



Penn Museum main gate and Warden's garden

He found the oldest-known beer on the planet...

The biomolecular archaeology of ancient alcoholic beverages

By Ian Hornsey

In May 2016 the World Beer Cup, splendidly organised by the Brewers' Association, was held in Philadelphia, the city where the 'American Dream' began. Having been invited to judge at the event, my thoughts turned to the University of Pennsylvania (UPenn) and its excellent Museum of Archaeology and Anthropology (known as The Penn Museum) – with its world-renowned Biomolecular Archaeology Project.

If time permitted, I might be able to take the short train journey from our downtown base, the Pennsylvania Convention Centre (PCC) and meet up with Penn Museum's Dr Patrick McGovern whose interests in the history of alcoholic beverages very much coincide with mine.

In fact, the chap I was going to meet has identified the world's oldest known barley beer and the oldest grape wine – and found the oldest alcoholic beverage of any kind on the planet!

After three hectic days of judging, I managed to find a mutually convenient slot for my visit to UPenn and caught the highly efficient SEPTA (Southeastern Pennsylvania Transportation Authority) train from Jefferson, a station almost inside PCC, to the University City stop, roughly midway between downtown and the airport. At the museum, I was met by McGovern, known in those parts as 'Dr Pat', who is now Director of the Biomolecular Project for Cuisine, Fermented Beverages and



McGovern in the laboratory

Health. He is also Adjunct Professor of Anthropology at UPenn, where he teaches molecular archaeology.

Much of McGovern's earlier work at Penn Museum was carried out under the auspices of the Museum Applied Science Centre for Archaeology (MASCA), which first saw the light of day in 1961 and from which studies on ancient organic materials were carried out.

In the early days of MASCA much of the work revolved around the then new technique of radio-carbon dating

but under its second director, Stuart Fleming, the scope of the Centre was broadened considerably and was to include topics such as the application of scientific techniques to anthropological questions.

Texas-born McGovern joined MASCA as a research scientist in 1979 and since then he has been engaged in a wide range of research in archaeological chemistry, including radiocarbon dating, caesium magnetometer surveying, neutron activation analysis, infrared spectrometry and HPLC. It is fair to say that McGovern's laboratory at UPenn has consistently been at the cutting edge in the development of analytical archaeochemistry.

The multidisciplinary nature of McGovern's work is an extension of his university studies, for his first degree was an AB in chemistry from Cornell University, which led to a period of graduate research at neurochemistry at the University of Rochester University in upstate New York.

This chemistry-orientated beginning to his training was followed by PhD studies in Near Eastern archaeology and literature at UPenn, where he would subsequently find employment as a research specialist in MASCA. An important part of that post involved the excavation of Bronze Age and Iron Age sites in the Baq'ah Valley, Jordan, a project which he directed for decades as a research associate in the Near Eastern section of the Museum.

Penn Museum restructuring

Over the years, Penn Museum, with its mission to: 'advance understanding of the world's cultural heritage', has acquired a unique reputation as a research institution which has carried out many significant archaeological projects, most notably in the Middle East, Mesoamerica, and the Mediterranean. The museum's field-based research set is aside from other university-based museums in the US.

At the end of November 2008, however, the archaeological world was stunned when Penn Museum announced that it was cutting a number of specialist anthropological and archaeological research positions. The cuts were officially attributed to a 'strategic planning decision' rather than to the downturn in the US economy.

As a result of this 'strategic planning', MASCA was to be disbanded and Patrick McGovern would be one of the casualties. Letters of protest poured in from antiquity departments, universi-



Grooved sherd from Godin Tepe

ties, scientists, scholars, and private institutions and individuals from around world, particularly bemoaning the potential loss of McGovern's ground-breaking research.

The general feeling was, both locally and internationally, that the decision represented a departure from the ethos of the 1887 founders. Subsequently, around two-thirds of the 'endangered' staff were offered new positions within the museum, generally as retired, non-paid 'volunteers'. McGovern now serves in this role, as he continues to carry out and direct significant biomolecular archaeological research.

McGovern's work

A glance through a list of his numerous publications indicates the breadth of the archaeological topics that he has studied in the forty-odd years he has been at UPenn. Although McGovern's main interests now involve the archaeochemistry of foodstuffs, particularly alcoholic beverages, his early work was much more diverse and included geophysical prospecting for archaeological sites.

Subsequently, he has identified and dated a number of diverse artefacts, including: a very early form of iron/carbon metal (steel) worked into anklets and bracelets found in burial caves in the Baq'ah Valley, a geological graben feature on the Transjordanian Plateau; colorants in ancient Egyptian glassmaking; identification of the earliest use of the dye Royal Purple which was widely used by the Phoenicians, and chemical and archaeological evidence for the earliest use of cacao (*Theobroma* spp.) in beverages.

Thanks to workers like McGovern and his associates, it is now evident that with the exception of Oceania and most of North America, tribal peoples from all the inhabitable parts of the planet that developed in climates capable of supporting the growth of

sugar/starch-rich plants, developed the technology for making their own alcoholic beverages – and there are very few, if any, societies whose peoples knew about ethanol – and so paid little attention to it. Forget about crystal meth and the like; today, ethanol is the most widely used psychoactive substance in the world.

Because of the inherent chemical stability of the principle of the above mentioned Royal Purple dye compound, which is 6,6'-dibromoindigotin (DBI), detection of it in ancient textile samples is relatively straightforward, as long as the sample has been suitably preserved. Ancient artefacts containing traces of fermented foods and beverages, however, which would have contained more labile compounds such as ethanol, present a totally different problem and 'surrogate' (marker) compounds must be identified to confirm the identity of the sample.

For evidence of wines, tartaric acid/tartrates are used as a marker, while for beers the oxalate ion (beerstone; calcium oxalate) is the marker. Over the years, McGovern has increasingly applied more sensitive and precise chemical techniques, starting out with a combination of FT-IR, HPLC, snf Feigl spot tests, and now generally using GC-MS and tandem LC-MS-MS, along with other methods (e.g., SPME and isotope analysis) as needed. The search for biomarkers continues. For example, the yeast sterol ergosterol [ergosta-5,7,22-trien'3β-ol] has been proposed as marker for identifying yeast fermentation activity.

McGovern and colleagues identified well-preserved ribosomal DNA strands of a 'precursor' of *Saccharomyces cerevisiae*, 840 base pairs in length, in the residues of imported wine jars from the tomb of one of Egypt's first kings, Scorpion I of Dynasty 0, at Abydos ca. 3150 BC (see below).

McGovern stresses that the chemical argument for an ancient fermented



Sumerian sign for beer (upper left)

beverage must also be bolstered by archaeobotanical and well-dated, well-preserved and well-provenanced archaeological evidence, including ancient texts and artwork, ethnography, – and experimental archaeology in testing the ingredients and production processes for the proposed beverages.

Godin Tepe

In terms of McGovern's publication chronology, the first report of direct relevance to beer relates to finds at the Late Uruk period (Period V; 3,500-2,900 BC) site at Godin Tepe in the central Zagros Mountains of western Iran.

This particular period in human evolution has provided *Homo sapiens* with many 'firsts', including irrigation systems, codes of law, bureaucracy and writing, and to these we can add 'chemical evidence for beer'.

As McGovern averred: "The Late Uruk period is contemporaneous with urban life as we know it." Excavations at Godin Tepe yielded a fragment from a pottery vessel which had characteristic criss-cross grooves on its inner surface. Deposited in some of these grooves was a yellowish residue which tested positive for the beerstone constituent calcium oxalate (Feigl test).

Although the outer surfaces of contemporary vessels were often scored for decoration, markings on the inside are unusual and must have some special significance. The suggestion was made that they promoted sedimentation of suspended material (e.g. yeast cells, and calcium oxalate in this case) and that the vessels were either used for brewing or for beer storage. It will be noted that the scoring on the inner surface of the ceramic fragment bears some resemblance to the Sumerian graphic sign for 'beer' – called *kaš* and depicting a pottery vessel with internal linear markings.

Beerstone oxalate emanates from barley, but this was not the sole plant species in the Godin Tepe vicinity to be a major source of oxalate ions; rhubarb and spinach in particular were also identified. However, these two plants only represent a minor part of the human diet when compared to cereals and so it is unlikely that they, or anything derived from them, would have been responsible for the jar deposits.

As McGovern said at the time: "The discovery of oxalate inside the Godin Tepe jug confirmed the archaeological and pictographic evidence that the vessel was a beer container. The result should not be surprising, since that



Some important Near Eastern archaeological sites in the search for wine

given the site was in close contact with lowland Greater Mesopotamia, where beer was the preferred drink. The beer at Godin Tepe was likely made from locally-grown barley because carbonised six-row barley predominated in the archaeobotanical material recovered from Period V."

To confirm that they were working along correct lines, McGovern's team applied the same methodology to a deposit from an ancient Egyptian New Kingdom (1550-1069 BC) vessel in which it is highly likely that beer was stored. Described as a 'blue-painted beer bottle', such a container is depicted in tomb paintings and reliefs being used in a 'bread and beer' ritual. Again, oxalate was detected.

The team also tested beerstone scrapings from a modern US micro-brewery in Philadelphia. The basis of the Feigl spot test (sensitive to 10^{-6} g) is the reduction of oxalate in an acid medium to produce glyoxalic acid – which then gives a pinkish-yellow colour with phenylhydrazine and hydrogen peroxide. More exacting techniques using FT-IR and tandem LC-MS-MS are now available, and are planned to be applied to a recently initiated project on chemically identifying residues inside large vats at the important early Neolithic site of Göbekli Tepe in eastern Turkey (as early as 9500 BC).

Göbekli Tepe is close to the proposed region where einkorn wheat was domesticated, according to DNA evidence. This work will be carried out in collaboration with the Deutsches

Archäologisches Institut (Orient-Abteilung) and the Forschungszentrum Weihenstephan für Brau- und Lebensmittelqualität.

In search of wine

Historically, the Zagros Mountains are more synonymous with viticulture and winemaking than beer and brewing, since the domesticated Eurasian grapevine (*Vitis vinifera* subsp. *vinifera*) which struggled in the arid lowland heat, flourished in upland Mesopotamia.

Possible evidence of winemaking equipment (a large funnel and a smaller lid) was found in a room of a building at Godin Tepe, but grape pips, which are often well preserved when carbonised, were absent. An interesting find was several shards from unusual narrow-mouthed, long-necked, jars, which on close inspection contained reddish deposits on their innermost sides and bases.

These deposits tested positive for tartaric acid. Assembly of the shards revealed they were of a unique pottery type that had an applied rope-like decoration in two inverted U-shapes on their outer surfaces. According to McGovern: "During the Late Uruk period, rope designs often indicated the placement of real rope. The shape and placement of the inverted U suggested a means by which these vessels could have been supported on their sides.

In fact, the red deposits on the interiors of one whole vessel were confined to the base and the sidewall. The red residue was on the same side of



Godin Tepe jug with applied 'rope' decoration

the vessel as the applied rope decoration on the outside. The deposit was precisely where materials would have settled out from the liquid if the vessel had been stored on its side."

With their taller necks and relatively narrow mouths, these jars differ from others of the same period and would be ideal for storing and pouring liquids. In addition, unfired clay 'stopper-like' artefacts were located nearby. Their diameters were slightly smaller than those of the jar mouth, suggesting that the jars might have been sealed. When presented with something like that red deposit on an

artefact, any analysis must be carried out without damage to the sample.

The first step is to find out whether the residue is 'organic' or 'inorganic' and to do this McGovern uses the versatile techniques of transmission and diffuse-reflectance Fourier-transform IR spectrometry (DRIFTS). Characteristic spectra are obtained which are compared to a control (deposit-free area of the jar) and a standard reference sample (an ancient jar known to have contained wine).

The DRIFTS results 'strongly suggested that the carboxylic acid in the extracts is tartaric acid.' Because the three stereoisomers of tartaric acid have different DRIFTS spectra, the spectrum from the Godin Tepe jar deposit sample was closely compared to, and matched, that from L-(+) tartaric acid, the naturally occurring isomer.

It is now that the Feigl spot test is used to confirm tartaric acid. HPLC analyses provided further support. If any one test had been negative, the wine hypothesis would have been nullified.

Despite one or two questions remaining unanswered, McGovern was confident enough to say: "Although the Godin Tepe jars very probably contained wine, it is still uncertain whether the beverage was produced on site from grapes grown locally. The evidence for a local wine-making installation is only a large funnel and a putative lid for pressing the grapes.

"Nevertheless, if one were searching for an early centre of wine production, Godin Tepe – centrally located on a major trade route in the central Zagros Mountains – would be an excellent place to begin. The people from the Transcaucasian region, approximately 600km to the north where wild grapes (*Vitis vinifera* subsp. *silvestris*) still grow today, were likely in contact with Godin Tepe in Period V.

"The emerging cities of lowland Mesopotamia, especially their elite classes, represented a large potential market for wine".

Hajji Firuz Tepe

Important though the Godin Tepe wine find was, chemical evidence of an even earlier instance of vinification was reported a little later. This came from Hajji Firuz Tepe, another site in the Zagros Mountains, just to the north of Godin Tepe.

Two pottery jars, dated to 5400-5000 BC, a period when the first permanent human settlements were being established, contained reddish and yellow-

ish residues which contained calcium tartrate. Also identified in the residue was the oleoresin from the terebinth tree (*Pistacia atlantica*), widely used as a wine additive and a medicine.

Following on from the Hajji Firuz Tepe discovery, collaborative genomic work into DNA-typing of grape cultivars from Transcaucasia and Anatolia, areas which have long been thought of as likely homelands for viticulture, was carried out. Using specific microsatellite markers, 116 accessions of cultivars from Turkey, Armenia and Georgia, together with wild grapes, were genotyped.

Analysis of the results indicated that: "Most of the Armenian, Georgian and Turkish germplasms were well separated and could have multiple origins, although they are likely to have common ancestors,"

Moreover, the wild Turkish grape clustered closely with the European cultivars, whereas the wild European grape was far removed from those cultivars and so cannot account for their origin. The implication is that as the domesticated grapevine was transplanted westwards from the Near East, wild vines crossed or introgressed with it to yield the modern European cultivars.

It was from the interest in this work that the Eurasian grape (*V. vinifera*) was chosen as the first domesticated fruit to have its genome fully sequenced.

The legacy of King Scorpion I

In another important contribution to ancient winemaking, McGovern's team were asked to examine jars found in excavations of an ancient Egyptian tomb at Abydos in the Middle Nile.

In this collaborative work, 'hundreds' of jars, dated to ca.3150 BC, which had been recovered from the tomb (designated U-j) of King Scorpion I, one of the first kings of Egypt, were examined. The jars contained organic debris (shown later to be remnants of yeast) which had emanated from wine (as evidenced by grape pips and the occasional whole grape). They were stacked in three rooms and it was calculated that, if each jar had been filled, there would have been 1,200 gallons of wine in tomb U-j.

Chemical tests showed that Scorpion I's wine was resinated with pine (and possibly terebinth, *Pistacia palaestina*) and had probable herbal additives, with wormwood/mugwort (*Artemisia* sp.), tansy, coriander, sage, germander, balm, savory, senna, thyme and/or mint being identified.



Wine jars from Abydos in the Middle Nile region



Wine cellar at the same site in Abydos



The legend of King Midas

The grapevine did not grow in ancient Egypt – so where did the grapes come from? Neutron activation analysis of the pottery indicated that it had come from the southern hill-country of Palestine and the Jordan Valley – so this was evidence of Early Bronze Age trade between Egypt and Palestine and its surrounds. Presumably, the jars were filled with wine before transport to Abydos.

Tomb U-j was deeply buried in sand, conditions conducive (i.e. near zero humidity) to preservation of organic material, so, using the usual anti-contamination precautions, the wine lees deposit from a tomb jar was subjected to standard ribosomal DNA extraction and PCR amplification techniques.

As McGovern said: “The recovery of whole dried figs and raisins from some jars indicates how extraordinary the preservation conditions were inside the tomb”. Results showed that an inordinately high level of yeast rDNA, of differing sizes, had been extracted – probably because dead cells were included – and calculated at 12 mg/jar (of approximately 6L capacity).

After an exhaustive list of possible causes of contamination of the sample had been discounted, it was concluded: “That the lees inside a ≈5000-year-old wine jar contain DNA from an organism that can confidently be assigned to *Saccharomyces cerevisiae* has important implications for the evolution of wine, bread, and beer yeasts... These results provide the oldest evidence of an association of a micro-organism of *S. cerevisiae* with human activities”.

The Midas touch?

Penn Museum started excavations at an artificially constructed tumulus (called ‘MM’) at Gordion (ca. 100 km south-west of Ankara) in central Turkey over fifty years ago.

Buried inside this 45-metre high mound of stones and soil was a sealed tomb, originally believed to be that of King Midas) who founded Gordion and ruled this area (then called Phrygia) around 700 BC. Archaeologists now generally agree that the body was that of King Midas’ father Gordius, but debate continues.

The date of burial was calculated at around 740-700 BC, and when the tomb was opened it revealed the body of a 60-65-year-old male lying on a huge pile of blue- and purple-dyed textiles – “Signifying royalty in the Near East,” McGovern tells me. Also prominent was: “The largest Iron Age drinking set ever found,” consisting of 160 bronze vessels, including large vats, jugs, and drinking bowls.

These objects were obviously used for a huge ‘farewell dinner’ prior to the body being interred. The utensils and food remains, along with items of wooden furniture (thought to have been dining and serving tables), were buried with the body – preserving them for posterity.

Items found included three large cauldrons on iron tripod stands, 19 large two-handled bowls, 100 bronze drinking bowls, 19 small jugs, and two long-spouted jugs. Probably the

A farewell dinner



Large cauldron from the Midas mound



Drinking bowl (or omphalos)



The ‘Midas mound’ at Gordion

most spectacular vessels were a brass lion-head bucket (*situla*) and a ram-head *situla* presumably for serving the beverage.

This follows standard Near East protocol as can be seen from the wall relief from the palace of the Assyrian king Sargon II at Khorsabad (modern Iraq) dated ca. 701 BC. It depicts *situlae* being used to serve drink from a large pedestal bowl during a ceremony to celebrate a military victory.

A number of ceramic jars were also recovered and these had a different type of deposit. To quote McGovern again: “Preservation conditions were extraordinarily good inside the tomb, which is the earliest known intact wooden structure in the world, dated at about 700 BC.”

And back to Penn

The Gordion samples had been stored for over 40 years at Penn Museum prior to McGovern examining them.



Ram head situla



Wall relief from Khorsabad showing situlae being used to serve drink from pedestal bowl

Dogfish Head brewery



When artefacts were returned to Penn Museum in the 1950s, it was noticed that many of the metal tomb vessels contained a golden-yellow residue likely to be the remnants of a liquid.

Analytical techniques of the day revealed 'carbon, nitrogen and other elements characteristic of organic materials', but via an array of techniques such as IR spectrometry, mass spectrometry and GLC, McGovern was able to identify these deposits more exhaustively. Deposits from a number of different vessels were examined and tartaric acid/tartrate was omnipresent.

Certain vessels tested positive for oxalate and the long-chained, saturated carbon compounds characteristic of beeswax were also confirmed. The latter, together with the presence of gluconic acid, confirmed the presence of honey. Thus, the liquid in those metal vessels, or 'Phrygian grog', as McGovern called it, was a wine/beer/honey mixture, probably rather like a medieval, north European 'braggot'.

Eighteen handleless ceramic jars (*dinoi*) and some small amphorae contained appreciable amounts (ca. 150g) of 'spongiform and brownish material, quite unlike the shiny dark residues in a yellowish matrix found inside the bronze drinking vessels.' The jars were surrounded by 'large clumps of similar material.'

Laboratory analysis of this, apparently homogeneous, material indicated that it consisted of the remnants of a splendid meal. The chemical profile suggested sheep or goat meat which



McGovern and Calagione

had been marinated in a mixture of olive oil, honey and wine (represented by oleic/elaidic acids, gluconic acid and tartaric acid) before being barbecued. The latter treatment is indicated by the presence of cresol and phenanthrene.

Large amounts of cereals and lentils were also recovered on site and in addition to what has been mentioned above, the remains of several buildings identified as possible breweries and/or bakeries have also been identified at Gordion, with evidence of charred grains, germinated barley, grinders, ovens and ceramic vessels; the latter possibly indicating beer consumption.

Dogfish Head collaboration

In 1999, McGovern collaborated with Sam Calagione's Dogfish Head brew-

ery to produce the first of their 'Ancient Ales' series of beers, 'Midas Touch Golden Elixir', which was brewed to a recipe based on McGovern's archaeo-chemical findings.

The brewery, founded in a brewpub in Milton, Delaware in 1995 (commercial brewing was illegal in Delaware in 1995 and Sam had to go to the floor of the State Senate to get the law changed!), and its beer quickly became very popular and a separate brewery was opened the following year.

Since then, a distillery and a hotel ('Dogfish Inn') have been added to the business and the company's name has been licensed to ale houses in other states. The brewery has always been noted for its innovative brewing ethos; the company motto being: "Off-centered ales for off-centered people."

Because of the inherent sweetness of the 'Midas Touch Golden Elixir' recipe, Calagione felt that he had to balance this with some bitterness. Hops were out of the question because they played no part in ancient Near Eastern brewing (or in ancient Egypt). Ultimately, McGovern proposed saffron because it is native to Turkey, slightly bitter, imparts a yellowish colour, and has that wonderful fragrance.

Malted barley and honey presented no problem for they are both known from the ancient Near East, but nothing was known about the grape used in Gordion in antiquity. They decided upon yellow Muscat grapes for 'Midas' since its DNA has affinities with the earliest grape varieties known in the Near East.



When the beer was first put out into the market in 2001, the name was shortened to 'Midas Touch' and it has proved very successful, being part of the regular beer portfolio. This Iron Age-era drink has been seen, by some, to be 'reminiscent of Sauternes.'

The Midas Touch episode attracted much media interest, especially when the beer started to win prizes; a silver medal at the 2005 Great American Beer Festival, a bronze at the 2008 World Beer Cup and several gold awards. The latter are particularly appropriate and help to make Midas Touch by far the most decorated Dogfish beer.

These successes inspired Calagione and McGovern to experiment with other recipes based on ancient finds, and, over the years, the following beers have appeared:

Theobroma (9.0% ABV; first brewed 2008), based on jar fragment deposits from Honduras which revealed the earliest chemical evidence for a fermented chocolate (*Theobroma cacao*) beverage, as early as ca. 1400-1100 BC. Brewed with Soconusco cocoa powder from the prime Aztec area of south-western Mexico, cocoa nibs, honey, chillies, and annatto tree seeds. **Chicha** (5.7% ABV; first brewed 2009), an unfiltered beer brewed with yellow and purple corn [see *Brewer and Distiller International*, July 2015.] Purple corn is masticated to impart enzymes for germination and then expectorated; yellow corn is malted. The beer has a 'purple-pink hue from the Peruvian corn, strawberries and pepper berries.'

Ta Henket (4.5% ABV; first brewed late-2010), based on an archaeobotanical evidence from Palaeolithic and Neolithic Egyptian sites and the chemical evidence from the Scorpion I wine jars.

Calagione and McGovern travelled to Egypt to produce a TV programme for the Discovery Channel's Brew Masters series and were filmed on a mission to 'capture' a 'wild' Egyptian yeast in a date palm grove. The sample was replicated in the laboratory and used for fermentation. Ingredients were gathered in the Cairo suq. The beer was brewed with emmer wheat loaves of hearth-baked bread, and flavoured with chamomile, dom palm fruit and the popular Middle Eastern herbal mixture, za'tar (thyme and savory).

Birra Etrusca Bronze (8.5% ABV; first brewed 2012), brewed from a two-rowed malted barley and an "heirloom Italian wheat". Ingredients include pomegranate, hazelnut flour, Italian chestnut honey, Delaware wildflower honey, clover honey, and "a handful" of whole hops. Most of the bittering comes from gentian root and myrrh resin;

Kvasir (10.0% ABV; first brewed 2013). The recipe is based on biomolecular archaeological evidence from sites in Denmark and Sweden (Gotland). It is brewed with red winter wheat, honey and birch syrup, cranberries and cowberries, and spiced with bog myrtle, clover, yarrow and juniper. To partially counterbalance sweetness, a 'handful of hops' is added.



Chinese interlude

The other beer in the 'ancient ales' portfolio, and the second after 'Midas Touch', is **Chateau Jiahu** (10.0% ABV), which was first brewed in 2006. McGovern and colleagues were responsible for identifying what has proved to be the world's earliest alcoholic beverage (ca. 7000-5500 BC). Evidence for this important event in human history comes from the much-studied early Neolithic site at Jiahu in the Chinese province of Henan.

The site is also noteworthy for its early Chinese china and some of the country's earliest short-grained rice, which is intermediate between the wild and domesticated forms. Jiahu has also yielded evidence of possibly very early Chinese written characters and, thus far, the earliest playable musical instruments (bone flutes).

The Jiahu beverage remains were from pottery jars, including two-handled, narrow-mouthed storage jars, and jars with high flaring necks and rims – suitable for pouring a liquid. Some perforated basins, possibly for preparation of the beverage, were also



Ceramics from Jiahu

found and their residues tested.

Fortunately, artefacts from a later period of Henan civilisation (ca. 1250-1000 BC) had been collected from another excavation and examination of the contents of these allowed McGovern the rare opportunity to assess later alcoholic beverage developments in China (or, at least, Henan Province).

The earliest texts from China (late-Shang dynasty; ca 1200-1046 BC) distinguish three alcoholic beverages: *li*, a seemingly a low-alcoholic (and sweet) rice or millet drink; *chang*, a herbal wine, and *jiu*, a fully-fermented rice or millet drink. At a likely alcohol content of 10-15% ABW, the later was essentially a wine.

McGovern visited China over the period 1999-2002 to work with his Chinese collaborators and samples were taken back to the US for analysis, results being first reported in 2004. Via the usual chemical methods, fingerprint compounds were identified for rice, beeswax, and wild grape/hawthorn signifying a mixed fermented beer/wine/mead beverage. The identification of this mixed beverage at Jiahu, as early as 9000 years ago, is of particular interest because it approximates to the time that grape wine and barley beer were being made in Middle East.



Some bronze vessel finds from an elite burial of the 2nd millennium BC had been so well preserved that they still had liquid content in them, because they had become hermetically sealed when their tightly fitting lids corroded, preventing evaporation. One type of vessel was a lidded 'teapot' and on opening it McGovern noted that there was still a pervading "fragrant aroma".

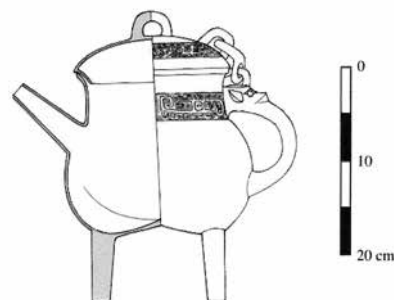
Chemical analysis of the liquid prompted McGovern to pen: "According to detected compounds such as camphor and alpha-cedrene, beta-amyrin and oleanolic acid, specific aromatic herbs (e.g., wormwood), flowers (e.g., chrysanthemum), and/or tree resins (e.g., China fir and elemi) had been added to the wines. In addition, benzaldehyde, acetic acid, and short-chain alcohols were characteristic of rice and millet wines."

The problems encountered in recreating a 9000-year-old drink tested the mettle of the McGovern/Calagione collaboration – and the result, 'Chateau Jiahu', is a compliment to all concerned. Determining and then sourcing meaningful ingredients was especially taxing.

Eventually, the following ingredients were used: pre-gelatinised rice (with bran included), malted barley, orange blossom honey, Muscat grape juice, and hawthorn fruit. The mash was fermented with sake yeast for one month. There was some consternation when the US Bureau of Alcohol, Tobacco and Firearms (ATF) disallowed the use of hawthorn fruit in an alcoholic beverage, but after 'endless negotiations', they relented by allowing the powder to be used.

McGovern, who has been described by his peers as 'part modern scientist, part Indiana Jones', has travelled extensively in Eurasia, from Georgia to China in his never-ending quest for samples of fermented beverage residues. Among many successful endeavours in his career, his ability to integrate scientific studies with the humanities stands out – and the field of biomolecular archaeology which he has pioneered is the epitome of an interdisciplinary study.

Having been fortunate enough to experience the euphoria of winning a major beer award myself, I feel that McGovern's recollection of his triumph at the 2009 Great American Beer Festival is worth noting: "Word came that Chateau Jiahu had taken gold in the specialty honey beer category. Sam and I quickly made our way to the podium, where no less than the home brewer incarnate, Charlie Papazian,



Metal lidded 'teapot' from Anyang (ca. 1250-1000 BC)

presented us with the award.

"Sam, who already had numerous medals, turned to me and draped the Jiahu medal around my neck. Back in Philadelphia, I set up a small shrine in my office. The medal now adorns a bottle of Chateau Jiahu with the enigmatic lady of Sam's dreams on its label. Several of the 9000-year old sherds, which we analyzed, keep her company. Every morning when I enter my lab, I bow to the shrine and gain inspiration for the day." I eagerly await the imminent publication of McGovern's latest book



McGovern's book Ancient Brews, with foreword from Calagione

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- The Midas mound at Gordion - University of Pennsylvania;
- Large cauldron from the Midas mound,
- Drinking bowl (or omphalos),
- Ram head situla - Gareth Darbyshire;
- Wine jars from Abydos in the Middle Nile region,
- Wine cellar at the same site in Abydos - Gunter Dreyer;
- Grooved sherd from Godin Tepe,
- Godin Tepe jug with applied 'rope' decoration - Virginia Badler