

**Arnold Aspinall, Neutron Activation and Archaeological Science**

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**Arnold Aspinall**

Arnold Aspinall studied physics at London University graduating in 1947. He then studied for an MSc in Radio-astronomy at Manchester which, with Professor Sir Bernard Lovell and the Jodrell Bank telescope, was at the forefront of research into astrophysics. Some of Arnold's earliest papers are in radio-astronomy, dealing in particular with meteor streams.

If our archival research is correct (we have not been able to source a complete listing of Aspinall's publications!), Arnold first published with Lovell in the *Monthly Notices of the Royal Astronomical Society* in 1949. In 1951, Arnold published in the *Philosophical Magazine* with John Clegg and Gerald Hawkins (Aspinall *et al.* 1951). The paper (*A radio echo apparatus for the delineation of meteor radiants*) describes observations made using transmitters and receivers designed to track ionization activity caused by the Geminid meteor shower in 1949 and 1950. One of the co-authors of this paper, Gerald Hawkins, went on to become Professor of Astronomy at Boston University and directed a lot of his energies into the study of putative astronomical alignments of megalithic monuments. In his 1965 book, *Stonehenge Decoded*, Hawkins argued, somewhat controversially, that the various features at the monument were arranged in sophisticated ways to predict a variety of astronomical events. In contrast to archaeo-astronomy, Arnold directed his own energies into applying physical science techniques to archaeological problems both in the field and in the laboratory.

Arnold moved to Bradford in 1951. He was appointed as Lecturer in Applied Physics at Bradford Technical College. In 1955, he was promoted to Principal Lecturer at the newly-formed Bradford

Institute of Technology. Arnold had already been in post for 15 years in Bradford when the University charter was awarded in 1966 and he became Senior Lecturer in Applied Physics. In 1974, he became Head of the Undergraduate School of Archaeological Science that grew from within the Department of Physics. He held this position for 10 years when restructuring resulted in him being appointed as Director of the School of Archaeological Science. In 1987, Arnold was finally appointed Head of the Department of Archaeological Sciences after a further reconfiguration of university structures. For students who studied under Arnold, including one of us (CH) between 1980 and 1984, Arnold was unquestionably the subject leader and figurehead at Bradford albeit with many colourful and distinctive personalities as associates.

Archaeological science at Bradford developed in the early 1960s from the active research group in nuclear physics led by Gordon Brown. In Arnold's own history of archaeological sciences at Bradford, he acknowledges that "Gordon Brown broadened the view taken of applications of nuclear physics by accepting the views of others of the potential of nuclear methods in the analysis of archaeological artifacts." A neutron activation counting facility had been installed on campus in order to study nuclear reactions and gamma ray radiations of various sources, including medical research applications. That noted it was in collaboration with archaeologists that neutron activation analysis became known at Bradford on the international scene.

At this juncture, it is important to emphasise, and we know that Arnold would exhort us to, the contribution of not one but many in documenting the success of archaeological sciences at Bradford. Indeed, scholars from different disciplines including archaeologists, physicists, chemists, biologists, anthropologists and many others interacted to develop a particular brand and image in scientific archaeology.

In teaching, Arnold Aspinall was instrumental in creating the MA in Scientific Methods of Archaeology. The first students of this MA course graduated in 1975, the same year that a new Bachelor's degree in Archaeological Sciences was launched (three of the twelve graduates from the first cohort in 1979 are joining us today – Julie Bond and Gerry McDonnell are both Senior Lecturers at Bradford. John Gater has had a very close association with Bradford, and with Chris Gaffney, was awarded an honorary degree by the University in July 2006). Bradford's success in teaching archaeological science is remarkable. Many other universities have followed Bradford's example and broadened the base of their archaeology departments to embrace scientific enquiry.

## Neutron Activation Analysis

Citing the undergraduate lecture notes of one us (CH) the principle of neutron activation analysis or NAA is described as follows: *Radioactivity is induced in a sample by exposing it to a course of neutrons. Neutron capture often creates an unstable isotope which releases specific amounts of excess energy in the decay process at a rate determined by the half-life of that particular nuclear species. Thus, in principle, we can identify the original chemical elements in the sample through a study of the induced radioactivity and, since we can readily quantify the radioactivity, we can measure the elemental concentrations. NAA is rapid, can be non-destructive and is extremely accurate. One drawback is the need for a nuclear reaction to provide the source of neutrons.*

The first paper of the Bradford group using NAA (Neutron activation analysis of medieval ceramics) was published in *Nature* in 1968. The same issue included a nice astronomical theme with some new high resolution images of the moon's surface. Rather more prosaic was a report that the University Grants Committee was reporting staff: student ratios in UK Universities for the first time in order to compare trends and costs across different subject areas.

This was not the first paper on NAA in archaeology. Edward Sayre and colleagues at Brookhaven and V. Emeleus at Oxford had already published studies of Mediterranean pottery and *terra sigillata* respectively. In the 1968 paper, Arnold published with a colleague from nuclear physics, David Slater, and with Phil Mayes who was then Director of the West Yorkshire Archaeological Unit. The short article signals potential in using trace element analysis to identify signatures that could be match pot sherds to specific kiln sites. Medieval pottery from sites in Yorkshire and the Midlands was highlighted in this study. The analysis of Medieval ceramics has been a special interest of Arnold's and he supervised numerous student projects on St Neots, Thetford, Torksey and other wares (Aspinall 1985; see Spoerry in this series of papers).

Numerous undergraduate, masters and PhD theses from Bradford applied trace elemental (both NAA and X-ray fluorescence) and petrographic analysis to determine the provenance of Romano-British and prehistoric ceramics too. The close involvement of Rick Jones ensured that these studies were

integrated into a wider framework of Roman economics. That is, once pots have been sourced, what can we then understand about the nature of the Roman economy and of the social relations between the people driving these markets and supply networks? PhDs were awarded to Jeremy Evans, David Devereaux, Mark Gillings, Peter Rush, Bessie Agyropoulos and others. Prehistoric pottery was investigated by Sally White, Peter Wardle and Ann Macsween.

Arnold collaborated widely, notably with Colin Renfrew, then at Southampton and Roy Newton, then at Sheffield. Influential publications followed on the provenance of obsidian, a volcanic glass, and of faience, a glass-like frit. It is true to state that these publications stimulated many further applications of analytical science but they also prompted further insights into the movement of archaeological finds and the cultural processes that resulted in distributions of artifacts far from their sources.

Obsidian is an acidic, volcanic glass formed by rapid solidification of a silica-rich lava flow. Since older sources become more crystalline, only geologically younger sources from the Tertiary and Quaternary are usable. Therefore the potential sources of this material are very limited. Obsidian was used to fabricate a wide range of stone tools, including blades and scrapers, small cups and even mirrors.

### **Arnold Aspinall and Aegean Obsidian**

Colin Renfrew writes (November 2006)

“Arnold Aspinall played a pivotal role in developing the application of neutron activation analysis to obsidian characterisation studies in the United Kingdom. Obsidian characterisation by trace element analysis had been developed in the 1960s using the technique of optical emission spectroscopy (Cann and Renfrew 1964), and had been successfully applied to the west Mediterranean, the Aegean and the Middle East. The technique of neutron activation analysis of obsidian had also subsequently been applied both to the Hopewell culture of North America and to the Middle East through the work of Wright and Gordus (Gordus *et al.* 1968). There remained, however, ample scope for more detailed work.

Arnold recognised the potential and we agreed to collaborate, so I set about assembling some interesting material for analysis, selecting material from the Aegean, where the most obvious source was the volcanic island of Melos. The analyses were very productive, confirming the earlier OES work, and providing new observations. They were published as ‘Neutron activation analysis of Aegean obsidians’ in *Nature* (Aspinall *et al.* 1972).

With this encouragement, the Bradford laboratory went on to conduct a project specialising in the obsidian trade in the west Mediterranean with Stanley Warren (Hallam *et al.* 1976). Perhaps the most interesting work, however, was on the very early obsidian samples found in the Franchthi Cave in Greece, extending back to the Upper Palaeolithic period, and providing the

earliest available evidence for seafaring in Europe. Arnold and I went on to do a detailed programme of work which was ultimately published in the relevant monograph of the Franchthi excavations (Renfrew and Aspinall 1990).”

Arnold, together with Stanley Warren, and a number of PhD students produced a large body of data on obsidian throughout the east and west Mediterranean (see also Aspinall and Feather 1978).

Considerable work on the central European and western Mediterranean sources was undertaken by Olwen Williams-Thorpe who received her PhD in 1978 and there were occasional forays into the thornier issues of the eastern Anatolian sources. Stanley Warren published extensively on the west Mediterranean sources including resolution of the complex Sardinian obsidian outcrops around Monte Arci. Obsidian sourcing, like any provenance investigation, is not an end itself and Aspinall and Warren were aware of this. By studying large numbers of samples, actual mechanisms of exploitation and exchange could be forwarded to explain how these materials were transported over such great distances.

Of course, Bradford’s contributions were not restricted to Medieval pottery and obsidian. The provenance of faience beads has been a long-standing archaeometric and archaeological debating point. H.C. Beck and J.F. Stone made a thorough investigation of the faience beads of the British Bronze Age, published in *Archaeologia* in 1936. They concluded that faience beads were of foreign origin probably from Egypt. Stone and Thomas applied optical emission spectroscopy (OES) in 1956. Once more, there was a tendency to assume import from the Near East via the Mediterranean and along the Danube or Rhine. A little later, these diffusionist arguments and assumptions were subject to far greater scrutiny. Colin Renfrew in his famous paper ‘Wessex without Mycenae’ (Renfrew 1968) argued on chronological and archaeological grounds that contact of this nature was not feasible. Also a statistical re-analysis of the Stone and Thomas’ 1956 OES data was carried out by Newton and Renfrew (1970). They found significant differences between the beads and thus re-affirmed independent manufacture by highlighting in their own words ‘grave difficulties with the import theory’ (p. 203). The 1972 paper in *Archaeometry* remains a classic. Authored by Arnold, Stanley Warren, John Crummett and Roy Newton, NAA was used to determine the composition of faience beads from Britain, central Europe and Egypt (Aspinall *et al.* 1972). Although the sample size was small, the analysis emphasized the differences in the composition of the beads with tin anomalously high in the British material. The analytical data allied to distinctive typological differences suggested “...a different, and perhaps local, source of origin for British beads” (p. 39).

Alison Sheridan (National Museum of Scotland) has been continuing the study of faience with Andrew Shortland (formerly at Oxford and now at Cranfield University) and Stanley Warren (Alison describes Stanley as a 'faience veteran'). New analysis and dating strongly supports the indigenous production and use of faience (Sheridan and Shortland 2004).

In the same issue of *Archaeometry*, Aspinall and Stuart Feather (who was based in the City of Bradford Art Gallery and Museum) published an article entitled 'Neutron activation analysis of prehistoric flint mine products'. In this paper, NAA was carried out on the same Neolithic artefacts that Gale de Giberne Sieveking and colleagues at the British Museum had subjected to emission and absorption spectroscopy in 1970. Flint is a different kettle of fish to obsidian. Concentrations of elements vary widely within specific sources and the elemental ranges overlap with other geological sources. Nevertheless, the 1972 article advanced understanding of this variation and suggested possible solutions. Arnold went on to collaborate with Pat Phillips at the University of Sheffield on honey-coloured flint in southern France (Aspinall *et al.* 1975; Phillips *et al.* 1977; Aspinall *et al.* 1979). The results were hampered by the exceptionally low concentrations of elements, leading to low measurement accuracy, and also significant within-sample inhomogeneities. Nevertheless, the results suggested that at least some of the honey-coloured flint found at the 5<sup>th</sup> millennium BC site of Le Baratin came from the more distant Vaux-Malaucene source in the uplands. Pat Phillips saw this as representing the movement to high ground to exploit animal pastures in the summer where flint was also collected and returned to the lowland areas. Clearly the challenges of provenancing flint occupied much of Arnold's time during the 1970s and he participated in fieldwork in southern France to collect samples for analysis and to acquaint himself with the surrounding area. We can only speculate on what made Arnold so committed to maintain links with this project over such a long period although it might have something to do the fact that the Middle Neolithic site in France excavated by Pat Phillips was only 5 kilometres to the north of the small French town of Châteauneuf-du-Pape.....

Arnold's interests extended further. With Norman Hammond's research in Central America, NAA was used in a project to source Mayan Jade and published in Earle and Ericson's influential volume *Exchange Systems in Prehistory* (Hammond *et al.* 1977). Closer to home, Gill Bussell's work on jet, supervised by Arnold, enabled a useful discrimination to be made between jet and other visually similar substances, such as cannel coal and shale. This work was taken forward by my co-author Mark, then at Oxford, with Gill (e.g., Pollard *et al.* 1981). Mark carried forward this work with Fraser Hunter and Siobhan Watts at Bradford in the 1990s.

There is a long history of good and bad relations between archaeologists and physical and biological scientists. Much of this has been captured in the literature. Poor relations tend to be fuelled by divergent philosophies, mutual suspicion and, in particular, poor communication. Another critical issue is how the findings of the physical and biological sciences are assessed by archaeologists. The techniques are sometimes rather complex, the literature on any given topic often voluminous and it is difficult for those working outside particular specialisms to adequately evaluate the theoretical adequacy or methodological rigour of specific studies. Yet the archaeologist is responsible for integrating these findings into more comprehensive archaeological interpretations. This is a two-way street, however, in that the archaeological scientist should have appreciation of the complexity of archaeological problems and the subtlety of the archaeological process of recovering evidence. Arnold was not often tempted to write on such subjects preferring others to take on such chores. Nevertheless, he was persuaded to put pen to paper in a 1984 volume edited by John Bintliff and Chris Gaffney entitled *Archaeology at the Interface: Studies in Archaeology's relationships with history, geography, biology and physical science*. Arnold's contribution (Aspinall 1984) is a succinct and highly pragmatic statement. Arnold also served on the Science-Based Archaeology Committee of the Science and Engineering Research Council and he carried his fair-minded approach to this task.

Arnold's colleague and formidable archaeometrist, Stanley Warren, can't be with us to celebrate these achievements. Stanley's publications in archaeometry include major articles on faience and glass, obsidian, pottery and metalwork. He commonly explored new techniques of analysis and dating and encouraged his students to do likewise. Aspinall and Warren worked together on many different projects. Together they organized a symposium on Archaeological Sciences held in Bradford in 1978 which emphasized the discussion of archaeometric progress in Britain at a time when the 'Oxford' Conference on Archaeometry had embraced the international scene. The 22<sup>nd</sup> International Symposium on Archaeometry was held in Bradford in 1982 and published in the same year (Aspinall and Warren 1982a). Aspinall and Warren also edited the *Proceedings of the Micro-Computer Jamboree* that was tagged onto the end of the Archaeometry symposium (Aspinall and Warren 1982b). Although it sounds analogous to a car-boot sale, it was actually a series of papers on computer applications in archaeology.

## Summary

Arnold has always combined his scientific expertise with a common sense and well informed outlook on archaeology, particularly in the history and archaeology of Yorkshire. He has worked with and supported countless professional and amateur groups in the region and beyond. They have had the opportunity to witness at first hand Arnold's unstinting dedication. There is also a deep appreciation of Arnold's contribution from graduates of Archaeological Sciences not only in the period before he retired in 1990 but from those who he continued to teach, supervise and research with especially in archaeological geophysics in his post-retirement years. Arnold was honoured by the University of Sheffield with an honorary degree of science in September 1992.

In conclusion, Arnold is not just an excellent archaeological scientist. He presided over a strong intellectual grouping at Bradford and I believe the legacy for the discipline as a whole is immense. At Bradford, this group also drew upon expertise and resources from outside the University to encourage success. Key supporters include Peter Addyman, Martyn Jope, Margaret Atherden, Keith Manchester and Don Ortner. It is our strong belief that Arnold's down-to-earth attitude, thorough decency and his vision for teaching and researching archaeological science at Bradford created a context for new opportunities to develop and flourish. Furthermore, Mark and I as Arnold's successors in leading Archaeological Sciences at Bradford truly feel that the respect for Arnold aided our task. In this short paper, it is impossible to do full justice to Arnold's friendship and mentoring over a quarter of a century. He has remained a passionate advocate of archaeological science in all of its manifestations and we are indebted to his unique contribution.

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