Chapter 3-2: Examples for $^{14}$C Dating Applications in Archaeology

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

2. Stonehenge
   (site analysis and site development)

3. Cherchen Man
   (Migration and colonization)
Example 1: Technological and Demographic Change
Iron Smelting Technique

Reduction of Iron oxide in ore to iron by heat in charcoal or coal driven fire, at heat carbon oxidizes

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

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)
Ancient furnace techniques and carbon content

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 ~1150°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 of 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 Meröi 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
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
Recent smelter discovery in Congo

Bécaré: funnel shaped tunnel
carbon dating (1995)
t=1870±70 (2σ 95%)
⇒ AD 55 to 195

Sabélé: circular hillock with pipe fragments
carbon dating (1995)
t=630±45 (2σ 95%)
⇒ 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.
Example 2: Site Analysis and Site Development
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; analysis of blue stone charcoal (limited results) 2280-2030 BC for phase 3.
Phase 3

Sarsen Circle gives Stonehenge sight. Limited dating material antlers at the bottom of holes. Dating gives 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.
Stonehenge as Burial and Execution Site

Skeleton found in 1978. Radiocarbon analysis gives time of burial to near the beginning of Phase 2: 2850±55 BC

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.
Support for migration theory

The Stonehenge Archer

Recent (2002) discovery of human remains near Stonehenge
Age of the Archer

The radiocarbon dates show that the Archer lived between 2,400 and 2,200 years BC. ¹⁴C dating of a second skeleton indicated slightly younger age.
Origin of Equipment

Element analysis through isotope analysis:

- Archer from Alpine Region
- Copper from Spain
- Gold from central Europe