

THE BIG STORY



Goddess of the Copper Age: this ceramic figurine was made some 7,000 years ago by Serbia's Vinča people, the culture which launched the world's first large-scale industrial revolution

## The first industrial revolution

Scientists have discovered the world's earliest known large-scale copper smelting industry – in the Balkans. As **David Keys** reveals, this prehistoric operation had a massive impact on human development

**A**RCHAEOLOGISTS have discovered the world's first major industrial revolution – an extraordinary technological breakthrough which occurred 7,000 years ago in the Balkans. They are also revealing, for the first time, exactly when the Stone Age began to end – and when the age of metallurgy first got under way.

The research has been carried out by a London-based scientific

team which has succeeded in locating the world's earliest known large-scale copper

**It helped accelerate forest clearance, boost agriculture, and increase settlement and population sizes**

smelting industry – at Belovode, a settlement site of the prehistoric Vinča culture, 70 miles south-east

of the Serbian capital, Belgrade. Although the smelting furnaces themselves have not been located,

the archaeologists have unearthed telltale evidence of the smelting process: fragments of once-

molten slag and copper metal, and lumps of copper ore.

The new research has revealed that hundreds of thousands of axes and other metal artefacts were being manufactured in the Balkans seven millennia ago. Smaller-scale and less sophisticated smelting was developed at around the same time in Iran, though no accurate dates have yet been obtained for this particular operation.

PROJECT VINČAVI MILADINOVIC/COURTESY OF PROF. NIEMAD N. TASIC

Before humanity discovered how to make metal, all heavy-duty tools had to be fashioned out of stone, bone or antler. But with the development of metallurgy, much stronger and more durable axes, knives and other tools could be made. Copper axes were more efficient than their predecessors and could be much more easily renewed than stone ones.

But the invention of metal smelting was much more than a technological revolution. In fact, it had a significant impact on human development, helping to accelerate forest clearance and boost agriculture. It also helped increase settlement and population sizes and played a key role in society becoming more hierarchical.

### In Context: → Inventing furnaces

In order to turn malachite into copper, the prehistoric technicians needed to create two things: heat and the poisonous gas, carbon monoxide. And to do the latter, they needed to restrict the charcoal fuel's access to air – by inventing the furnace. First, at 500°C, the malachite disintegrated into copper oxide. Then, at 700°C, the carbon monoxide transformed itself into carbon dioxide by 'stealing' oxygen from the copper oxide, thus leaving behind a mixture of pure copper, ash and mineral impurities.

To separate out the pure copper, the mixture had to be heated still further until it melted at 1100°C. At that stage the impurities and ash floated to the top – and the world's first metallurgists were able to retrieve the world's first smelted copper. But even then, temperatures had to be maintained between 1100°C and 1150°C – otherwise the ceramic crucibles would also have melted and the precious copper would have been lost.



Archaeologists at work at Belovode – a site of the prehistoric Vinča culture

Archaeological research is also shedding light on the remarkable process by which the metallurgical revolution came about. It suggests that these first metal-makers were true scientists – deliberately and constantly repeating and modifying experiments and observing changed outcomes.

The first step seems to have taken place around 9,000 years ago when people started making beads out of malachite, a beautiful, shiny green rock, rich in copper. Substantial quantities of these beads have been found in the Balkans and elsewhere.

The next stage was almost certainly the production of very small artefacts from rare chunks of naturally-occurring pure copper (as opposed to malachite). These irregular lumps, with their characteristic green patinas, could be alternately hammered and heated ('annealed') in an ordinary cooking hearth and hammered again into a required shape. Such 'native copper' lumps could therefore be made into artefacts long before smelting had been invented. In the Balkans, the earliest probable dates for this type of artefact is around 6000 BC, a thousand years before the 'smelting revolution' – but a key step along the road to it.

The next step involved another type of distinctive rock – a sometimes shiny form of lead ore known as galena. Like native copper it could be turned into

AD 410

## Remembering the Romans

**H**ISTORIANS AND archaeologists are preparing to commemorate the 1,600th anniversary of the end of Roman Britain with a series of conferences, re-enactments and other events.

This month (13/14 March), 20 senior academics will be speaking at a two-day British Museum conference on AD 410. The museum is also publishing a book on the subject. A second two-day event focusing on western Britain in late Roman and sub-Roman times will be held at Cardiff University in late October. Five more local conferences will be held at Lincoln, Sevenoaks, York, Aberystwyth and South Shields between now and November.

English Heritage is planning a two-day AD 410 re-enactment

A late Roman belt buckle, now in Verulamium Museum, St Albans



event at Old Sarum, Wiltshire on 19/20 June featuring living history encampments, battles, a display of Roman surgery, and even a group from Brittany, where many Britons migrated after Britain ceased to be part of the empire. Lights will also be lit along Hadrian's Wall (13 March).

At St Albans, Verulamium Museum (in conjunction with the British Museum) is organising a small display of late Roman artefacts and a one-day late Roman re-enactment event, both this summer. Chichester Museum is planning a series of talks and walks with an entertainingly ambiguous title borrowed from Monty Python: Romans Go Home.

The anniversary even has

its own website:

[www.410.org.uk](http://www.410.org.uk)

**i** David Keys

For more

on the end of

Roman Britain, turn

to pages 44 and 82

artefacts with the help of the heat produced by an ordinary cooking hearth.

Unlike native copper, galena actually metamorphosed (into lead, which melted in the heat), and Balkan and other people probably made small objects from the molten lead it produced. (These objects have not yet been found in the Balkans, but the telltale galena ore has been discovered in settlements).

Lead is the only relatively common metal that melts at such a low temperature (around 330°C) but it seems to have suggested to prehistoric Balkan technologists that what worked for galena might just work for malachite.

Changing malachite into metal was, however, a far more complex

business – and much deliberate experimentation must have been undertaken before an effective technique was found. The process (see box, left), which the experimentation seems to have produced, created the age of metals and laid the foundations for our modern world.

The research has been carried out by: Miljana Radivojević and Professor Thilo Rehren of University College London's Institute of Archaeology; Dušan Šljivar of Serbia's National Museum in Belgrade; and Professor Ernst Pernicka of Tübingen University. It received funding from the Institute for Archaeo-Metallurgical Studies, the Freeport-McMoRan Copper and Gold Foundation and the Serbian government. **i**