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Keynote lecture

Abstract

The Story of Mortar Dating – from an Archaeological Point of View

Why mortar dating?
Mortar dating has the potential key to the chronology of mortared stone- or brick constructions. Differently from other datable materials mortar is usually available, in the original, in abundance from all stages of construction. And differently from other materials it really dates the time of the construction – the time when the mortar hardens.

Why an archaeological point of view?
Mortar dating is the result of interdisciplinary collaboration between humanists and scientists. Archaeologists and architectural historians formulate the questions - scientists provide the answers. Therefore, ideally, the discussion should include all parties involved, and not only consist of scientists presenting their research to other scientists.

The story of Mortar Dating and the International Mortar Dating Project:
The birth of *The International Mortar Dating Project* is closely connected to an archaeological question - when were the medieval stone churches of the Åland Islands (between Finland and Sweden) erected? Due to lack of written contemporary sources the age of these churches finally needed settling after centuries of qualified guesswork.

The principle of mortar dating has been known since the 1960s. When in 1989 it was first brought to my attention by Högne Jungner (the Dating Laboratory, Helsinki University) it still meant conventional ^{14}C-analysis, with all the known risks of large samples, contamination, and wide error margins. Nevertheless, at that stage we were prepared to try every available method to solve the chronology. Immediately the first interdisciplinary group for mortar dating was formed. The first mortar dating results of the *Åland Churches Project* (1990-94) resulted in uneven dates and unacceptably large error margins.

In 1992 Mark Van Strydonck, together with Högne Jungner one of the pioneers of mortar dating in the 1980s, published an article where he recommended the use of ^{14}C AMS analysis for mortar. At that stage, however, he did not continue developing the method himself.

After their ^{14}C AMS analysis of the Newport tower in Rhode Island, Jan Heinemeier (AMS ^{14}C Dating Centre, Aarhus University) and Högne Jungner presented their promising results at a meeting in the Åland Islands in 1994. As a consequence, all results from conventional dating from Åland were nullified, and that very same year the project converted to ^{14}C AMS analysis.

At the same time Alf Lindroos (Åbo Akademi, Finland) joined the team and took over the mechanical separation. In the quest of spotting contaminating unburned lime stone in the aggregate, he introduced geological control using thermoluminescence. At this stage mechanically separated samples were analyzed in two CO_2 fractions, using 85% phosphoric acid in the chemical separation.

In comparison with dendrochronologically dated structures the results from non-hydraulic lime mortar from Åland seemed convincing. But we needed to go further, outside medieval Scandinavia.

The period 1997 – 2000 presented a possibility to test the method in Classical Archaeology, on non-hydraulic lime mortars from the Roman villa Torre de Palma, Portugal. Results were promising when analyzed according to the formula described above.

In 1998 another important step was taken - analyzing hydraulic pozzolana mortar in Rome, under guidance of Lynne Lancaster, expert on vaulted pozzolana constructions. The different chemistry of pozzolana mortar meant that expectations of success were low. The results were indeed varying and difficult to interpret, but not entirely unacceptable.
To try to solve the problem, a model of chemical separation in five CO_2 fractions was introduced in 2001. Age profiles thus created reflected the entire solution process.

In 2005 the collaboration included the RLAHA, Oxford, and 2006 the NSF AMS laboratory, Tucson. In Tucson other versions of hydrolysis (HCl) were used. We investigated which acid was optimal to use in the chemical separation.

In 2008 *The Building Roma Aeterna* conference in Rome meant a wider gathering of archaeologists discussing different aspects of construction in the Roman Empire.
Reliability criteria were defined to validate the results in cases when mortar dating was the only option. They were:

> Criterion I - When the two first CO_2 fractions in an age profile agree within the given error margins.
> Criterion II - When the first CO_2 fractions from at least three different age profiles per building unit reach the same result.

In Åland, when compared to age control from other methods available, a degree of 96% success was reached. In Roman pozzolana concrete, however, success covered only 50% of the results. But with pozzolana we did learn why so much of the analysis had failed, and therefore what to avoid in the future.
At a meeting with Mark Van Strydonck 2009 in Hawaii, at the *20th Radiocarbon conference*, plans of an international mortar dating workshop were taking shape.
When in 2010 the *First International Mortar Dating Workshop* was organized in Turku and Åland, Finland, it meant important brainstorming, with participants from different parts of Europe, Jordan and the United States. Alf Lindroos took over also the chemical separation, and started focusing on lime lumps embedded in the mortar.
2012 the *Second International Mortar Dating Workshop* in Mallorca (organized by Mark Van Strydonck) saw the creation of a wider mortar dating network. Important questions were the possible advantages of analyzing lime lumps embedded in the mortar, the optimal type of chemical solution. Other preparatory methods were presented, and plans were made for the future interchange of information, of students and regular meetings.
2013 at the *7th ^{14}C and Archaeology conference* in Ghent, an entire session was devoted to mortar dating, accompanied by an informal workshop considering a more formal European network. By then the *International Mortar Dating project* had analyzed more than 600 samples, in more than 2000 CO_2 fractions. Collaboration with G.L. Pesce planned on analyzing lime lumps.
2014 April 14-16. *The Third International Mortar Dating Workshop in Padova*.

New areas of research have generally been initiated by archaeologists. The archaeological point of view, including the necessary interdisciplinarity with constructive mutual understanding, is reflected by the team members:

Members of the Åland Churches project 1989-1994: Åsa Ringbom (archaeology/art history, Åbo Akademi, Finland), Högne Jungner (physics), Milton Nunez and Kenneth Gustavsson (archaeology, The Åland Museum).
Members of the International Mortar Dating Project 1994-2014: Åsa Ringbom, Alf Lindroos (geology), Jan Heinemeier (physics). 2007-2010 Pia Sonck-Koota (geology), Pia Sjöberg (art history). 2010- Lars Berggren (project leader, art history).
Additional members: At Torre de Palma Stephanie Maloney and John R. Hale (archaeology), University of Louisville, Kentucky. At Rome Lynne Lancaster (archaeology, University of Athens, Ohio). Fiona Brock (physics) RLAHA, Oxford, UK; Gregory Hodgins (physics) the NSF Arizona AMS Laboratory, US. Heikki Ranta and Joakim Hansson (archaeology and art history), Gotland and Scania, Sweden.