Piecing together a shattered history

In 2020, an explosion in Beirut caused 218 deaths and widespread destruction. It also shattered one of the world’s richest collections of ancient glass artefacts. Now, researchers are using the devastation to fill in gaps in the history of this vital material, says James Dacey.

It can be formed into optical fibres and used to deliver the internet across the globe, and it is a component of renewable energy technologies – solar power in particular. In fact, the United Nations has declared 2022 the International Year of Glass to celebrate its importance.

Yet glass wasn’t always so ubiquitous. Early humans used obsidian, or volcanic glass, and other natural forms for tools, but it wasn’t until the late Bronze Age that our ancestors began to manufacture glass objects. Archaeologists have found evidence of this early glassware in tombs and temples dating from around 1600 BC onwards, located across what was then ancient Mesopotamia – the region that today incorporates Iraq, Kuwait and parts of Iran, Syria and Turkey (see map).

Glass is formed by the jumbled, or amorphous, arrangement of its molecules, distinct from the ordered structure of crystalline materials. Profoundly versatile, glass has become a vital material in the modern world, from the windows that let light into buildings and the spectacles that correct vision to the camera lenses that capture images and the optics in microscopes and telescopes that reveal nature at its smallest and grandest.

The incident was also a cultural calamity. The wider region around Lebanon is touted as the crucible of glass production, a material that has helped shape civilisation. As one of the oldest museums in the area, the AUB housed a particularly rich collection of ancient glass artefacts. The blast smashed 72 jars, bowls, cups and other vessels dating back to the ancient Romans (1st century BC to 5th century AD), the Byzantine Empire (4th to 15th century AD) and the Islamic Golden Age (8th to 13th century AD).

Rather than try to fix everything, however, AUB Archaeological Museum curator Nadine Panayot saw an opportunity in the debris. Much about the origins of glass production is opaque and yet modern material analysis techniques could offer clarity, if only they could be brought to bear on such precious collections. The shattered fragments of material presented an ideal way to do this. Now, Panayot is collaborating with physicists and engineers from around the world in the hope of opening new windows on the world of ancient glass.

The basic recipe for glass was the same then and is now: you take some silica, often just a pile of sand, then heat until molten in the presence of salts and other “fluxes” that lower its melting temperature. Additives can then add colour and alter the material’s physical properties.

Yet much of the history of glass remains a mystery. Precisely how and, in particular, where glass was made and processed in ancient times are questions that have been hard to address, owing to the lack of archaeological evidence from ancient glass-manufacturing sites. Finding more examples of these would be a breakthrough.

A further complication is pinpointing the provenance of glass. An item’s form and style can give you a decent idea of where it was created, be it a jug, drinking vessel or item of jewellery. But these were rarely produced in the same place as the ingots of raw material. “Chunks of glass, the size of a head, were

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Below: A pile of ammonium nitrate exploded in Beirut, Lebanon, on 4 August 2020. The blast killed 218 people and injured thousands.
shipped across the Roman Empire,” says Thilo Rehren, an archaeological materials expert at the Cyprus Institute. “You find them up in York [UK], Madrid [Spain], Lyon [France] and Bulgaria. Local workshops were remelting the glass and blowing it into the local preferred shape and style of an object. As a result, the origin of a glass object isn’t necessarily the same as the origin of the material it is made of since the basic building blocks of ancient glass varied little across wide areas, to answer the where and when of its origins, you need to search for subtle differences in the material’s trace elements. Only advanced chemical analyses can identify how the basic mix varied, which gives clues to the material’s provenance. Researchers have already identified the type of sand or crushed quartz pebbles used in some ancient glass, and from that the regions where production of the glass probably took place. Rehren says that 99 per cent of the glass ingots used in the Roman, Byzantine and early Islamic periods were produced along the eastern Mediterranean coast, in a stretch from the Nile delta up to present-day Lebanon. Nevertheless, tracking the movement of the material and finished pieces could give greater clarity to the early years of glass production. Three or four of the museum’s glass artefacts have a documented place of origin or office age, and for many items, curators only have a rough idea of their provenance from studying the form and style. “Take that elegant, turquoise tinted jug, for instance (see main image, overlaid). Curators think it dates to the first or second century AD, but now they can attempt to corroborate such inferences. Analysis of other regional glass from the period has identified the mineral natron mined from dry lake beds in Egypt as a flux, and it is likely that most objects from the AUB were also produced with this flux. However, the kind of analysis Panayot has unleashed could reveal the source of the silica, the additives and fuel used and ultimately where the raw glass for these pieces was produced and transported. As well as identifying bulk materials, traces of decoration (such as engraving or paint) could shed light on the artisanal techniques and tastes of the time, while residues within a vessel might indicate its use. The Lebanese Atomic Energy Commission has now provided the museum with a handheld X-ray fluorescence analyser. It looks like a cross between a hairdryer and a barcode scanner, beam emits X-rays that stimulate elements within a material to give off light at specific frequencies, depending on the substances present. In this way, it can reveal the material’s composition, even including elements that account for just a fraction of a per cent by weight. The AUB team has already used it to collect some data from the glass shards. While fresh shard edges are an advantage, it is a non-invasive technique, and next the researchers plan to scan the more than 1200 pieces that survived the blast intact as well.

Elemental deduction

Måle Tabbal, the AUB physicist who is leading the analysis project, is also in close contact with vitreous materials scientist Andrew Meek and colour scientist Joanne Dyer at the British Museum in London. They have been analysing fragments of the eight glass objects sent there for repair and took some to colleagues at University College London to probe with a specialised form of mass spectrometry. They burned tiny pits invisible to the naked eye in the glass with a laser beam, releasing fine particles of evaporated material. The electrically neutral atoms and molecules of this evaporated material are then charged, so that comparisons of their mass versus their charge can be used to reveal even trace elements in glass down to parts per billion. Twenty years ago, researchers could only identify the 10 to 12 most abundant components; with this technique, they can now typically spot 50 to 55, which means they can pin down the location of the sand used in the glass far more accurately. Meek says comparison of provisional findings from the eight objects with large collections of well-provenanced material may reveal previously unknown ancient glass-producing sites. “It may be that a couple of pieces not quite so easy to fit into currently established groups could be found to have been produced in Lebanon,” says Meek.

Pinpointing workshops in the ancient Near East where the very first glass production occurred remains a key goal in glass archaeology. Even if the current analysis doesn’t lead there directly, the Beirut blast project can build the local science capacity to enable such breakthroughs in the future. Much of Lebanon is yet to be excavated, leaving scope for big archaeological discoveries in the future. For her part, Panayot has been investigating the archaeological site of Anfah in northern Lebanon, an important economic centre from the late Bronze Age to the Ottoman period. With such a rich cultural history, Lebanon can emerge as an important player in heritage studies in the coming years. It is just a pity it took a tragedy for that to happen.

James Dacey is a freelance journalist based in Madrid