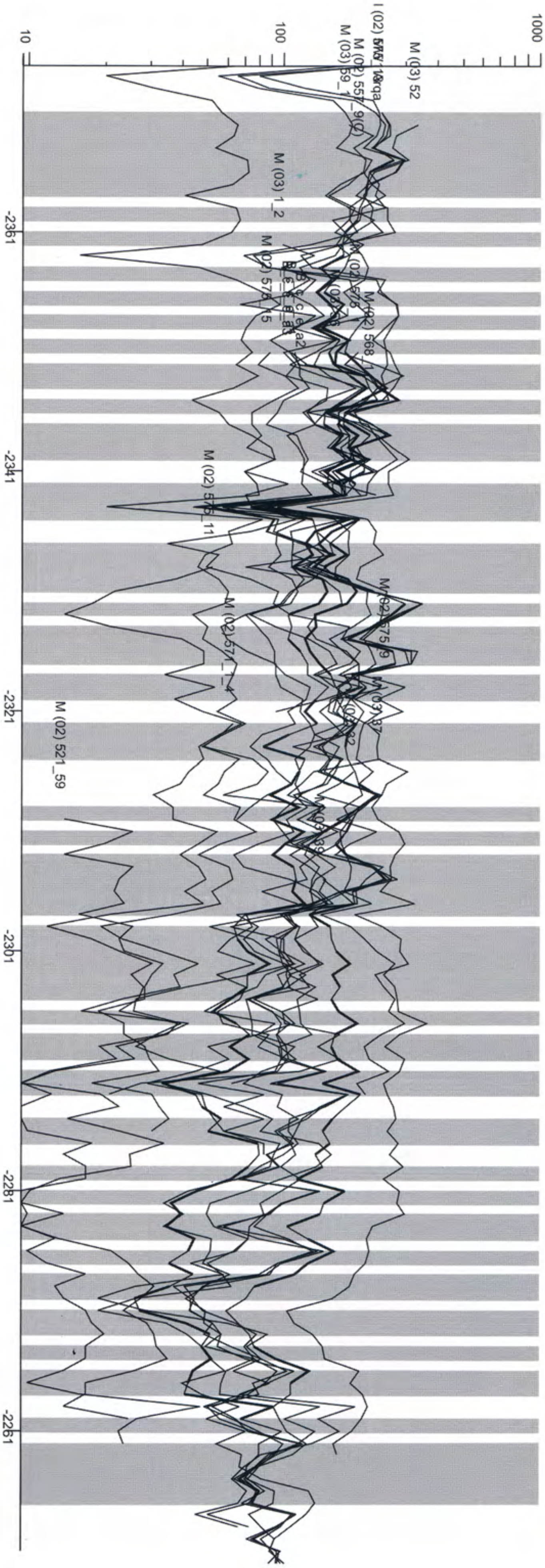
21 Overlapping method using similar ring patterns in times, when both trees were growing, to calculate a mean and to extend the sequence.

Since the planks and beams were broken into many tiny pieces, the first task was to reconstruct the samples. The square surfaces were ground, polished and scanned at 2400 dpi. On these scans, the ring width of all visible rings was measured with an accuracy of 1/100mm. Some rings were missing on single pieces, as especially in drought years, the growth does not take place around the entire circumference of the stem or branches of a tree. On the other hand, density variations or bands of traumatic resin ducts may give the appearance of true rings – these are the main possibilities for error. But when comparing many single measurements, these errors are sorted out as they do not occur in each piece. The result of this operation is a data list of ring width of all single pieces of wood.



The next step was the synchronization of the single pieces. This is a much more difficult task (contrary to the pieces of a single beam) since it is unknown whether the two samples overlapped in time. If this overlap is long enough, or has a unique pattern of tree rings, the correct position in relation to each other can be proven by statistical tests. The basic idea is shown in fig. 21

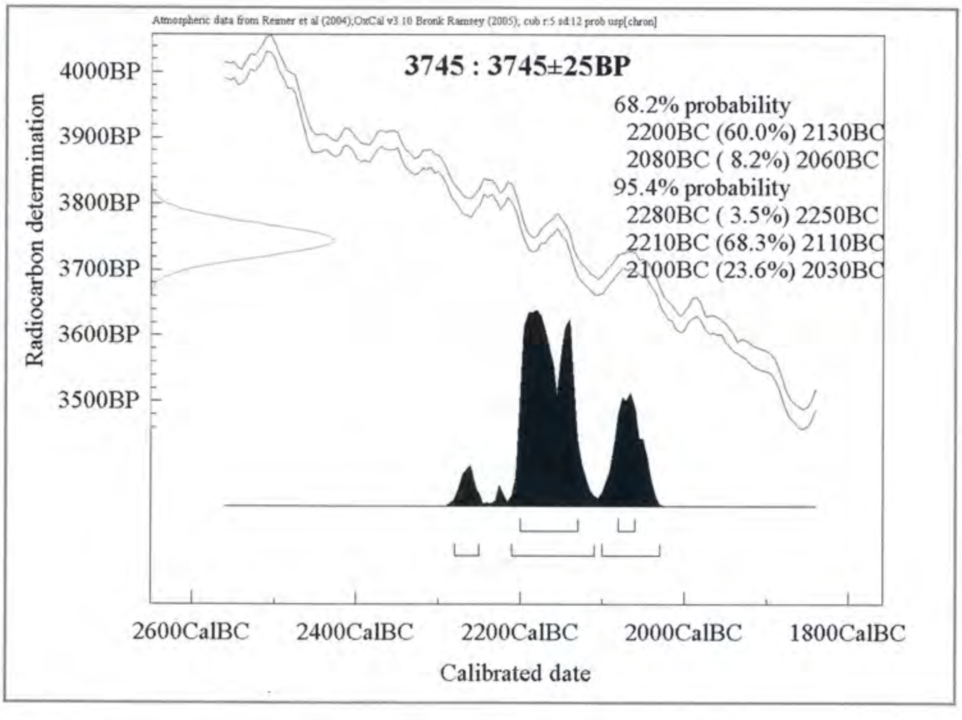




22 Synchronization of single beams from Arqa with sequences from coffin nr. 7512 KHM Vienna, and a plank from al-Hourriyeh cave.

where the overlap should be some 50-70 years to be on the safe side. After successful synchronization, the mean of both data sets is calculated. After repeated use of this procedure, the final result is a floating chronology of all samples. These samples should provide high statistical test values as they will be used for future absolute dating purposes.

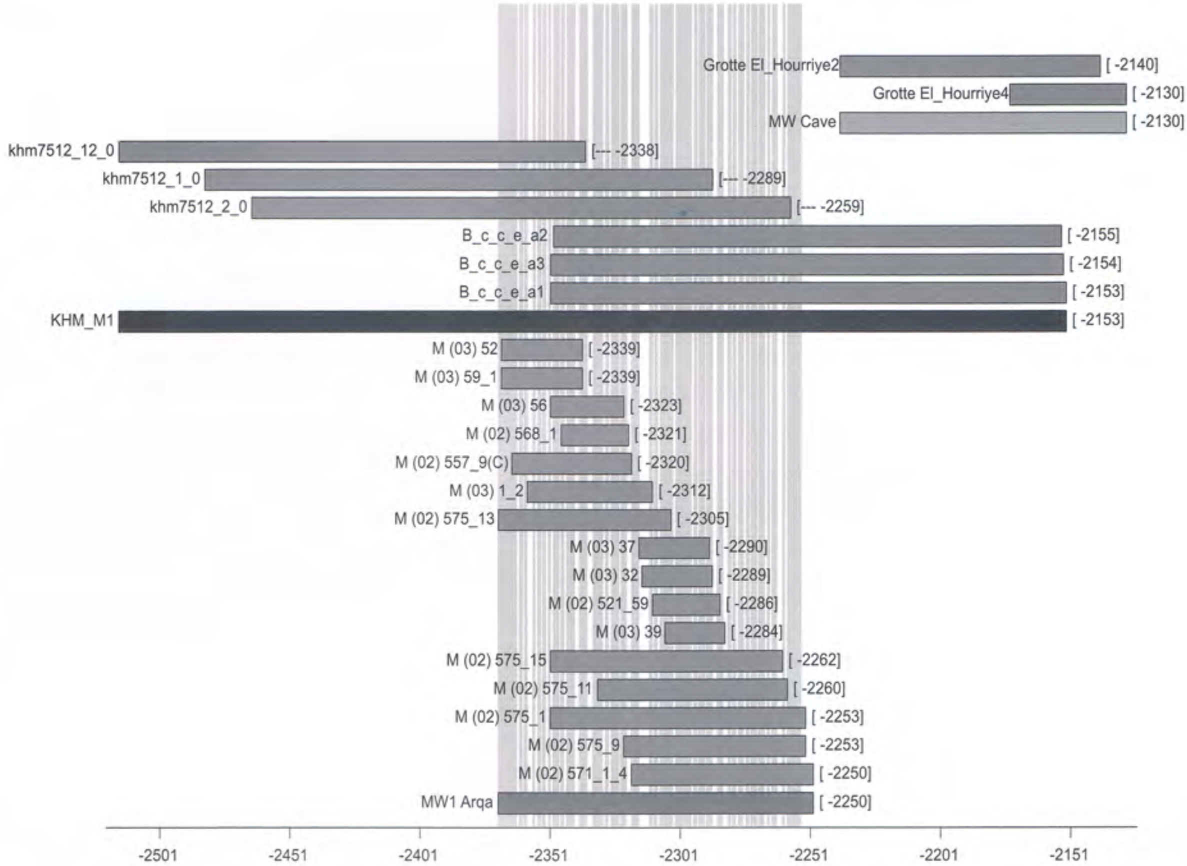
In fig. 22 and 24, three floating sequences were combined: one from Arqa (122 years), the sequence of a 5th dynasty coffin from Giza (Kunsthistorisches Museum Vienna, Nr. 7512, 365 years) and the sequence from a plank from al-Hourriyeh cave (111 years, O. Cichocki, 2002). As the latter plank provided a C14 date (VERA 2662 / 3745 +-25 BP / 2210 – 2110 cal. BC – 65%), it was possible to position all the sequences approximately in time by positioning the end of this plank to 2160 B.C. This position is supported by the C14 data for some Arqa wood samples mentioned above. It is necessary to stress at this point that the relative position of these three floating sequences to each other is a result of dendrochronology (with a one year accuracy), while the position of the entire system in time is a result of the C14 analysis (with an uncertainty of ±50 years in this case).



23 C14 calibration graph for the date of al-Hourriyeh cave plank.

The floating sequence can then be used for deriving relative information about the relative position in time for the single pieces. To enlarge the spectrum of this information, samples with aberrant features within their data (which, when used alone, would destroy the floating sequence) can also be incorporated.

In investigating the relative position of samples from Arqa it might be possible to see four groups (= phases ?): 2369, 2350, 2314, and 2280 ±50 years BC. But to prove this observation and to draw archaeological conclusions from it, more detailed investigations will have to be done.



24 Block diagram of fig. 22; note the groups of Arqa beams ending at similar years (=construction phases?).

To arrive at absolute dates by means of dendrochronology the construction of a standard for Cedar has to cover a time span from the Bronze Age until today. To accomplish such a task, we need to find enough samples of the right species from the same geographic growth area with continuous overlaps in time. This work has already begun with the special research program SCIEM2000 (*The Synchronization of Civilizations in the Eastern Mediterranean in the Second Millennium BC.* See O. Cichocki, 2000, 2002, in print and O. Cichocki *et al*, 2004) and has by now bridged approximately half of this time span.

This undertaking was only made possible with the help of many scholars, especially Jean-Paul Thalmann, who not only supported this project with the Arqa charcoals, but also helped find samples from the Bcharre and Barouk cedars. He also initiated contacts with Anis Chaaya to investigate wood remains from the various monasteries and hermitages in the Qadisha Valley, and contacted archaeologists working at the important sites of Qatna and Ebla. The present author is mostly indebted to him for his invaluable assistance in making the impossible come true, as well as for inviting me to come to Arqa to participate in this project. After all, closing a long day of work, nothing beats those stunning sunsets atop the ancient city of Irqata!

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