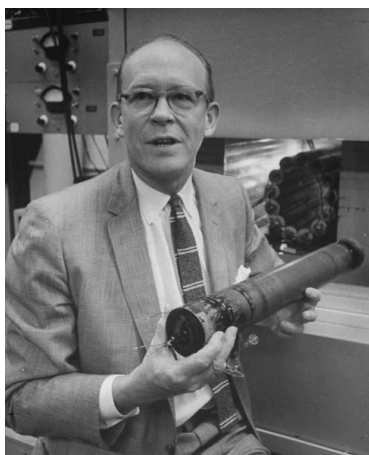# Radiocarbon Dating (or Carbon 14 dating) and Sutterby

Until the 1950s the only way archaeologists had of telling the age of the artefacts they were digging up was by their direct association with objects (pottery, metalwork etc) whose 'type' had already had a date ascribed to them. (known as dating by Typology).

It was a very shaky science and there was much disagreement between bearded professors.

In 1949, Willard Libby, an American scientist working at Chicago University developed a method to measure the ratio of the radio-isotopes carbon 12 and carbon 14 in organic materials. So What! you might say.
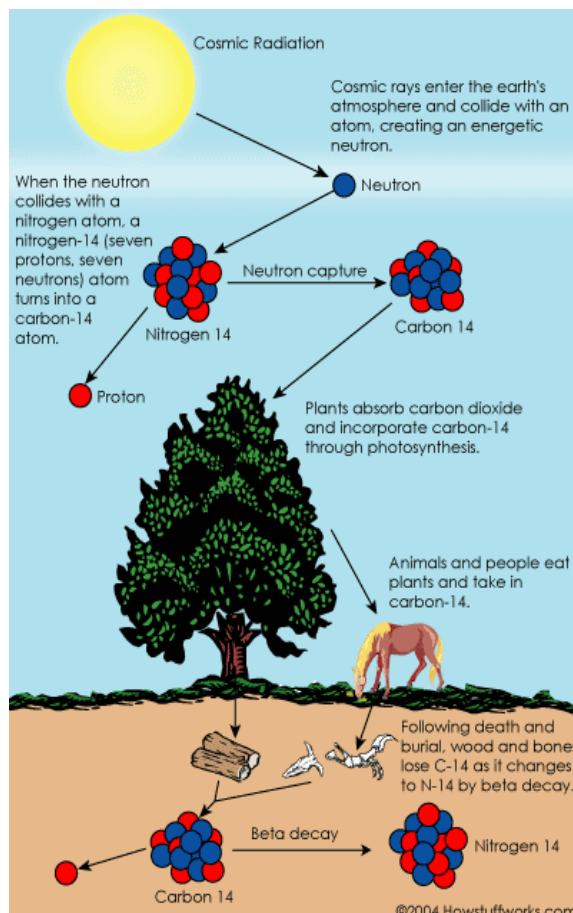
Carbon is a common element - one of the basic building blocks of the Universe. The world around us contains three types of carbon (carbon 12, carbon 13 and carbon 14). We need only concern ourselves with 12 and 14 at present.

Carbon 12 is the most prevalent form and is quite stable, but carbon 14 is temporary - it forms in the upper atmosphere and gets mixed up with the natural carbon. Plants take it in by absorption (plants use carbon dioxide to grow) and animals (including us) take it in by eating the plants. Through a plant or animal's lifetime, it absorbs and incorporates carbon 14 at a consistent rate. Your body contains a known ratio of carbon 12 to carbon 14.

BUT, when a plant or animal dies it stops absorbing any more carbon. The carbon 12 stays just the same as it always was but the carbon 14 changes back to carbon 12 at a known rate. (This is known as radioactive decay). So as the centuries pass, the ratio of carbon 12 (C12) to carbon 14 (C14) slowly changes until there is no carbon 14 left.

Willard Libby, the scientist who discovered carbon 14 dating in 1949

This then, is the principle of carbon dating. The discovery by Libby of how to measure the ratio of C12 to C14 led to a revolution in dating for archaeologists. It could only work if there was some 'organic' material found in association with the archaeological artefacts - that is some natural material containing the element carbon - for instance plant remains, peat, wood, bones, shells, (or the burnt remains of any of them). It cannot date inorganic materials such as pottery, metalwork, stone etc, but can give indications of their dates by association with datable materials.

One drawback with radiocarbon dating is that it is based on radioactive decay. Although the half-life of carbon 14 is accurately known (5730 years) calculations of age are subject to statistical probability - a simple date cannot be given - what is given is a probability figure, thus a radiocarbon date is always quoted as plus or minus ($\pm$) a range e.g. 900 years before present $\pm$ 36years ... which means that there is a 68.2%* probability that the age of the object lies within 864 and 936 years old.

Cosmic Radiation

Cosmic rays enter the earth's atmosphere and collide with an atom, creating an energetic neutron.

Neutron

When the neutron collides with a nitrogen atom, a nitrogen-14 (seven protons, seven neutrons) atom turns into a carbon-14 atom.

Nitrogen 14

Neutron capture

Carbon 14

Proton

Plants absorb carbon dioxide and incorporate carbon-14 through photosynthesis.

Animals and people eat plants and take in carbon-14.

Following death and burial, wood and bones lose C-14 as it changes to N-14 by beta decay.

Beta decay

Carbon 14

Nitrogen 14

©2004 Howstuffworks.com

* The figure of 68.2% is 'one standard deviation' in statistical terminology

Another drawback is that after *c.*50,000 years there is so little C14 left unchanged it is hard to measure it - so effectively carbon 14 dating only works on things up to 50,000 years old.

Libby won the Nobel Prize for his work in 1960 and for a while, archaeologists were blissfully happy with their new scientific method. The mix and confusion of Ancient Egypt, Syria, Greece and Rome was slowly being straightened out
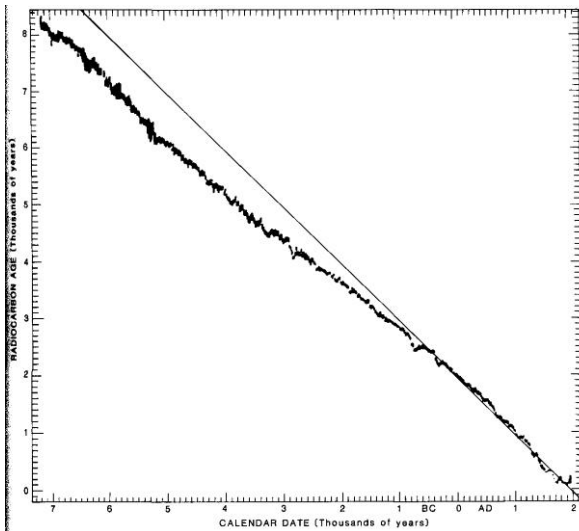
The correction curve based on bristlecone pine recalibration of carbon 14 dating

BUT ..... Unknown to them, there was a problem ... Libby had made an assumption when he did his calculations that the C12 to C14 ratio had always been the same since the beginning of the world. This assumption is OK back to about 800BC - older than that and it starts to change.

What was needed was a way of calculating the C12 to C14 ratio back in time. This was found in the very long lived tree called the bristlecone pine which grows at high altitude in the western United States. These trees can live to over 5000 years. By sampling their tree rings (one grows each year) the C12 to C14 ratio can be corrected.

So carbon dating could be **Recalibrated** and the archaeologists were happy again!

But all this means that you do not get a simple date when you send a carbon 14 sample off to be measured.

THE SUTTERBY CARBON 14 DATE

At Sutterby we took a sample of bone from the skeleton that had been cut through by the building of our earliest foundations. Whatever date was calculated for that sample would mean that the wall must have been built **AFTER** that date (although we can't say how long after).

When the C12 to C14 ratio was measured the 'raw' result was that there was a 68.2%* probability that the body was buried between 858 and 926 years 'ago' (between AD1024 and 1092 - because the 'ago' is calculated from 1950, the baseline date for all carbon dating).

BUT HOLD ON ... there's another calculation to make because of the recalibration.

When we apply the recalibration curve to our 'raw' dates that gives us a 'calibrated date' range. Annoyingly the recalibration curve is a bit lumpy at this period giving us lesser accuracy.

So ... there is a 68.2%* probability that the body was buried between AD1049 and 1206 and a 95.4%[$] probability that it was buried between AD1039 and 1217. We could speculate that there is slightly more probability that it was buried towards the end of the period than the beginning, but that is moving onto thin ice! Our best statement is "***This burial dates somewhere from the mid-eleventh to the end of the twelfth century".***

So, the earliest phase of wall building observed at the west end of Sutterby Church most likely dates from during or after the twelfth century. But the stratigraphy cannot tell us how far after - we must look to other evidence to fix this dating more firmly.

* 68.2% probability is 'one standard deviation' in statistical analysis
$ 95.4% probability is the result of 'two standard deviations' in statistical analysis

Here is the graphical result for our Sutterby carbon 14 date. On the left (in pink) is the 'raw' date plotted to 1 standard deviation. (don't forget BP is calculated from 1950)
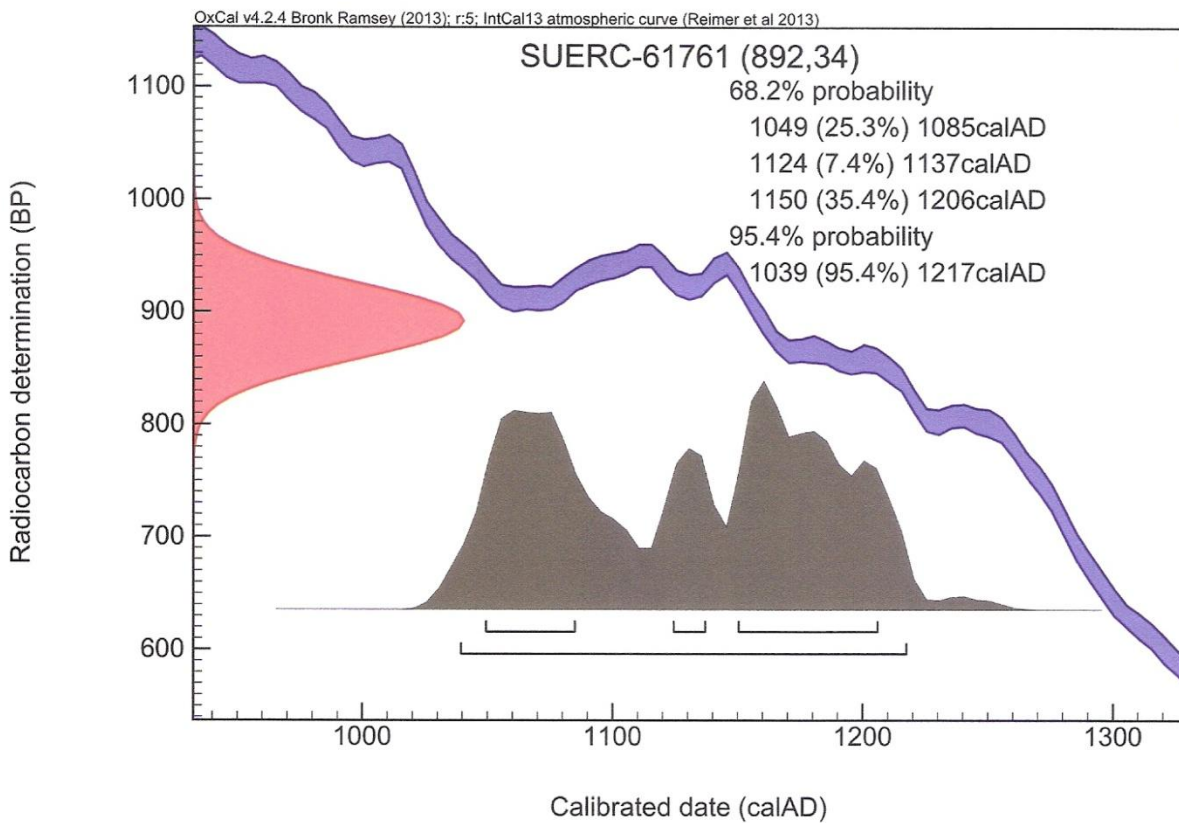
The blue wiggly line is the recalibration curve and the grey bumps beneath it are the resultant calibrated date with various ranges of probability. The curve is unkind to us in this era as it spreads our date range out.

So the body was probably buried in the period from the mid eleventh through to the end of the twelfth century

...   and the wall foundation cut through it SOME TIME AFTER that date.

A small archaeological project like Spirit of Sutterby would not normally be able to afford the luxury of a radiocarbon date - the process is quite expensive. Two of our volunteers offered to fund the radiocarbon date and we are MOST grateful to them.

Dave Start,
October 2015