GEOARCHAEOLOGY IN THE A-LEVEL CLASSROOM: COMMUNICATING ARCHAEOLOGICAL INTERDISCIPLINARITY

by

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ABSTRACT

Geoarchaeology is a discipline that has difficulty with communication, in part because academia struggles with interdisciplinarity. To improve the communication of this field, a teaching pack was developed for a foundational level – communication to novice geoarchaeologists. The teaching pack was modified through pre-interviews with teachers and trialled in two A-level classes – classical civilisation and geography. In-class observations, student feedback and pre-post knowledge questionnaire data suggest that the teaching pack was successful at engaging students and teaching them foundational geoarchaeology concepts. Students averaged a high learning gain (0.42) that did not differ significantly between groups, suggesting that students of varying backgrounds (current and previous classes enrolled, gender) were able to achieve an equal outcome. Student perceptions of geoarchaeology and archaeological interdisciplinarity, measured on the pre-post questionnaire, became more expert-like after the teaching pack. Student and teacher feedback were used to make final revisions to the teaching pack, which is ready for wider implementation. Geoarchaeological communication at all levels would benefit from closer attention to an interdisciplinary studies structure that separates individual disciplinary knowledge, perspectives and analyses before combining them through synthesis. This should be supported by relevant, practical examples of a challenging level and guided considerably. These findings may be extrapolated to other interdisciplinary fields of archaeology and have important implications for cross-disciplinary university recruitment.

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INTRODUCTION

Geoarchaeology is a rich field that provides unique approaches to questions of landscape and environment, by fusing the geosciences with archaeology. It is interdisciplinary and many of its practitioners would consider themselves interdisciplinarians (e.g. Donahue and Adovasio, 1985). Geoarchaeology is just one of many interdisciplinary fields in archaeology, including zooarchaeology, archaeobotany and paleoanthropology, among others. Many archaeologists appreciate the interconnectedness of humans with their environments and utilise these connections in their many approaches to questions of past inhabitance. Despite this, the confluence of various disciplines is relatively seamless and not readily apparent to novice or even some expert archaeologists.

Most practitioners of geoarchaeology consider it a driver of conceptual questions and an integrated component of archaeological studies, rather than simply an application of earth science techniques (e.g. Butzer, 1982; Canti, 2001). Environmental archaeology, where geoarchaeology is sometimes nested, grapples with many similar problems in its quest to be understood by the archaeological community as a whole (e.g. Albarella, 2001). These issues largely take root in the processual/post-processual debate (e.g. Patterson, 1990), as well as questions regarding the inclusion of science and interdisciplinarity within archaeology (e.g. Boivin, 2005; Martin, 2005). It is often challenging to be interdisciplinary in any subject, working within the confines of the traditional higher education system.

There are, however, many benefits to being interdisciplinary. "Interdisciplinary studies" generally recognise the positive impact of a broader learning environment with a focus on building skills that are transferable and applicable to almost any scenario, through programmes or modules (e.g. Squires et al., 1975). Individual activities or exercises may even introduce issues and perspectives of interdisciplinarity, though with a restricted context, theme or problem.

The complexity of these settings and problems is hierarchical and the student expertise necessary to understand them follows as such. At a most basic level, teaching the appreciation and skills of interdisciplinarity is possible in a limited setting or with a novice group, though it may be more challenging and require further attention to planning (e.g. Singer et al., 2005; Brown et al., 2011).

Although a considerable effort in planning, background research and design is needed, the secondary school setting provides an exciting range of benefits for the introduction of interdisciplinary connections. Not only do students build transferable skills and gain an appreciation of interdisciplinarity, they get exposure to content from a connecting field that they otherwise may not have been familiar with. Teachers are not always versed in the specifics of interdisciplinary teaching or the content of the related field and may also gain the chance to broaden their own perspectives and abilities.

This study approaches geoarchaeological communication through education, using novice students as a model for a foundation leading to increased complexity. An interdisciplinary teaching pack on geoarchaeology for A-level classes has been developed using informed approaches to teaching and learning, with attention to explicit learning objectives (e.g. Simon and Taylor, 2009). This development will be placed in the context of prior research and assessed using several robust methods of data collection and analysis. Finally, the implications of the findings will be articulated and summarised, with attention to an improved capacity for communication with the wider academic community.

RESEARCH CONTEXT

Geoarchaeology combines the geosciences with archaeology to address critical questions of inhabited landscapes. It utilises techniques from these individual disciplines, but most importantly it asks fundamentally new archaeological questions.

This definition has evolved through the development of geoarchaeology and is still a contentious issue today when it comes to its integration with archaeological work.

Many of these issues occur because it is difficult to be interdisciplinary in the traditional academic setting and therefore, difficult to communicate an interdisciplinary field. However, there are benefits to incorporating interdisciplinary work in academia and some are successful at communicating it. Teaching and learning approaches and techniques, or "pedagogy", exist for both geoarchaeology and interdisciplinary studies at a variety of levels, offering grounded examples of communication. Through an analysis of the theoretical developments of the fields of geoarchaeology and interdisciplinary studies and their connections to practical developments in education, a broader understanding of the academic communication of geoarchaeology may be achieved.

GEOARCHAEOLOGY: A BRIEF HISTORY

Before attempting to communicate geoarchaeology, regardless of setting, an understanding of the discipline itself is necessary. What follows is a description of the evolution of geoarchaeology focused on the early 1960's through to the current day. Connections between the earth sciences and archaeology certainly existed prior to this (see Pollard, 1999 for a discussion), but it is during the last fifty years that the field has become increasingly well defined. Near continuous discussion over its definition and place within the archaeological community has helped to shape its current state (e.g. Davidson and Shackley, 1976; Butzer, 1982; Pollard, 1999); however, this state is by no means uniformly agreed upon (e.g. Canti, 2001; Fouache, 2007). This description is not intended to be exhaustive, but to highlight several critical stages in geoarchaeology and their associated works. Discussion regarding the state of geoarchaeology has not occurred in isolation, and where relevant, connections with "mainstream archaeology" (Luff and Rowley-Conwy, 1994, p.2) are made. Echoing many other authors, it is in the spirit of continual reflexivity that this is written.

Early moves to integrate science and the scientific method

Geoarchaeology was formally established when science was increasingly being considered in the archaeological world. As the push to pay closer attention to the scientific method became widespread, many workers looked towards other sciences for methods and concepts (Davidson and Shackley, 1976). This movement was later termed the "new archaeology" or "processual archaeology" (e.g. Binford, 1962; Butzer, 1971; Binford, 1972) and drove others to define "post-processual archaeology" (e.g. Hodder, 1986; Shanks and Tilley, 1987; Tilley, 1990). The new archaeology emphasised the tenets of the scientific method: formation of a theory, construction of a model and the testing of hypotheses (Earle and Preucel, 1987). Through this lens, culture was looked upon as a process within an ecosystem (Trigger, 2006). In the wake of processual archaeology, many new and increasingly specialised sub-disciplines were articulated (Earle and Preucel, 1987), one of which was geoarchaeology.

Incorporating the geosciences

Explicit connections with branches of science began to be utilised in archaeology. The geosciences were a natural fit for many; in fact, many of the earliest archaeological investigations were conducted by geologists (e.g. Butzer, 1982, p.35; Rapp and Hill, 1998, p.5). Colin Renfrew made possibly the earliest reference to the term "geoarchaeology", reiterated in the introduction of one of the first volumes of the field, Davidson and Shackley's *Geoarchaeology: Earth Science and the Past* (1976): "...every archaeological problem starts as a problem in geoarchaeology" (p.2). This collection of papers was largely methods-focused, arguing that using techniques from the physical and biological sciences was a "current trend in archaeology" (Davidson and Shackley, 1976, p.vii). Binford (1972) termed this the "methods explosion" (p.452) and although it was a considerable first step for geoarchaeology, it

did not give much credence to the theories and approaches that could be integrated from the geosciences.

Butzer's early writings in *Environment and Archaeology* (1972) covered some of the possible contributions of the biological and earth sciences to archaeology, but it was the later *Archaeology as Human Ecology* (1982) and the move away from the techniques-based definition of that solidified the place of these disciplines in the archaeological realm. In this work, human-environment interactions were detailed and synthesised in comprehensive models. These models were central to the conceptual approach that Butzer advocated; one that moved geoarchaeology beyond a suite of techniques that could be applied to archaeological materials (p.xii). He argued that geoarchaeology needed to be integrated into archaeological research questions and that this interdisciplinary approach would improve objectivity in interpretation (p.42). The types of research questions asked are what differentiates "archaeological geology" from "geoarchaeology", the former being heavily geologic questions that may be applied to archaeology (p.5). With any of these approaches, Butzer cautioned against the tendency for geoarchaeologists to preference physical explanations over human ones (p.39).

The post-processual movement

As early geoarchaeological works were beginning to be more widely considered, the post-processual movement was being established. Critics of processualism were arguing for a more anthropological archaeology (e.g. Hodder, 1986; Shanks and Tilley, 1987; Tilley, 1990). At a general level, they argued that processualism was too reductionist and objective, and that it didn't allow for enough human agency (e.g. Patterson, 1990; Preucel, 1995). The arguments of the "radical critique" were more extreme: processualism was a failure, it was unconscious of its own biases and it saw science as a standalone (Clark, 1993, p.206). Although Butzer (1982) had warned against the privileging of environmental agency (p.39), the way in

which the systems approach touted objectivity and could easily be aligned with processualism caused geoarchaeology to be largely overshadowed by the post-processual denouncement, at least in the UK.

Geographical differences

Although geoarchaeology initially did not take hold in the post-processualism dominated UK of the 1970's and 80's, it continued to grow in North America. There the post-processualist movement was seen as more of a complement to processualism as opposed to its antithesis – what Hegmon (2003) calls "processual-plus" (p.214). Anthropology was already connected with archaeology in the North American university structure, and thus post-processualism did not have the impact that it had in Europe (Pollard, 1999). Additionally, common research questions surrounding the peopling of North America (tracing and dating human-environment relationships; see Holliday, 2009 for a discussion) and the characterisation of lithic tools (material analyses and provenience studies) made geoarchaeological connections more natural (Pollard, 1999). Much of this earlier research had often called on quaternary geology and geomorphology, particularly for dating purposes (Renfrew, 1976; Holliday, 2009).The archaeological geology division of the Geological Society of America was created in 1978 to serve this exact need (GSA-Archaeological Geology Division, 2011).

Recent views on geoarchaeology and environmental archaeology

Eventually geoarchaeology did take hold in the UK and the field grew rapidly during the 90's (Pollard, 1999; French, 2003). However, many arguments surrounding its integration with archaeology are still occurring today. Like Butzer (1982), most authors suggest that concepts should drive geoarchaeology, not simply techniques or methods (e.g. Canti, 2001; Fouache, 2007; Fouache et al., 2010). Geoarchaeology is scale-dependent, with a variety of approaches and techniques available given the studied environment, or context (Butzer, 1982). For example,

geomorphology is applicable to landscape-scale investigations (i.e. through landscape archaeology; e.g. Stafford, 1995; French, 2003). However, some are arguing for enhanced specialism and separation of earth science-archaeology connections from their respective parent disciplines (e.g. Thornbush, 2012).

Environmental archaeology practitioners, most from archaeological backgrounds, are also arguing for conceptual integration, where the most effective research will occur when they are included in all project stages (e.g. Luff and Rowley-Conwy, 1994; Albarella, 2001; O'Connor, 2001). It is not surprising that developments in geoarchaeology and environmental archaeology have paralleled one another as many consider geoarchaeology to be a branch of environmental archaeology (Canti, 2001). Though this is yet another aspect of geoarchaeology that is up for debate, it is clear that it is beneficial for the two to look to each other as these discussions progress. In the words of Rapp and Hill (1998); "Perhaps when archaeology embraces archaeological science to the same extent that it has embraced classical and anthropological traditions, it [geoarchaeology] will find its footing" (p.7).

INTERDISCIPLINARITY

The integration of geoscientific and archaeological perspectives cannot be achieved without the understanding of interdisciplinarity. It is not uncommon to hear geoarchaeologists referring to themselves or their field as interdisciplinary. Donahue and Adovasio (1985) describe geoarchaeology as "the interface between geology and archaeology" (p.306) and identify their own work as "interdisciplinary studies" (p.306). Holliday (2009), discussing issues surrounding studies of the peopling of the New World refers to geoarchaeologists as the "interdisciplinary collaborators" (p.310) of American archaeologists. Fouache et al. (2010) believe that "geoarchaeology is not a discipline, but an interdisciplinary approach" (p.207). Waters (1992) hopes that his volume will "enhance the interdisciplinary cooperation

between the geosciences and archaeology" (p.xxi). Despite this, ideas of interdiscplinarity are often taken for granted. Interdisciplinary theory offers a way to think about the component parts of geoarchaeology and how they are put together. This is central to the identity and perspective of geoarchaeologists and hence, how the discipline is communicated to others.

Interdisciplinarity in higher education

Significant attention to interdisciplinarity in educational institutions began in the 1970's (Squires et al., 1975). At this time, education was becoming more flexible and many new connections were being made between existing disciplines, particularly in the sciences (Squires et al., 1975). Like geoarchaeology, the concept of interdisciplinarity has only flourished in the last two or three decades (Klein, 2006). Early on, the definition of "interdisciplinary studies" was not well established (Newell and Green, 1982) and in the wake of its recent popularity the term "interdisciplinary" has been misused (Klein, 2006).

Of most relevance to this research is the difference between "multidisciplinary" and "interdisciplinary". Multidisciplinary studies present a breadth or juxtaposition but do not integrate perspectives, the knowledge effectively acting as "separate voices" (Klein, 2006, p.5). Interdisciplinary studies extend this by blending the voices engaged using a perspective-centred approach, often unified by a common theme or problem (Klein, 2006). Most archaeological sub-disciplines aspire to be interdisciplinary and not multidisciplinary. For example, Rapp and Hill (1998) describe geoarchaeological "collaboration" as "multidisciplinary" (p.9) and believe that this has transformed into "integration" in recent years (p.13).

What is a discipline?

In the context of academia, the "discipline" is difficult to define. Its Latin roots draw from the educational world - *discere* (to learn) and *disciplina* (instruction). At a broad level it can be thought of something that may be taught, learned and

researched, but it also carries with it assumed structural meanings, especially within a university. A discipline is able to sustain a university department, though it may consist of several sub-disciplines (Squires et al., 1975, Klein, 2006). To be an established discipline is to have assumed validity, as an area of expertise than can be funded, researched and taught. Perhaps most importantly, disciplines have a distinct world view and an attached power system (Klein, 2006; Newell, 2007). This final definition emphasises the functional existence of a discipline, and it will be used in this research as such, interchangeably with "subject" and "field". "Sub-discipline" will be used contextually, where the relationship of one discipline to a larger, umbrella discipline is being discussed.

Disciplines typically form in one of two ways: by convergence or divergence (Newbould, 1975). For example, biology formed through the convergence of several related disciplines: botany, zoology, genetics and microbiology (Newbould, 1975). Geoarchaeology also formed by convergence, of archaeology with the geosciences (Rapp and Hill, 1998, p.13). Geography has largely become divergent along the lines of physical versus human geography (Newbould, 1975), though pragmatically it has remained together. It is the author's observation that environmental archaeology may be in the process of divergence, with subjects like zooarchaeology and archaeopalynology sometimes being detached from the core of the discipline.

Challenges to interdisciplinary studies

Breaching common disciplinary boundaries is often a difficult thing to do as a researcher and/or educator. In both cases, eliminating irrelevant content is challenging (Thomas, 1975), as it is easy to believe that double, triple, etc. the information is critical to understanding the number of disciplines that are engaged in the research (Rapp and Hill, 1998, p.xi). A careful calculation of depth versus breadth is necessary. Practitioners need to be willing to adapt their way of thinking and have support to do so (Wieseman and Moscovici, 2003). It is also necessary to be clear

about the standards and nuances that are inherent in the work (Squires et al., 1975), as those are naturally taken on from the home discipline. Communication with people from the disciplinary extremes of a blended field requires attention to clarity and the explication of assumed knowledge or guidelines of those extremes.

There are also structural difficulties that may come with being an interdisciplinarian in a typical higher education system. Because universities were built around the traditional disciplinary model, it may be difficult to exist in the middle (Squires et al., 1975). Existing separately from any department or attempting to encompass several departments may cause logistical issues within a university. It is sometimes considered a "professional risk" to engage with interdisciplinary research and/or teaching (Squires et al., 1975, p.20). For example, getting a university to recognise interdisciplinary modules that include students from several disciplines may present challenges, including the compensation of interdisciplinary instructors (Pearce et al., 2010).

Benefits to interdisciplinary studies

Despite the challenges to interdisciplinary research and teaching, they offer a holistic view that is beneficial (Squires et al., 1975; Pearce et al., 2010; McClam and Flores-Scott, 2012). They reflect the real world more accurately (Thomas, 1975; Newell, 2007), as an interconnected system rather than agents in isolation. Interdisciplinarity buffers against over-specialisation (Squires et al., 1975), a problem that is widely recognised in academia. It is also functionally instructive by teaching critical research and general skills, especially when collaborative, through discussion and interaction (Vale et al., 2012). Ultimately, interdisciplinary thought advances problems in novel ways (Repko, 2008), perhaps in a way that might not have been possible with a single disciplinary perspective (Newell, 2007). These benefits are bigger than any of the challenges to interdisciplinary studies and may greatly strengthen the quality of associated research and education.

Interdisciplinary research and education, which can generally be thought of as forms of academic communication, are the practical manifestations of interdisciplinary theory and heuristic ideals. The ability to communicate with particular audiences is critical to interdisciplinarity (Woods, 2007; Pearce et al., 2010). At a research level, this audience is made up of practitioners from the disciplinary extremes, e.g. the geosciences and archaeology. At an educational level, this audience is comprised of students (who may come from the disciplinary extremes). Woods (2007) details several key factors for "interdisciplinary communicative competence" (p.854). Factors critical to communicating across knowledge domains (i.e., differences in disciplinary knowledge) are: "conceptual competence, competence in negotiating meaning and competence in interdisciplinary text production" (Woods, 2007, p.860). Factors critical to communicating across academic cultures (i.e., differences in disciplinary operation) are: "knowledge, skills of interpreting and relating, skills of discovery and interaction, attitudes and critical disciplinary awareness" (Woods, 2007, p.860). These abilities are particularly important to the educational aspects of interdisciplinary communication.

APPROACHES TO TEACHING AND LEARNING

The critical foundation for educational design is pedagogy. Pedagogy commonly refers to theoretical and practical aspects of instruction, which is understood in different ways by students and teachers (Hotam and Hadar, 2013). Pedagogy is informed by disciplinary definitions and identity (Cook, 2009) that feed into content considerations. The development of educational activities or curricula is guided and supported by pedagogical and content evidence (e.g. Pearce et al., 2010; Mamo et al., 2011; Dohaney et al., 2012). Two types of evidence are relevant to this study: that which is specific to the teaching of geoarchaeology and that which pertains to interdisciplinary teaching in general.

Components of geoarchaeological teaching and learning

Archaeology and geology are typically not given much attention pre-higher education and practitioners of both are calling for increased integration of these subjects with others in the curriculum (e.g. Fleming, 2000; Lee and Fortner, 2005; Henson, 2008). In a survey of fifty-one primary and secondary geoscience educators from fifteen different countries, "integration approaches" was the number one choice selected for the "most appropriate" science education approach for the 21st century from a list of seven, including "conceptual change approaches" and "informal teaching and learning" (Lee and Fortner, 2005, p.199). Fleming (2000) suggests that several archaeological concepts could be interlinked with other A-level subjects, history in particular.

Some validated attempts have been made to integrate archaeology and geology individually with other subjects through curriculum development or teacher training. Brown et al. (2011) successfully implemented an archaeo-astronomy summer school focused on Peak District localities, broadly covering the topics of archaeology, astronomy, ecology and citizenship. Others (e.g. Wieseman and Moscovici, 2003; Plotnick et al., 2009) have focused on introducing archaeological and geological connections to primary and secondary teachers, but it is unclear to what extent, if any, these connections were transferred to their own teaching. Saindon and Downs (1992) indicated that all teachers who participated in an intra-university archaeology workshop developed related units for their classrooms; however, the work did not focus on the specific content of the units. Kline et al. (2005) helped primary and secondary teachers develop units that integrated engineering and physics with archaeology and anthropology and found them to be highly successful. It is clear that integration of seemingly disparate subjects can be achieved, especially through teacher training; however, none of these tackled the combination of the geosciences.

Evidence-based geoarchaeological teaching at the secondary level is seemingly absent from the literature and lacking from many of the major institutions

providing online resources (e.g. English Heritage, 2007; Archaeological Institute of America, 2013; National Geographic, 2013). These institutions do provide un-validated archaeological (English Heritage, 2007; Archaeological Institute of America, 2013) and geographical (National Geographic, 2013) activities and lesson plans for a range of age groups, with no theory or evidence included. The Higher Education Academy (HEA, 2009) offers the most comprehensive support for archaeological teaching and learning through its online guides directed specifically at pedagogy; however, these address a limited number of general issues.

More attention is being given to geoarchaeology in higher education. The literature suggests that geoarchaeological concepts are primarily being taught at the advanced undergraduate or postgraduate level; however, the specifics of these approaches vary greatly. Some undergraduate/postgraduate modules broadly address geoarchaeology or archaeological geology as a field (Donahue and Adovasio, 1985; Nicolaysen and Ritterbush, 2005). Other undergraduate/postgraduate modules are focused on particular aspects of geoarchaeology, though they are not always identified as such (e.g. Barrett et al., 2004; Battles and Hudak, 2005). Certainly additional examples exist; however, they have not been analysed in the geoscience or archaeological education literature or included in the major archaeology education repositories (English Heritage, 2007; Higher Education Academy, 2009; Archaeological Institute of America, 2013; National Geographic, 2013). With a lack of pre-higher education geoarchaeological resources and no apparent consistency to the documented teaching and learning approaches in higher education, a broader analysis of the interdisciplinary studies literature is necessary.

Components of interdisciplinary teaching and learning

At a more general level, interdisciplinary education does appear to have several unifying approaches. It commonly progresses through four key steps: base knowledge, separate models or perspectives, analysis and synthesis (Figure 1; e.g.

Newell and Green, 1982; Klein, 2005; Repko, 2008). Although building a knowledge base or foundation is often thought of as something that is time-consuming, this isn't necessarily the case. In fact, the foundational knowledge stage is relative, depending on the content and temporal scope of the exercise or module, and can be as short as five minutes of reading. The second stage presents disciplinary models or perspectives as separate entities and is extremely careful to do so. Novices are unable to see the connections between them without first understanding what they carry separately. Analysis asks students to evaluate the characteristics of the disciplinary models or perspectives presented and synthesis asks the students to summarise them as an integrated whole.

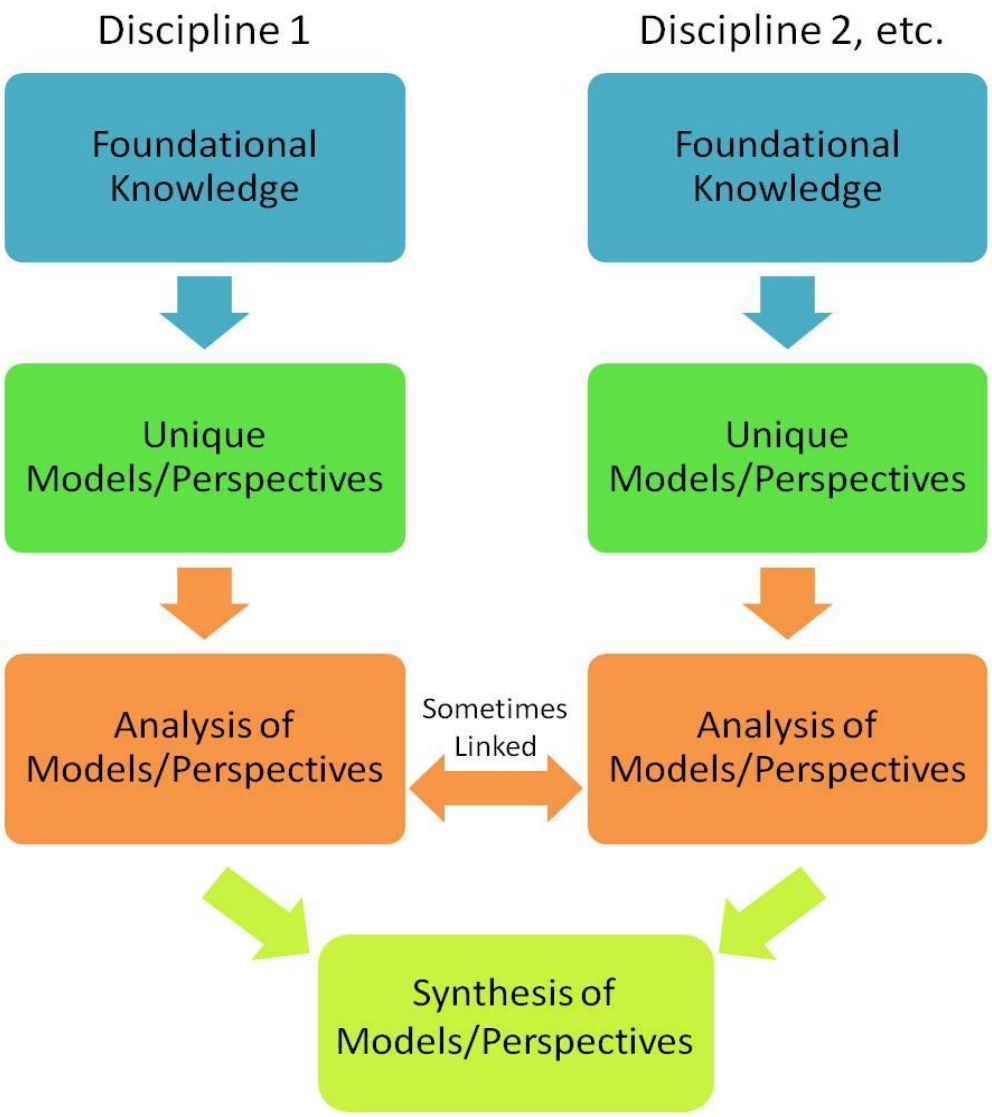

Figure 1. Interdisciplinary studies educational structure. This structure separates foundational knowledge and models/perspectives from the disciplines before analysing and synthesising them.

Theoretical issues of convergence become practical in the teaching of interdisciplinary subjects and in the early years of interdisciplinarity, practitioners were wary of crossing this line. Edge (1975) maintained that true integration created a new discipline, and therefore, left it to the students to make their own connections between disciplinary perspectives. Jevons (1975) opted for more of a deliberate integration, where connections are emphasised but disciplinary perspectives are maintained, which matches closest with the modern day interdisciplinary approach (e.g. Newell and Green, 1982; Klein, 2006; Repko, 2008). Experts in interdisciplinary fields like geoarchaeology understand the worldview of their field as one entity, as a whole made up of fluidly connected parts, rather than a selection of disjointed pieces (Hammer, 1994). These connections are learned and appreciated by novices only when instructors deconstruct their disciplinary worldview into its constituent perspectives.

There is no one pedagogic solution to incorporating the four key stages of interdisciplinary education. Inquiry-based learning, team or group work and case studies are the most common approaches (Klein, 2005; Klein, 2006). These methods suggest active learning and practical segments of pre-higher education curricula are seen as a critical location for content integration (Singer et al., 2005). A similar kind of teaching is often referred to as "cross-curricular" (e.g. Klein, 2006; Woods, 2007; Simşek and Elitok Kesici, 2012). Though this is closer to multidisciplinary studies than interdisciplinary studies, it is widely appreciated and has the potential to evolve into more integrated approaches.

CONCLUSION

This study aims to teach basic geoarchaeological concepts in an interdisciplinary manner. It requires an understanding of geoarchaeology's evolution as a field and its struggles in being truly integrated with wider archaeological studies. These struggles emerge through interdisciplinarity and its challenges, but are

outweighed by the strengths of working with the knowledge and perspectives of multiple disciplines. Effective communication is needed to convey these strengths and education is a useful example of communication, sourced for these purposes through geoarchaeology and interdisciplinary studies. Teaching and learning is critical and reflexive when at its best, allowing it to be analysed with rigour.

This work is one of seemingly few documented attempts at the teaching of pre-higher education geoarchaeology and serves to introduce geoarchaeology and interdisciplinarity to these students. It approaches this by first articulating the theoretical and contextual constructs necessary to design the study. By understanding and improving the teaching and learning of novice geoarchaeology, the building blocks for interdisciplinary communication at the academic level may be created.

RESEARCH DESIGN

Understanding how to best convey the benefits and concepts of geoarchaeology to academics, as well as archaeologists in training, is critical to the success of the field. This study aims to address the communication of geoarchaeology and interdisciplinarity in archaeology by designing a teaching pack for A-level classes. Herein, a "teaching pack" is used to refer to a suite of teaching materials of any type designed for a particular ability level of students, intended to be delivered over a certain period of time. For example, a teaching pack could be a single worksheet designed for use with GCSE through A-level students or a five lesson independent project designed for university students. A-level classes provide a practical geoarchaeological teaching application that may be scaled up to more advanced levels of communication (i.e. university students or academics). The most basic foundation possible provides wide extrapolation possibilities, rather than attempting to simplify more advanced communications. It may also be applied more broadly with other interdisciplinary fields of archaeology. The following questions are posed within this research context:

(1) How might geoarchaeological communication be approached through teaching and learning?
(2) How effective is this approach at teaching the foundational concepts of geoarchaeology?
(3) How effective is this approach at increasing awareness of geoarchaeology and interdisciplinarity in archaeology?
(4) How might this improve the academic communication or understanding of geoarchaeology and archaeological interdisciplinarity?

The design stages of this project require careful attention herein, as a major part of the research. These include the research setting (A-level classes), approach to the initial teaching pack development and methodological structure. The design required both theoretical and practical considerations based upon the relevant literature detailed in the previous section and a cursory exploration of conditions relevant to this particular setting.

RESEARCH SETTING

Secondary school

In this work, "secondary school" is used in order to adopt a more universal term for the final three or four years of schooling for children. Secondary school precedes higher education, or post-secondary, and generally results in the awarding of a diploma. In particular, the final two years of secondary school are focused upon in this work, referred to as "A-levels" in the UK. These last two years are also known as college or sixth form, but in more global terms would be considered the latter half of secondary school.

A-levels are comprised of two stages of national qualifications, called AS and A2 (BBC, 2013). Students, typically sixteen to seventeen years of age, select four subjects to study at AS. Students at this level are also known as Year Twelves (Y12s), what was previously called Lower Sixth. At A2, students usually drop one of these

subjects for a total of three A-levels. Students at this level are also known as Year Thirteens (Y13s), previously called Upper Sixth.

Key Stage 4 precedes A-levels and culminates in the GCSE national qualifications (GOV.UK, 2013). During Key Stage 4, students are approximately fourteen-sixteen years old (Y10 and Y11). They select optional subjects in addition to the compulsory subjects of English, Maths, Science, Information and Communication Technology, Physical Education and Citizenship. For A-levels, students often remain at the same school they studied GCSEs, but some do choose to go to a different college or sixth form.

Relevant A-level classes

The A-level classes offered that are most directly related to geoarchaeology are geography, classical civilisation, geology and archaeology, though there are certainly others (e.g. history, languages). Of these, geography and classical civilisation are the most common, with geography taught everywhere and classical civilisation taught at the majority of schools at both GCSE and A-level. Geology and archaeology are not available at GCSE and are rarely offered at A-level, only a small number of schools in the Sheffield area offer them.

In England there are four exam boards that offer A-level and GCSE qualifications. Preliminary searches suggested that the Assessment and Qualifications Alliance (AQA) was the most commonly used exam board in the Sheffield area, and therefore, the AQA curricula were used as a model for prior student learning that would be relevant for a geoarchaeology teaching pack.

Geography curricula

At A-level, geography students learn about both the physical and human aspects of the field, including studies on sedimentation, river management, hazards and hazard management, population development, food, energy and health (AQA, 2011). They work with maps, photographs, graphs and statistics, using skills of

investigation and interpretation. GCSE topics include hazards, mapping, rocks, resources and population development (AQA, 2012). Many of these topics provide a foundation for A-level geography and a relatively deep level of knowledge is expected upon GCSE completion.

Classical civilisation curricula

A-level classical civilisation is heavily focused on Greek and Roman literature, with small art and architecture components taught in some classrooms (AQA, 2009c). Regardless, all studies in classical civilisation involve the geographical and societal contexts of the literature, making geoarchaeology highly relevant to classical civilisation. Literacy and critical thinking skills are particularly important. At GCSE, more topics relating to geoarchaeology and archaeology in general are offered, but the classical civilisation curriculum is still largely literary (AQA, 2009b). Related topics include: archaeological and historical studies of Roman Britain, social life and civilisation and Pompeii and Herculaneum surrounding the eruption of Mt. Vesuvius.

Archaeology curricula

A-level archaeology teaches relevant concepts in religion and ritual (Roman Europe is a topic option), social control and power, landscape and adaptation, resources and spatial studies (AQA, 2009a). Students learn about excavation, site formation processes, geological sourcing, dating, environmental analysis and use maps and photographs throughout.

Geology curricula

Geology is not offered through AQA but is offered through Oxford, Cambridge and RSA Examinations (OCR), another common exam board. The curriculum includes plate tectonics and associated hazards (with a focus on earthquakes), structural geology, processes and products of all three rock types

(including volcanic activity, hazards and management), energy and minerals, engineering geology and dating (OCR, 2013). Students are expected to build experimental and problem solving skills through field and practical work using graphs and maps.

TEACHING PACK APPROACH

Geoarchaeological content focus

The existing geoarchaeology education literature is limited and does not offer a consensus on what should be taught at the introductory level (e.g. Donahue and Adovasio, 1985; Nicolaysen and Ritterbush, 2005). Natural hazards were selected as the focus of the teaching pack, for several reasons: 1) they are crucial to understanding site formation processes, fundamental to geoarchaeology; 2) they are inherently interdisciplinary; 3) they clearly overlap all of the A-level classes that relate to geoarchaeology; 4) they have real world relevancy for students.

Natural hazards are an important component of geoarchaeological basics, in processes of site formation and preservation. A focus on natural hazards responds directly to the interdisciplinary impetus of the research and the interest in increased integration of these subjects at the secondary school level (e.g. Lee and Fortner, 2005; Henson, 2008). Natural hazard topics have an obvious human angle, where both environmental processes and cultural impacts can be studied independently and combined easily. Environmental processes and/or cultural impacts of natural hazards are addressed in some way in each of the geography, classical civilisation, archaeology and geology curricula. Natural hazards are relevant to the modern day "real world" in management, development and tourism. The response of societies to natural disasters is an important current topic of research in geoarchaeology and recent volumes have been published on the subject (e.g. McGuire et al., 2000; Grattan and Torrence, 2002).

Volcanic hazards in particular were selected as a focus for the teaching pack for a few reasons. 1) Volcanic geoarchaeology is a cutting edge, global area of study that is highly interdisciplinary, as recent works can attest (e.g. Balmuth et al., 2005; Grattan and Torrence, 2007). 2) Volcanoes are particularly relevant to the classical world. Some examples include: Mt. Vesuvius (Pompeii and Herculaneum; e.g. Andronico and Cioni, 2002; Mastrolorenzo et al., 2010), Mt. Thera or Santorini (Minoan civilisation; e.g. Sewell, 2001; Bruins et al., 2008) and Mt. Stromboli (e.g. Rosi et al., 2000; Speranza et al., 2008; Ayala et al., 2012). 3) Volcanoes are an exciting topic for many, no matter their disciplinary background or level of education. 4) Materials collected from Mt. Stromboli were readily available, along with expertise in volcanic archaeology (G. Ayala, pers. comm., 2012).

Interdisciplinary approaches to pedagogy

Hamilakis (2004) attests that within the wider archaeological community both theoretical and practical considerations of pedagogy are uncommon, due to the difficulties that come with being non-traditional in research and education while existing in the rigidity of the university system. The limited geoarchaeological education literature offers a handful of examples (e.g. Battles and Hudak, 2005; Nicolaysen and Ritterbush, 2005), but none relevant to natural hazards or the classical world. Although there are online archaeology resources produced by organisations such as the English Heritage (EH, 2007), the Higher Education Academy (HEA, 2009) and National Geographic (NG, 2013), none are applicable to this age group and content.

It is useful to adopt a general approach that relies heavily on interdisciplinary pedagogy for the construction of this teaching pack, to be able to adopt proven, evidence-based principles in its construction. Interdisciplinary theory offers a strong model for teaching and learning that creates independent foundational knowledge for each discipline, details their unique models or perspectives and analyses them, then

finally connects the disciplines through synthesis (Figure 1). The teaching pack structure was modelled after this approach to interdisciplinary learning. Broader related examples were utilised in the foundational knowledge and separate perspectives portions of the teaching pack. A case study formed the bulk of the teaching pack, incorporating an analysis of data from the separate disciplinary perspectives and a synthesis that connects them completely. Questions relating to evidence surrounding this case study were envisioned to be completed in small groups. Both group work and case studies are suggested interdisciplinary pedagogies (Klein, 2006). Practical teaching is important for secondary school (e.g. Singer et al., 2005) and hands on, active pedagogies are recommended for most educational interactions, including interdisciplinary studies (Klein, 2006).

METHODOLOGICAL DESIGN

The project methodology was designed to be reflective throughout, including evaluations of each stage (Figure 2). It began with an initial teaching pack design based on the approaches to content and pedagogy gleaned from the literature. These informed intentions were structured to evolve during the iterative pre-interview stage, as A-level teachers provided feedback and perspectives. A pilot version of the teaching pack was produced and trialled by some of the interviewees in their classes. During the pilot studies, observations were collected by the researcher and students answered questionnaires relating to their perceptions and knowledge before and after the teaching pack. On the post-questionnaire they also provided basic feedback on their experience. Finally, the teachers who participated in the pilot studies were interviewed post-pilot in order to provide final feedback and perspectives. These varied methods provided a comprehensive educational dataset which was analysed to determine the success of the teaching pack at communicating geoarchaeology as an interdisciplinary field. This study received approval by the Department of Archaeology at the University of Sheffield's ethics committee.

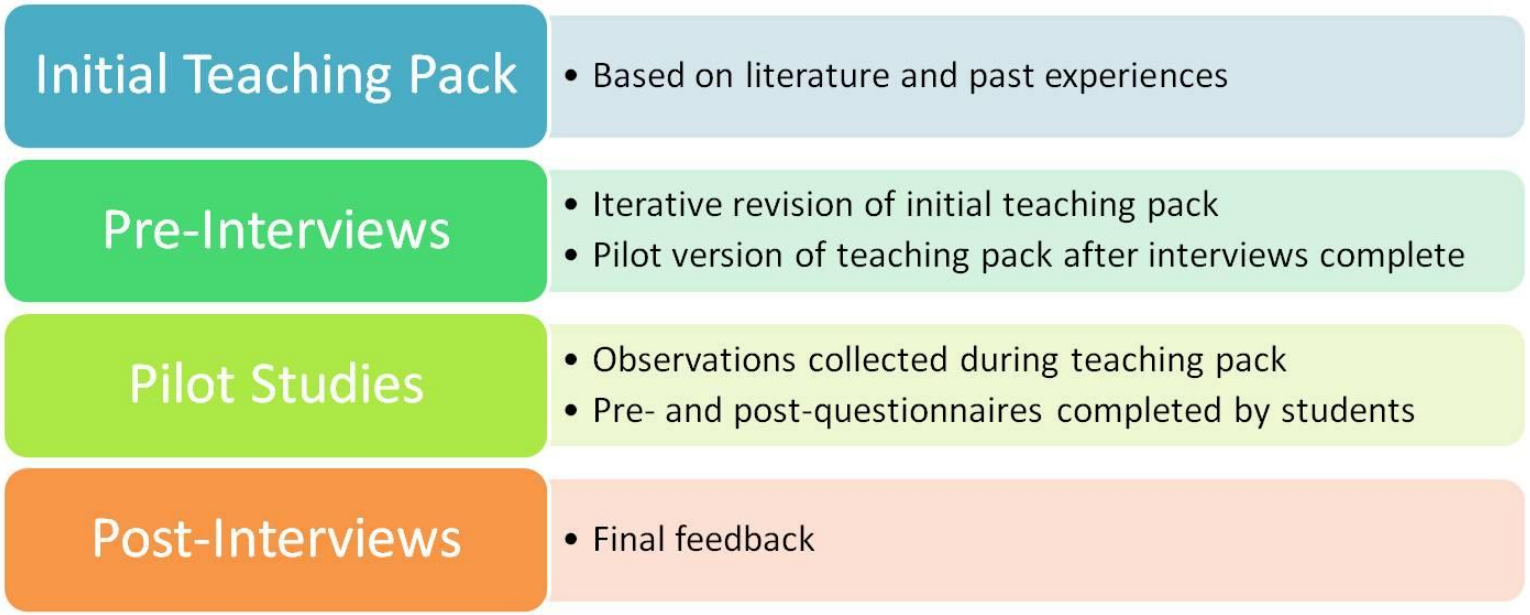

Figure 2. Methodological design, consisting of four major stages and associated data inputs and outputs.

METHODS

INITIAL TEACHING PACK

Using the design mentality detailed in the previous chapter, a partial set of teaching materials was created prior to the first teacher pre-interview to serve as a starting point for discussion (Appendix A). It was presented with considerable allowance for change, heavily dependent on the teachers' responses.

The interdisciplinary studies teaching model was used to structure the teaching pack around two major segments: a more traditional, but interactive short lecture by powerpoint (background and perspectives) and a suite of questions surrounding a case study (analysis and synthesis). The A-level class duration and teacher contribution time was unknown, but was expected to be around one hour. The initial teaching pack was intentionally longer than this (closer to two hours with thirteen case study questions), to give the opportunity for more careful selection and fine tuning when shortening it.

The main case study was focused on the excavation of a Bronze Age Village at San Vincenzo, Mt. Stromboli (Ayala et al., 2012). Real data and materials from the site were readily available and could provide an opportunity for research-led teaching. In order to maximise disciplinary relevance, the bulk of the examples provided during the powerpoint were from Mt. Vesuvius and Santorini. Iceland and New Zealand were used when no obvious classical examples were available.

The teaching pack was split into four sections by scale of investigation: 1) large scale physical geography (volcanic landscape features), 2) small scale physical geography (volcanic deposits), 3) large scale archaeology (landscape mapping, spatial distributions and sites) and 4) small scale archaeology (occupation structures, sediment, artefacts and bodies). Geoarchaeology topics were included in the archaeology sections but made explicit under "geoarchaeology connections" headers. A five to ten minute lecture on each of the four sections was followed by two-four

case study questions surrounding that topic, creating variety and maximising student interaction. The final question was an essay that asked students to integrate and synthesise the disciplinary knowledge in a landscape history for Stromboli. Lastly, s summary would be delivered by the instructor.

PRE-INTERVIEWS

Contact with schools

A total of 27 schools from Sheffield and surrounding areas were contacted in succession, over the course of two and a half months (Table 1). Most of the schools offered two of the relevant A-level subjects of geography, classical civilisation, archaeology and geology, some offered three. An email was sent with project details, contact information and an attached information sheet (Appendix B) to all A-level teachers of these subjects, as well as to the Head of Sixth Form, or College. In most cases no contact information was provided for individual staff through the school's website and the request had to be sent through the general enquiries contact. A firm interview schedule was not provided, but teachers were offered the flexibility of participating in the interview or interview and pilot study. The interview could be conducted in person, over telephone or via Skype. An explicit timeline was provided with all contact in the latter five weeks, stating that interviews and pilot studies would take place four and six to eight weeks later, respectively.

Table 1. School contact timeline and sources.

Number of Schools	Time Since Initial School Contact	Time Until Follow Up	Source	Reference (all pers. comm., 2013)
6	N/A	5 weeks	Dept. Intake List 1 (DIL 1)	J. Rempel
9	3 weeks	2 weeks	DIL 1 and Faculty List	J. Rempel and L. Billam
1	5 weeks	N/A*	DIL 1	J. Rempel
6	6 weeks	N/A*	DIL 1	J. Rempel
5	10 weeks	N/A*	Dept. Intake List 2	J. Rempel

*too close to interview stage for follow up to be possible

Interview structure

Three of the twenty-seven contacted schools were interested in participating in an interview. Four teachers participated in a total of three interviews, one at each school (including a paired interview). All of the interviewed teachers were female and taught GCSE and A-level classes. Three of them taught classical civilisation (including those that took part in the paired interview) and one taught geography.

Before beginning the interview, participants were given a brief verbal description of the project, a consent form detailing both the interview and pilot study (Appendix C; also provided over email after the interview was scheduled) and a chance to ask questions. Interviews ranged from thirty minutes to one hour in length and were audio-recorded.

An "interview guide approach" was taken, using themes and questions that were outlined in advance (Cohen et al., 2007, p.353). The wording and order of these questions could be changed throughout the interview. Questions were open-ended and further probes were included in the outline. This style of interview is advantageous because it allows the interviewer to find and close any logical gaps that arise during the course of the interview (Cohen et al., 2007). However, the potential for differences between interviews does reduce data comparability (Cohen et al., 2007). Interviewees were told to approach the interview as an informal conversation without a set sequence that could be interrupted at any point.

The purpose of the pre-interviews was to gain an understanding of the teaching context, potential teaching pack approaches and teachers' perceptions of geoarchaeology and interdisciplinarity. The interviews always began with questions regarding teacher and student backgrounds, to help ease into the questions and aid in building rapport. General perspectives could be used to help structure the teaching pack, whereas specific feedback could respond to how it had been developed up to that point. It was also important to discuss what prior knowledge students would have and what was expected of them at A-level, as exam board curricula offer little in the

way of teacher perspectives. Teachers were asked a few questions about geoarchaeology and interdisciplinary teaching. Although detailed discussions of these topics were beyond the scope of this study, a cursory understanding of their inherent themes was expected to be beneficial.

A total of fourteen primary questions were included in the interview protocol (Appendix D). Some changes were made to these after the first interview, most of which were minor and served to improve interview clarity and avoid repetition by restructuring the question groupings. The only substantial change to the protocol was to remove questions asking the teachers to define the terms "multidisciplinary" and "interdisciplinary", as this was not strictly relevant and could come across as intimidating. This was replaced with a question addressing what interdisciplinarity means to them and how it connects to their field. This was also a more natural lead in to their personal examples of interdisciplinary teaching. The teaching pack was designed to evolve iteratively alongside the interviews and changes were made upon completion of each one. These changes are detailed in the "Results" chapter.

PILOT STUDIES

All of the teachers, including the geography teacher, expressed interest in the pilot study during the interviews; however, one of the schools could not be included due to scheduling conflicts. This was the school where the paired interview took place; therefore, two of the four interviewed teachers participated in a pilot study. They were provided the final teaching pack design (Appendix E) two weeks prior to provide sufficient preparation time. Teachers sent out the information sheet for parents/guardians (Appendix F) at this time. Parents/guardians were asked to opt-out of the data collection if they or their child were uncomfortable with the research but students would still be able to participate without their data being collected. None of the students opted out.

Class A, the geography class, was offered the teaching pack in regular class time with two groups of students and class periods combined (two hours total). Class B, the classical civilisation class, was offered the teaching pack as a two hour enrichment activity and had a choice between it and a computer-based classics investigation offered by another teacher. The demographics of the participating students from the two pilot studies (geography, n=17 and classical civilisation, n=13) are provided below (Table 2).

Table 2. Demographic information of the pilot study students.

Demographic Category	Demographic Variable	Class A (n=17)	Class B (n=13)	Total (n=30)
Gender	Female	5	10	15
	Male	12	3	15
Age	16	1	2	3
	17	16	11	27
Ethnicity	White British	16	5	21
	Asian	1	3	4
	Persian	0	1	1
	Caribbean	0	1	1
	Declined to answer	0	3	3
Current and Previous Classes	Geog. GCSE	17	5	22
	Geog. A-level	17	3	20
	Class. Civ. GCSE	2	2	4
	Class. Civ. A-level	0	13	13
	History GCSE	2	8	9
	History A-level	2	1	3

Observations of students and teachers during the teaching pack

The teachers provided the teaching pack instruction in order to: 1) strengthen their own learning, 2) maintain teaching environment continuity, 3) promote sustainable future teaching pack implementation and 4) allow the researcher to observe the teaching pack in action. A basic observation protocol was developed using existing protocols and modifications in the literature (Appendix G; Hora and Ferrare, 2009; F. Jones, pers. comm., 2012; Kennedy et al., 2013; Lane and Harris, in

prep). Two main aspects of the classroom were characterised through the observations: what the teacher was doing (techniques and timing) and how engaged the students were with the material.

The researcher observed from the back of the classroom and made all notes by hand (later digitised). Basic room conditions were noted, including the desk arrangement, number of students, date and time of the teaching pack. Observations included: teaching techniques, noted continuously using six codes (Cr-creating, Eg-example, In-interpretation, Ltell-traditional lecturing (telling), MM-multimedia and Q-questioning), student questioning (infrequent) and student engagement (every three minutes with time stamp). During the powerpoint sections, the same randomly selected students were observed and the number engaged were noted (out of ten). Previous work has shown that a subsample of ten students is indicative of overall class engagement (Kennedy et al., 2013). During the case study questions, a group engagement rating was given out of the total number of groups (four, in both cases). This was determined using behavioural cues, such as eye contact with the teacher, learning forward (engagement) vs. head down, talking with neighbour (disengagement; Lane and Harris, in prep). Qualitative notes were made whenever detail was needed to explain or elaborate upon the quantitative engagement rating and/or the discrete teaching technique characterisation.

Observations allow for a situated characterisation and description of the teaching pack's successes and failures and their potential explanations. For the most part, the observations were non-participant, meaning that the researcher was not involved in the teaching pack delivery. However, it was important to ensure that teachers were comfortable instructing the teaching pack, by making assistance available from the researcher. Geography Teacher 1 (Class A) called on the researcher only for occasional questions. Classical Civilisation Teacher 1 (Class B) asked occasional questions and requested that the researcher circulate during the rock and sediment sample questions, as she was relatively unsure of this content.

Therefore, no quantitative engagement ratings were made for this time period but qualitative notes were made after the fact. Although this created a slight gap in the data, the direct interaction with students provided an enhanced insight to how they dealt with the questions.

Pre-post questionnaires

Questionnaires were used to measure the impact that the teaching pack had on student knowledge and perception of geoarchaeology, by comparing their responses before and after instruction. The lack of developed and validated (i.e., interpreted as intended by students and confirmed by experts) geoarchaeological instruments meant that it was necessary to construct new ones. The validation process takes several years (Adams and Wieman, 2011) and thus was not feasible here. However, the pre-post questionnaire has been constructed with careful attention to the teaching pack aims and objectives and was vetted for content validity (i.e., correct phrasing and questions covering appropriate content) by an expert in geoarchaeology. The learning objectives for the teaching pack, describing specific concepts that the students are expected to learn, are as follows:

1) Describe some archaeological approaches and how geoarchaeology builds on them.
2) Describe the two major types of volcanoes and some related volcanic deposits.
3) Interpret geoarchaeological materials.
4) Use these interpretations to help you explain what it was like before and during the eruption at Pompeii.

The teaching pack and learning objectives were guided by a larger set of aims, describing skills and abilities:

1) Introduce geoarchaeology and its foundational concepts.
2) Compare and contrast geographical and archaeological settings and materials.
3) Summarise the landscape history of Pompeii ca. 79 AD, incorporating both geographical and archaeological findings.
4) Explore the benefits and challenges of interdisiciplinarity in archaeology.

Six questions regarding student perceptions were asked on the pre-post questionnaire (Table 3; Appendix H). Student perceptions, sometimes referred to as attitudes, go beyond the content of their learning and address bigger picture skills. Perceptions are a critical part of learning, as students become more expert-like in the way that they think (Adams et al., 2006). No perception surveys exist for archaeology, and thus, the questions in the pre-post questionnaire were based upon perception surveys in other disciplines, e.g. geography and geology (Adams et al., 2006; Walker, 2006; Jolley et al., 2012). Student perceptions of geoarchaeology and interdisciplinarity in archaeology were measured on a five-point Likert-scale, from strongly disagree to strongly agree (Likert, 1932).

Table 3. Pre-post questionnaire questions, sections and response formats.

Section	Question	Response Format
Perception	It is useful to approach problems by connecting ideas from multiple disciplines (fields of study).	5 point Likert-scale
Perception	It is time-consuming to approach problems by connecting ideas from multiple disciplines.	5 point Likert-scale
Perception	I can imagine connections between archaeology and other disciplines (aside from geography/geology).	5 point Likert-scale
Perception	Archaeology is made stronger when it is connected to other disciplines.	5 point Likert-scale
Perception	I think I have a good idea about what it means to study geoarchaeology.	5 point Likert-scale
Perception	I think that geoarchaeology would be fun to study.	5 point Likert-scale
Knowledge	Give **two** examples of the type of information that come from the study of artefacts from an archaeological site.	Open-ended
Knowledge	Name **two** differences between **shield volcanoes** and **stratovolcanoes** (complex volcanoes). Which one is more explosive?	Open-ended
Knowledge	**Compare and contrast** some different types of information that **geographers** and **archaeologists** might want to study on a site that has been preserved by volcanic eruption. **Give one example** of how they could collaborate to better understand the site.	Open-ended
Feedback*	Which part of the lesson did you enjoy the **most**? Why?	Open-ended
Feedback*	Which part of the lesson did you enjoy the **least**? Why?	Open-ended
Feedback*	Which part of the lesson did you find the **easiest**? Why?	Open-ended
Feedback*	Which part of the lesson did you find the **most challenging**? Why?	Open-ended

*only asked on post-questionnaire

Knowledge surveys, or concept inventories, measure how much students know about a particular set of related concepts and when administered pre-post, how much they have learned over a certain period of time. Typically, these concepts are drawn directly from module or lesson learning objectives. The use of knowledge surveys began with the development of the Force Concept Inventory to measure knowledge of introductory physics concepts and its finding that these concepts were not being taught effectively (Hestenes et al., 1992). They are now widely used in the science education research community (Libarkin, 2008). The Geoscience Concept Inventory was developed for introductory geology (Libarkin and Anderson, 2005) but no archaeological knowledge surveys have been published. Again, new questions had to be constructed, as existing instruments do not match closely enough with teaching pack content. Three, open-ended knowledge questions were asked on the pre-post questionnaire (Table 3; Appendix H).

On the pre-questionnaire, optional demographic information was collected from the students: gender, age, ethnicity and relevant current and previous classes studied at GCSE and A-level (Table 2). On the post-questionnaire, four open-ended teaching pack feedback questions were asked instead (Table 3; Appendix H). All students were asked not to write their own names on the pre-post questionnaires, but to come up with a memorable pseudonym so that their responses could be matched anonymously.

Ten minutes were given for the completion of the pre-questionnaire and fifteen minutes were given for the post, due to its greater length and the hypothesised increase in student knowledge. The small number of questions is not ideal for perception or knowledge surveys, as statistical robustness increases with sample size; however, given the time limitations of the teaching pack this was the maximum number possible. The careful selection of questions using learning objectives and directed data analysis serves to mitigate this limitation.

Case study question sheets

Each group was given a single question sheet on which it was suggested that they take basic notes that would aid in their writing the long form, final synthesis question. The question sheets, with the same pseudonyms as the pre-post questionnaire, were collected for a rough indication of group thought processes.

POST-INTERVIEWS

The post-interviews with the two teachers that participated in the pilot studies were more limited in scope than the pre-interviews. They were approximately fifteen minutes in length, audio-recorded and focused solely on the teachers' experience and feedback regarding the preparation process and instruction of the teaching pack pilot (Appendix I). An interview guide approach (Cohen et al., 2007) was again used with flexible question wording and order, but the questions were more direct with less possible probing.

DATA ANALYSIS

All of the data (pre-interviews, observations, pre-post questionnaires, case study question sheets and post-interviews) were transcribed and digitised. A rubric was developed to compute a quantitative score on the open-ended knowledge questions (Table 4). Qualitative student feedback was coded (i.e., binned by content) to characterise common themes in responses (Cohen et al., 2007). Responses were never longer than two sentences and therefore coding was relatively simplistic. The list of codes was determined during a first pass characterisation and codes were assigned during a second pass. Interview data are paraphrased and supported by example quotes. Basic descriptive statistics were computed for numerical data and t-tests are used to compare various populations where relevant, using Microsoft Excel 2007 and Graph Pad Prism 6. Normalised learning gains were calculated for the knowledge questions (Hake, 1998):

Learning gain = [post % - pre %] / [100% - pre %]

Table 4. Scoring rubric for the knowledge questions on the pre-post questionnaire.

Q#	Question	Max. Score	Scoring	Example
1	Give **two** examples of the type of information that come from the study of artefacts from an archaeological site.	2	**1 point each** for an archaeological example	Artefacts could tell archaeologists what social status the people had and the age of the site or layer in which they were found.
2	Name **two** differences between **shield volcanoes** and **stratovolcanoes** (complex volcanoes). Which one is more explosive?	3	**1 point each** for a characteristic that is paired or modified with "more" or "less" (must be clear which type of volcano is referred to). **1 point** for stratovolcano as more explosive.	Lava from shield volcanoes is less viscous and contains less gas. Stratovolcanoes are more explosive.
3	**Compare and contrast** some different types of information that **geographers** and **archaeologists** might want to study on a site that has been preserved by volcanic eruption. **Give one example** of how they could collaborate to better understand the site.	3	**1 point each** for a clear geographic and archaeological type of information or study. **1 point** for a clear example that connects the two.	Geographers might be interested in the eruptive style of a volcano whereas archaeologists might study the type of occupation structure that has been buried. They could collaborate by understanding what the people would have been doing in the structure and how they would have experienced the eruption.

RESULTS

The methodological stages of this project produced a range of qualitative and quantitative data that are detailed in succession below, according to their sources: pre-interviews, observations, case study question sheets, pre-post questionnaires and student and teacher feedback.

PRE-INTERVIEWS

The pre-interviews with teachers were conducted as described above, in the "Methods" chapter. Results of these interviews have been grouped by four themes: 1) teaching context and goals, 2) students' prior knowledge, skills and engagement, 3) teachers' perceptions of geoarchaeology and interdisciplinarity and 4) preliminary feedback about the teaching pack. Teacher responses are paraphrased and supported with quotes, where relevant.

Teaching context and goals

The three classical civilisation teachers were initially sceptical of the teaching pack's relevancy to their own classrooms, as well as the prior knowledge required of themselves and their students. However, after hearing that it was focused on classical geoarchaeology and required no prior background, all of them expressed interest in trying it in their own classrooms.

Teachers were asked what their students typically go on to study in higher education. They observed that a handful of classical civilisation students from each year go on to take classics and/or archaeology, often having stumbled into it at A-level:

> *"It actually happens quite a lot that we get students that pick up classical civilisation not having done anything like it before, not even knowing what it is, but as their fourth AS. And they carry it on to A2 and it is quite common that some of them then go on to take it at university."* ***(Classical Civilisation Teacher 2)***

Unfortunately, opportunities for them to be exposed to archaeology topics before higher education are rare. Although it is less common for geography students to study archaeology in higher education, the breadth of geography means that many of them go on to work in interdisciplinary fields. The geography teacher has observed that roughly half of her students tend to prefer human geography over physical geography

and vice versa, but all are exposed to the interplay between these two. She even thought that GCSE students would be capable with and interested in this type of teaching pack and content.

All of the teachers, regardless of their discipline/background, described broad, holistic goals when asked what they want students to come away from their course with. These goals were largely focused on perspectives and skills, with a clear emphasis on critical thinking and connections to people and society:

> *"So an appreciation of the literature, but what comes out of the literature is also the values, the religion, models, aspects of society…a different world. You know, that they can compare, contrast with their own."* ***(Classical Civilisation Teacher 1)***
>
> *"*[I want them] *to be good independent learners, to be able to ask questions, to be able to see the whole, holistic picture I suppose. And see that unless you understand the process you can't understand management…*[for example] *why are tectonic environments very positive places to live in as well? Looking at that aspect of it. I suppose that would come out in the terrain and the landscape, you know. Why did people live there?"* ***(Geography Teacher 1)***

Students' prior knowledge, skills and engagement

When asked how familiar their students were with maps, all teachers indicated that they were used regularly and that their students were proficient with reading them, including those in classical civilisation:

> *"Yes, we use maps a lot actually…in the other room, we've got that big, big, lovely map of the classical world. The Aegean." (****Classical Civilisation Teacher 2)***
>
> *"Yep. We have a lot of fun with that map…when I'm doing the Aeneid."* ***(Classical Civilisation Teacher 3)***

In addition to considerable map work, Geography Teacher 1 indicated that her students have had experience with graphs, diagrams and the evaluation of these data presentation methods:

> *"…they're used to a data analysis part of the question. So that could be a text, where you've got to outline the key features of. They're used to graphs, they're used to cartoons, they're used to diagrams…information where you have layering of say, proportional pie, of proportional circles with choroplething on it…certainly the A-level students are. And GCSE* [students] *to a certain extent…one of the questions is to evaluate the success of that method of presentation as well. That's a skill they're expected to have."* ***(Geography Teacher 1)***

Teachers indicated that classical civilisation students are generally unfamiliar with these methods of data analysis and presentation. Classical civilisation teachers also indicated that most of their students have less developed observational skills. These students work intensively with the written word, where implied meanings and contexts are commonplace and critical. To state what is directly in front of them is rather unfamiliar territory.

The teachers universally agreed that hands-on, active learning (even with replica samples) is paramount for students' engagement with the material. Classical Civilisation Teacher 3 described this as a difference maker, something that *"gets them to make the connection"*. The teachers tied hands-on learning to group work and reported it as another important approach for building and sustaining student engagement.

All of the teachers felt that volcanoes, especially Mt. Vesuvius and Pompeii, would be a captivating focus for the teaching pack. They also thought that international and real world examples would be preferred over local and synthetic examples, though they noted that there were instances where the latter would be appropriate.

Teachers' perceptions of geoarchaeology and interdisciplinarity

Although discussions regarding teacher perceptions were limited, some common themes emerged. These themes are relevant to teaching pack development, in understanding the background and attitudes of those who will be delivering.

The field of geoarchaeology and teachers' interest in it

None of the teachers had heard of geoarchaeology before and they held differing conceptions of what it could be, including teachers trained in archaeology. In classical civilisation: Teacher 1 solely mentioned natural disasters, 2 could not hazard a guess and 3 referred to environmental archaeology. Geography Teacher 1 was familiar with the use of geophysics and satellite imagery and thought that these would be particularly important.

Regardless of their previously held ideas about the discipline, all were interested in geology and learning more about it. Even a classicist who was unfamiliar with geoarchaeology had been captivated when she accompanied students on physical geography field trips:

> *"I had no geography* [background], [but I] *used to find it fascinating. How these things had been formed and things like that. And yeah I think, yeah, I like geology. It's big, isn't it?"* ***(Classical Civilisation Teacher 2)***

Interdisciplinarity in their field and interdisciplinary teaching

All of the interviewees thought of their field, classical civilisation or geography, as interdisciplinary. However, they were able to provide only limited examples of interdisciplinary teaching in their classrooms, past or present. The teachers attributed their lack of success and altogether avoidance of this teaching style to its time-intensive organisation and the need for the person teaching it to expand their expertise. In spite of this, interdisciplinary teaching was thought to be beneficial for both the teachers themselves (e.g., it builds appeal of the subject and keeps jobs by enhancing student enrolment) and the students (e.g., it helps them

experience the content in action, see its relevance and be creative) when approached deliberately.

Preliminary feedback about the teaching pack

During each interview, specific comments were made about the version of the teaching pack on hand. Classical Civilisation Teacher 1 suggested that Mt. Vesuvius would make a better focus for the main case study, as many students were familiar and fascinated with it. She also stressed the need to keep the amount of "scientific data" to a minimum, as she felt that classical civilisation teachers and students would both struggle with this. She felt that holding the pilot study at the end of the year would mean that it would sit more as an interest piece for further study, rather than a supplement to the Roman cultural aspects covered in the curriculum.

The two teachers interviewed for the second interview (Classical Civilisation Teachers 2 and 3) agreed that the teaching pack must be held over a two hour period, rather than thinning it down to fit into a one hour lesson. One of them remarked that approaching the mentality of people experiencing the disaster could be interesting, especially for classical civilisation students:

> *"…something of the humanitarian aspect. Like, what do you think was going through people's minds?…the agony on the casts and things like that…I think I would not be able to resist."* ***(Classical Civilisation Teacher 2)***

The main feedback from Geography Teacher 1 was that the students would benefit from some embedded support in the teaching pack (specifically, a key terms list for the whole lesson and a writing guide for the long form final question). She felt that this kind of support is important because it provides guidance and prompt words to help students of all abilities *"achieve an outcome and some learning on the same aspect of it"*.

OBSERVATIONS OF STUDENTS AND TEACHERS DURING THE TEACHING PACK

Both pilot studies were observed by the researcher, following the protocol discussed in the "Methods" chapter. The two teachers used the powerpoint and case study questions as a guide, but differed in some aspects of how they were delivered. During the powerpoint slides, both teachers adopted a traditional lecture style (i.e., where the material is conveyed by telling), integrated with provided examples. No questioning sequences were provided on the slides or in the teacher preparation material, yet both teachers were able to seamlessly pose improvised questions relevant to their own discipline. Classical Civilisation Teacher 1 (Class B) asked more questions of her students than Geography Teacher 1 (Class A). In both classes, students generally responded well to these questions, though they did not ask many of their own questions unless prompted in the small group environments (i.e., the case study questions).

Students of both classes were highly engaged throughout the teaching pack, though this was more variable during the case study questions (Figure 3). In both the individual and group sections, Class B (Classical Civilisation) had a higher average engagement than Class A (Geography), though neither were significantly different (individual: B-8.67 vs. A-8.25, $p=0.29$; group: B-3.08 vs. A-2.81, $p=0.37$). In both classes, engagement dropped around the 12 minute mark in the first powerpoint section. However, in Class B this recovered three minutes later and reached a peak for the entire teaching pack (10/10 engaged) when the teacher passed around the obsidian sample and asked several improvised questions about it. Class A did not show a similar recovery or peak when discussing the sample. In general, both classes decreased in engagement with the later individual, powerpoint sections (Figure 3a).

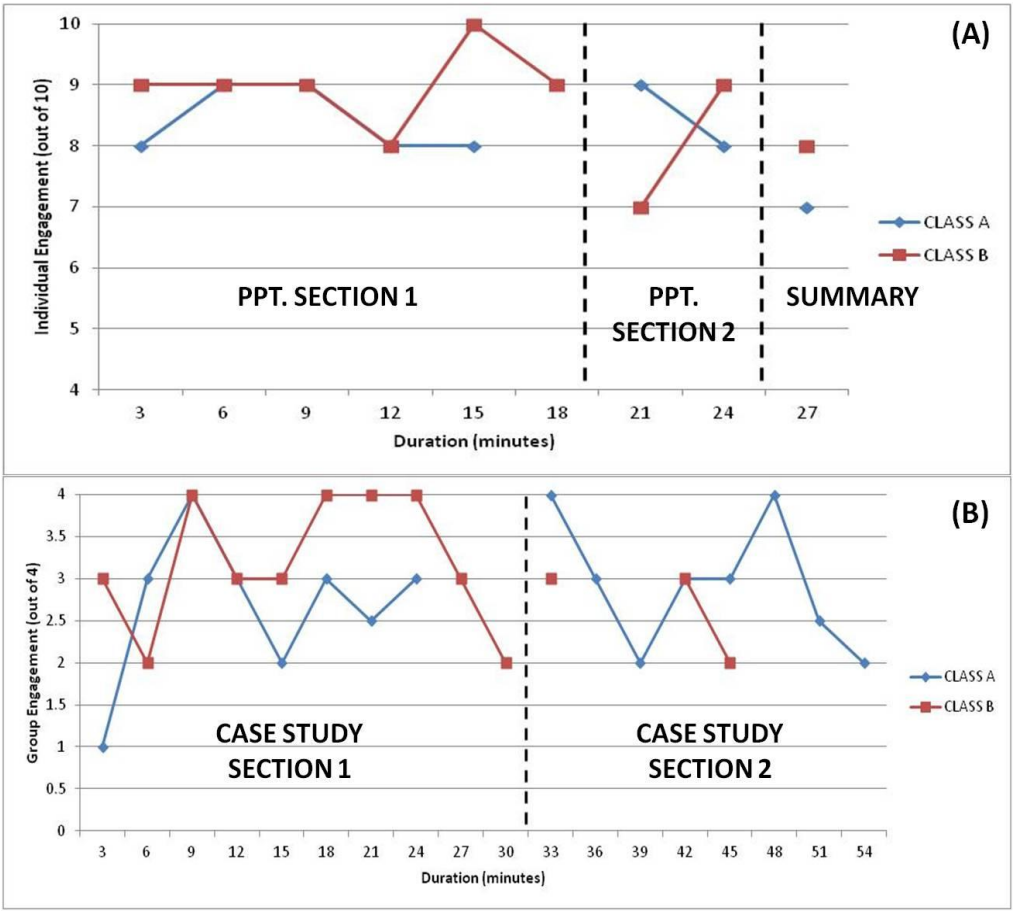

Figure 3. Student engagement during the powerpoint (A) and case study (B) sections. Section 1 consisted of the powerpoint followed by the case study questions, as did section 2. These were followed by the summary powerpoint. **(A)** Engagement rated out of a randomly selected sample of 10 students. The peak in Class B's engagement at a duration of 15 minutes corresponds to the passing around of the obsidian sample. **(B)** Engagement rated by group, out of the total number of groups (4).

Initially, group engagement was low during the case study questions, but this increased shortly after (Figure 3b). Classical Civilisation Teacher 1 opted to conduct whole class set ups and recaps of each individual question in addition to wandering around and providing support where needed. Geography Teacher 1 wandered around the classroom and provided support, but did not set up or recap individual questions with the whole class. Despite the overall variability of group engagement, Class B sustained higher levels towards the end of the first case study question section than Class A. During the second case study question section, Class A's engagement continued to be highly variable, whereas Class B's was more consistent. However, for the majority of this section with Class B, the researcher was assisting with the rock sample questions as requested by Classical Civilisation Teacher 1. Therefore, numerical engagement ratings could not be taken.

Students of Class B were highly engaged with the samples, asking several questions of the researcher that went beyond the content of the teaching pack. Many students were confused about the idea of grain size distributions, finding it difficult to discern between the two different proportions of mixed or similar size material. The use of the terms "conformity" and "variety" by Classical Civilisation Teacher 1 seemed to help mitigate this confusion, more so than the descriptions given in the teaching pack – "all one size or mix of sizes".

Unfortunately, Classical Civilisation Teacher 1 forgot to set up the long form synthesis question and instead went straight to the recap of the question and teaching pack. Class A did partially complete this question, though with only twelve minutes provided, as Geography Teacher 1 cut the teaching pack short to let the students go for an early break (because their lesson time had been doubled).

CASE STUDY QUESTION SHEETS

Student group responses to the case study questions were collected at the end of the teaching pack. Students were encouraged in the case study instructions to make

notes on each question to help them with the final synthesis; however, analysis of the group sheets showed that they were sparsely completed. The first two questions (interpreting a passage from Pliny the Younger and artefacts from Pompeii and Herculaneum) were filled out by all groups in both classes but the response rate declined through the rest of the questions, with the exception of the stratigraphic and sample description tables.

Classical Civilisation Teacher 1 provided her class with highlighters to help them pick apart different portions of the passage in question 1 and all of the group sheets from Class B showed this to some extent. Class A did not address this question in the same way (they were not provided with highlighters, nor did they have experience with analysing classical literature). Some students in Class A did circle or underline phrases or terms without prompting. It was clear that some groups (in both classes) were highly interested in the artefact interpretation question, evidenced by the sophistication of their answers:

> *"Pompeii appeared to stem from a farming background which made it (and residents) very rich. Pompeii also appeared to have a healthy cultural background, with grand religious temples and musical instruments. The city was also at the forefront of 'modern' technology with glass and effective eating utensils."* ***(Group 4, Class A)***

As the final question was cut short with Class A and forgotten with Class B, responses to it were limited. However, some groups displayed strong critical thinking skills and summarised their findings in a clear and concise way, for example:

> *"Before* [the eruption]*: Pompeii would have been a rich farming town. We can tell this firstly from the murals that depict farmers tending to the land on and around the slopes of Vesuvius. We also know that land around Vesuvius would have been ideal to farm on due to its fertility from the* [volcanic] *ash. Arts would have been critical to daily life, we can see this from the large, grandly furnished temple and the abundance of"* [ends here]. ***(Group 4, Class A)***

PRE-POST QUESTIONNAIRES

Knowledge – learning gains

The average learning gain for all students on the pre-post knowledge questionnaire was 0.42 (Table 5); meaning that on average, students experiencing the teaching pack improved their knowledge by a meaningful amount, similar to interactive courses in other studies (e.g. Hake, 1998). There were no significant differences in learning gains between class enrolled (A or B), gender or additional classes taken (geography students that had taken at least one classical civilisation class at GCSE or A-level and vice versa). Both classes have a similarly wide distribution of pre-questionnaire scores to learning gains, with no distinct trend (Figure 4).

Table 5. Pre-post questionnaire percentage scores and learning gains sorted by groups of differing characteristics.

Group	n	Pre %	Post %[1]	Gain[2]
Class A	17	33.82 (18.10)	62.50 (18.75)**	0.40 (0.34)
Class B	13	27.88 (19.20)	58.65 (24.68)*	0.44 (0.28)
Male	15	33.33 (12.20)	56.67 (21.06)*	0.35 (0.29)
Female	15	29.17 (23.46)	65.00 (21.23)**	0.49 (0.32)
Both Classes[3]	7	30.36 (18.90)	55.36 (21.48)^	0.35 (0.25)
One Class	23	31.52 (18.80)	62.50 (21.32)**	0.44 (0.33)
All	30	31.25 (18.50)	60.83 (21.21)**	0.42 (0.31)

^p<0.05, *p<0.01, **p<0.001
[1]compared to Pre %
[2]no groups had significantly different learning gains at the 0.05 level; standard deviation in brackets
[3]geography students that had taken at least one classical civilisation class at GCSE or A-level and classical civilisation students that had taken at least one geography class at GCSE or A-level

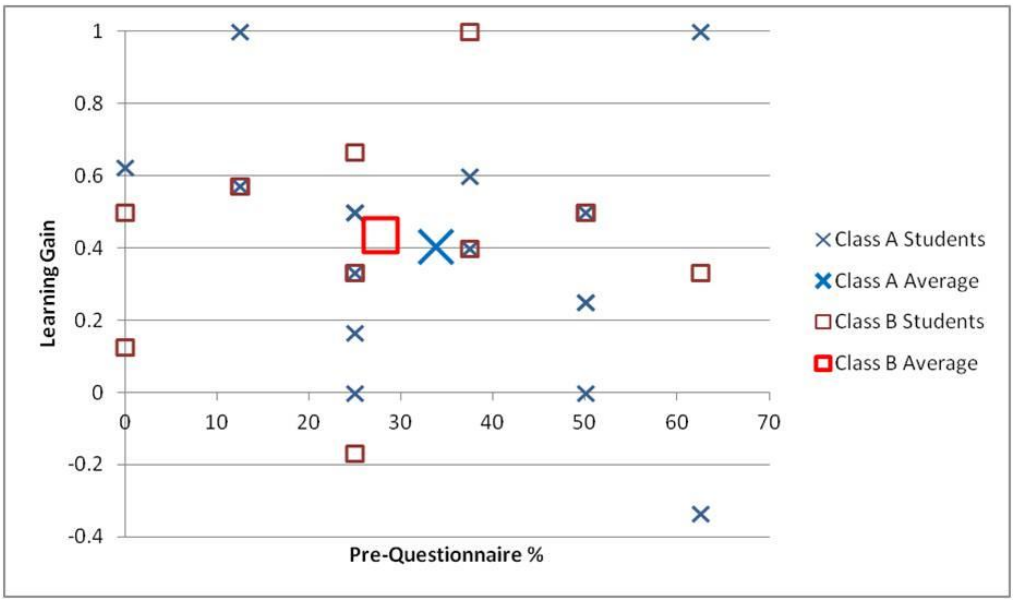

Figure 4. Knowledge questionnaire results by class.
Learning gain= [post % - pre %] / [100% - pre %] (Hake, 1998).

On each of the three knowledge questionnaire questions, students averaged an increase in score (Table 6). This increase was not significant on question 1 (archaeology content), which was scored out of 2. All groups other than those enrolled in both geography and classical civilisation (n=7) had a significant increase on question 2 (physical geography content), which was scored out of 3. All groups other than males and those enrolled in both classes had a significant increase in score on question 3 (geoarchaeology connections), which was scored out of 3.

Table 6. Knowledge questionnaire results by question sorted by groups of differing characteristics.

Group	n	Question 1- Archaeology (/2)		Question 2 – Physical Geography (/3)		Question 3 – Geoarchaeology Connections (/3)	
		Pre	Post[1]	Pre	Post[1]	Pre	Post[1]
Class A	17	1.06 (0.75)	1.39 (0.70)	0.94 (0.83)	2.11 (0.90)**	0.71 (0.85)	1.44 (1.10)^
Class B	13	1.14 (0.77)	1.31 (0.85)	0.43 (0.76)	1.46 (0.88)*	0.57 (0.85)	1.92 (1.04)*
Male	15	1.20 (0.77)	1.20 (0.77)	0.73 (0.59)	2.00 (1.07)**	0.73 (0.80)	1.33 (1.05)
Female	15	1.00 (0.76)	1.47 (0.74)	0.73 (1.03)	1.67 (0.82)*	0.60 (0.91)	2.07 (0.96)**
Both Classes[2]	7	0.86 (0.69)	1.29 (0.76)	0.57 (0.98)	1.29 (1.11)	1.00 (1.00)	1.86 (1.07)
One Class	23	1.17 (0.78)	1.35 (0.78)	0.78 (0.80)	2.00 (0.85)**	0.57 (0.79)	1.65 (1.07)**
All	30	1.10 (0.76)	1.33 (0.76)	0.73 (0.83)	1.83 (0.95)**	0.67 (0.84)	1.70 (1.06)**

^p<0.05, *p<0.01, **p<0.001
[1]compared to pre score; no pre or post scores between groups had significant differences at the 0.05 level; standard deviation in brackets
[2]geography students that had taken at least one classical civilisation class at GCSE or A-level and classical civilisation students that had taken at least one geography class at GCSE or A-level

Perceptions of geoarchaeology and interdisciplinarity

Students averaged positive shifts (i.e, became more like an expert) on five of the six pre-post perception questionnaire statements (Table 7). These shifts were significant on: Q1) the usefulness of connecting disciplines, Q3) imagining connections between archaeology and other disciplines, Q4) the strength of connecting archaeology with other disciplines and Q5) having a good idea about what it means to study geoarchaeology. The shift on thinking geoarchaeology would be fun to study (Q6) was insignificant. Slightly more students thought that it was "time-consuming" to connect disciplines after the teaching pack (Q2; average of 3.45 to 3.53 out of 5), which is considered a negative shift (i.e., away from how an expert would respond). However, this shift was not significant.

Class A had significant positive shifts on usefulness of connecting disciplines and imagining connections between archaeology and other disciplines. Class A and Class B both had significant positive shifts on having a good idea about what it means to study geoarchaeology (Table 7).

Males and females both had significant positive shifts on the strength of connecting archaeology with other disciplines and having a good idea about what it means to study geoarchaeology; males also had significantly lower pre-perceptions on the strength of connecting archaeology with other disciplines (Table 7). Females also shifted significantly and positively on the usefulness of connecting disciplines.

Regardless of additional classes taken, students had significant positive shifts on the strength of connecting archaeology with other disciplines (Table 7). Those that took both geography and classical civilisation also had significant positive shifts on imagining connections between archaeology and other disciplines. Those that did not take both classes also had significant positive shifts on the usefulness of connecting disciplines and having a good idea about what it means to study geoarchaeology.

Table 7. Perception questionnaire results by question.

Group	n	Q1: Useful to connect disciplines		Q2: Time-consuming to connect disciplines		Q3: Imagine connections between archaeology and other disciplines		Q4: Archaeology is made stronger with other disciplines		Q5: Good idea about what it means to study geoarchaeology		Q6: Geoarchaeology would be fun to study	
		Pre	Post[1]	Pre	Post[1]	Pre	Post[1]	Pre	Post[1]	Pre	Post[1]	Pre	Post[1]
Class A	17	4.18 (0.53)	4.59 (0.62)^	3.65 (0.61)	3.88 (0.93)	4.00 (0.79)	4.41 (0.71)	3.88 (0.78)	4.47 (0.62)^	2.88 (1.05)	3.94 (0.83)*	2.18 (0.81)	3.24 (1.03)
Class B	13	3.92 (0.64)	4.38 (0.51)	3.17 (1.03)	3.08 (1.26)	4.23 (0.60)	4.62 (0.51)	4.23 (0.60)	4.69 (0.63)	3.15 (1.14)	4.15 (0.55)^	3.54 (0.78)	3.92 (1.04)
Male	15	4.20 (0.56)	4.53 (0.64)	3.60 (0.83)	3.80 (1.26)	4.13 (0.64)	4.47 (0.74)	3.73 (0.80)[2]	4.40 (0.74)^	3.07 (0.96)	4.00 (0.65)*	3.40 (0.83)	3.80 (0.94)
Female	15	3.93 (0.60)	4.47 (0.52)^	3.29 (0.83)	3.27 (0.96)	4.07 (0.80)	4.53 (0.52)	4.33 (0.49)[2]	4.73 (0.46)^	2.93 (1.22)	4.07 (0.80)*	3.27 (0.80)	3.27 (1.16)
Both Classes	7	4.14 (0.69)	4.57 (0.53)	3.29 (0.95)	3.43 (1.51)	4.14 (0.38)	4.71 (0.49)^	4.00 (0.58)	4.71 (0.49)^	3.29 (1.11)	4.14 (0.69)	3.71 (0.76)	4.00 (1.00)
One Class	23	4.04 (0.56)	4.48 (0.59)^	3.50 (0.80)	3.57 (1.04)	4.09 (0.79)	4.43 (0.66)	4.04 (0.77)	4.52 (0.67)^	2.91 (1.08)	4.00 (0.74)**	3.22 (0.80)	3.39 (1.08)
All	30	4.07 (0.58)	4.50 (0.57)*	3.45 (0.83)	3.53 (1.14)	4.10 (0.71)	4.50 (0.63)^	4.03 (0.72)	4.57 (0.63)*	3.00 (1.08)	4.03 (0.72)**	3.33 (0.80)	3.53 (1.07)

^p<0.05, *p<0.01, **p<0.001; [1]compared to pre score; [2]only significant difference of pre- or post-scores between groups (p=0.02); standard deviation in brackets
"Both classes" refers to students who have taken at least one of each class: classical civilisation and geography.

Student feedback on the post-questionnaire

Students were generally brief, but clear and forthright, on the open-ended post-questionnaire feedback questions. They most enjoyed the aspects of the teaching pack that related to the case study questions: the range of resources available (n=6), cultural aspects of Pompeii and Herculaneum (n=4), group work (n=4) and the questions themselves (n=2; Figure 5). Students also enjoyed the examples and multimedia presented within the powerpoint portion of the teaching pack (n=4). The aspects that the students enjoyed the least were the pre-post questionnaire (n=6) and "lecture" (i.e., powerpoint; n=4). Some students did not enjoy the cultural aspects of Pompeii and Herculaneum (n=3). The sediment description and hand sample was frequently stated as the most (n=9) and least enjoyed (n=5); however, those who said they didn't enjoy it usually attributed this to the fact that they had trouble with it: *"Analysing the rocks, as I found it difficult."****(Student, Class A)***

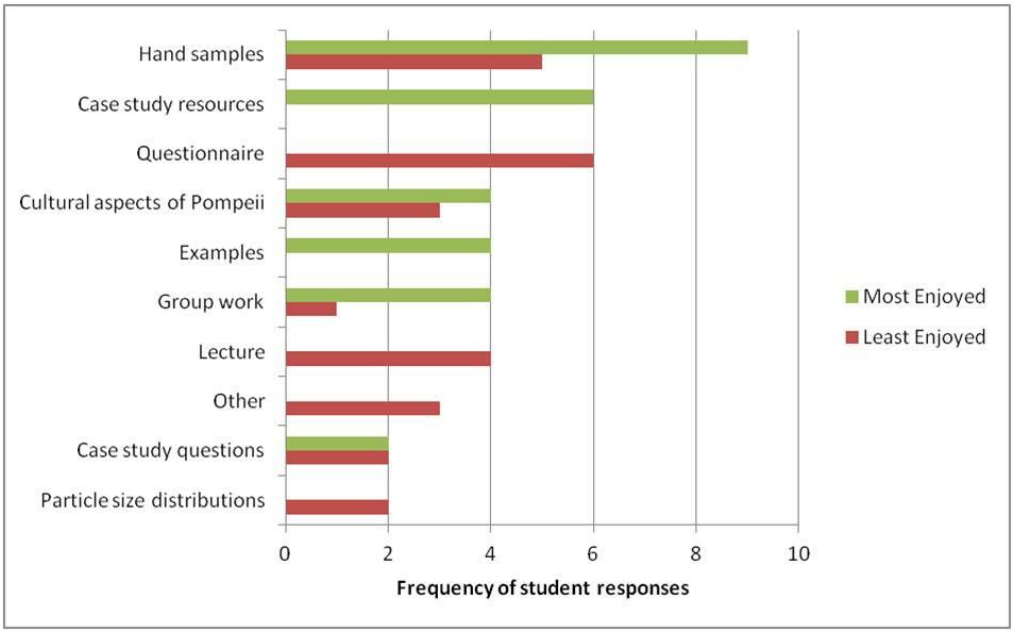

Figure 5. Most common student responses: most and least enjoyed aspects of the teaching pack (feedback questions, Table 3). Total number of students=30.

Student perceptions on the difficulty level of the hand samples/sediment description were mixed. This was the most frequently listed on both the easiest (n=5) and the most challenging (n=8) part of the teaching pack (Figure 6). Many found the cultural aspects of Pompeii and Herculaneum easy to interpret (n=4) and others found it the easiest to sit through the powerpoint lecture (n=4) because they *"didn't have to do anything"* ***(Student, Class A)***. Some felt that the case study questions were the most challenging (n=4), along with a range of other responses (Figure 6).

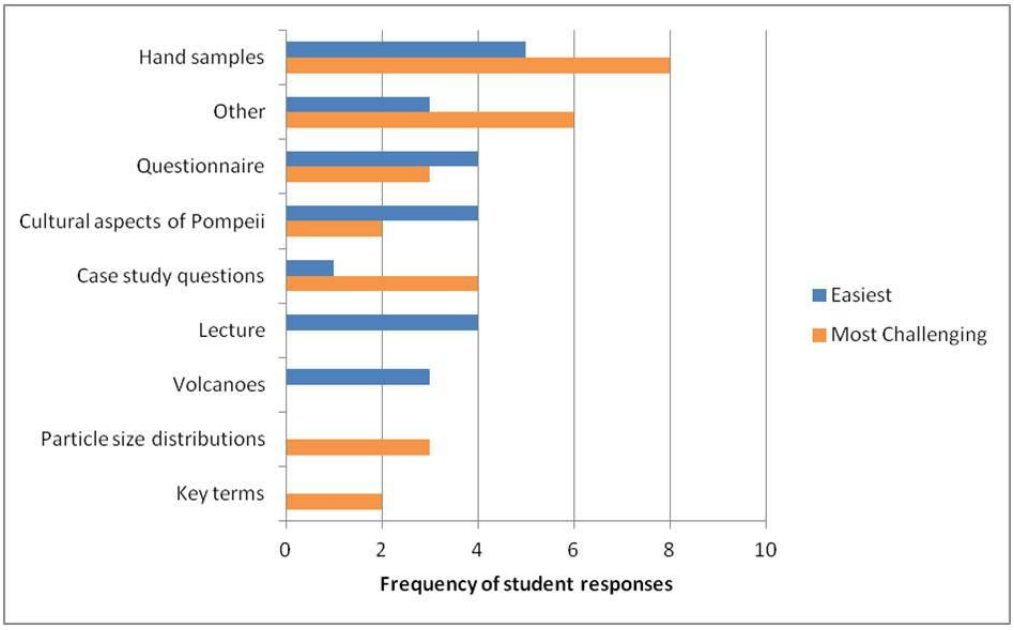

Figure 6. Most common student responses: easiest and most challenging aspects of the teaching pack (feedback questions, Table 3). Total number of students = 30.

Teacher feedback in the post-interviews

Teachers provided feedback through the post-interview process, immediately after delivering the teaching pack. The teachers reported preparation times of half an hour and two hours to read through and understand the teaching pack components. Neither reported finding it overly difficult to teach, including those concepts that were new to them. One suggested that built in questioning slides might help focus the interactive lecture portions, though she asked several relevant questions to the students throughout the lecture without any aids. Both teachers felt that an answer key for the case study questions would have helped with preparation and teaching, especially regarding the particle size graphs, which caused difficulties for students and teachers alike.

In both classes, teachers found their students to be more talkative than usual. One noted that the discussion may have been a good thing during the group work, indicating the students' interest in the material. This teacher was also highly impressed with her students' ability to interact and succeed with the teaching pack:

> *"I was happy* [with] *how they engaged with it…the group work…I think some groups worked better than the others but they do in any class…it kept them interested. And the ones that were really keen, I found it, it stretched them as well. You know, they're finding, they're doing stuff out of real life..."*
>
> ***(Classical Civilisation Teacher 1)***

Both teachers felt that the timing of the pilot study (post-exam break) may have also caused the students to be more talkative.

The teachers felt that their students were most engaged with the practical, hands-on content and Classical Civilisation Teacher 1 thought that the literary passage and artefact pictures were particularly captivating for her students.

In the future, both teachers say that they would use the teaching pack as an enrichment activity, but not in regular class time. In this setting, they believe it would serve well as a base for cross-curricular work or a window to future studies. In

classical civilisation, the teaching pack may be used with archaeology workshops, to help introduce students to the field.

DISCUSSION

The results of this work are placed into context and their implications for teaching, learning and communication are discussed, guided by four research questions:

(1) How might geoarchaeological communication be approached through teaching and learning?

(2) How effective is this approach at teaching the foundational concepts of geoarchaeology?

(3) How effective is this approach at increasing awareness of geoarchaeology and interdisciplinarity in archaeology?

(4) How might this improve the academic communication or understanding of geoarchaeology and archaeological interdisciplinarity?

Finally, recommendations for future investigations are made based on the findings and implications discussed herein.

APPROACHING GEOARCHAEOLOGICAL COMMUNICATION THROUGH TEACHING AND LEARNING (RESEARCH QUESTION 1)

A responsive and reflective approach to communication and education was critical to the success of the project directives. By using multiple sources and perspectives, informed decisions could be made in the project design stages, effectively creating a base for subsequent revisions. It was important, however, to continually reflect upon and be willing to modify this base using new evidence.

Because geoarchaeology is a field with a complicated identity, it was paramount to understand this identity before addressing teaching and learning. Analyses of geoarchaeology led into the broader identity of interdisciplinary workers

in academia. Understanding the wider perspective of interdisciplinarity and the parallels between the identity crises of geoarchaeology and those which had emerged in other interdisciplinary fields helped offer additional examples through a discipline-general view (i.e., one that is transferable to many contexts).

These two unique and equally important sources, geoarchaeology and interdisciplinary studies, were utilised to translate the theoretical background through to education. In particular, the interdisciplinary educational model (which had been developed and researched in much more depth than the curricular examples from geoarchaeology) was central to the initial teaching pack design. Although this design was heavily informed by the literature, it needed to be modified and solidified through discussions with teachers, the details of which are described in the following section.

Assessing and meeting teachers' needs and perspectives

The teaching interviews grounded the teaching pack development in real perspectives and examples. Using a flexible approach, these perspectives were used iteratively to further shape the teaching pack by connecting to teachers and classes more directly. Discussions regarding teacher perspectives of geoarchaeology and interdisciplinarity indirectly impacted the teaching pack material, by improving the understanding of the teachers' approach to this subject material and how to best address their interests and needs.

After the implementation of the pilot teaching pack, post-interviews with educators were used to significantly modify the material. This feedback aided in the understanding of the educator experience in teaching the material and contributed to the final revisions that were made to the teaching pack, discussed in detail later in this chapter.

Developing the teaching pack – ideas, feedback and perspectives

The support of all teachers for a focus on volcanoes, real world and international examples/case studies confirmed basic structural decisions that were already in place with the initial teaching pack design. The teachers were also unanimous in support of group and practical work, echoing the major pedagogical designs already in place. The various maps included in the teaching pack did not have to be simplified and could be frequent, as all students were familiar with reading a variety of maps, regardless of their enrolment in geography or classical civilisation. Although geography students were comfortable with graphs and diagrams, classical civilisation students were not and therefore, care had to be taken to ensure that these components were not overly difficult and kept to a minimum. Knowing that classical civilisation students had, in many cases, less developed observational skills, the focus of the teaching pack was shifted to provide more direct lines of questioning and enhanced support with observation questions, through examples and "fill in the blank" tables.

All of the specific teaching pack recommendations made in the pre-interviews were directly responded to. After the first interview, the decision was made to lead the teaching pack with the archaeology section, rather than the geography section, to build interest early on, especially with the classical civilisation students. Questions involving scientific data were also reduced. Although there were logistical reasons for selecting Mt. Stromboli as the major case study in the teaching pack, the interest in and relevance of Mt. Vesuvius to classical civilisation groups in particular was decidedly more important. Following the second interview, a question focused on the human response to disaster was added as per the teachers' suggestion, utilising a classical passage written by Pliny the Younger. The decision was also made to structure the teaching pack for a two hour window, even if this meant splitting it up over two lessons. After the third interview, final revisions were made to provide more embedded support in the teaching pack, as the educator indicated that

this was lacking. This meant further improving lines of questioning so that they were more direct and clearly separated from one another, adding a key terms list and creating a writing guide for the final synthesis question.

Broader, somewhat theoretical discussions were useful in determining how the educators would approach the teaching pack and whether it might be successful in specific environments. Given that all teachers had holistic goals for their classrooms that were largely focused on literacy, critical thinking and societal connections, it seemed likely that they would connect with the interdisciplinary philosophies of the teaching pack. They were all interested in geoarchaeology, geology and geography, and would hopefully enjoy the experience. Even if they did not know exactly what geoarchaeology was, they were familiar with some of its possible perspectives and how its work would have real benefits. Although all of the educators spoke about varying degrees of reluctance with past interdisciplinary teaching, the reasons they gave for this were logistical (time commitment, organisation, expertise) and could be overcome with a pre-built teaching pack and support from its developer. Additionally, given that all of the teachers described themselves and their field as interdisciplinary, they already held a strong belief in content that bridges disciplinary boundaries.

Revising the teaching pack – post-interview feedback

Debrief sessions with the two pilot study instructors offered insight into the experience of preparing and instructing the teaching pack and an assessment of its success from the person that knows their classroom best. The teachers' self-reported preparation times were half an hour and two hours, the latter of which matches the expected time quoted in the teacher preparation package. The positive comments given about the teaching experience, even when dealing with unfamiliar concepts, support the teaching pack approach and structure. The practical components, as well as the literary passage and artefacts for classical civilisation students, were viewed as highly successful at engaging the students, echoing pre-interview comments and

supporting observations taken during the pilot study. Students were seen as more talkative than usual, possibly indicative of the active learning occurring. This may also be due to the post-exam break timing of the pilot study. The pride that the classical civilisation teacher in particular showed for her students' engagement and success with the teaching pack is perhaps more notable than students being slightly more talkative.

Specific changes suggested by the teachers were minor and easy to incorporate: a bigger font size and some pictures added to the case study questions and a rubric or prompt guide for instructors to use with these questions. One of the teachers thought that embedded questioning slides in the powerpoint section might help; however, both of them were highly successful at questioning on the spot and generated unique questions that were specific to their own class.

EFFECTIVENESS OF THE TEACHING PACK

Foundations of geoarchaeology (research question 2)

Group notes on the case study questions are not the best gauge of learning, due to the low response rate. However, those who did have clear answers had strong interpretations. Success with question 1 (the literary passage) was more definitive with Class B, the one that was given highlighters to help delineate differing themes. The groups' abilities to synthesise large amounts of data and see connections between archaeology and the geosciences appeared to be strong with one group but these data are inconclusive, given the lack of time allotted for this question (Appendix E, Case Study Question 7).

The strong average learning gain on the knowledge questionnaire indicates that the teaching pack was successful at teaching the foundational concepts of geoarchaeology (Table 5). Neither the class in which the students were enrolled (geography or classical civilisation), their gender nor their previous classes taken (if they had taken both geography and classical civilisation at some point) made a

difference to the learning gains that they accomplished. The teaching pack is therefore accessible to students of varying academic backgrounds, though the unbalanced sample for previous classes taken (n=7 for both, n=23 for one) should be noted. None of the groups showed a significant increase on the archaeology perspectives question, though it was only scored out of two (Table 6). It may also have been more intuitive to guess what an artefact might tell you, in contrast to the differences in magma characteristics between shield and composite volcanoes. On this geography perspective question, students did show significant differences in scores between pre- and post-questionnaires. Although the case study synthesis question was inconclusive, the synthesis question on the knowledge questionnaire provided more insight into this aspect of the students' learning. All groups averaged a significant increase on this question, with a post-questionnaire score of 1.7 out of 3.0. The teaching pack was effective at improving the ability to synthesise geoarchaeological connections, though there is still considerable room to grow.

Awareness of geoarchaeology and interdisciplinarity (research question 3)

Results from the perception questionnaire indicate that student perceptions were impacted significantly on several concepts relating to geoarchaeology and interdisciplinarity (Table 7). More students found it useful to connect disciplines (Table 7, Q1), were able to imagine connections between archaeology and other disciplines (Q3), felt that archaeology was stronger when connected with other disciplines (Q4) and had a good idea about what it means to study geoarchaeology (Q5). Therefore, the teaching pack was successful at introducing geoarchaeology and improving the understanding of interdisciplinary studies, specifically those within archaeology. The teaching pack did not impact the students' perceptions of their enjoyment with geoarchaeology (Q6) or the amount of time it takes to connect disciplines (Q2). It is possible that the teaching pack did not adequately address these perceptions or that they are unable to be changed over shorter periods of time.

In contrast to the knowledge questionnaire findings, many groups displayed significant differences between their shifts in perceptions (Table 7). Only Class A, the geography class, showed a significant increase on imagining connections between archaeology and other disciplines, perhaps because they were less familiar with archaeology than Class B to begin with (but not significantly so). Perhaps geography takes its interdisciplinarity as a given (e.g. Skole, 2004) and does not often break down its components for novices to see, as only Class A significantly increased on their perception of the usefulness of connecting disciplines.

It is not clear why males had a significantly lower pre-agreement with the strength of connecting archaeology with other disciplines, the only significant difference in pre-perceptions amongst any of the groups. Additionally, it is unclear as to why only females significantly increased on their agreement of the usefulness of connecting disciplines.

Those students who have at some point taken both geography and classical civilisation significantly increased on being able to imagine connections between archaeology and other disciplines, as they have likely already been making these connections on their own (e.g. Edge, 1975), to some extent. Likewise, students who have not taken both would likely be unfamiliar with geoarchaeology and/or interdisciplinary studies, explaining why they may have had significant increases on both the usefulness of connecting disciplines and having a good idea about what it means to study geoarchaeology.

Powerpoint sections and student engagement

The information provided to the teachers beforehand and the layout of the teaching pack were clear, as both teachers were able to follow the material in a similar manner, with their own unique modifications. Each incorporated some of their own style and content into the questions that they posed to the class. The moderate-high level of student engagement (average of Class A and B=8.46/10, individual;

2.95/4, group; Figure 3) indicates that students were largely interested in and paid attention to the teaching pack. However, this engagement dropped in both classes when section 1 of the powerpoint reached a limit for their attention, around the twelve minute mark. This section of the powerpoint lasted too long and simple questioning was not enough to hold their engagement. Classical Civilisation Teacher 1 (Class B) overcame this by dedicating some time to the obsidian sample, allowing every student to hold it in their hands before asking further questions, rather than talking over them as they viewed it. Breaking apart the lecture by giving all students a chance to individually connect with the physical material (10/10 engaged) was a strong addition to the teaching pack. Students need an effective bridge (e.g. Giustini, 2009) similar to this at the beginning of the latter two powerpoint sections (Figure 3a), to improve their engagement and avoid the decline seen throughout the teaching pack.

Case study questions and small group work

Small group work (ideally, but not in all cases, 3-4 group members) was where students showed the most personal interest in the teaching pack material. Although their average engagement was not as high as the individual sections (73.8%-group vs. 84.6%-individual), more students asked questions, including those who did not answer or ask questions in the larger class environment. The lively discussion sometimes made it difficult to accurately determine engagement or disengagement, except when the content of their discussion was audible.

Interacting with the students in Class B (to assist the teacher) added further confidence in the strength of the case study question format. However, there were some problems with this format. Groups still needed more support throughout the questions, evidenced by the increased engagement with Classical Civilisation Teacher 1's set ups and recaps of each individual question. The particle size distribution question was not clear to the teachers or the students without some added description,

which would have been better delivered within the structure of the questions rather than verbally.

Student feedback on the post-questionnaire

Open-ended student feedback on the post-questionnaire echoed much of the above observations and post-interview comments made by their teachers, especially regarding the success of the case study questions (Figures 5 and 6). In particular, the group work, range of resources and cultural components were well received by the students and teachers. Although some students didn't like the hand samples because they were challenging or difficult, many did enjoy them. A lesser self-reported student enjoyment does not necessarily mean that the question was not useful. Few students stated anything specifically problematic with the samples or related questions, aside from the issues with the clarity of the particle size distributions. These comments suggested that a level of desirable difficulty was met, i.e. that the students were challenged adequately (e.g. Labroo and Kim, 2009).

In contrast, the powerpoint was seen as easy by some of the students because they felt they didn't have to do anything. These students likely did not engage with the questions posed to the whole class and therefore, more is required to build the "buy in" for these less interested students (e.g. Xu et al., 2012). They may need to see that the material will come up in an assessment elsewhere, or be forced to answer questions through personal response software. As many students appreciated the examples and multimedia in the powerpoint, more could added to the beginning of later powerpoint sections in particular, to act as a bridge and captivate students from the start.

ACADEMIC GEOARCHAEOLOGICAL AND INTERDISCIPLINARY COMMUNICATION (RESEARCH QUESTION 4)

A teaching approach that is effective at improving both geoarchaeological knowledge and awareness of interdisciplinarity in archaeology may be translated to

the academic communication of these concepts, to serve the need to improve geoarchaeology's acceptance and integration in archaeology (e.g. Rapp and Hill, 1998; Canti, 2001; Fouache, 2007). Similar methods may be successfully applied to expert archaeologists and geographers, by adding complexity to scaling up the foundational communication.

Critical factors governing communication

Communicating across knowledge domains

The geoarchaeology teaching pack developed all of Woods' (2007) factors related to communicating across knowledge domains (i.e., differences in disciplinary knowledge): "conceptual competence, competence in negotiating meaning and competence in interdisciplinary text production" (p. 860). Students' conceptual competence was shown on the knowledge questionnaire results and this competence was universal for groups of differing characteristics. Competence in negotiating meaning was evident during the case study questions, where students interpreted real data. Although some of their question sheets weren't entirely complete, those who answered the questions displayed a thorough understanding of the material. Between the few answers provided for the synthesis question on the question sheet and the significant improvement on the synthesis question on the knowledge survey, many students showed competence with interdisciplinary text production. Therefore, secondary students exposed to this material could conceivably communicate within its differing domains of knowledge effectively.

Communicating across academic cultures

Woods' (2007) factors for communicating across academic cultures (i.e., differences in disciplinary operation) are somewhat more complicated than those relating to knowledge domains: "knowledge, skills of interpreting and relating, skills of discovery and interaction, attitudes and critical disciplinary awareness" (p.860).

This teaching pack was effective at building the students' knowledge and attitudes (perceptions), by demonstrating gains in learning and more expert-like ways of thinking. An understanding of what geoarchaeology is, the strength and possibilities of archaeological interdisciplinarity and the usefulness of interdisciplinarity in general were conveyed within the confines of this teaching pack. Perceptions of the time it takes to do interdisciplinary work and enjoyment of geoarchaeology were not conveyed, but might be beneficial for communication across academic cultures, particularly with skills of discovery and interaction. These and other skills of academic culture (interpreting and relating, critical disciplinary awareness) are therefore beyond the scope of this teaching pack.

Teaching pack applications to communication

The above improvements to communication factors were accomplished through the delivery of the teaching pack, assisted by several key aspects. These aspects can be incorporated in some way to varying forms of academic communication, including publications, conference presentations, lectures and research conversations.

Structure of communication – the interdisciplinary teaching model

The interdisciplinary teaching model that progresses through separate disciplinary foundational knowledge, models/perspectives, analyses and finishes with a synthesis of the involved disciplines (Figure 1) was successful in the teaching pack, aside from minor changes to the individual sections that needed to be made. This structure could be useful with most forms of geoarchaeological communication and viewed as a logical progression where disciplinary perspectives are not conveyed until the audience has some level of foundational knowledge. Each phase is relative and the amount of information needed to communicate changes with the desired scope of the final understanding and synthesis.

The foundational knowledge portions in particular, i.e. the powerpoint sections, need to establish more "buy in" through an increase in active involvement for each individual and a vested interest in the knowledge itself (e.g. Xu et al., 2012). For students this may be electing to participate in an enrichment activity or knowing that content will be assessed at a later date, whereas experts may have an enhanced self-interest.

Content of communication – clear, practical examples

Geoarchaeological communication is helped by providing clear, relevant examples, through a range of resources with an attention to the cultural and personal aspects of the site. A practical example, e.g. hand sample, is highly useful, though may be difficult for those who are unfamiliar with observation and geological approaches. However, the desirable difficulty designed for experts who have a vested interest in the topic would likely be far higher than that of students who have not personally elected to participate in the activity (i.e., a non-enrichment setting).

Perceptions of geoarchaeology and interdisciplinarity in archaeology will vary with different groups and the focus can be placed on different aspects of these. For example, with classical civilisation groups less time may be spent on the possible connections between archaeology and other disciplines and the usefulness of connecting disciplines than with geography groups, as they shifted significantly on these categories but did not have significantly different pre- or post-perceptions than the geography group.

Modes of communication – active, small group work with guidance

Whenever possible, geoarchaeology should be communicated via hands-on, active means. As with any educational interaction, lecture time should be minimised and multimedia should be used with examples where appropriate. Small groups (i.e., 3-4 people) are more effective for engaging with the material than larger groups (i.e., class-sized). Considerable guidance should be provided throughout the

communicative interaction, in particular to support the portions where expert knowledge may be lacking.

FUTURE WORK

This work has implications for a variety of contexts: geoarchaeological teaching and learning at the secondary through post-secondary level, academic geoarchaeological communication and teaching and learning and communication of other interdisciplinary archaeological fields. Several of these aspects are discussed below: the revisions made to the teaching pack and recommendations for its further use, improvements to geoarchaeological communication and additional interdisciplinary connections with archaeology. It is expected that many of these findings will be applicable to other interdisciplinary fields, but they are beyond the scope of this study.

Revised teaching pack and recommendations for implementation

The teaching pack has been proven effective at teaching foundational geoarchaeology concepts and improving students' awareness of geoarchaeology and interdisciplinarity in archaeology, through an approach to communication largely sourced from the interdisciplinary education community. In future implementations, users should always be cognisant of its effectiveness, as this may change in differing settings. Although it was piloted with A-level students, teachers indicated its potential with GCSE students. It is also suitable for university students earlier in their first year. In the future, at least with secondary school students, its use should be directed towards enrichment opportunities rather than curriculum mainstays, unless there is a stronger incentive for students to engage with the material.

Nearly all of the suggested revisions have been made to the teaching pack, in order to produce a final version for future implementation (Appendix J). These include: suggested attention to the hand sample example in the first section of the powerpoint, improved bridges for the latter powerpoint sections and a bigger font

size, pictures and more guidance with the case study questions. It is recommended that students are provided with highlighters for the literary passage in question one. The final essay question has been removed and instead each group member will be responsible for summarising one or two questions on sticky-notes. The group must order and connect these to produce a synthesis of Pompeii before and during the eruption of Mt. Vesuvius.

The teachers are now provided with a case study question answer key, but questioning slides have not been added to the powerpoint sections because they may detract from the individualisation of each class' experience. This uniqueness and flexibility for each teacher to adapt the delivery to their own style is a major strength of the teaching pack. In the future, a question bank could be built by collating questions asked by users from all disciplines. Relevant questions could then be chosen and even imported into real time questioning software, i.e. personal response systems.

Improving geoarchaeological communication

Future studies would benefit from a direct test of these geoarchaeological communication findings at the academic level (e.g. Wieseman and Moscovici, 2003), as it is possible that certain aspects that were successful with novices might not be successful with experts. For example, pre-conceptions (i.e., pre-existing views of topics) might make experts more resistant to some ideas, whereas this group of students had no strong pre-conceptions. Experts might have more self-interest than novices but this may be more difficult to maintain with knowledge outside of their specialty. They might also be tougher critics than students and quicker to disengage if they are not hooked early on.

Further methods could be devised to measure the impact of these communication recommendations on Woods' (2007) forms of communication across academic cultures that were not addressed in the teaching pack (skills of discovery

and interaction, interpreting and relating, critical disciplinary awareness). They may evolve on larger timescales of growing expertise than over one teaching pack or require additional group or field work experience.

Studies like these could be conducted using written or verbal, formal or informal communication in order to validate the translation of these approaches to academic interactions. Ideally, interviews with experts would drive this, with the potential of added questionnaires to provide quantitative values on changes in knowledge and perceptions, much like the questionnaires herein.

Further interdisciplinary connections with archaeology

Teaching packs in other sub-disciplines

Similar teaching packs could be developed for other interdisciplinary archaeology fields, such as zooarchaeology, historical archaeology and palaeoanthropology. These teaching packs would serve to introduce new concepts and connections with archaeology to different groups of students than are reached by geoarchaeology, such as biology and history (e.g. Fleming, 2000). Outreach is critical for classicists in particular, who are generally quite interested in archaeology but have limited opportunities to explore it. Care must be taken to minimise the amount of scientific data when attempting connections with the humanities, as many educators are wary of overloading their science-phobic students or selves. Interest in the teaching pack was quick to build once the researcher discussed its aims with the teachers in person, but generating response during a busy time of year was difficult. Future contact may benefit from being initiated earlier in the school year.

Cross-disciplinary recruitment through interdisciplinary teaching packs

Interdisciplinary teaching packs may serve as useful cross-disciplinary recruitment tools for universities, especially in times where standards for university entry to archaeology are becoming stricter and student recruitment needs to be

broadened. There are valuable opportunities to introduce archaeology and its potential connections to students from fields like geography and biology. Along with this, the university and department may be showcased, particularly in their attitudes towards interdisciplinary studies.

The data obtained through this research have been shown to be highly flexible and translatable to several related scenarios. Through the creation and testing of a new and innovative teaching pack for secondary school students, connections to the improvement of academic geoarchaeological communication have been made. There are a wide range of possible future investigations springing from this work, including applications to other interdisciplinary archaeological fields and their communication, teaching and learning and university recruitment.

CONCLUSION

Using an iterative, reflexive methodology, a geoarchaeology teaching pack was developed to introduce the field to A-level students. This teaching pack was used as a model for improved academic communication, as is needed in geoarchaeology (e.g. Rapp and Hill, 1998; Canti, 2001; Fouache, 2007).

The teaching pack design originated through an analysis of the relevant literature and was modified through pre-interviews with A-level teachers. These covered the specifics of the teaching pack and the teachers' attitudes towards teaching and learning, geoarchaeology and interdisciplinary studies. Following these, the teaching pack was piloted with one classical civilisation and one geography class in the Sheffield area, delivered by the teachers of those classes. The pilot studies were observed and student data regarding knowledge and perceptions of geoarchaeology and interdisciplinarity were collected through pre-post questionnaires. Instructors participated in post-interviews immediately following the delivery of the teaching pack.

Geoarchaeological teaching and learning was best approached by using insights from both geoarchaeology and interdisciplinary studies, in theory and in educational practice. Understanding the broader, interdisciplinary context of geoarchaeology helped to deconstruct how the field operates and to envision possibilities for improving its communication. The geoarchaeological education literature was limited and was effectively bolstered by that of the field of interdisciplinary education. Interviews with teachers were a critical complement to the literary approaches to geoarchaeological teaching and learning.

The teaching pack was effective at generating learning of the foundational concepts of geoarchaeology. The group answers written on the case study questions showed evidence of conceptual understanding. Student learning increased, with an average normalised learning gain of 0.42 on the pre-post knowledge questionnaire. Improvement was greater on the physical geography question than the archaeology question. Students also improved significantly on the synthesis question of the pre-post questionnaire, supported by the long form answers produced during the case study questions and pilot study observations.

The teaching pack was also successful at improving student perspectives, which became significantly more expert-like on several concepts. Student awareness of archaeological interdisciplinarity and geoarchaeology increased after participating in the pilot study. More students felt that it was useful to connect disciplines, were able to imagine connections between archaeology and other disciplines, felt that archaeology was stronger when connected with other disciplines and had a good idea about what it means to study geoarchaeology. Observations of the pilot study indicated highly engaged and interested students.

Many of the teaching pack outcomes may be translated to various forms of academic geoarchaeological communication. The teaching pack was successful with improving factors related to communicating across “knowledge domains” (i.e., different disciplinary knowledge) and to a lesser extent, across “academic cultures”

(i.e., different disciplinary operations; Woods, 2007, p.860). The interdisciplinary studies model drove the structure of communication, separating disciplinary foundational knowledge, models/perspectives, analysing them and then finally combining the disciplines through synthesis. Practical and relevant examples that achieve desirable difficulty for the audience and that are well guided by the primary communicator are important to successful geoarchaeological communication.

A final revision was made to the teaching pack, incorporating student and educator feedback and research findings. The teaching pack is now ready for implementation in classical civilisation, geography, archaeology and geology A-level classes. It is also suitable for GCSE and first year university students. Further communication studies directly involving experts from geoarchaeology and the broader archaeological community would complement this work. Similar approaches should be taken with other interdisciplinary archaeology teaching and learning developments and may be particularly useful for cross-disciplinary university recruitment. The world of archaeology education and communication has many opportunities to build understanding, in ways that will benefit students, educators and researchers of all levels.

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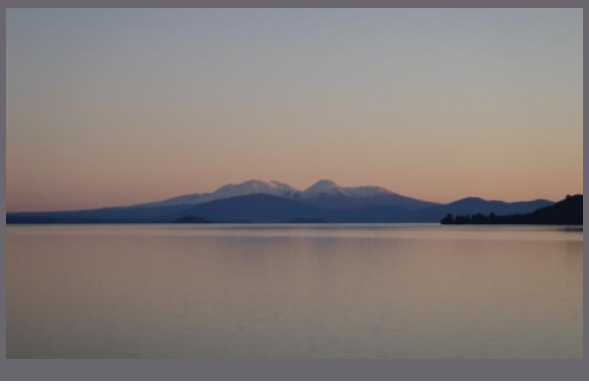
Appendix A. Initial teaching pack design.

AN INTRODUCTION TO GEOARCHAEOLOGY



The University Of Sheffield.

Living with volcanoes

Outline

2

- Objectives
- Introduction
- Volcanic Setting
- Volcanic Deposits
- (Geo)Archaeological Setting
- (Geo)Archaeological Materials
- Summary

Objectives

3

- Describe the two major types of volcanoes and their characteristics.
- Interpret volcanic deposits and materials.
- Describe archaeological techniques and their products.
- Interpret archaeological materials.
- Describe geoarchaeology and its main approaches.

Introduction

4

- Geoarchaeology uses geographical and archaeological approaches to understand a landscape or site.
- It is **interdisciplinary,** requiring a wide range of knowledge and the ability to connect it.
- Today we'll learn about volcanic geography and archaeology and combine them in order to understand a case study: a Bronze Age settlement at Stromboli.

Case Study Background

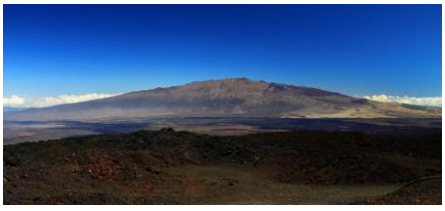
5

- Stromboli is an active volcanic island in Italy
- Bronze Age settlement on its Eastern edge
- As we learn more about volcanic geography and archaeology, you will receive more information about this landscape that you will have to interpret

Volcanic Setting

6

- All volcanoes can be classified as one of two types: shield volcano or stratovolcano



Mauna Kea, Hawaii

Mayon Volcano, Philippines

Volcanic Setting

7

- This physical difference is dictated by the general characteristics of the magma that forms them

Characteristic	Shield Volcano	Stratovolcano
Composition	Low Silica	High Silica
Colour	Darker	Lighter
Viscosity	Low (Runny)	High (Sticky)
Gas Content	Low	High

- These also dictate the explosivity of the eruption: stratovolcanoes are generally more explosive than shield volcanoes

Volcanic Setting

8

- Video of how viscosity affects volcano shape

Volcanic Setting

9

- Knowing whether a volcano is explosive or not isn't enough, need to know how much so that human impacts can be understood
- Scientists use the Volcanic Explosivity Index (VEI)

VEI	0	1	2	3	4	5	6	7	8
Volume (m^3)	$<10^4$	10^4-10^6	10^6-10^7	10^7-10^8	10^8-10^9	10^9-10^{10}	10^{10}-10^{11}	10^{11}-10^{12}	$>10^{12}$
Composition	Low Silica			Moderate Silica		High Silica			
Column Height (km)	<0.1	0.1-1	1-5	3-15	10-25	>25			
Duration (hrs.)	<1		1-6		6-12	>12			

Volcanic Setting

10

- Initial phase of eruption of Vesuvius in 79 CE/AD (Pompeii):
  - Approximately 32 km high eruption column
  - Eruption duration 20 hours
  - Magma moderate in silica (deposits grey in colour)
  - Eruption volume of 1.5 x 10^9 m^3 (1 500 000 000 m^3)

Case Study: Part 1

11

- Now you will explore the volcanic setting of Stromboli, using real data.

Physical Setting (Volcanoes)

12

- One additional component of the VEI is the "classification", to compare the eruption to well known volcanoes
- Have also tallied the % of eruptions of each type that have had fatalities

VEI	0	1	2	3	4	5	6	7	8
Volume (m^3)	$<10^4$	10^4-10^6	10^6-10^7	10^7-10^8	10^8-10^9	10^9-10^{10}	10^{10}-10^{11}	10^{11}-10^{12}	$>10^{12}$
Composition	Low Silica			Moderate Silica		High Silica			
Column Height (km)	<0.1	0.1-1	1-5	3-15	10-25	>25			
Duration (hrs.)	<1		1-6		6-12	>12			
% with Fatalities	1	2	3	12	31	38	60	100	-
Classification	Hawaiian	Strombolian	Vulcanian	Plinian		Katmaian			

Volcanic Deposits

13

- Lava (usually low silica basalt)

Volcanic Deposits

14

- Tephra (material of varying sizes transported by air)
  - Ash (<2 mm)
  - Lapilli (2-64 mm)
  - Blocks and bombs (>64 mm)

Volcanic Deposits

15

- Pyroclastic flow
  - Very fast moving cloud of hot gas and tephra

Volcanic Deposits

16

- Video of pyroclastic flow at Unzen Volcano, Japan

Volcanic Deposits

17

- Lahar (volcanic mudslide)
  - Heat from volcano melts snow/ice, causing mudslide

Case Study: Part 2

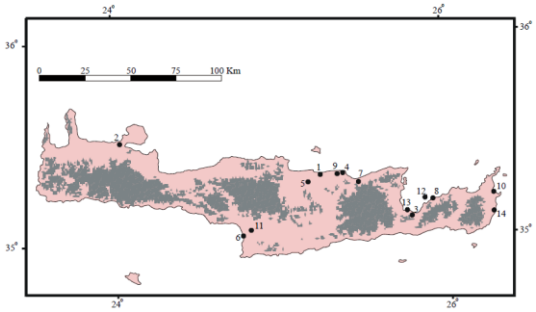
18

- Now you will look at some actual volcanic material and deposit maps from Stromboli.

Archaeological Setting

19

- Field walking and survey
  - Larger scale, usually to understand spatial distribution and/or identify areas of further interest (e.g. artefacts, churches, burials, sites, etc.)

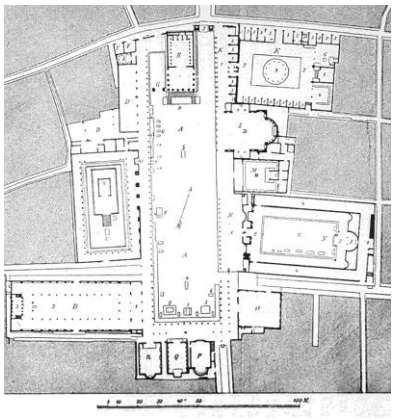


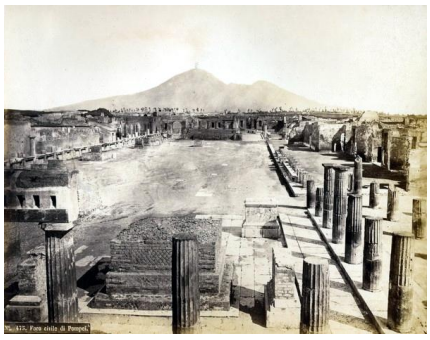
Coastal survey in Crete for possible impacted sites from tsunami generated by Bronze Age eruption at Santorini (modified from Sewell, 2001). Dark grey represents elevation over 500 m.

Archaeological Setting

20

- Site/building plans
  - Smaller scale, settlement and usage patterns

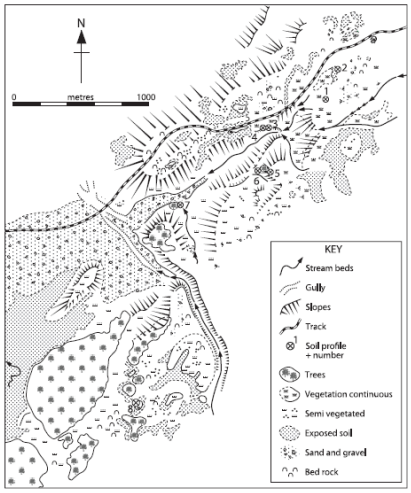




Geoarchaeology Connections

21

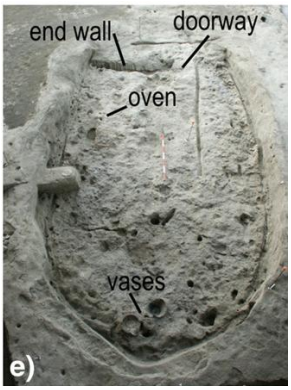
- Geoarchaeologists will conduct similar surveys and maps, but will extend this to the region around the site ("off-site")
- Attention to landforms that are not human-made

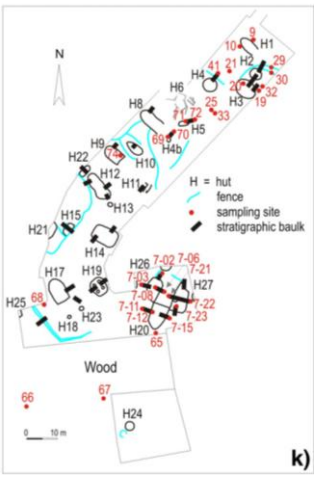


Archaeological Setting

22

- Excavation
- Stratigraphy



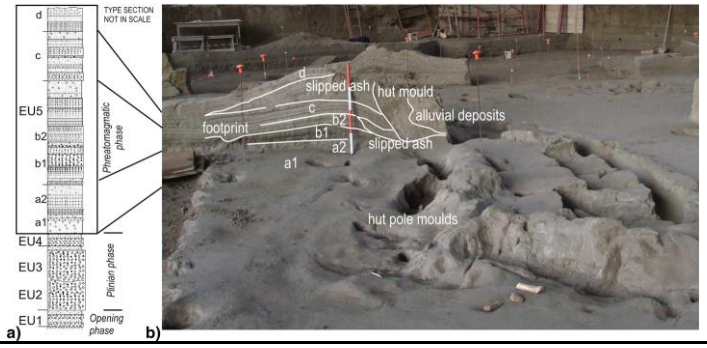


Excavated hut (left) and excavation map at Bronze Age village of Afragola, Italy affected by eruption of Vesuvius. Sample and stratigraphy locations marked (Di Vito et al., 2009).

Geoarchaeology Connections

23

- Not only the artefacts that are recovered, but the deposits that they are contained in
- Context of the deposits – strata above and below the "archaeological" layers
- Other non-artefact materials within the deposits



Case Study: Part 3

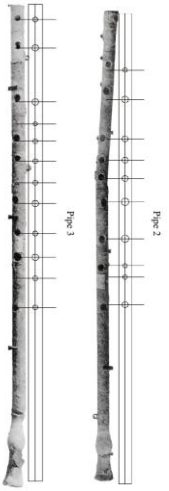
24

- Now you will explore the archaeological setting at Stromboli, using photographic evidence, site plans and stratigraphic data.

Archaeological Materials

25

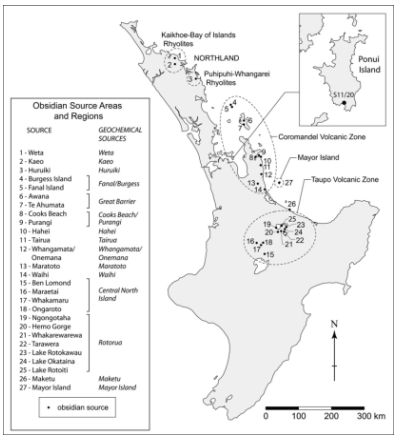
- Artefacts



Geoarchaeology Connections

26

- Artefact composition, for utility and for sourcing



Archaeological Materials

27

- Casts and skeletons

Geoarchaeology Connections

28

- State of preservation reveals details about eruptive conditions
- At Pompeii, temperatures were around 250°C: hot enough to be fatal, but not hot enough to vaporise tissues (delayed breakdown leaves a cavity which is then filled with plaster-like material to produce a cast)
- At Herculaneum, temperatures were around 500°C: hot enough to vaporise organic matter and leave only the skeletons behind

Archaeological Materials

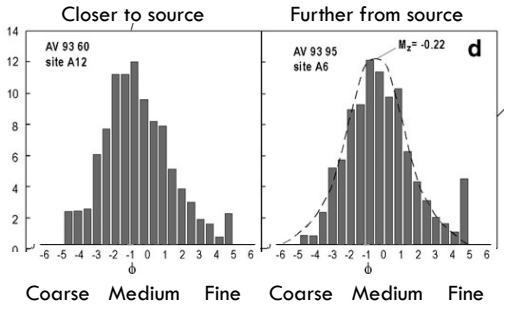
29

- Occupation structures and surfaces
- Soils and sediments

Geoarchaeology Connections

30

- Building material composition (utility and sourcing, as done with artefacts)
  - Use of volcanic rocks as building stones in Ancient Rome
- Particle size

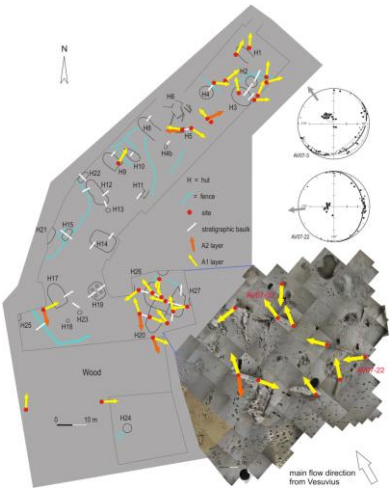


Geoarchaeology Connections

31

- Magnetic susceptibility

Site	*Locality*	*Archaeomagnetic age*	*Attributed eruption*
P21	Masseria Galassi	800±20	**AD 787**
P06	Terrioni Quarry	850±40	9th century
P16	San Vincenzo Postiglione	870±30	9th century
P10	Calastro	900±30	10th century
P30	NA-SA Portici-Bellavista	900±20	10th century
P25	Granatello	900±30	10th century
P18	Scogli della Scala	900±40	10th century
P12	Torre Annunziata, soccer field	900±20	10th century
P28	Torre Annunziata, palazzo Monteleone	900±30	10th century
P23	Masseria Bosco del Monaco	920±30	10th century
P15	Torre Bassano	940±30	10th century, **968**
P09	Fossa Monaca	1000±40	968, **999**, 1006–07
P03	Torre Scassata	1000±30	968, **999**, 1006–07
P02	Villa Inglese, lower lava	1000±50	968, **999**, 1006–07, 1037
P14	Scogli di Prota-Villa Balke	1000±50	968, 999, **1006–07**, 1037
P26	Vesuvius' café, N of Torre del Greco	1000±50	968, 999, **1006–07**, 1037
P01+P20	Villa Inglese, upper lava	1050±30	999, 1006-07,**1037**
P19	Lido Incantesimo	1050±30	1006–07, **1037**
P11	NA-SA Ercolano	1080±60	1037, **1139**
P29	Cupa dei Monti, N of Ercolano	1100±40	**1139**
P17	Passanti	1100±40	**1139**
P04	S flank W of Boscotrecase	1140±40	**1139**



Case Study: Part 4

32

- Now you will put together the final details about the archaeological materials at Stromboli.

Summary

33

References

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Geoarchaeology Case Study Questions: Bronze Age Stromboli, Italy

Part 1

1. What type of volcano is Stromboli? Does it fit all of the characteristics of that type?
2. What was the VEI of the Bronze Age eruption (need approx. date) at Stromboli? Discuss how scientists are able to determine the VEI of past eruptions, especially prehistoric eruptions. Is this an exact value?

Part 2

3. Describe (e.g. colour, size, texture) and identify the materials in vials A, B and C.
4. List 3 types of deposits found at Stromboli? Use the geologic map for this.
5. List 3 types of hazards found at Stromboli? Use the hazard map for this.
6. Briefly compare and contrast the type of information that geologic and hazard maps portray.

Part 3

7. Describe the terrain where modern day settlements are located at Stromboli, using the aerial photo ("bird's eye view") and geomorphologic map. Where do you think archaeologists should look for past settlements?
8. Describe the approach of the archaeologists investigating the Bronze Age site of San Vincenzo, Stromboli, using the site plan. Where would you recommend they sample further or excavate in more detail?
9. Locate the Bronze Age archaeological layer in the stratigraphy at Stromboli. Describe the deposits found above and below this layer.

Part 4

10. Describe the types of artefacts and building structures found at San Vincenzo.
11. Describe the particle size data from Stromboli. Compare it with xx. What does this say about the environment of deposition of these sediments?
12. Describe the magnetic susceptibility data from Stromboli. Compare it with xx. What does this say about the processes involved?

Summary

13. Write a paragraph describing how people lived within the landscape of Stromboli in the Bronze Age, using your conclusions above. Highlight some of the volcanic and archaeological settings and materials and the connections between these.

Appendix B. Teacher information sheet.

The University Of Sheffield.

Participant Information Sheet - Teachers
"Geoarchaeology in the A Level Classroom"

Researcher : Alison Rae Jolley, M.Sc. Candidate
Email: arjolley1@sheffield.ac.uk
Phone : 07954150688

You are being invited to participate in a research project by the Department of Archaeology at the University of Sheffield. Please take the time to read the following details about the project in order to help you decide whether or not you would like to participate. If anything is unclear or you would like more information, please contact the researcher.

This project, entitled "Geoarchaeology in the A Level Classroom", aims to develop teaching materials for A level students. These materials will highlight the interdisciplinary nature of geoarchaeology, using a case study relevant to both Archaeology and Geography A levels. The development of these materials will be informed by interviews with A level teachers and trialled with A level students. Finally, the effectiveness of the materials will be assessed, using further teacher interviews and student surveys of perception and knowledge of geoarchaeology.

You have been contacted because you are a teacher of A level Archaeology or Geography in the Sheffield area. Should you choose to participate, you will be asked to contribute approximately 4 hours of your time (including one lesson of teaching time). Firstly, you will be interviewed by the researcher for no more than one hour, to get an idea of what prior knowledge your students have, what content might interest them, and what teaching styles they are most familiar with. After the materials have been developed, you will lead your students through the activity and surveys, at a time and date that is most convenient to you. We expect that you will require 1 hour of preparation time with the materials before teaching the lesson, and will provide you with the final version at least two weeks prior. Finally, you will be interviewed by the researcher for no more than one hour, to assess the success of the activity.

Your participation is voluntary and you may withdraw from the research project at any time without penalty, by contacting the researcher. You may keep this information sheet and you will be asked to sign a consent form prior to your first interview with the researcher.

There are no known disadvantages or risks to participating in this study. Benefits of participation include the chance to familiarise yourself and your students with new and cutting edge material and to contribute to the development of a novel teaching activity.

All personal data will be accessed only by the researchers and will be kept on password protected computers and in locked filing cabinets. It will remain confidential and be anonymised when used in reports or publications regarding the project. Should you choose to withdraw, your data will be destroyed immediately. Interviews will be audio recorded and storage of these data will follow the above procedures. If you would like to have access to any reports or publications on the research, please contact the researcher.

This project has received ethics approval from the Department of Archaeology's Research Ethics Committee, which is overseen by the University of Sheffield's Research Ethics Committee. Any complaints or concerns may be addressed to the Research Supervisor, Dr. Gianna Ayala, at g.ayala@sheffield.ac.uk (0114-2222935). If you feel that your complaint has not been handled to your satisfaction, you may contact the University of Sheffield's Registrar and Secretary (registrar@sheffield.ac.uk).

Thank you for taking the time to read this information sheet. If you would like to participate in the research project, please contact the researcher.

Appendix C. Teacher consent form.

The University Of Sheffield.

Participant Consent Form - Teachers
"Geoarchaeology in the A Level Classroom"

Researcher : Alison Rae Jolley, M.Sc. Candidate
Email: arjolley1@sheffield.ac.uk
Phone : 07954150688

Participant Identification Number for this Project (*to be filled out by the researcher*): _____

	Please Initial Box Below
1. I confirm that I have read and understand the information sheet dated 5 December 2012 explaining the above research project (including what is required of me) and I have had the opportunity to ask questions about the project.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.	
3. I understand that my responses will be kept in locked/password protected storage facilities and remain strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.	
4. I understand that I may contact the researcher (or research supervisor) regarding any questions, and/or to receive access to any reports or publications on the findings of the project.	
5. I am aware of who to contact should I have any concerns or complaints regarding the research project.	
6. I am aware that interviews will be audio recorded, and the treatment of this data will follow the methods detailed in point (3).	
7. I agree to take part in the above research project.	

Name of Participant	Date	Signature
Lead Researcher	Date	Signature

Appendix D. Pre-interview protocol.

These questions serve to help us understand the specific classroom setting, prior student knowledge, best approaches to teaching pack content and pedagogy, and existing perceptions of geoarchaeology and interdisciplinarity.

Demographics/Background

In order to understand the context of this study and for others to understand how transferable our findings are, we need to have a rough idea of the background of yourself and your students.

1. Roughly, what is the demographic range of your students?
    a. Achievement? Age? Gender? Ethnicity?

    b. *If applicable*Do you expect there to be any overlap between this group of students and the students taking _____ (if two courses at this school are participating)?

2. What do most students go on to do after studying this subject at A level? Any examples?

3. What was the subject area of your highest qualification? If education, what about undergrad?

    a. Within this subject area, what are you most interested in? Why?

4. Prior to this study, had you heard of geoarchaeology?

    a. What do you think it means? Hazard a guess if unsure.

Geoarchaeology is a sub-discipline of archaeology that combines the perspectives of geography/geology and archaeology to approach problems in a new way.

Teaching Pack

At this point describe the current conception for the teaching pack, and show any materials that have been designed up to this point (if any).

5. Any first impressions? General feedback?

6. Content.
    a. How best to make it relevant? Could it be tied into something already being taught in class more explicitly?

Possible connections include artefact types tying into what society was like, eruptions and site preservation of site ("frozen in time"), history of eruption and what it was like to live through it and writers of the time describing the landscape/environment, eruption.

b. Difficulty level?

7. Pedagogy.
    a. Will it be natural enough for them?

    b. Do you want to use any aspect for assessment? We can work that in if need be.

<u>Student Knowledge</u>

8. What aspects of the classical civ (or geography) curriculum that you teach that would have already been covered on the following topics? What are the key learning outcomes of these? *refer to AQA curricula summaries*
    a. Volcanology and related landforms/deposits?

    b. Soil and Sediments?

    c. Maps?

    d. Other?

9. What are the key learning outcomes of A Level classical civ (or geography) as a whole? *refer to AQA curricula summaries*

<u>Interdisciplinarity</u>

10. *If interview environment is conducive* How would you define "interdisciplinary"?

Although definitions of these vary and distinctions are admittedly blurred, these are the most common definitions. "Interdisciplinary" refers to studies where differing perspectives/disciplines are blended in order to solve a problem. "Multidisciplinary" refers to studies where differing perspectives/disciplines are addressed for breadth, but they remain separate.

11. Do you often teach (or have you in the past taught) a problem/theme/question in an interdisciplinary manner? Why or why not? Give an example. Benefits and challenges?

    a. Multidisciplinary? Why or why not? Give an example. Benefits and challenges?

<u>Pedagogy</u>

12. What do you find is the most effective content for engaging students?

    a. International vs. local?

b. Real vs. fictional?

c. Maps?

d. Descriptions?

e. What are students used to in your classroom?

13. What do you find is most effective teaching style for engaging students?

a. Lectures?

b. Group work?

c. Practical work?

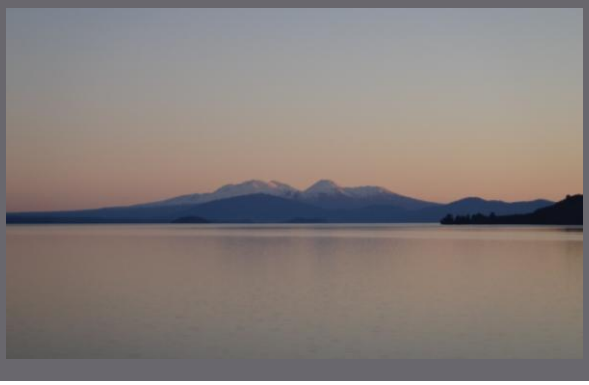
d. Is it a combination of the above? Do you find that blended learning is an effective approach?

e. What are students used to in your classroom?

14. Any final comments or questions on anything?

Appendix E. Pilot teaching pack design.

AN INTRODUCTION TO GEOARCHAEOLOGY



The University Of Sheffield.

Living with volcanoes

Pompeii

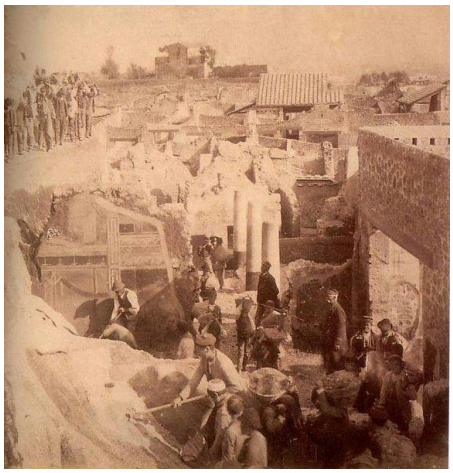
2

- "Then the flames and smell of sulphur which gave warning of the approaching fire drove the others to take flight and roused him to stand up. He stood leaning on two slaves and then suddenly collapsed, I imagine because the dense fumes choked his breathing by blocking his windpipe...when daylight returned on the 26th—two days after the last day he had seen—his body was found intact and uninjured, still fully clothed and looking more like sleep than death." – Pliny the Younger writing to Cornelius Tacitus about the death of his Uncle, Pliny the Elder

Why do we care about the volcano?

3

- If we understand the volcano with the **archaeology**, we can put together a full picture of what it was like to live during the eruption
- The volcanic deposits buried the site and helped to preserve architecture, **artefacts** and people



Objectives

4

- By the end of this lesson, you should be able to:
  - Describe some archaeological approaches and how geoarchaeology builds on them.
  - Describe the two major types of volcanoes and some related volcanic deposits.
  - Interpret geoarchaeological materials.
  - Use these interpretations to help you explain what it was like before and during the eruption at Pompeii.

What is geoarchaeology?

5

- **Geoarchaeology** uses geographical and archaeological approaches to understand a landscape or **site**.
- It is **interdisciplinary**, requiring a wide range of knowledge and the ability to connect it.
- Today we'll learn about volcanic **geography** and **archaeology** and combine them in order to understand a case study: the eruption of Mt. Vesuvius in 79 AD.

Case Study Background

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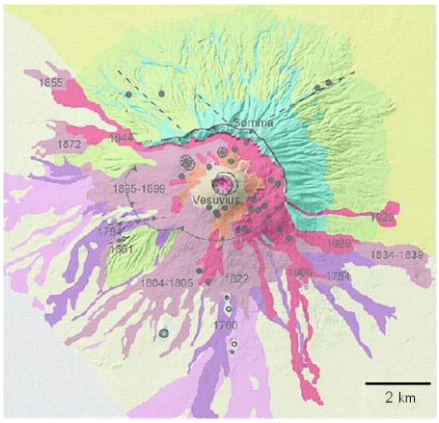
- Mt. Vesuvius is an active volcano in Italy
- It is well known for its eruption in 79 AD that destroyed Pompeii and other Roman settlements
- As we learn more about volcanic **geography** and **archaeology**, you will receive more information about this landscape that you will have to interpret

Archaeological Setting: Landscape

7

- Ideas of settlement choice, trade networks, relationship to environment/resources and how these might change over time and space
- Use maps (topographic, geological, archaeological survey) and compare to **site** distributions

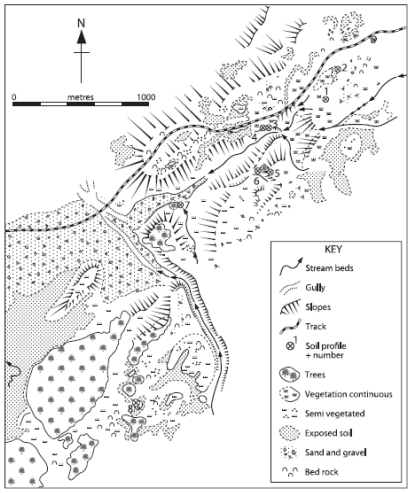


Geologic map of Vesuvius: different colours represent different types and ages of volcanic deposits. For example, the pinks/purples are lava flows from the labelled time periods.

Geoarchaeology Connections: Landscape

8

- Geoarchaeologists will conduct similar surveys and maps, but will extend this to the region around the site ("off-site")
- Attention to landforms that are not human-made



Archaeological Setting: Site

9

- **Excavation**
  - Guided digging to expose archaeological materials
- **Stratigraphy**
  - Description of layers of soils and sediments in which archaeological materials are found

Geoarchaeology Connections: Site

10

- Greater attention to the **stratigraphy**, including the layers that do not contain archaeological materials
- Helps understand more about the landscape at the time when the soils/sediments were deposited

Archaeological Materials: Artefacts

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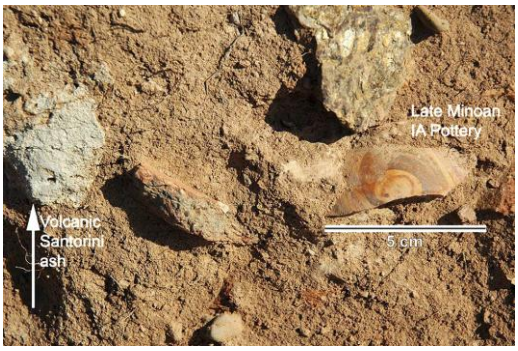
- **Artefacts** reflect culture in purpose (how they are used) and expression
- May be attributed to specific time period according to their features (can help to date events in time)



Geoarchaeology Connections: Artefacts

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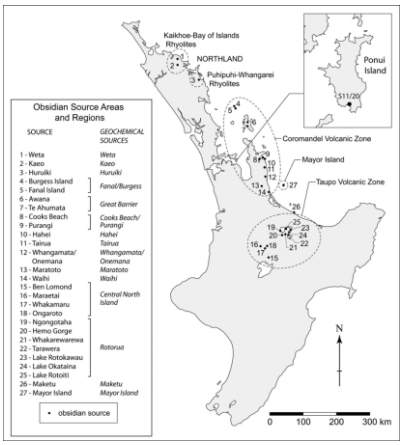
- **Artefact** composition (sourcing studies; manufacture and trade)
  - Understand how they were used and where the materials came from



Archaeological Materials: Bodies

13

- **Casts** and skeletons
  - Rarely preserved this well and in these numbers, eruption provides unique scenario

Geoarchaeology Connections: Bodies

14

- State of preservation reveals details about eruptive conditions
- At Pompeii, temperatures of deposits were around 250°C: hot enough to be fatal, but not hot enough to vaporise tissues (delayed breakdown leaves a cavity which is then filled with plaster-like material to produce a **cast**)
- At Herculaneum, temperatures of deposits were around 500°C: hot enough to vaporise tissues and leave only the skeletons behind

Case Study: Part 1

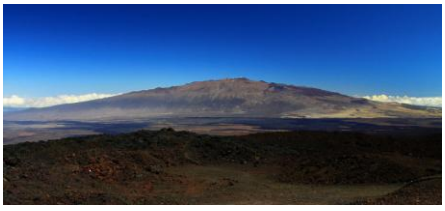
15

- Now you will interpret some of the archaeology and geoarchaeology from Pompeii and the landscape around Vesuvius.

Volcanic Setting: Landscape

16

- All volcanoes can be classified as one of two types: **shield volcano** or **stratovolcano**



Mauna Kea, Hawaii, USA

Mayon Volcano, Philippines

Volcanic Setting: Magma Characteristics

17

- The shape that they take is caused by the characteristics of the **magma** that form them

Characteristic	Shield Volcano (shallow slopes)	Stratovolcano (steep slopes)
Deposit Colour	Darker	Lighter
Viscosity (Stickiness)	Low (Runny)	High (Sticky)
Gas Content	Low	High

- **Stratovolcanoes** are generally more explosive than **shield volcanoes** (stickier **magma** with more gases)

Volcanic Deposits: Lava

18

- Moves very slowly so people usually have time to get away
- But it will eventually destroy building structures

Volcanic Deposits: Air Fall

19

- The smaller the material, the easier it is to transport
- **Ash** (<2 mm) blocks out sunlight
- It builds up on rooftops and can become heavy, especially when it is raining (may cause collapse)

Volcanic Deposits: Air Fall

20

- **Lapilli** (2-64 mm) and **blocks/bombs** (>64mm) aren't carried as far
- Most pumice is of **lapilli** size, it won't knock you out but you would want to avoid it
- **Blocks/bombs** could kill you but you would have to be very close to the volcano to be hit

Volcanic Deposits: Pyroclastic Flow

21

- Fast moving cloud of hot gas and ash, along with larger fragments (up to lapilli size) picked up along the way
- Very dangerous due to the combination of speed and heat, unlikely to survive it

Volcanic Deposits: Pyroclastic Flow

22

Video of pyroclastic flow at Mt. Unzen, Japan.

Case Study: Parts 2 and 3

23

- Now you will interpret the final details of the volcanic geoarchaeology of Pompeii and put together all of your findings from today.

Case Study: Before the Eruption (Paragraph 1)

24

- The landscape around Vesuvius was relatively flat and the volcano would have been the central feature (map evidence)
- The land around Pompeii was farmed in order to provide resources for its people (artefact evidence)
- Pompeii was a wealthy town where arts, culture and religion were important (artefact evidence)

Case Study: During the Eruption (Paragraph 2)

25

- Before most of the deaths at Pompeii, there was a substantial air fall of lapilli-sized material (stratigraphic evidence)
- Ash in the air blocked out the sunlight, making it appear dark even though it was daytime (literary evidence)
- People were frantic, had to decide whether or not to leave family members behind and some even questioned the existence of the gods (literary evidence)
- Then the pyroclastic flow hit, killing people with its intense heat and rapidly burying them, their possessions and the structures of the town in a mass of sediment (stratigraphic evidence)

Today's Summary

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- You have had a chance to explore the connections between **geography** and **archaeology** using the eruption of Vesuvius in 79 AD
- These connections form the basis of the field of **geoarchaeology** and involve a variety of approaches to a single **site** or landscape

- We have focused on volcanoes here; however, geoarchaeological studies go far beyond this and include more stable landscapes as well (not just disaster landscapes)

Geoarchaeology Case Study Questions:
Mt. Vesuvius, Italy

For Parts 1 and 2, discuss your ideas with your group, and make brief notes after you agree on your answers. For the end of the case study (part 3), you will be asked to summarise all of your findings in paragraph form, so you may find it helpful to have made good notes along the way!

Part 1

1. Read the following passage from one of Pliny the Younger's letters to Cornelius Tacitus. This passage gives us insight about what was going through the mind of an average citizen of Pompeii during the **onset of the eruption**. What would it have **felt** like? What **decisions** did they need to make? What did people **understand** about what was happening?

"Soon afterwards the cloud sank down to earth and covered the sea; it had already blotted out Capri and hidden the promontory of Misenum from sight. Then my mother implored, entreated and commanded me to escape the best I could—a young man might escape, whereas she was old and slow and could die in peace as long as she had not been the cause of my death too. I refused to save myself without her, and grasping her hand forced her to quicken her pace. She gave in reluctantly, blaming herself for delaying me. Ashes were already falling, not as yet very thickly. I looked round: a dense black cloud was coming up behind us, spreading over the earth like a flood. 'Let us leave the road while we can still see,' I said, 'or we shall be knocked down and trampled underfoot in the dark by the crowd behind.' We had scarcely sat down to rest when darkness fell, not the dark of a moonless or cloudy night, but as if the lamp had been put out in a closed room. You could hear the shrieks of women, the wailing of infants, and the shouting of men; some were calling their parents, others their children or their wives, trying to recognize them by their voices. People bewailed their own fate or that of their relatives, and there were some who prayed for death in their terror of dying. Many besought the aid of the gods, but still more imagined there were no gods left, and that the universe was plunged into eternal darkness for evermore."

2. Look at the photos of **artefacts, artwork and architecture** found at Pompeii. These help us understand what the Pompeiian society and economy were like **before the eruption**. Were arts, culture and religion **important** to people in Pompeii? Do you think Pompeii was a **wealthy** town? How might they have used the surrounding land to **feed** the population?

3. Describe the landscape **around** Vesuvius, using the resource provided for this question (part 1, question 3). Is it hilly, mountainous, flat, or a combination of the above? How **easy** would it have been to **use the land** or **move around** in it (use the artefacts from question 2 to help you with this)? Would Vesuvius have been widely visible or only visible from select locations?

4. Use the table below to help you describe the two main **stratigraphic** layers at Pompeii (**within and below** where the body **casts** were found).

	Colour	**Shape of particles (round or sharp?)**	**Distribution of particles (all one size or mix of sizes?)**	**Size of particles (describe amount of small, medium and large*)**
Example X	Grey	Sharp	Mix	Half medium-large and half small
Layer 1				
Layer 2				

*Note: small=clay (or mud), medium=sand, large=rocks bigger than your hand

Part 2

5. Geoarchaeologists and geographers often combine the size and distribution of particles into a bar graph (or histogram) in order to help them visualise the results. Use the table below to **describe samples 3 and 4**, **match them** with the appropriate **particle size graph** provided (A or B) and **match them** with a **similar layer** from question 4 (Layers 1 or 2).

	Distribution of particles (all one size or mix of sizes?)	**Size of particles (describe amount of small, medium and large*)**	**Graph (A or B)**	**Similar Layer in Q4 (1 or 2)**
Sample 3				
Sample 4				

6. Based on your earlier descriptions of layers 1 and 2 (question 4) and the correlation of these with particle size graphs A and B, what types of volcanic deposits (refer to the list of key terms) are layers 1 and 2? If most of the body casts were found in layer 1, what was happening **before** most of the deaths at Pompeii? Can you tell what caused **most** of the fatalities by identifying the deposit type?

Part 3

7. Describe how people lived in Pompeii, supporting it with some of the evidence that we have talked about today. Write one paragraph thinking about what life was like **before the eruption**, and another imagining what it was like to be in Pompeii in the hours **during the main eruption**. Make sure to **connect** the sources of evidence (don't just repeat your notes from the previous questions), including **literary, archaeological and geoarchaeological**. *(Refer to the writing guide for hints on how to answer this question. You may continue writing on the back of this page.)*

Case Study Figures

Part 1, Question 2 (1)

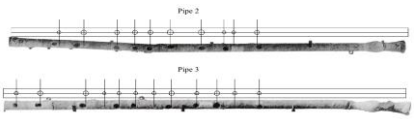
Mural (left).

Roman relief (above).

Artist's rendering of the Temple of Apollo (left).

Part 1, Question 2 (2)

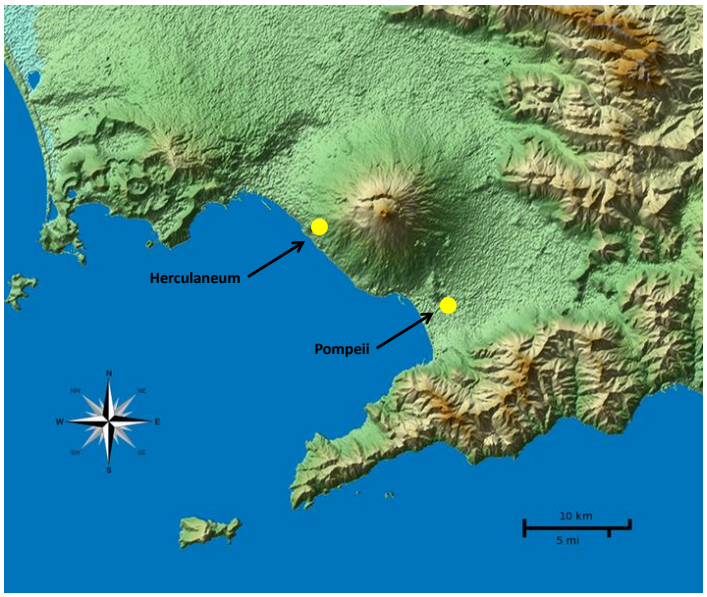
Jewelry found with female skeleton.



'Aulos' wind instruments.

Glass (above) and silver (below).

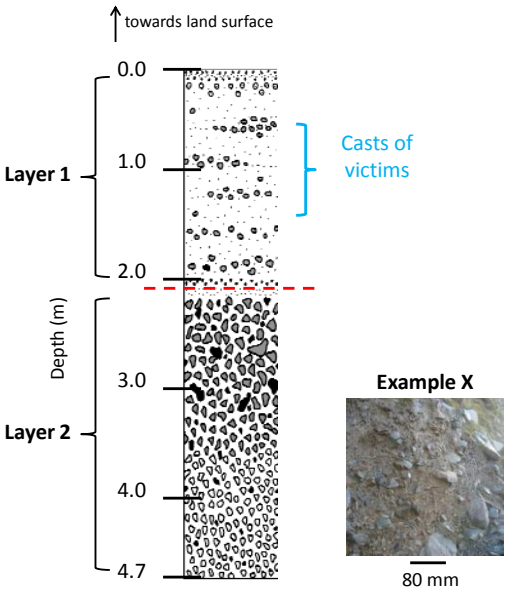
Part 1, Question 3



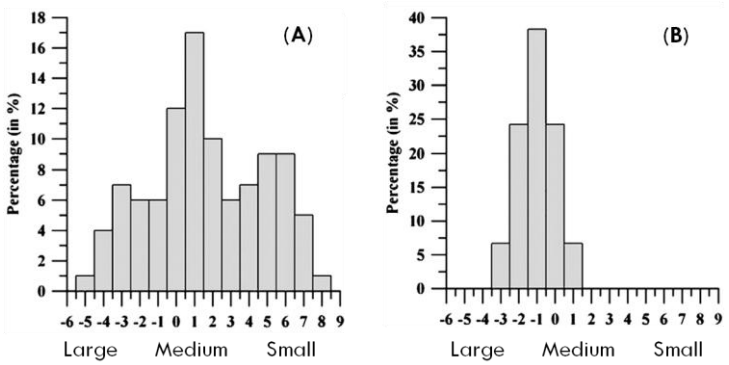
Part 1, Question 4; Part 2, Questions 5 and 6


60 mm


60 mm



Part 2, Question 5



Note: samples 3 and 4 are also needed for this question.

Appendix F. Parent/guardian information sheet.

The University Of Sheffield.

Participant Information Sheet - Parents
"Geoarchaeology in the A Level Classroom"

Researcher : Alison Rae Jolley, M.Sc. Candidate
Email: arjolley1@sheffield.ac.uk
Phone : 07954150688

Your child is being invited to participate in a research project by the Department of Archaeology at the University of Sheffield. Please take the time to read the following details about the project in order to help you decide whether or not you would like them to participate. If anything is unclear or you would like more information, please contact the researcher.

This project, entitled "Geoarchaeology in the A Level Classroom", aims to develop new teaching materials for A level students. These materials will introduce the field of geoarchaeology and highlight how it combines geography and archaeology, using a case study relevant to both of these A level subjects. The development of these materials will be informed by interviews with A level teachers and trialled with A level students. Finally, the effectiveness of the materials will be assessed, using further teacher interviews and student surveys of perception and knowledge of geoarchaeology.

You have been contacted because your child's teacher (A level Archaeology or Geography) has elected to participate in the research project. Should you allow your child to participate, they will be asked to fill out surveys of both their perception and knowledge of geoarchaeology before and after the teaching activity. They will also be observed by the researcher throughout the activity, in order to assess its impact on their learning of the subject. Their contribution will occur entirely within class time, will not affect their grades in any way, and will remain entirely anonymous. If you do not wish your child to participate in the research project, they will still be able to be a part of the teaching activity but will not be observed or asked to fill out any surveys.

The participation of your child is voluntary and you may withdraw them from the research project at any time without penalty, by contacting the researcher. You may keep this information sheet for reference.

There are no known disadvantages or risks to participating in this study. All students benefit by learning about a field that they likely would not be exposed to otherwise. The data obtained from those who participate in the research will help to improve future versions of this activity and the quality of knowledge gained by future students.

All personal data will only be accessed by the researchers and will be kept on password protected computers and in locked filing cabinets. It will remain confidential and anonymised when stored and used in reports/publications regarding the project. Should you choose to withdraw your child from the project, their data will be destroyed immediately. If you would like to have access to any reports or publications on the research, please contact the researcher.

This project has received ethics approval from the Department of Archaeology's Research Ethics Committee, which is overseen by the University of Sheffield's Research Ethics Committee. Any complaints or concerns may be addressed to the research supervisor, Dr. Gianna Ayala, at g.ayala@sheffield.ac.uk (0114-2222935). If you feel that your complaint has not been handled to your satisfaction, you may contact the University of Sheffield's Registrar and Secretary (registrar@sheffield.ac.uk).

Thank you for taking the time to read this information sheet. If you would not like your child to participate in the research project, please fill out the slip below and have your child return it to their teacher.

I **do not** want my child, _____, to participate in the research project mentioned above.

I understand that they will still be able to take part in the teaching activity, but they will not be observed by the researcher or asked to fill out any surveys.

_____	_____	_____
Name of Parent/Guardian	Date	Signature

Appendix G. Observation protocol.

Date:
Time:
Location:
Participant number:
Number of students:
Number of groups:
Physical layout of room:

Section	Length (min)	Time (~/3 min)	Method	Engage	Quest? (Y/N)	Describe
PPT. PT. 1	**Approx.:** 15					
	Start:					
	End:					
	Actual:					
	[redacted]					
CASE STUDY PT. 1	**Approx.:** 30					
	Start:					
	[redacted]					

Section	Length (min)	Time (~/3 min)	Method	Engage	Quest? (Y/N)	Describe
	[redacted]					
	End:					
	Actual:					
PPT. PT. 2	**Approx.:** 10					
	Start:					
	End:					

Section	Length (min)	Time (~/3 min)	Method	Engage	Quest? (Y/N)	Describe
	Actual:					
CASE STUDY PT. 2	**Approx.:** 30					
	Start:					
	[redacted]					
	End:					

Section	Length (min)	Time (~/3 min)	Method	Engage	Quest? (Y/N)	Describe
	Actual:					
RECAP	**Approx./ Start:** 5/					
	End/ Actual: **/**					

For each time bracket: assign method (**LTell**-lecture, **Eg**-example, **MM**-multimedia, **In**-interpretation, **Cr**-creating), rate engagement (/10 for ppt., /group no. for case study), note any questions asked (teacher or student) and describe (narrative).

Additional notes (continued on back):

Appendix H. Pre-post questionnaire.

An Introduction to Geoarchaeology: Pre-Questionnaire

This questionnaire helps us understand what you think and know before doing the activity. There are no right or wrong answers. Please read the questions thoroughly and answer honestly, as the responses we get help us to improve the activity in the future. DO NOT use your real name on this paper or any of the other papers today. Choose a 'pseudonym' (fake name) that you will use during the whole activity. Don't forget your pseudonym!

Part 1

Please circle the number (1 to 5) that best represents your agreement with the following statements (strongly disagree to strongly agree).

	1-strongly disagree	**2-disagree**	**3-neither agree nor disagree**	**4-agree**	**5-strongly agree**
1. It is useful to approach problems by connecting ideas from multiple disciplines (fields of study).	1	2	3	4	5
2. It is time-consuming to approach problems by connecting ideas from multiple disciplines.	1	2	3	4	5
3. I can imagine connections between archaeology and other disciplines (aside from geography/geology).	1	2	3	4	5
4. Archaeology is made stronger when it is connected to other disciplines.	1	2	3	4	5
5. I think I have a good idea about what it means to study geoarchaeology.	1	2	3	4	5
6. I think that geoarchaeology would be fun to study.	1	2	3	4	5

Part 2

Please answer the following questions in full sentences.

1. Give **two** examples of the type of information that come from the study of artefacts from an archaeological site.

2. Name **two** differences between **shield volcanoes** and **stratovolcanoes** (complex volcanoes). Which one is more explosive?

3. **Compare and contrast** some different types of information that **geographers** and **archaeologists** might want to study on a site that has been preserved by volcanic eruption. **Give one example** of how they could collaborate to better understand the site.

Demographic Information

The following questions are optional. If you do not feel comfortable answering any or all of these questions, please leave them blank.

4. **Gender:** _____

5. **Age:** _____

6. **Ethnicity:** _____

7. **Related studies:** p*lease tick (✓) the box to the LEFT of each subject/level that you have taken or are currently taking.*

Archaeology				AS		A2
Classical Civilisation		GCSE		AS		A2
Environmental Science		GCSE		AS		A2
Geography		GCSE		AS		A2
Geology		GCSE		AS		A2
History		GCSE		AS		A2

An Introduction to Geoarchaeology: Post-Questionnaire

This questionnaire helps us understand what you think and know after doing the activity. There are no right or wrong answers. Please read the questions thoroughly and answer honestly, as the responses we get help us to improve the activity in the future. Remember to use the same 'pseudonym' (fake name) that you have been using throughout the activity today.

Part 1

Please circle the number (1 to 5) that best represents your agreement with the following statements (strongly disagree to strongly agree).

	1-strongly disagree	**2-disagree**	**3-neither agree nor disagree**	**4-agree**	**5-strongly agree**
1. It is useful to approach problems by connecting ideas from multiple disciplines (fields of study).	1	2	3	4	5
2. It is time-consuming to approach problems by connecting ideas from multiple disciplines.	1	2	3	4	5
3. I can imagine connections between archaeology and other disciplines (aside from geography/geology).	1	2	3	4	5
4. Archaeology is made stronger when it is connected to other disciplines.	1	2	3	4	5
5. I think I have a good idea about what it means to study geoarchaeology.	1	2	3	4	5
6. I think that geoarchaeology would be fun to study.	1	2	3	4	5

Part 2

Please answer the following questions in full sentences.

1. Give **two** examples of the type of information that come from the study of artefacts from an archaeological site.

2. Name **two** differences between **shield volcanoes** and **stratovolcanoes** (complex volcanoes). Which one is more explosive?

3. **Compare and contrast** some different types of information that **geographers** and **archaeologists** might want to study on a site that has been preserved by volcanic eruption. **Give one example** of how they could collaborate to better understand the site.

Part 3

The following questions refer to the geoarchaeology lesson that you took part in today. Please answer honestly with specific examples, where possible.

4. Which part of the lesson did you enjoy the **most**? Why?

5. Which part of the lesson did you enjoy the **least**? Why?

6. Which part of the lesson did you find the **easiest**? Why?

7. Which part of the lesson did you find the **most challenging**? Why?

Appendix I. Post-interview protocol.

These questions help us understand the effectiveness of the teaching pack (both the lecture and the case study) from the teacher's perspective.

Preparing for the Activity

1. How long did you spend preparing to teach the material in the teaching pack (both the lecture and the case study)?

2. What did you find was the easiest part of preparing to teach the teaching pack-lecture? Why?

3. What did you find was the hardest part of preparing to teach the teaching pack-lecture? Why?

4. What did you find was the easiest part of preparing to teach the teaching pack-case study? Why?

5. What did you find was the hardest part of preparing to teach the teaching pack-case study? Why?

Teaching the Activity

6. Did you find it easy to teach the material in the teaching pack-lecture? Why or why not?

7. Did you find it easy to run the teaching pack-case study? Why or why not?

8. When were students the most engaged during the teaching pack-lecture? Why?

9. When were students the least engaged during the teaching pack-lecture? Why?

10. When were students the most engaged during the teaching pack-case study? Why?

11. When were students the least engaged during the teaching pack-case study? Why?

12. What do you think students struggled with the most during the teaching pack-lecture? Why?

13. What do you think students struggled with the most during the teaching pack-case study? Why?

Changing the Activity

14. Do you think that interdisciplinary, or cross-curricular, teaching is a valuable way to introduce these and other concepts? Please refer to the materials provided here.

15. What would you keep the same, regarding the format and/or material, in future uses of the teaching pack? Why?

16. What would you change, regarding the format and/or material, in future uses of the teaching pack? Why?

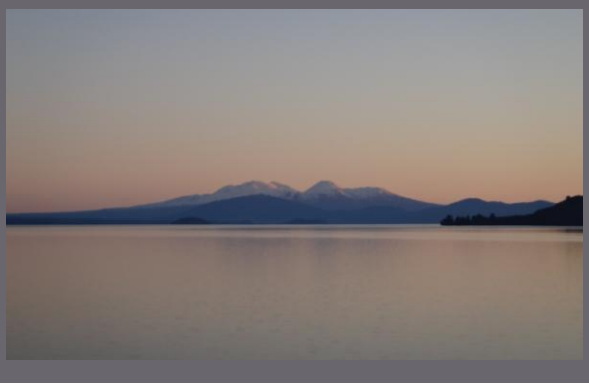
17. Do you plan to use the teaching pack in the future? Why or why not?

18. Any final comments or questions?

Thank you for all of your time and effort in both the teaching of and the feedback on this project. Expect to hear from me upon the production of the final version of the teaching pack and the completion of the dissertation. Feel free to keep in touch.

Appendix J. Final teaching pack design and accompanying documents.

AN INTRODUCTION TO GEOARCHAEOLOGY



The University Of Sheffield.

Living with volcanoes

Pompeii

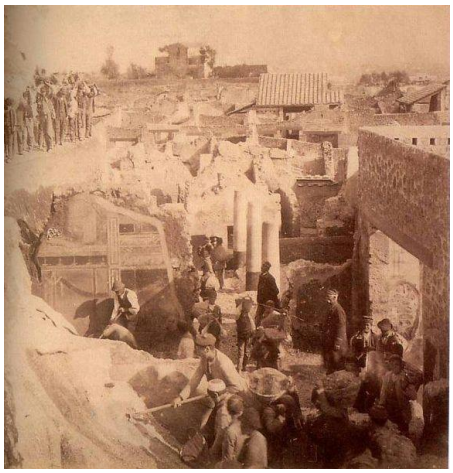
2

- "Then the flames and smell of sulphur which gave warning of the approaching fire drove the others to take flight and roused him to stand up. He stood leaning on two slaves and then suddenly collapsed, I imagine because the dense fumes choked his breathing by blocking his windpipe...when daylight returned on the 26th—two days after the last day he had seen—his body was found intact and uninjured, still fully clothed and looking more like sleep than death." – Pliny the Younger writing to Cornelius Tacitus about the death of his Uncle, Pliny the Elder

Why do we care about the volcano?

3

- If we understand the volcano with the **archaeology**, we can put together a full picture of what it was like to live during the eruption
- The volcanic deposits buried the site and helped to preserve architecture, **artefacts** and people



Objectives

4

- By the end of this lesson, you should be able to:
  - Describe some archaeological approaches and how geoarchaeology builds on them.
  - Describe the two major types of volcanoes and some related volcanic deposits.
  - Interpret geoarchaeological materials.
  - Use these interpretations to help you explain what it was like before and during the eruption at Pompeii.

What is geoarchaeology?

5

- **Geoarchaeology** uses geographical and archaeological approaches to understand a landscape or **site**.
- It is **interdisciplinary**, requiring a wide range of knowledge and the ability to connect it.
- Today we'll learn about volcanic **geography** and **archaeology** and combine them in order to understand a case study: the eruption of Mt. Vesuvius in 79 AD.

Case Study Background

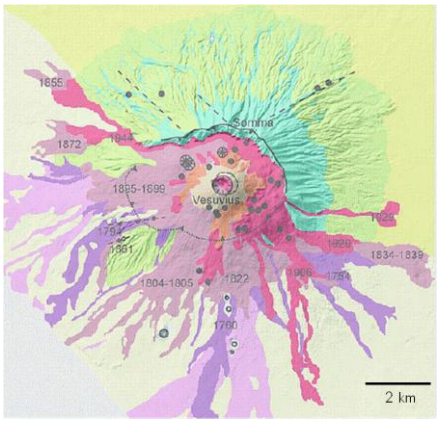
6

- Mt. Vesuvius is an active volcano in Italy
- It is well known for its eruption in 79 AD that destroyed Pompeii and other Roman settlements
- As we learn more about volcanic **geography** and **archaeology**, you will receive more information about this landscape that you will have to interpret

Archaeological Setting: Landscape

7

- Ideas of settlement choice, trade networks, relationship to environment/resources and how these might change over time and space
- Use maps (topographic, geological, archaeological survey) and compare to **site** distributions

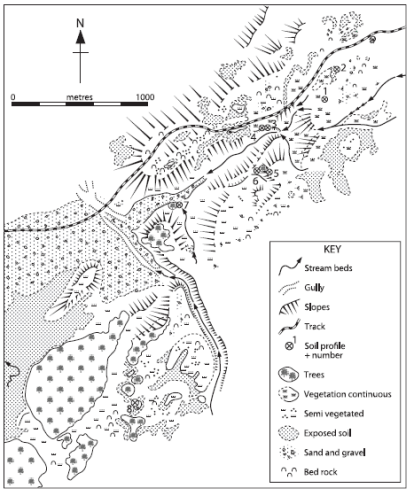


Geologic map of Vesuvius: different colours represent different types and ages of volcanic deposits. For example, the pinks/purples are lava flows from the labelled time periods.

Geoarchaeology Connections: Landscape

8

- Geoarchaeologists will conduct similar surveys and maps, but will extend this to the region around the site ("off-site")
- Attention to landforms that are not human-made



Archaeological Setting: Site

9

- **Excavation**
  - Guided digging to expose archaeological materials
- **Stratigraphy**
  - Description of layers of soils and sediments in which archaeological materials are found

Geoarchaeology Connections: Site

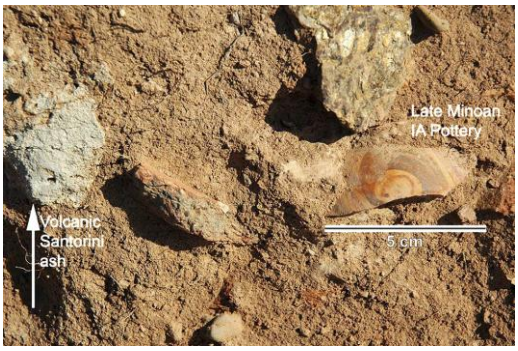
10

- Greater attention to the **stratigraphy**, including the layers that do not contain archaeological materials
- Helps understand more about the landscape at the time when the soils/sediments were deposited

Archaeological Materials: Artefacts

11

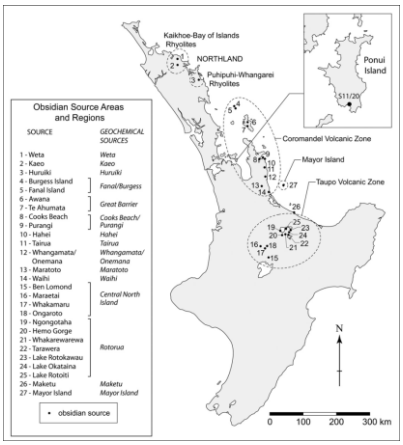
- **Artefacts** reflect culture in purpose (how they are used) and expression
- May be attributed to specific time period according to their features (can help to date events in time)



Geoarchaeology Connections: Artefacts

12

- **Artefact** composition (sourcing studies; manufacture and trade)
  - Understand how they were used and where the materials came from



Archaeological Materials: Bodies

13

- **Casts** and skeletons
  - Rarely preserved this well and in these numbers, eruption provides unique scenario

Geoarchaeology Connections: Bodies

14

- State of preservation reveals details about eruptive conditions
- At Pompeii, temperatures of deposits were around 250°C: hot enough to be fatal, but not hot enough to vaporise tissues (delayed breakdown leaves a cavity which is then filled with plaster-like material to produce a **cast**)
- At Herculaneum, temperatures of deposits were around 500°C: hot enough to vaporise tissues and leave only the skeletons behind

Case Study: Part 1

15

- Now you will interpret some of the archaeology and geoarchaeology from Pompeii and the landscape around Vesuvius.

Volcanic Deposits in Action

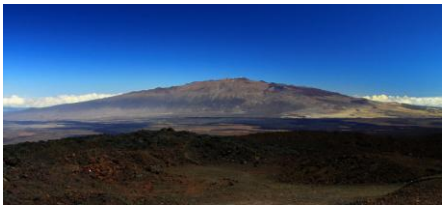
16

Video of pyroclastic flow at Mt. Unzen, Japan.

Volcanic Setting: Landscape

17

- All volcanoes can be classified as one of two types: **shield volcano** or **stratovolcano**



Mauna Kea, Hawaii, USA

Mayon Volcano, Philippines

Volcanic Setting: Magma Characteristics

18

- The shape that they take is caused by the characteristics of the **magma** that form them

Characteristic	Shield Volcano (shallow slopes)	Stratovolcano (steep slopes)
Deposit Colour	Darker	Lighter
Viscosity (Stickiness)	Low (Runny)	High (Sticky)
Gas Content	Low	High

- **Stratovolcanoes** are generally more explosive than **shield volcanoes** (stickier **magma** with more gases)

Volcanic Deposits: Lava

19

- Moves very slowly so people usually have time to get away
- But it will eventually destroy building structures

Volcanic Deposits: Air Fall

20

- The smaller the material, the easier it is to transport
- **Ash** (<2 mm) blocks out sunlight
- It builds up on rooftops and can become heavy, especially when it is raining (may cause collapse)

Volcanic Deposits: Air Fall

21

- **Lapilli** (2-64 mm) and **blocks/bombs** (>64mm) aren't carried as far
- Most pumice is of **lapilli** size, it won't knock you out but you would want to avoid it
- **Blocks/bombs** could kill you but you would have to be very close to the volcano to be hit

Volcanic Deposits: Pyroclastic Flow

22

- Fast moving cloud of hot gas and ash, along with larger fragments (up to lapilli size) picked up along the way
- Very dangerous due to the combination of speed and heat, unlikely to survive it

Case Study: Parts 2 and 3

23

- Now you will interpret the final details of the volcanic geoarchaeology of Pompeii and put together all of your findings from today.

Vesuvius: the Good and the Bad

24

Case Study: Before the Eruption

25

- The landscape around Vesuvius was relatively flat and the volcano would have been the central feature (map evidence)
- The land around Pompeii was farmed in order to provide resources for its people (artefact evidence)
- Pompeii was a wealthy town where arts, culture and religion were important (artefact evidence)

Case Study: During the Eruption

26

- Before most of the deaths at Pompeii, there was a substantial air fall of lapilli-sized material (stratigraphic evidence)
- Ash in the air blocked out the sunlight, making it appear dark even though it was daytime (literary evidence)
- People were frantic, had to decide whether or not to leave family members behind and some even questioned the existence of the gods (literary evidence)
- Then the pyroclastic flow hit, killing people with its intense heat and rapidly burying them, their possessions and the structures of the town in a mass of sediment (stratigraphic evidence)

Today's Summary

27

- You have had a chance to explore the connections between **geography** and **archaeology** using the eruption of Vesuvius in 79 AD
- These connections form the basis of the field of **geoarchaeology** and involve a variety of approaches to a single **site** or landscape

- We have focused on volcanoes here; however, geoarchaeological studies go far beyond this and include more stable landscapes as well (not just disaster landscapes)

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28

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Geoarchaeology Case Study Questions:
Mt. Vesuvius, Italy (Answer Key)

Please discuss the following questions with your group and then write your answers in the space provided.

Part 1

1. Read the following passage from one of Pliny the Younger's letters to Cornelius Tacitus. This passage gives us insight about what was going through the mind of an average citizen of Pompeii during the **onset of the eruption**.

Artist's rendering of the eruption.

"Soon afterwards the cloud sank down to earth and covered the sea; it had already blotted out Capri and hidden the promontory of Misenum from sight. Then my mother implored, entreated and commanded me to escape the best I could—a young man might escape, whereas she was old and slow and could die in peace as long as she had not been the cause of my death too. I refused to save myself without her, and grasping her hand forced her to quicken her pace. She gave in reluctantly, blaming herself for delaying me. Ashes were already falling, not as yet very thickly. I looked round: a dense black cloud was coming up behind us, spreading over the earth like a flood. 'Let us leave the road while we can still see,' I said, 'or we shall be knocked down and trampled underfoot in the dark by the crowd behind.' We had scarcely sat down to rest when darkness fell, not the dark of a moonless or cloudy night, but as if the lamp had been put out in a closed room. You could hear the shrieks of women, the wailing of infants, and the shouting of men; some were calling their parents, others their children or their wives, trying to recognize them by their voices. People bewailed their own fate or that of their relatives, and there were some who prayed for death in their terror of dying. Many besought the aid of the gods, but still more imagined there were no gods left, and that the universe was plunged into eternal darkness for evermore."

a. What would it have **felt** like, physically and emotionally?
   - The sky would have been dark and the approaching cloud from the pyroclastic flow would have been threatening. Ash was falling and beginning to coat people and objects.
   - Upsetting to hear the screams of people around them and worry about their loved ones. Trying desperately to save themselves in any way possible, through flight, prayer, etc.

b. What **decisions** did they need to make?
   - People needed to decide whether or not they wanted to leave their property and belongings. Many had to consider leaving relatives behind who were unable to save themselves, or telling loved ones to go ahead without them if they did not feel that they could keep up.

c. What did people **understand** about what was happening?
   - The scientific explanation for what a volcano is would not have been known by the people of Pompeii and they may not have recognised its signs. They would have looked to the gods for help. Some even thought that the gods were gone and that the universe was ending.

2. Look at the photos of **artefacts, artwork and architecture** found at Pompeii. These help us understand what the Pompeiian society and economy were like **before the eruption**.
   a. Were arts, culture and religion **important** to people in Pompeii?
      - Yes, arts, culture and religion were important in Pompeii. They had elaborate temples serving the gods, beautiful murals and architecture and musical instruments.

b. Do you think Pompeii was a **wealthy** town?
   - Yes, Pompeii was a wealthy town. Aside from its art and architecture, some of its residents possessed glass, silver and gold vessels and jewellery.

c. How might they have used the surrounding land to **feed** the population?
   - Pompeii was an agricultural town, evidenced by the Roman relief depicting horse and cart operations in the fields.

3. Look at the landscape **around** Vesuvius, using the resource provided for this question (part 1, question 3).

Mt. Vesuvius viewed from the ruins of Pompeii.

a. Is it hilly, mountainous, flat, or a combination of the above?
   - The land immediately surrounding Vesuvius is mostly flat and the sea is nearby. Further in the distance it becomes more mountainous and hilly.

b. How **easy** would it have been to **use the land** or **move around** in it (use the artefacts from question 2 to help you with this)?
   - The flat landscape would have made it quite easy to use the land (farm) and move around in it. The Romans had efficient horse and cart set ups for this purpose.
   - Boats also would have been a viable mode of transport.

c. Would Vesuvius have been visible **all over** the landscape or **only** visible from Pompeii and Herculaneum?
   - Vesuvius would have been visible all over the landscape.

4. Use the table below to help you describe the two main **stratigraphic** layers at Pompeii (**within and below** where the body **casts** were found). "Example X" has been provided for you as a guide.

	Colour	**Shape of particles (round or sharp?)**	**Distribution of particles (mostly one size or mix of sizes?)***	**Size of particles (describe amount of small, medium and large)^**
Example X	Grey	Sharp	Mix	Half medium-large and half small
Layer 1	Beige-brown	Round	Mix	Majority are small through medium with some large
Layer 2	Grey	Sharp	Mostly one	All medium-large to large

*Use the idea of **conformity** (mostly one size) vs. **variety** (mix of sizes) to help you with this.
^**small**=clay (or mud), **medium**=sand, **large**=rocks taking up ¼ or more of your palm

Part 2

5. Geoarchaeologists and geographers often combine the size and distribution of particles into a bar graph (or histogram) in order to help them visualise their results. Use the table below to:
    a. **Describe** samples 3 and 4.
    b. **Match** them with the appropriate **particle size graph** provided (A or B).
    c. **Match** them with the more **similar layer** from question 4 (1 or 2).

Each graph and layer **may only be selected once**, using only the features in this table (**not** colour or shape).

	Distribution of particles (mostly one size or mix of sizes?*)	**Size of particles (describe amount of small, medium and large^)**	**Graph (A or B)**	**Similar Layer in Q4 (1 or 2)**
Sample 3	Mostly one	Mostly medium-large with some medium	B	2
Sample 4	Mix	Range from small through medium with some large	A	1

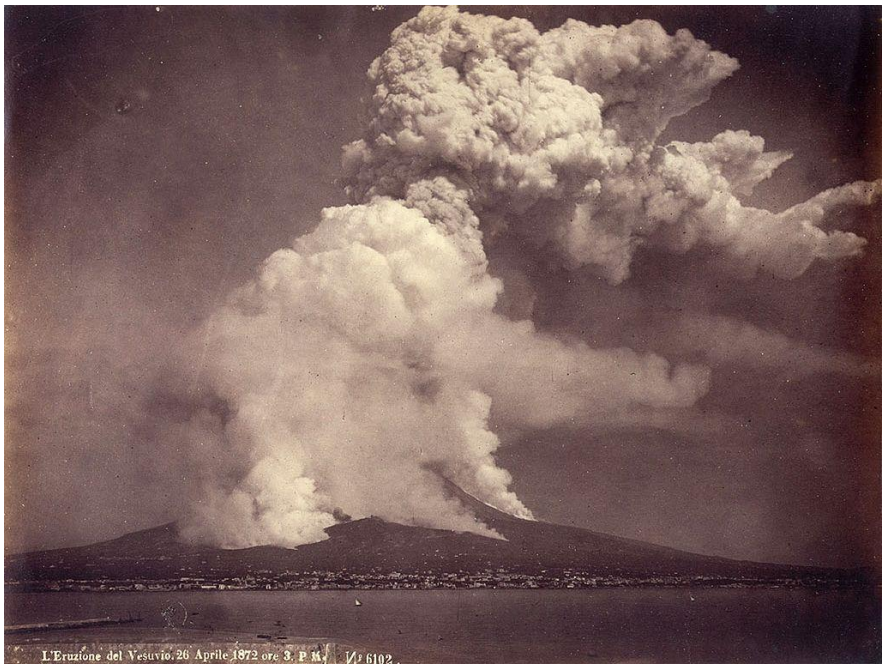
*Use the idea of conformity (mostly one size) vs. variety (mix of sizes) to help you with this.

^**small**=clay (or mud), **medium**=sand, **large**= rocks taking up ¼ or more of your palm

6. Use your earlier descriptions of layers 1 and 2 (question 4) and the correlation of these with particle size graphs A and B (question 5) to help you with this question.
    a. What types of volcanic deposits (refer to the list of key terms) are layers 1 and 2?
        - Layer 1: pyroclastic flow
        - Layer 2: air fall (lapilli)

    b. If most of the body casts were found in layer 1, what was happening **before** most of the deaths at Pompeii?
        - Before most of the deaths at Pompeii, lapilli-sized particles were being ejected from the volcano and falling on the town.

c. Can you tell what caused **most** of the fatalities by identifying the deposit type that they were found in?
    - Most of the fatalities were caused by the pyroclastic flow, due to its high temperature and fast speeds.



Mt. Vesuvius erupting in 1872.

Part 3

7. Assign each of your group members one or two of the six questions above, depending on your group size. Each question should only be assigned to one person.
    a. Think about the implications of your findings – what does your answer to that question say about how people lived in Pompeii? Summarise this on **only one** sticky-note for each question. This should be completed individually, don't just repeat the group answer you already have written down.

    b. After everyone has completed their summary/ies, share them with the group.

    c. Arrange the six summary sticky-notes into two chronological blocks: one for summaries that have to do with life in Pompeii **before the eruption** and one for those that relate to life **during the eruption**. Think about telling a story. You may add additional sticky-notes to connect your summaries if you wish.

As per the summary in the powerpoint, before the eruption:

- The landscape around Vesuvius was relatively flat and the volcano would have been the central feature (map evidence).
- The land around Pompeii was farmed in order to provide resources for its people (artefact evidence).
- Pompeii was a wealthy town where arts, culture and religion were important (artefact evidence).

As per the summary in the powerpoint, during the eruption:

- Before most of the deaths at Pompeii, there was a substantial air fall of lapilli-sized material (stratigraphic evidence).
- Ash in the air blocked out the sunlight, making it appear dark even though it was daytime (literary evidence).
- People were frantic, had to decide whether or not to leave family members behind and some even questioned the existence of the gods (literary evidence).
- Then the pyroclastic flow hit, killing people with its intense heat and rapidly burying them, their possessions and the structures of the town in a mass of sediment (stratigraphic evidence).

Case Study Figures

Part 1, Question 2 (1)

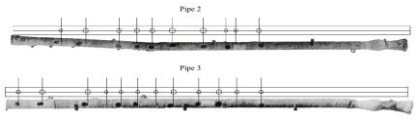
Mural (left).

Roman relief (above).

Artist's rendering of the Temple of Apollo (left).

Part 1, Question 2 (2)

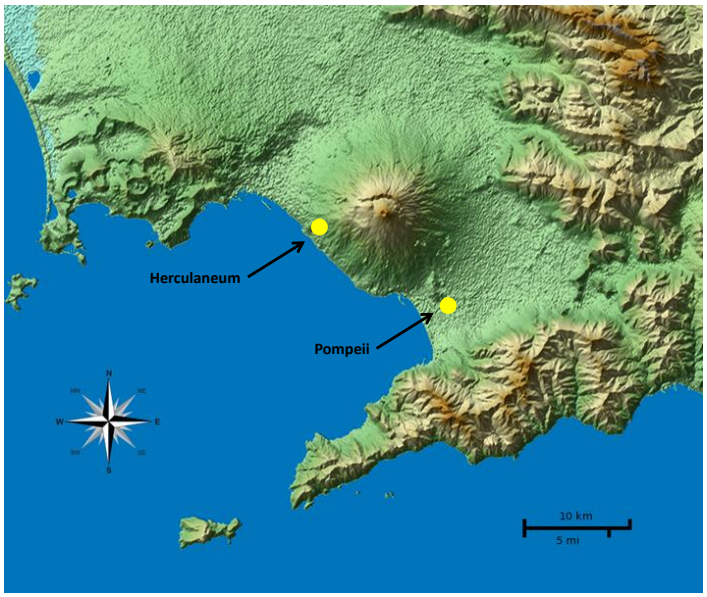
Jewelry found with female skeleton.



'Aulos' wind instruments.

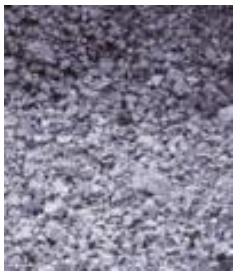
Glass (above) and silver (below).

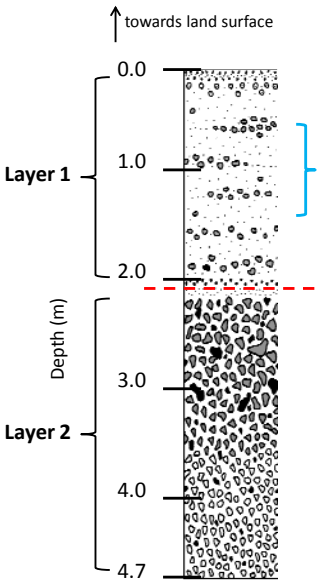
Part 1, Question 3



Part 1, Question 4; Part 2, Questions 5 and 6


60 mm

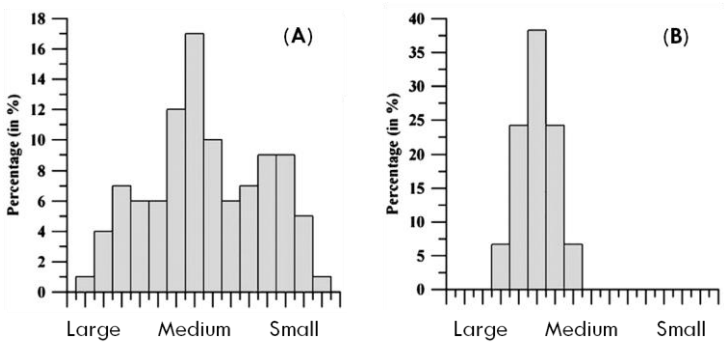

60 mm



Example X


80 mm

Part 2, Question 5



Note: samples 3 and 4 are also needed for this question.

References: Images

Case Study Figures

- Fruit mural: Wikimedia Commons, The Yorck Project [https://commons.wikimedia.org/wiki/File:Pompejanischer_Maler_um_70_001.jpg]
- Temple of Apollo artist's rendering: Wikimedia Commons, image copyright CyArk: http://archive.cyark.org [http://en.wikipedia.org/wiki/File:Cyark_pompeii_reconstruction2.jpg]
- Roman-Gallic harvester relief: Wikimedia Commons, public domain (expired copyright) [https://en.wikipedia.org/wiki/File:Harvester.jpg]
- Jewelry found with female skeleton: VRoma Project (available for non-commercial purposes) [http://www.vroma.org/~bmcmanus/clothing_sources.html]
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- Sliver artefacts: Wikimedia Commons, author Claus Ableiter [http://commons.wikimedia.org/wiki/File:Silberschatz_Pompeji_retouched.jpg]
- Shaded terrain map of Vesuvius (modified): Wikimedia Commons, author Morn the Gorn [https://commons.wikimedia.org/wiki/File:Vesuvius_SRTM3.png]
- Pyroclastic flow deposit (modified): Sulpizio, R., and Dellino, P. (2008). Chapter 2: sedimentology, depositional mechanisms and pulsating behaviour of pyroclastic density currents. *Developments in Volcanology,* 10, pp.57-96.
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- Particle size distributions (modified): Macedonio, G., Costa, A., and Folch, A. (2008). Ash fallout scenarios at Vesuvius: numerical simulations and implications for hazard assessment. *Journal of Volcanology and Geothermal Research,* 178, pp.366-377.

References: Images

Case Study Questions

- Artist's conception Vesuvius: Wikimedia Commons, Discovery Channel [http://commons.wikimedia.org/wiki/File:Pompeii_the_last_day_1.jpg]
- Vesuvius from Pompeii: Wikimedia Commons, user *drew [http://commons.wikimedia.org/wiki/File:Vesuvius_from_Pompeii.jpg]
- Eruption of Vesuvius, 1872: Wikimedia Commons, public domain due to expired copyright [http://commons.wikimedia.org/wiki/File:Vesuivio_Eruzione_26.04.1872.jpg]

An Introduction to Geoarchaeology: List of Key Terms

*Key terms used are defined below. Each of these terms is in **bold and red** font in the teaching presentation, so follow along on this sheet to help your understanding.*

- **Archaeology** – the study of past human activity
- **Artefact** – an object of interest to the study of past human activity
- **Ash** – volcanic material transported by air and smaller than 2 mm across
- **Blocks/bombs** – volcanic material transported by air and larger than 64 mm across (blocks have sharp edges, bombs have round edges)
- **Cast** (preservation method) – the filling of an imprint or cavity left by an object with a hardening material (often plaster is used)
- **Excavation** – the directed uncovering (digging) of a site in order to expose archaeological remains
- **Geoarchaeology** – the study of earth science materials (soils/sediments, landscapes) relating to past human activity
- **Geography** – the study of Earth's landforms and people, and the interactions between them
- **Interdisciplinary** – a field or study that integrates the approaches/perspectives of two or more disciplines
- **Lapilli** – volcanic material transport by air and between 2-64 mm across
- **Lava** – melted rock that is on the surface of the Earth (by erupting out of a volcano)
- **Magma** – melted rock that is underneath the Earth
- **Pyroclastic flow** – fast (up to 700 km/h or 450 mph) moving cloud of gas and rock that travels down the slopes of a volcano
- **Shield volcano** – shallow sloped volcano made up of magma with low viscosity and gas content that is generally darker in colour; non-explosive
- **Site** (archaeology) – an area of an archaeological investigation containing possible evidence of past human activity
- **Stratigraphy** – the (mostly vertical) layering of soil/sediment deposits and the study of these layers
- **Stratovolcano** – steeply sloped volcano made up of magma with high viscosity and gas content that is generally lighter in colour; explosive
- **Viscosity** – the thickness (or stickiness) of a fluid; fluids with low viscosity are runny (e.g. water) and those with high viscosity are sticky (e.g. honey)

An Introduction to Geoarchaeology: Teaching Guide

This 'Teaching Guide' describes the materials and approaches associated with the 'An Introduction to Geoarchaeology: Living with Volcanoes' teaching pack developed by Alison Jolley, Department of Archaeology, University of Sheffield for A-level Classical Civilisation, Geography, Archaeology and Geology. This guide is intended to be read as an aid in the preparation for teaching the pack. The total preparation period (including the reading of this guide and familiarising yourself with the teaching pack materials) is not expected to exceed two hours.

Aside from the specific objectives mentioned in the teaching slides (see below), there are larger, guiding aims for the teaching pack:

- Compare and contrast geographical and archaeological settings and materials.
- Summarise the landscape history of Pompeii ca. 79 AD, incorporating both geographical and archaeological findings.
- Introduce geoarchaeology and its foundational concepts.
- Explore the benefits and challenges of interdisiciplinarity.

The teaching pack has an approximate run time of 90 minutes. See the table below for a breakdown of each section.

Teaching Pack Section	Slide or Question Numbers	Expected Run Time (min.)
Powerpoint Part 1	Slides 1-15	15
Case Study Part 1	Questions 1-4	30
Powerpoint Part 2	Slides 16-23	10
Case Study Parts 2 and 3	Questions 5-7	30
Recap and Summary	Slides 24-26	5

Teaching Slides (.pptx/.pdf)

The teaching slides are a powerpoint presentation that introduces all of the background concepts relevant for successfully completing the case study questions. They are broken up into two major segments: archaeological/geoarchaeological approaches and materials (followed by part 1 of the case study) and volcanic geography and deposits (followed by parts 2 and 3 of the case study). There are also three final slides that summarise the key points from part 3 of the case study (group synthesis using sticky-notes) and the teaching pack as a whole.

The objectives for the teaching pack are as follows:

By the end of this lesson, you should be able to:

- Describe some archaeological approaches and how geoarchaeology builds on them.
- Describe the two major types of volcanoes and some related volcanic deposits.
- Interpret geoarchaeological materials.
- Use these interpretations to help you explain what it was like before and during the eruption at Pompeii.

The majority of the information that should be communicated to the students is written directly on the slides. Key terms (see below) are **bolded and coloured red**. In some occasions, there is additional instruction or information in the 'Notes' field within the powerpoint file. Please feel free to use your own words as you communicate the information that is on the slides/notes field. Asking the students questions throughout the powerpoint is highly recommended.

Information relating to the descriptions of images used on the slides is contained within the 'Notes' field, in *italics.* The full list of all of the references used for content and images in the slides is written on hidden slides at the end of the powerpoint. All images used are fair use and have predominantly been sourced from Wikimedia Commons.

Case Study Questions (.docx/.pdf)

The case study questions are intended to be active/practical and completed in groups of 3 or 4. Students discuss answers with their groups and then write their final answers on the question sheet. An answer key and prompt guide for the case study questions is provided in a separate file and described below. Students are generally more engaged with the questions when the instructor sets up and recaps each individual question before and after they work on it.

Part 1 follows the archaeologically/geoarchaeologically focused teaching slides and Parts 2 and 3 follow the geographically focused teaching slides. Questions 1-6 (Parts 1 and 2) are accompanied by reference figures (see below) and hand samples. Question 7 (Part 3) is a synthesis question that asks students to summarise the implications of their findings from questions 1-6.

In question 7, each group assigns two questions to each group member (two students will have one question if they are in a group of 4). Each question should only be assigned to one person. The group members then summarise what each question's findings mean for how people lived in Pompeii on one sticky-note. This should take less than 10 minutes. The group then re-convenes and after sharing their sticky-notes, arranges them into two blocks, one for before the eruption and one for during the eruption. They may add connecting phrases or sentences on additional sticky-notes if they wish. They should then have produced a cohesive synthesis of how people lived in Pompeii (before and during the eruption), using all of their own findings. If there is time, give them a few minutes to wander around and look at the other groups' syntheses before progressing to the powerpoint summary.

Case Study Questions Answer Key (.docx/.pdf)

This document lists the answers for the case study questions and may be used for both preparation and teaching the activity. Students generally need a considerable amount of support with the questions and it is helpful for them if the teacher wanders around asking and answering questions. The answer key will also help with setting up and recapping the questions before and after the students complete them, which has been found to increase student engagement.

Case Study Figures (.pptx/.pdf)

The case study figures make up the majority of the reference material required for the case study questions. One copy of them (5 pages total) should be provided per group, in colour if possible.

The full list of all of the references used for content and images in the slides is written on hidden slides at the end of the powerpoint. All images used are fair use and have predominantly been sourced from Wikimedia Commons.

List of Key Terms (.docx/.pdf)

The key terms for the teaching pack have been defined on a one page list. Each student should receive their own copy. The key terms match with the words in the teaching slides that are **bolded and coloured red**.

Additional Reference Material (and Hand Samples)

List of materials needed:

- OS Map from any location (to contrast with geologic and geomorphologic maps mentioned in the teaching slides)
- Obsidian (to pass around when artefact provenience studies are mentioned in the teaching slides)
- Highlighters (for question 1 to help pick apart the literary passage)
- Sample 3 (for questions 5 and 6): approximately 70% of range of lapilli sized clasts (sub-rounded to rounded) with approximately 30% sand
- Sample 4 (for questions 5 and 6): range of all sizes; approximately 25% of larger lapilli sized clasts (sub-rounded), approximately 40% sand, approximately 35% ash or dry silt/clay (if ash is unavailable)
- Sticky-notes, large (for question 7)