3.3. Mapping Change & Development

1. The roots of iron age (technological and demographic change)

   A. C. Cook, J. R. Southon, and J. Wadsworth, Using Radiocarbon Dating to Establish the Age of Iron-Based Artifacts, JDM (2003), 15

2. Stonehenge (site analysis and site development)

Technology transfer and Demographic Change
Iron Smelting Technique

Reduction of Iron oxide in ore to iron by heating charcoal or coal driven fire, at a certain heat level the carbon will oxidize

\[2C + O_2 \Rightarrow 2CO\]

Carbon monoxide interaction with iron oxide

\[Fe_2O_3 + CO \Rightarrow 2Fe_3O_4 + CO_2\]
\[2Fe_3O_4 + 2CO \Rightarrow 6FeO + 2CO_2\]
\[FeO + CO \Rightarrow Fe + CO_2\]

Slight enrichment of carbon in iron possible (temperature dependent process)
Charcoal based smelters could only reach temperatures of ~ 700 °C
• Produces red hot but solid mass of iron (bloom)
• Iron relatively soft (wrought iron), needs smithing to work it
• <0.5% carbon

Increase of temperature by air blowers (oxygen) to 1150-1200 °C
• rapid increase of Carbon up to 3.5%
• melting point of iron-carbon alloy
• Iron very hard (cast iron), but fragile
The dating of iron age artifacts

Important fact for radiocarbon dating charcoal was necessary to heat the furnace up to sufficient temperatures \( \sim 1150^\circ C \) for ore reduction and iron smelting. Furnace remains, slag debris, iron tools or weapons contain sufficient carbon impurities, accumulated during the ore reduction process.
roots and expansion of iron age

Radiocarbon analyses show chronological expansion of iron industry through trade in Africa:

- origin in Hittite and Babylon empire 1800-1750 BC
- superior weapon development lead to several defeats of Egyptian armies through Hittites (1299 BC by Kadesh, Syria) & Assyrians (666 BC near Thebes)

slow expansion to Merōi by (400 BC)
expansion by sea trade

- by ~1500 BC Phoenicians controlled harbors (for iron ore), took over iron trade in the eastern Mediterranean.
- foundation of Carthage (~815 BC)

its port was protected with iron chains
Centuries of caravan trade
In western Sahara on fixed routes
Several weeks of travel at >120°F

P. Masonen, Ethnic Encounter and Cultural Exchange, Bergen 1997, 116-142
expansion by migration

- Slow expansion by Bantu migration through Angola and Congo to Transvaal 500 BC-500 AD was followed by tedious radiocarbon links.

- caravan trade with the west African empires of Ntreso and Nok (iron in exchange of gold and ivory) between 1000-500 BC

C. Robion-Brunner, et al., A thousand years of iron metallurgy on the Dogon plateau (Mali); Proc. of the 18th Biennial meeting of the Society of Africanists Archaeologists, Calgary, 2006, 1-3
Recent smelter discovery in Congo

**Bécaré:** funnel shaped tunnel
carbon dating (1995)
$t=1870\pm 70 \ (2\sigma \ 95\%)$
$\Rightarrow \ AD \ 55 \ to \ 195$

**Sabélé:** circular hillock with pipe fragments
carbon dating (1995)
$t=630\pm 45 \ (2\sigma \ 95\%)$
$\Rightarrow \ AD \ 1320 \ to \ 1410$

The last 500 years

iron smelting industry 500 AD in Palabora mining area in South Africa

open pit mining since 1964 AD

smelting industry 2000 AD in Palabora

Modern Iron smelting works with coal (since ~1780) fossil fuel, dating is not possible anymore since fossil fuel is $^{14}$C depleted by natural decay.
Location and Structure of Stonehenge

Circular stone structure in South England. Built in several stages 2800 - 1800 BC. Speculation on the reason it was built range from human sacrifice to astronomy.
LCS Radiocarbon dating of the entire Stonehenge structure

The dating program for this project was designed to address:

• The provision of a series of reliable absolute dates and the construction of a reliable chronology for each major phase of the monument.

• The elucidation of the chronology and sequence of major events or sub-phases within phase 3.

• The assigning of specific features to a phase by radiocarbon dating where other evidence was sparse.

• The dating of specific cultural artifacts with intrinsic significance.
First evidence for human activity from mesolithic age are some pits northwest the monument, which presumably used to hold some kind of totem poles. Artifacts of burned bone and charcoal were dated. These gave evidence of activity between 8500-7650 BC and 7500-6700 BC.
circular ditch (2m deep, 2m wide); white chalk in green pasture, inner ring was made out of deer antlers. $^{14}$C dating was made on antler material gathered over period of 20-160 years. Time of construction was determined to 3020-2910 BC.
Phase 2-3

Transition from earth dig with totem poles (tree trunks) to the circular setting of blue stones (imported from Wales). Analysis of wood left-over gave a period between 2700-2500 BC for phase 2; the $^{14}$C analysis of some blue stone charcoal samples (limited results) 2280-2030 BC for phase 3.
Phase 3

Sarsen Circle defines the Stonehenge sight. Limited dating material antlers at the bottom of holes. The $^{14}$C dating reveals a construction period between 2480-2100 not clear if blue stone circle or Sarsen circle came first? Additional outer ring attempt, x y holes (with antlers as stake outs) was dated to 2200-1800 BC but never finished.
Radiocarbon dates

PHASE 2
SEQ
PHASE 2
XREF OxA-5981
XREF OxA-5982
UB-3791
OxA-4904
OxA-4881
OxA-4841
OxA-4882
OxA-4880
OxA-4843
OxA-4883
LAST last infill
R_COMB Beaker burial
PHASE Aubrey Hole
C602

Calendar date
5000cal BC 4000cal BC 3000cal BC 2000cal BC 1000cal BC

Sarsen Circle material
Z Hole material

Acquisition of material in Y Hole

Stonehole E
Acquisition of material in Stonehole E
Acquisition of material under Bluestone Circle

Sarsen Trilithons
Acquisition of material under Sarsen Trilithon

Bluestone Horseshoe material

PHASE 3
SEQ
PHASE
LAST Stonehole E

LAST Sarsen Trilithon

SEQ
LAST Sarsen Circle

PHASE
LAST Z Hole
LAST Y Hole

Calendar date
3500cal BC 3000cal BC 2500cal BC 2000cal BC 1500cal BC
A skeleton was found in 1978. The radiocarbon analysis gives the time of burial to be near the end of Phase 2: 2400-2200 BC.

Another skeleton found in 1923 shows indication of decapitation, at ~700AD.

Spirit of Stonehenge

Stonehenge and its purpose is still a matter of emotional debate. Geometry and SW-NE alignment point to astrological (astronomy) purpose – immigration of Sumerian people through trade and sea fare.

Henry of Huntingdon wrote in 1130 AD:
"No one can conceive how such great stones have been so raised aloft, or why they were built here".
Migration towards Stonehenge?

Radiocarbon dating of early Indo-European settlement and farming movement.

Agreement with the Genetic map?


The interpretation is based on “Principal Component Analysis” (PCA), a statistical method, yet the interpretation of the results is not unambiguous. Principal component analysis of genetic data; David Reich, Alkes L Price, and Nick Patterson; Nature Genetics 40, 491 - 492 (2008)