15 credit unit in Term II, 2016-17
Lectures Mondays 09.00-11.00, Room B13
Museum visits on specified Thursday mornings

Turnitin Class ID: 3225944
Turnitin Password IoA1617
Assessment deadlines 24 February, 24 April

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Office Hours: Monday 13.30-15.00, Room 210

Please see the last page of this document for important information about submission and marking procedures, or links to the relevant webpages.
ARCLG111 Archaeological Glass and Glazes

1 OVERVIEW

Short description

The course outlines the development of the production of glass and glazes from the Bronze Age through to the early modern period, with examples from a wide range of periods and cultures. All aspects of glass production are considered from raw materials through to the fabrication of beads, vessels and windows. Attention is drawn to the relationship between form and technology and the development of glassmaking ingredients over time. Particular emphasis is placed upon the chemical composition of glass, how and why it changes with time, and how it can be used to address problems such as provenance and dating. The course is well illustrated with examples of glass working from the literature, experimental archaeology and ethnographic observations. While archaeometric analyses form a key element of the course they are introduced in a user friendly way so that they are understandable by participants with an arts/humanities background.
<table>
<thead>
<tr>
<th>Week</th>
<th>Title</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. 23 January</td>
<td>Pre-Roman glass – trade and technological change</td>
<td>LBA long distance movement of glass; trace elements and isotopes Iron Age Glass. Continuity and change from the LBA. Early natron glass. <em>Turkish Bead-makers video (Marie-Dominique Nenna)</em></td>
</tr>
<tr>
<td>5. 6 February</td>
<td>Byzantine, Sasanian and Islamic glass</td>
<td>Byzantine and Islamic coloured glass; tin-opacification, gold glass. Continuity in the East. Parthian and Sasanian glass. The change from natron to plant ash. Early Islamic glass. Lustre decoration. Enamelled glass. Dynamic enamelling. <em>Roman glassmaking experiment video</em> <em>Issue of data analysis exercise (assessment 2)</em></td>
</tr>
<tr>
<td>Reading week</td>
<td>13-17 February</td>
<td>NO TEACHING</td>
</tr>
<tr>
<td>6. 20 February</td>
<td>Ceramic Glazes</td>
<td>Clay glazes, alkaline and lead glazes. Islamic glazed wares; stoneware bodies, tin opacification and the spread of tin-glaze technology. Lustre decoration. Overglaze and underglaze decoration. <em>Thursday 23rd – Petrie visit</em></td>
</tr>
<tr>
<td>7. 27 February</td>
<td>Far eastern glass, glazes and vitreous pigments</td>
<td>India, raw glass, beads and mirrors; compositions and trade China: Early high temperature glazes; porcelain development. Early Chinese glass, Han Blue, Han Purple. Interactions between glass and ceramics. Parallels and contrasts China and West. <em>Papanaidupet video (Marie-Dominique Nenna)</em></td>
</tr>
<tr>
<td>8. 6 March</td>
<td>Enamels on metalwork, early medieval (post-Roman) glass.</td>
<td>Recycling and re-use. Trace elements. Anglo-Saxon glass. San Vincenzo. <em>Gold glass beads video (James Lankton)</em> <em>Thursday 9th – BM visit</em></td>
</tr>
<tr>
<td>9. 13 March</td>
<td>Medieval Europe</td>
<td>Early soda plant ash glass in northwestern Europe. Potash-lime glass industry. Stained glass windows. <em>Answers to data analysis exercise</em></td>
</tr>
<tr>
<td>10. 20 March</td>
<td>Renaissance and later glass; fakes and forgeries</td>
<td>Crystal glass and vitrum blanchum. Venetian, English, Bohemian crystal. Compositional change. Solvay process; saltcake glass. Trade beads and European expansion. Windows and portable XRF. Nineteenth century historicism and “fakes”</td>
</tr>
</tbody>
</table>

Please note: The details of this schedule (third column) may be adjusted as the course progresses. Videos marked with an asterisk (*) depend upon the time available.
Basic texts

The following books are good starters and references:


For an overview of current research agendas, see:


Methods of assessment

The course is assessed by an essay of 2850-3150 words (worth 75% of the total mark) plus a data interpretation exercise of 950-1050 words (worth 25%). Essay titles are given below; the data assessment exercise will be provided in week 5.

If you are unclear about the nature of an assignment, please contact the Course Co-ordinator. If you wish to discuss essay topics or prepare a brief (single-page maximum) outline of how you intend to approach the essay prior to writing the essay, I will be happy to discuss this.

Teaching methods

The course is taught primarily through the lectures delivered in the Monday sessions. As much of the primary information comprises numerical or graphical information, an assessed data interpretation exercise is set to ensure engagement with this type of information. Where appropriate and available, video recordings of ethnographic and/or archaeological work will be shown to illustrate the concepts covered in the course. Optional visits to the Petrie and British Museum will allow further opportunity to familiarise students with the course subject matter.

Workload

There will be 20 hours of lectures for this course. Students will be expected to undertake around 80 hours of reading for the course, plus 50 hours preparing for and producing the assessed work. This adds up to a total workload of some 150 hours for this course.

Optional visits and demonstrations

Optional museum visits take place on the mornings of Thursday 23 Feb (Petrie – handling session) and 9 March (British Museum – gallery talk), each lasting up to 60 minutes. For those who are not familiar with the analysis of materials, there will be an SEM demonstration on the afternoon of Wednesday 1 February. These will be delivered in groups, which will be arranged later.
2 AIMS, OBJECTIVES AND ASSESSMENT

Aims

The course aims to provide an understanding of the broad development and spread of glass, glazes and vitreous pigments in their archaeological and historical contexts from the Late Bronze Age up to the early modern period. It will introduce the technologies of glassmaking and glazing and their development over time. This includes an introduction to the concept of glass as a specific type of material, with specific properties. The course aims to illustrate how the production and use of glass in society is related to its chemical composition and properties and how these relationships changed over time. To do this the course strives to convey some of the basic chemical and physical processes relevant to the making, working and scientific analysis of glass and other vitreous materials such as glazes and synthetic pigments, following a broad chronological outline. A critical approach is encouraged by the inclusion of current research topics where there may be no universally accepted opinion, and where thinking is in flux as progress is being made.

Objectives

On successful completion of the course students will:

- Have a general understanding of glass as a material, glass raw materials and glass production
- Have a general understanding of the chronological development of glass forms and their relationship to technology and cultural context
- Have developed an understanding of compositional data on glass in tabular and graphical forms and be able to interpret the general technological and chronological significance of individual glass compositions (assessment 1)
- Be able to read, critically evaluate and synthesise evidence on early glass production from a range of approaches, including archaeometric analysis (assessment 2)
- Be able to recognise relevant evidence such as moils, industrial ceramics and other production waste.

Information for intercollegiate and interdepartmental students

Students enrolled in Departments outside the Institute should obtain the Institute’s coursework guidelines from Tina Paphitis (email t.paphitis@ucl.ac.uk), which will also be available on the IoA website. Inter-collegiate students should also contact Tina to obtain an information services username and password so you can access on-line reading material, available through the on-line reading list.
Coursework

The two pieces of assessed work required for this course are given below. If you are unclear about the nature of an assignment, please contact the Course Co-ordinator. If you wish to discuss essay topics or prepare a brief (single-page maximum) outline of how you intend to approach the essay prior to writing the essay, I will be happy to comment on this.

Word counts

All submitted work should include a word-count. The following are not included in the word-count: title page, contents pages, lists of figure and tables, abstract, preface, acknowledgements, bibliography, lists of references, captions and contents of tables and figures, appendices.

Penalties will only be imposed if you exceed the upper figure in the range. There is no penalty for using fewer words than the lower figure in the range: the lower figure is simply for your guidance to indicate the sort of length that is expected.

In the 2016-17 session penalties for overlength work will be as follows:

- For work that exceeds the specified maximum length by less than 10% the mark will be reduced by five percentage marks, but the penalised mark will not be reduced below the pass mark, assuming the work merited a Pass.

- For work that exceeds the specified maximum length by 10% or more the mark will be reduced by ten percentage marks, but the penalised mark will not be reduced below the pass mark, assuming the work merited a Pass.

Coursework submission procedures

- All coursework must normally be submitted both as hard copy and electronically.
- You should staple the appropriate colour-coded IoA coversheet (available in the IoA library and outside room 411a) to the front of each piece of work and submit it to the red box at the Reception Desk (or room 411a in the case of Year 1 undergraduate work).
- All coursework should be uploaded to Turnitin by midnight on the day of the deadline. This will date-stamp your work. It is essential to upload all parts of your work as this is sometimes the version that will be marked.
- Instructions are given below.

Note that Turnitin uses the term ‘class’ for what we normally call a ‘course’.

1. Ensure that your essay or other item of coursework has been saved as a Word doc., docx. or PDF document, and that you have the Class ID for the course (available from the course handbook) and enrolment password (this is IoA1617 for all courses this session - note that this is capital letter I, lower case letter o, upper case A, followed by the current academic year)
2. Click on http://www.turnitinuk.com/en_gb/login
3. Click on ‘Create account’
4. Select your category as ‘Student’
5. Create an account using your UCL email address. Note that you will be asked to specify a new password for your account - do not use your UCL password or the enrolment password, but invent one of your own (Turnitin will permanently associate this with your account, so you will not have to change it every 6 months, unlike your UCL password). In addition, you will be asked for a “Class ID” and a “Class enrolment password” (see point 1 above).
6. Once you have created an account you can just log in at http://www.turnitinuk.com/en_gb/login and enrol for your other classes without going through
the new user process again. Simply click on ‘Enrol in a class’. Make sure you have all the relevant “class IDs” at hand.
7. Click on the course to which you wish to submit your work.
8. Click on the correct assignment (e.g. Essay 1).
9. Double-check that you are in the correct course and assignment and then click ‘Submit’
10. Attach document as a “Single file upload”
11. Enter your name (the examiner will not be able to see this)
12. Fill in the “Submission title” field with the right details: It is essential that the first word in the title is your examination candidate number (e.g. YGBR8 In what sense can culture be said to evolve?),
13. Click “Upload”. When the upload is finished, you will be able to see a text-only version of your submission.
14 Click on “Submit”

If you have problems, please email the IoA Turnitin Advisers on ioa-turnitin@ucl.ac.uk, explaining the nature of the problem and the exact course and assignment involved.

One of the Turnitin Advisers will normally respond within 24 hours, Monday-Friday during term. Please be sure to email the Turnitin Advisers if technical problems prevent you from uploading work in time to meet a submission deadline - even if you do not obtain an immediate response from one of the Advisers they will be able to notify the relevant Course Coordinator that you had attempted to submit the work before the deadline

General policies and procedures concerning courses and coursework, including submission procedures, assessment criteria, and general resources, are available in your Degree Handbook and on the following website: http://wiki.ucl.ac.uk/display/archadmin. It is essential that you read and comply with these.

Assessment 1. Data Interpretation exercise

This will comprise a table of analyses of ten examples of ancient glass. You will be asked to produce a paper of 950-1050 words commenting on the likely raw materials, colour and chronology of each glass. The information needed to complete the exercise will be provided in the classes over weeks 1 -5. It is advisable to attend all the classes to optimize your result. There is no single source or textbook which deals with all of the issues. The exercise will be provided in Week 5 (6 February) and the submission date is Friday 24 February 2017. This exercise represents 25% of the assessment for the course.

Assessment 2. Essay

A 2850-3150 word essay comprises 75% of the assessment for this course. The deadline for submission via Turnitin and in hard copy is Monday 24 April 2017. You may choose from one of the titles listed below. Several references are provided as a starting point for your research into the topic. However, they may be neither the most recent nor the most pertinent research papers but simply pointers to the types of evidence or to the work of certain authors. You will need to research your essay using bibliographies and reference lists from books and articles as well as online tools such as Web of Science and Google Scholar. Academia.edu and Researchgate.net are useful sources of references from key authors such as Dungworth, Henderson, Jackson and Rehren. You are encouraged to register with those sites as the authors post pdf files of papers which are not available electronically elsewhere. You should design your searches carefully and search for authors as well as topics. A good answer is likely to include a range of references to the up-to-date literature as well as to older publications which set the topic in context.
A range of evidence is expected to be drawn upon which, dependent upon topic, might include archaeological, historical, archaeometric, experimental, materials science or ethnographic sources. Maps, graphs and tables are useful as they condense a great deal of information into a single item which is not part of the wordcount. I would expect to see the use of graphic or tabulated evidence in answers to most of the essay questions. Each should have a caption and be numbered sequentially as Fig 1, Fig 2…. or Table 1, Table 2 ……. Photographic images, plans and line drawings should also be labelled and captioned as Figs.. The sources of the images should be credited in the captions.

Essay Titles

1. Outline and discuss the evidence for the independent production of glass and faience from their raw materials in Europe (including Italy and Greece) in the Bronze Age


2. Explain how cobalt pigment varies in composition in ancient glass and glaze and, explain how its composition has been used in investigations of its provenance. Use examples from different periods, cultures and regions.


3. Outline the evidence for the occurrence, use and fabrication method(s) of glass windows in the Roman Empire.


4. **Summarise and discuss the evidence for the composition, provenance and manufacture of glass and glass beads in sub-Saharan Africa**


5. **Outline the development of lead crystal glass in the late seventeenth century. To what extent was “English” lead crystal glass an English innovation?**


6. **How was kelp produced and what is the evidence for its use in glass making?**


3. **SYLLABUS AND READING.**

Suggested reading of relevance throughout the course:

The journal *Journal of Archaeological Science* regularly has good-quality papers on glass and related topics, as do *Archaeological and Anthropological Sciences, Journal of Archaeological Science Reports* and *Archaeometry, Heritage Science* and *Journal of Cultural Heritage* increasingly publish articles on glass. The conference proceedings of the *Association Internationale de l'Histoire du Verre (AIHV)* (see web address below) are another good way to keep on top of current developments, and to research about all things glassy. Finally,
the *Journal of Glass Studies* is the trade journal of the academic glass history profession, and offers archaeological, art historical and scientific papers on the subject.

You should also be familiar with [Google Scholar](https://scholar.google.com), reached through the “More” dropdown menu on the Google search page. Use of appropriate keywords will take you to the majority of current literature in the area that you are researching. Follow up on a particular paper by looking at who has cited it recently and reading the most recent contributions.

Many authors now post their publications in on-line repositories such as [Academia.com](https://www.academia.edu) or [Research Gate](https://www.researchgate.net). These are good places to find book chapters and articles from conference proceedings which aren’t fully available in on-line form.

*A major collection of papers, covering a range of topics is:*

**Janssens K. (2013)** Modern Methods for Analysing Archaeological and Historical Glass. Wiley. Available on line through UCL Library. *Over 700 pages and 30 chapters focussing on the scientific aspects of glass, many of which are pertinent to the course and by well-known researchers. Available on-line through the library. Even so, take care. Books of this nature are not always comprehensively refereed and may not always be fully representative. You should always find a second source to confirm what you read. In the essays we will be looking for the use of primary research papers as references, rather than textbooks.]*

### Session 1. Introduction; Nature and properties of Glass

In this session we discuss glass as a material – how does it differ from other materials and what are its special properties? What are the essential components of glass and why does glass have such a characteristic range of compositions? Why are some glasses clear and transparent, others coloured and some opaque? Why does glass corrode and how does it affect our archaeological understanding? We will watch a video about a traditional glass workshop in Afghanistan and discuss what it tells us about the raw materials, the chaîne opératoire, the workshop and the working conditions of the craftspeople. We will also introduce some of the basic methods of chemical analysis.

**Key background reading**


[https://historicengland.org.uk/images-books/publications/glassworkingguidelines/](https://historicengland.org.uk/images-books/publications/glassworkingguidelines/)


**Bibliography**

Session 2 Bronze Age Vitreous Materials

There are a number of Near Eastern precursors to glass in the strict sense. These so-called vitreous materials are made from essentially the same components as glass but combined in different proportions using different production technologies. The best known of these are Egyptian blue and faience and they will be discussed in the present session. We will then move on to Late Bronze Age glass, core-forming and colourants.

Key background reading:


Tait, H., (1991), Five Thousand Years of Glass. British Museum Press, London. See the chapter at the end by Gudenrath for glass-working techniques


Bibliography specific to the lectures:

Note: some of the papers on a specific topic, e.g Egyptian Blue or Faience, cover much the same ground


Rehren T 1997 Ramesside glass colouring crucibles. Archaeometry 39/2, 355-368

Rehren, Th. & Pusch, E. 2005. Late Bronze Age Egyptian glass production at Qantir-Piramesses. Science 308, 1756-1759.


Further related reading


Session 3: Bronze Age Trade and Iron Age glass: the introduction of natron

A few years ago, we had only a limited understanding of the sources of Late Bronze Age glass and the movement and trade of this material. However, improvements in analytical methods and our understanding of production have allowed significant advances to be made in this area.

At some point in the late second-early first millennium BC, a major change in flux type occurred and glass makers began to move from the use of plant ash to natron. In addition, the use of sand as a source of silica slowly replaced the use of crushed quartz pebbles. These changes permitted the massive expansion in glass production which was to occur in the Hellenistic and Roman periods.

Key Background Reading


Late Bronze Age: Provenance


Venclova N et al. (2011) Late Bronze Age mixed-alkali glasses from Bohemia. Archeologick ústav Akademie vûd âR, Praha, vvi, p.559. [Comprehensive multi-authored paper on northern Italian made glass in the late Bronze Age and its occurrence across Europe. Find it on the web, e.g. Julian Henderson’s Academia page]

Iron Age Glass; Natron


Forming methods in the late Iron Age and early Roman period; the introduction of blowing

Session 4. The Roman glass industry

Natron-based glass was used West of the Euphrates River to the virtual exclusion of plant-ash based glass through most of the first millennium AD. For many years we were unable to determine the origins of this material but from the late 1990s, archaeological discoveries, advances in chemical analysis, and ethnographic work in India gave rise to a new model, which emphasises the division of production between a few primary workshops which made the glass, and a large number of secondary workshops which worked the glass. Most researchers are now careful to distinguish the terms “glass making” and “glass working”, which refer to distinct types of activity. As part of our understanding of these developments, we will discuss the use of chemical analyses to distinguish quite subtle differences between production centres. We will also discuss the important new developments in isotopic studies which are allowing advances in our understanding of glass origins and provenance.

Key Background Reading


Bibliography


**Colour in Roman glass**


**Session 5: Byzantine, Sasanian and Islamic glass**

While Roman glass was based upon the use of natron as a flux, east of the Euphrates, in the regions of the (Persian) Parthian and Sassanian Empires, glass continued to be made from plant ash, and compositions are not so different from those of the Bronze Age. Following the Arab expansion in the early seventh century CE, natron use continued but around 850 CE in Egypt, and at about the same time in the Levant, there was a switch back to plant ash. We will then discuss some of the compositions and technologies that are particularly associated with later Byzantine and Islamic glass focusing especially upon opaque glasses, enamelling and gold glass.

**Key Background Reading**


Shortland, A., Schachner, L., Freestone, I. & Tite, M., 2006. Natron as a flux in the early vitreous materials industry: sources, beginnings and reasons for decline. Journal Archaeological Science 33, 521-530. [outlines the issues but see Phelps et al 2016, for where we are now]

**Bibliography**


Entwistle, C. and James, L. eds., (2012). New light on old glass: recent research on Byzantine mosaics and glass. London: British Museum. [Good collection of papers, especially on coloured glass in mosaics; note the views expressed in the paper by Lierke are controversial]


**Session 6: Ceramic Glazes**

A glaze is a coating of glass on a ceramic body. While early glazes are compositionally related to the glass of contemporary vessels, marked difference develop later. An understanding of glazes cannot be attained without an understanding of the constraints placed by the firing of the ceramic body. In this session we will take a chronologically-based survey of ceramic glazes, from the Bronze Age to the Islamic period. Topics to be covered include alkali glazes, lead glazes and tin-glazes.

**Key Background Reading**


**Bibliography**


Session 7. Far eastern vitreous materials
This session covers some of the remarkable ethnographic evidence from India for early techniques; the different compositions of Indian glasses; and the very different trajectory of vitreous materials development in China.

Key Background Reading


Bibliography

Chinese and East Asian glass


**Chinese Glazes**


**India and South Asia**


Session 8: Enamels on Metal, Early Medieval Europe and Recycling

Where was glass obtained when the Romans left northern Europe in the fifth century? To what extent was a reservoir of old Roman glass recycled, as opposed to the importation of fresh material? In this session we will look at recycling in some detail. There are interesting examples from the craft of enamelling, which produced some of the most beautiful objects of the medieval period.

Key Background Reading


Bibliography

Early medieval glass; recycling


**Glass on metal**


Session 9 Medieval Europe: Potash-lime glass and stained glass windows

New coloured and opaque glasses were introduced to northern Europe as the reservoir of old Roman glass declined and demand increased. Plant ash glass from the Mediterranean appears in the form of high quality vessels. Coloured window glass represents the major output of medieval glasshouses in northern Europe and was an important material in medieval buildings. How was it made and how did it develop? To what extent was it a “new” technology and to what extent derived from earlier practices? Archaeological approaches can tell us a good deal about this technology, which has been traditionally the domain of art historians.

Bibliography


Session 10 Renaissance and later glass

From the Renaissance, the glass industries undergo more rapid change. The search for clear, colourless “crystal” leads to the development of several diverse formulations and close attention to the purity of raw materials. Eventually, industrially produced chemicals and new colourants such as chromium and uranium lead to glass which is broadly similar to earlier materials but very different in detail. This is fortunate, as it allows us to separate the many nineteenth century copies (so-called “fakes”) from genuinely ancient items. Fakes and Forgeries and their detection by chemical techniques provide a good overview of aspects of the course.


Cable M and Smedley I W (1987) "Liquidus temperatures and melting characteristics of some early container glasses." Glass Technology 28, 94-98.


MacLeod, C., 1987, Accident or Design? George Ravenscroft’s patent and the invention of lead-crystal glass. Technology and Culture 28, 776-803.


4 ONLINE RESOURCES

An online reading list is available for this course. Please note that according to the digital licence, these readings are only available to our own students and staff. Intercollegiate students taking the course should contact Judy Medrington to be registered for a college IS username and password. This should be done when students register for the course.

Useful websites include:

www.romanglassmakers.co.uk. Masses of material about glassworking techniques and furnaces

www.cmog.org Corning Museum of Glass. Search the collection on-line; on-line glass dictionary; “underwater archaeology” video on the Ulu Burun wreck; Timeline of glass; Catalogue of the Rakow Research Library. See some of the helpful information and videos in the “Research” section of the site.

http://www.afaverre.fr/acteurs_bibliographie.php French Association for the Archaeology of Glass has lists of publications of many of those active in the field. On-line copies of Bulletin which has some very useful short articles.


https://www.google.com/culturalinstitute/collection/the-british-museum?f.text=glass&v.view=grid This fine collection of British Museum objects may be seen on the website of the Google Cultural Institute. It used to be available on the BM website, prompting us to reflect upon the nature of cultural imperialism in a globalised market economy.

http://www.historyofglass.org.uk/index.html The British Association for the History of Glass (AHG). Produces a Newsletter and holds one or two meetings per annum. Also provides grants for glass researchers (including students) to attend conferences and complete projects.

www.academia.edu Many researchers (e.g. Julian Henderson, Caroline Jackson, Thilo Rehren) have their own pages and upload their research papers to this site which are freely downloadable. Search on their names. (NB. You may have to register to access the site, do so as a “graduate student” and put your course or module coordinator down as supervisor).

http://www.beadresearch.org Excellent resource on beads, including glass beads. Downloadable annotated bibliographies of various aspects of beads, including technology and archaeometry.

Google Scholar. Use of the appropriate keywords and author names will produce a far more focussed result than a normal Google web search.

Google images. For pictures of glass vessels.

5 ADDITIONAL INFORMATION

Important Collections of Glass in London:

The British Museum – has the best collection of ancient glass in the world, spread through its galleries, as well as arguably the best ceramics collection. The Percival David Gallery of Chinese ceramics has the best porcelain and stoneware you are likely to see anywhere
The Victoria and Albert Museum – has an excellent gallery devoted to glass, including pull out display cases allowing the reserve collection to be viewed. Also excellent ceramic galleries

The Museum of London – Excavated material from London’s Roman glass workshops and a good range of glass and ceramic artefacts through the galleries

The Petrie Museum - Material from excavations in Egypt, in archaeological context
**APPENDICES: SUPPORTING MATERIAL**

G111 Glass and Glazes: Some chronological terms used in the course

<table>
<thead>
<tr>
<th>Year BCE</th>
<th>East Mediterranean</th>
<th>Mesopotamia</th>
<th>Western Europe</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 BCE</td>
<td>Late Bronze Age</td>
<td>Late Bronze Age</td>
<td>Late Bronze Age</td>
<td>Shang</td>
</tr>
<tr>
<td>1000 BCE</td>
<td>Iron Age</td>
<td>Iron Age</td>
<td>Iron Age</td>
<td>Zhou</td>
</tr>
<tr>
<td>500 BCE</td>
<td>Hellenistic</td>
<td>Achaemenid</td>
<td>Warring States</td>
<td></td>
</tr>
<tr>
<td>CE-BCE</td>
<td>Roman</td>
<td>Hellenistic</td>
<td>Han Dynasty</td>
<td></td>
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<tr>
<td></td>
<td>Sasanian</td>
<td>Parthian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 CE</td>
<td>Byzantine</td>
<td>Early Medieval</td>
<td>Tang Dynasty</td>
<td></td>
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<tr>
<td></td>
<td>Islamic</td>
<td>Islamic</td>
<td></td>
<td></td>
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<tr>
<td>1000 CE</td>
<td></td>
<td></td>
<td>High Medieval</td>
<td>Song</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Yuan</td>
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<tr>
<td>1500 CE</td>
<td>Renaissance</td>
<td></td>
<td>Yuan</td>
<td>Ming</td>
</tr>
<tr>
<td></td>
<td>Post-medieval</td>
<td></td>
<td></td>
<td>Ming</td>
</tr>
<tr>
<td></td>
<td>(Early modern)</td>
<td></td>
<td></td>
<td>Qing</td>
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</tbody>
</table>

*Health Warning:* this table is to allow those unfamiliar with archaeological chronologies to more-or-less fit things together; it should not be considered definitive in any way
### G111: Simplified Chart of Chinese Dynastic Periods and Glass and Ceramic Development

<table>
<thead>
<tr>
<th>Dynasty</th>
<th>Period</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xia</td>
<td>2100-1600</td>
<td>First ash glazes</td>
</tr>
<tr>
<td>Shang</td>
<td>1600-1046</td>
<td></td>
</tr>
<tr>
<td>Zhou</td>
<td>1046-256</td>
<td></td>
</tr>
<tr>
<td>Western Zhou</td>
<td>1046-771</td>
<td>Imported faience&lt;br&gt;Chinese faience (potassic flux)&lt;br&gt;Proto-porcelain well developed</td>
</tr>
<tr>
<td>Eastern Zhou</td>
<td>770-256</td>
<td></td>
</tr>
<tr>
<td>Spring and Autumn period</td>
<td>770-476</td>
<td>Imported eye beads&lt;br&gt;Chinese Blue and Purple pigments&lt;br&gt;Proto-porcelain well developed</td>
</tr>
<tr>
<td>Warring States period</td>
<td>475-221</td>
<td>Coloured glazed beads and pigment coated vessels</td>
</tr>
<tr>
<td>Qin Dynasty</td>
<td>221-206</td>
<td>Terracotta warriors</td>
</tr>
<tr>
<td>Han Dynasty</td>
<td>202 BCE – 220 CE</td>
<td>Low-fired lead glazed ceramics&lt;br&gt;Glass funerary suits&lt;br&gt;Yue celadons emerged in the end of this period</td>
</tr>
<tr>
<td>Three Kingdoms</td>
<td>220-265</td>
<td>Yue celadons well developed</td>
</tr>
<tr>
<td>Jin</td>
<td>265-420</td>
<td>Yue celadons well developed</td>
</tr>
<tr>
<td>Northern and Southern Dynasties</td>
<td>420-589</td>
<td>Celadons popular</td>
</tr>
<tr>
<td>Sui Dynasty</td>
<td>581-618</td>
<td>White porcelain</td>
</tr>
<tr>
<td>Tang Dynasty</td>
<td>618-907</td>
<td>Pattern of Southern Celadons and Northern White&lt;br&gt;Xing &amp; Ding porcelaneous ware&lt;br&gt;Sancai (3 colour) lead glazes</td>
</tr>
<tr>
<td>Five Dynasties &amp; Ten Kingdoms</td>
<td>907-960</td>
<td></td>
</tr>
<tr>
<td>Northern Song</td>
<td>960-1127</td>
<td>Guan, Ge, Ding, Ru &amp;Jun, the so-called five major kilns</td>
</tr>
<tr>
<td>Southern Song</td>
<td>1127-1279</td>
<td>Qingbai porcelain&lt;br&gt;Longquan celadon</td>
</tr>
<tr>
<td>Yuan</td>
<td>1270-1368</td>
<td>Underglaze blue and white</td>
</tr>
<tr>
<td>Ming</td>
<td>1368-1644</td>
<td>Copper “sacrificial” red monochrome glazes&lt;br&gt;Polychrome porcelains</td>
</tr>
<tr>
<td>Qing</td>
<td>1644-1911</td>
<td>Jesuits help establish imperial glass workshop&lt;br&gt;Enamelled ceramic wares: Famille Verte, Famille Rose, Famille Noire</td>
</tr>
</tbody>
</table>

Only use this table as a general guide. Both the dynastic chronologies and the materials development are very simplified. Only some of the major ceramic wares are mentioned.
Main Compositional Types of Archaeological Glass (Mediterranean, West Asia and Europe)

Depend upon the flux used to lower the melting temperature of the silica:

(1) Natron from Egypt (soda-rich)
(2) Plant ash from hot countries (soda-rich)
(3) Wood ash from temperate Europe (potash rich)

Chronological ranges of main glass types:

<table>
<thead>
<tr>
<th></th>
<th>BC</th>
<th>AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant ash</td>
<td>1500</td>
<td>1000</td>
</tr>
<tr>
<td>Natron</td>
<td>0</td>
<td>500</td>
</tr>
<tr>
<td>Potash</td>
<td>500</td>
<td>1000</td>
</tr>
</tbody>
</table>

Glasses made from soda-rich plant ash and natron can be distinguished by their contents of potash and magnesia, which are higher in plant ash glass (plant ash has more impurities).
### The use of opacifiers in glass through the ages

#### OPACIFYING AGENTS IN GLASS, 1450 B.C. TO A.D. 1961

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>TYPE OF GLASS</th>
<th>OPACIFYING AGENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1450 B.C. to fourth century A.D.</td>
<td>Opaque white and blue</td>
<td>Ca$<em>{3}$Si$</em>{2}$O$_{9}$</td>
</tr>
<tr>
<td></td>
<td>Opaque yellow</td>
<td>(occasionally CaSi$<em>{2}$O$</em>{9}$)</td>
</tr>
<tr>
<td></td>
<td>Opaque red</td>
<td>Cubic Pb$<em>{3}$Si$</em>{2}$O$_{9}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cu$_{2}$O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cu$_{2}$O + Cu or Cu</td>
</tr>
<tr>
<td>Fifth century A.D. to seventeenth century A.D.</td>
<td>Opaque white and blue</td>
<td>SnO$_{2}$ usually</td>
</tr>
<tr>
<td></td>
<td>Opaque yellow and green</td>
<td>3Ca$_{3}$O$(PO_4)_3$, CaF$_3$, CuF$_3$, PbF$_2$</td>
</tr>
<tr>
<td></td>
<td>Opaque red</td>
<td>occasionally</td>
</tr>
<tr>
<td>Eighteenth century A.D. to present day</td>
<td>Opaque white</td>
<td>Cu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cu + Cu$<em>{2}$O rarely or Cu + SnO$</em>{2}$, sometimes</td>
</tr>
</tbody>
</table>

Taken from Rooksby H P (1962) Opacifiers in opal glasses through the ages. *GEC Journal* 29, 20-26
Old now, but still more-or-less true.
### Some Glaze Compositions

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali Glaze</td>
<td>14</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
<td>11</td>
</tr>
<tr>
<td>Lead Glaze</td>
<td>4</td>
<td>0.5</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Lead Glaze</td>
<td>6</td>
<td>0.5</td>
<td>1</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Feldspathic Glaze</td>
<td>0</td>
<td>60</td>
<td>30</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Salt Glaze</td>
<td>70</td>
<td>30</td>
<td>56</td>
<td>64</td>
<td>65</td>
</tr>
<tr>
<td>soda Na₂O</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>potash K₂O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lime CaO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lead PbO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>silica SiO₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>alumina Al₂O₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Typical of pre-Roman Near Eastern pottery, Egyptian faience, and some later Islamic-period wares. Made by applying glass frit or a glaze mixture to the surface (in the case of some faience, by efflorescence). Low maturing range, around 900-1000°C. Corrodes easily, depending on lime content (sometimes lower than that shown here, especially in faience). Not a good fit to body, often crazed.

2. Typical of medieval wares in Britain and Europe. Forms as a reaction between galena (PbS), or lead oxide, and clay, while the pot is fired. Matures around 800-900°C. Alumina content is derived from the body. Often slightly corroded.

3. Typical of post-medieval wares, this is from 18th C English porcelain. Note lower lead content, matures around 1000-1100°C. The glaze is applied as a frit to the surface of the ware.

4. Typical of hard paste porcelains and stonewares, this is from Chinese celadon. The high alumina is derived from the use of clay in the glaze mixture. This means that the glaze has a high maturing temperature 1200-1350°C. The high alumina also makes the glaze very resistant to corrosion.

5. Salt glazes are formed by a reaction between alkali vapour and clay body. They are essentially clay plus soda and are fired at around 1150-1250°C. High alumina means very resistant to corrosion, so although they are very thin, they often come out of the ground looking good.
Compositions of some enamels on metalwork

Celtic opaque red enamel

<table>
<thead>
<tr>
<th></th>
<th>Iron Age/Romano-British</th>
<th>Early Medieval</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>silicon dioxide</td>
<td>41</td>
</tr>
<tr>
<td>CaO</td>
<td>calcium oxide</td>
<td>3.9</td>
</tr>
<tr>
<td>Na₂O</td>
<td>sodium oxide</td>
<td>10.6</td>
</tr>
<tr>
<td>PbO</td>
<td>lead oxide</td>
<td>32</td>
</tr>
<tr>
<td>CuO</td>
<td>copper oxide</td>
<td>6.4</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>aluminium oxide</td>
<td>1.8</td>
</tr>
<tr>
<td>FeO</td>
<td>iron oxide</td>
<td>0.6</td>
</tr>
<tr>
<td>MgO</td>
<td>magnesium oxide</td>
<td>0.6</td>
</tr>
<tr>
<td>K₂O</td>
<td>potassium oxide</td>
<td>0.5</td>
</tr>
<tr>
<td>SnO₂</td>
<td>tin oxide</td>
<td>0.4</td>
</tr>
<tr>
<td>Sb₂O₃</td>
<td>antimony oxide</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Comment – these are high lead glasses and easy to melt. The Iron Age glass was probably made by adding lead and copper oxide to a pre-existing soda-lime-silica glass base; the early medieval is a simpler copper-lead-silica composition. Both are opaque red due to the presence of dendritic crystals of cuprite, care is required to maintain the glass in a reduced state while heating.

Mosan enamel (Romanesque, 12th century, made in the Liège region)

<table>
<thead>
<tr>
<th></th>
<th>Green</th>
<th></th>
<th>Turquoise</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mosan enamel</td>
<td>Roman mosaic</td>
<td>Mosan enamel</td>
<td>Roman mosaic</td>
</tr>
<tr>
<td>Na₂O</td>
<td>16.4</td>
<td>17.4</td>
<td>16.6</td>
<td>18.1</td>
</tr>
<tr>
<td>MgO</td>
<td>0.5</td>
<td>0.7</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>2.2</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>SiO₂</td>
<td>63.6</td>
<td>65.6</td>
<td>65.7</td>
<td>66.2</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.5</td>
<td>0.7</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>CaO</td>
<td>5.5</td>
<td>6.2</td>
<td>5.3</td>
<td>6.0</td>
</tr>
<tr>
<td>FeO</td>
<td>0.6</td>
<td>0.7</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>MnO</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>CuO</td>
<td>2.9</td>
<td>1.5</td>
<td>2.3</td>
<td>2.0</td>
</tr>
<tr>
<td>PbO</td>
<td>4.8</td>
<td>2.8</td>
<td>2.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Sb₂O₃</td>
<td>1.0</td>
<td>0.6</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Comment - These are soda-lime-silica glasses, made opaque by fine particles of lead antimonate (green) and calcium antimonate (turquoise). The medieval enamels are very similar in composition to analyses of Roman mosaics and it is generally accepted that the twelfth century author Theophilus was correct when he described the removal of glass tesserae from Roman wall mosaics to make enamels and coloured window glass. These compositions are stable in the museum environment, although, like many glasses, they will corrode in the soil.
Methods of Analysis
The Scanning Electron Microscope - How it works...

1. The image

The SEM consists of a column which is kept under vacuum. Electrons are generated from a filament at the top of the column and pass down it due to a potential difference of thousands of volts.

The electrons are focused on the object by "lenses" which are magnets. Scanning coils move the electron beam backwards and forwards across the sample (just like the cathode ray tube in an old TV or computer screen).

When the electrons hit the surface of the object, more electrons are knocked out of the surface ("secondary electrons"). These are registered by the secondary electron detector, which interfaces with an amplifier to give a TV image of the sample.

Advantages over a light microscope:

Very high magnifications – can easily see features less than one thousandth of a millimetre.
Hills and valleys in focus at the same time
Very sharp images

Features rich in heavy elements (metals such as copper, lead and iron) appear brighter than those rich in light elements – reveals the microstructure of alloys, ceramics etc.
2. Chemical analysis

In addition to secondary electrons, X-rays are given off from the sample. These depend on the chemical elements present. The energies of the X-rays correspond to different elements and the amounts of the X-rays give the amounts of the elements.

So it is possible to get a chemical analysis of a single spot, or of an area being scanned.

Energy dispersive analysis in the SEM (SEM-EDXA) allows us to:
- Analyse a small area of an artefact – e.g. a coating on metal or a glaze on pottery or a mineral inclusion
- Analyse a very small sample – e.g. a tiny fragment of glass or a shaving of metal

Its main limitation is that it can only detect the major and some minor elements – those present at levels above about 0.1%. It can’t analyse trace elements.

Other limitations include the need for a flat sample for a good analysis; the need to coat the sample with a conductive material such as carbon.
Other methods of analysis you will encounter in the Literature

**Electron Microprobe (EPMA)** – sophisticated type of SEM which uses wavelength rather than energy dispersive analysis (WDS vs EDS). Advantageous as it gives good analysis of minor elements, especially antimony and tin which can be problematic with SEM-EDS. These methods require solid samples of only a few millimetres diameter.

**Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)** A good method for the analysis of trace elements. Usually coupled with EPMA for the major elements. Needs a sample to be dissolved in acid. However, laser ablation ICP-MS (LA-ICP-MS) is almost always used on glass, which requires removal of a minute sample (less than 1 mm across). It works by ablating the surface of the sample with a laser and sucking the ablated material up into the spectrometer. The technique can be used “non-destructively” for small artefacts such as beads, which will fit into the sample chamber. The best labs can use LA-ICPMS to analyse both major and trace elements.

**Hand held or portable X-ray fluorescence spectrometry (pXRF or hhXRF).** “Non-destructive” method which gives unreliable numbers in many cases because of the need for a flat sample and surface corrosion and dirt and because of limitations of the manufacturer’s correction programmes. Exceptions to this generalization are the work of the group under Prof Nakai from Japan where the results get pretty close to those of EPMA and David Dungworth’s work on post-medieval window glass where the windows are flat (naturally) and pretty well cleaned so there is not a surface layer of dirt and corrosion.

**X-ray diffraction (XRD)** This tells you the crystals (opacifiers) present in the glass, but glass itself is non-crystalline so it does not give the composition of the glass. Every year, somebody suggests the use of XRD for the analysis of glass chemistry in their essay. DON’T MAKE THIS MISTAKE!

**Raman Spectrometry.** Capabilities a bit like XRD, in that it gives the opacifiers present. Used in such a way, it can be a useful non-destructive method for glass. However, it does not give a chemical composition and is only occasionally used in glass studies. Again, you are unlikely to find papers using Raman useful in the context of this course.

**Isotope Analysis.** Usually carried out using Thermal Ionisation Mass Spectrometry (TIMS) or a special form of ICP-MS called Multi-Collector ICPMS (MC-ICP-MS). These are highly expensive instruments and specialized techniques and access to specialist laboratories is needed to use them. Isotopic studies are very useful in the characterization and provenance of certain glass types.
Elements in Glass and Glazes

Major and minor elements

<table>
<thead>
<tr>
<th>Element Symbol</th>
<th>Name</th>
<th>Oxide</th>
<th>Informal oxide name</th>
<th>Typically added as</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>Silicon</td>
<td>SiO₂</td>
<td>Silica</td>
<td>Sand</td>
</tr>
<tr>
<td>Al</td>
<td>Aluminium</td>
<td>Al₂O₃</td>
<td>Alumina</td>
<td>Sand</td>
</tr>
<tr>
<td>Fe</td>
<td>Iron</td>
<td>FeO/Fe₂O₃</td>
<td></td>
<td>Sand (colourant)</td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
<td>MnO</td>
<td>Sand (colourant/decourant)</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>Magnesium</td>
<td>MgO</td>
<td>Magnesia</td>
<td>Sand/flux</td>
</tr>
<tr>
<td>Ca</td>
<td>Calcium</td>
<td>CaO</td>
<td>Magnesia</td>
<td>Sand/flux</td>
</tr>
<tr>
<td>Na</td>
<td>Sodium</td>
<td>Na₂O</td>
<td>Soda</td>
<td>Flux</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
<td>K₂O</td>
<td>Potash</td>
<td>Flux</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorus</td>
<td>P₂O₅</td>
<td>Phosphate</td>
<td>Flux (plant ash)</td>
</tr>
<tr>
<td>Pb</td>
<td>Lead</td>
<td>PbO</td>
<td></td>
<td>Flux/colourant</td>
</tr>
<tr>
<td>Sb</td>
<td>Antimony</td>
<td>Sb₂O₅</td>
<td></td>
<td>Opacifier/colourant</td>
</tr>
<tr>
<td>Sn</td>
<td>Tin</td>
<td>SnO₂</td>
<td></td>
<td>Opacifier</td>
</tr>
<tr>
<td>Cu</td>
<td>Copper</td>
<td>Cu₂O/CuO</td>
<td></td>
<td>Colourant</td>
</tr>
</tbody>
</table>

Major element analyses are usually given as weight percent oxide, e.g. 71.3% SiO₂

Some Trace Elements of interest

| B   | Boron  |
| Co  | Cobalt |
| Ni  | Nickel |
| Cr  | Chromium |
| Ti  | Titanium |
| Ag  | Silver |
| As  | Arsenic |
| Au  | Gold |
| Zr  | Zirconium |
| Rb  | Rubidium |
| Sr  | Strontium |
| Ba  | Barium |
| La  | Lanthanum |
| Ce  | Cerium |
| Nd  | Neodymium |
| U   | Uranium |
| Th  | Thorium |

Trace element analyses are usually reported as parts per million, e.g. 33 ppm La. (Sometimes you will see this expressed as milligrams per kilogram which is essentially the same number).

100% = 1, 000, 000 ppm
10% = 100, 000 ppm
1% = 10, 000 ppm
0.1% = 1, 000 ppm
0.01% = 100 ppm
IMPORTANT: INSTITUTE OF ARCHAEOLOGY COURSEWORK PROCEDURES

General policies and procedures concerning courses and coursework, including submission procedures, assessment criteria, and general resources, are available on the IoA website. It is essential that you read and comply with these. Note that some of the policies and procedures will be different depending on your status (e.g. undergraduate, postgraduate taught, affiliate, graduate diploma, intercollegiate, interdepartmental). If in doubt, please consult your course co-ordinator.

GRANTING OF EXTENSIONS: Note that there are strict UCL-wide regulations with regard to the granting of extensions for coursework. Note that Course Coordinators are not permitted to grant extensions. All requests for extensions must be submitted on a the appropriate UCL form, together with supporting documentation, via Judy Medrington’s office and will then be referred on for consideration. Please be aware that the grounds that are acceptable are limited. Those with long-term difficulties should contact UCL Student Disability Services to make special arrangements. Please see the IoA website for further information. Additional information is given here: http://www.ucl.ac.uk/srs/academic-manual/c4/extenuating-circumstances/

G111 Course Schedule (Term 2, 2016-17, Mondays 09.00-11.00)

<table>
<thead>
<tr>
<th>Week</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 9 January</td>
<td>Nature and Properties of Glass</td>
</tr>
<tr>
<td>2. 16 January</td>
<td>Late Bronze Age vitreous materials</td>
</tr>
<tr>
<td>3. 23 January</td>
<td>Pre-Roman glass – trade and technological change</td>
</tr>
<tr>
<td>4. 30 January</td>
<td>The Roman glass industry</td>
</tr>
<tr>
<td>5. 6 February</td>
<td>Byzantine, Sasanian and Islamic glass</td>
</tr>
<tr>
<td>Reading week</td>
<td>13-17 February</td>
</tr>
<tr>
<td>6. 20 February</td>
<td>Ceramic Glazes</td>
</tr>
<tr>
<td>7. 27 February</td>
<td>Far eastern glass. glazes and vitreous pigments</td>
</tr>
<tr>
<td>8. 6 March</td>
<td>Early medieval (post-Roman) glass, glass enamels on metalwork.</td>
</tr>
<tr>
<td>9. 13 March</td>
<td>Medieval Europe</td>
</tr>
<tr>
<td>10. 20 March</td>
<td>Renaissance and later glass; fakes and forgeries</td>
</tr>
</tbody>
</table>

Assessment deadlines:

Assessment 1 (data) due Friday 24 February
Assessment 2 (essay) due Monday 24 April