RADIOCARBON DATING WITH THE UPPSALA TANDEM ACCELERATOR

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Abstract

Since 1981 the Uppsala tandem accelerator system has been developed to be used in ultra sensitive mass spectrometry, where radiocarbon dating is one of the most interesting applications. At present (november 1984) the improvements of the accelerator have reached a level where samples of milligram sizes can be dated with an accuracy of 1—2 % within a measuring time of about one hour.

Although the technique of using a particle accelerator in dating is not older than seven years, between twenty and thirty laboratories all over the world already work with this application. Some laboratories even run up to 300 samples a week in routine ^{14}C-dating work. Several articles have also been published on this subject (Purser et al., 1979; Litherland, 1980; Mast and Muller, 1980; Hedges, 1981; Possnert and Olsson, 1984; Andersen, 1984). Therefore only the most pertinent new in using of an accelerator will be discussed.

The greatest advantage of using accelerator mass spectrometry (AMS) when measuring the ^{14}C content in a sample is, that the required sample size is reduced by a factor ~ 1000 compared to what is needed in the conventional technique. With AMS, 0.5—1 mg of carbon is enough instead of 1—5 g, earlier needed. The AMS technique is based on direct ion counting and thus independent of the half life of ^{14}C which is the restricting factor in the conventional decay counting method. Furthermore it is important to notice that a measuring time of only 0.25—1 hour is needed for one sample, instead of 1—5 days necessary with the conventional technique.

The different technical improvements of the Uppsala accelerator system that have been undertaken will not be presented here since a technical description already has been published (Possnert, 1984). Of more interest is, however, to discuss what an archaeologist has to think of when using the AMS-method in ^{14}C dating. The most important thing is that as much material as possible always is collected during the field work, despite the fact that only a milligram of carbon is needed in the actual measurement. The main reason for this is that the problem of contamination of organics from the surrounding with a different age, may be overcome by making a refined chemistry in the pretreatment and/or making several measurements of different parts from the same sample. The small sample size needed may of course be of benefit in dating e.g. an artifact or a bone, where one does not like to destroy the whole object in order to determine its age.

After the pretreatment (physical and chemical cleaning) of the sample, the carbon

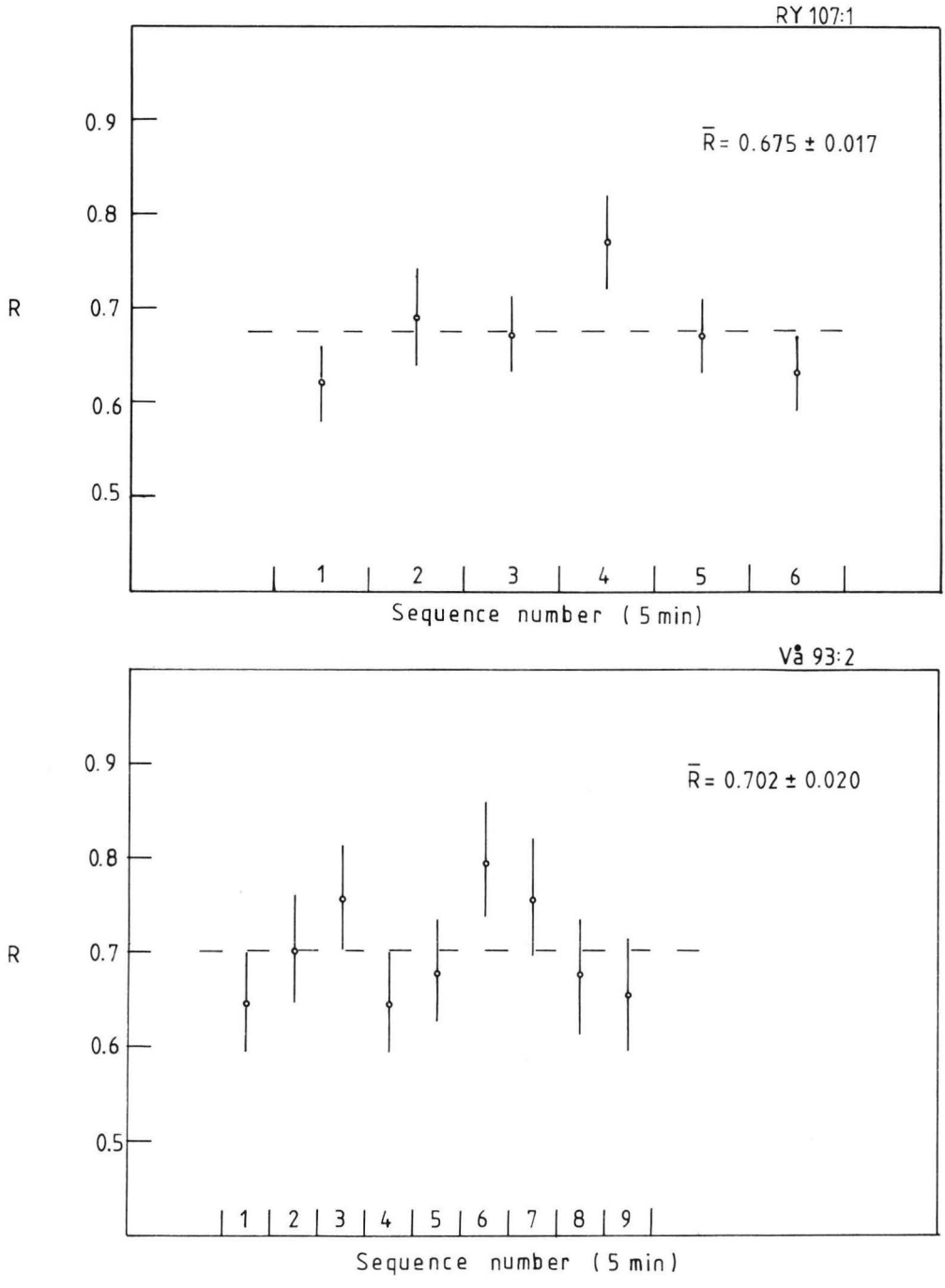

Fig. 1. Normalized ^{14}C content (see text) in charcoal from heaps of fire cracked stones (RY 107: 1; Vå 93: 2).

has to be converted to a form suitable for the accelerator ion source. Graphite is most preferable since a high negative beam current is obtained and thus making a short measuring time possible. We have, however, until recently used iron carbide (FeC) because

of the simplicity in the preparation, but with the disadvantage of 3—10 times lower beam current. Fortunately a simple technique of preparing graphite has recently been presented (Vogel et al., 1984). The sample preparation scheme in Uppsala will therefore from now on be the following:

Sample collection — pretreatment — combustion (CuO at ~ 800°C) — catalytic graphitization (Fe at ~ 600°C) — tandem accelerator (^{14}C measurement) — date evaluation.

To give an example of what the results look like in an AMS measurement, I would finally like to present the first measurement on archaeological samples performed with the Uppsala machine.

A series of eleven samples (10—200 mg) from early bronze age dwelling sites, was submitted by the Institute of Archaeology at the University of Umeå (Tomas Larsson, Hans Lundmark and Evert Baundou). The samples consisted of charcoal from heaps of fire cracked stones in the county of Östergötland, Sweden.

Before the FeC pellets (2 mg carbon) were prepared, the samples were pretreated (»washed» with NaOH and HCl) in the Uppsala ^{14}C-laboratory (I.U. Olsson, et al.). Figure 1 shows the first results obtained for two of the samples (RY 107: 1 Tängneby, Rystads sn, Östergötland; Vå 93: 2 Hovetorp, Vårdsbergs sn, Östergötland). The ratio R in the figure represents a normalized (NBS oxalic acid used as standard) ^{14}C value which has been measured in sequences of 6 × 5 minutes and 9 × 5 minutes respectively. As a guidance for the reader R = 0.7 corresponds to a ^{14}C-age of 2700 BP ($T_{½}$ = 5570 y). No δ ^{13}C measurements are yet performed and therefore are no dates presented here.

Summary

The Uppsala tandem accelerator system is at present developed to a stage where ^{14}C measurements can be performed with an accuracy of 1—2 % (measuring time 0.25—1 hour). The system will of course be further improved in order to shorten the measuring time and decrease the errors. Routine work will to some extent start during spring 1985. The costs and priority of the samples to be dated will be handled by a committe in accordance with well-established practice in the conventional ^{14}C-laboratories.

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