# Online Supplementary Information

## Temporal dynamics of Linearbandkeramik houses and settlements, and their implications for detecting the environmental impact of early farming

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## OxCal model code

The following CQL code will run in OxCal v4 (Bronk Ramsey 2009), which is available online at <https://c14.arch.ox.ac.uk/>. Full details of how the program works and what individual functions are designed to do is given at <http://c14.arch.ox.ac.uk/oxcalhelp/hlp_contents.html>. A full bibliography is also provided. Please contact the corresponding author if you experience difficulties using the models.

### Model A

Plot("Model A")

{

Outlier\_Model("collagen",T(5),U(0,4),"r");

Phase()

{

Sequence("SW settlements")

{

Boundary("SW start");

Phase("SW houses")

{

Phase("house 70")

{

R\_Date("Poz-106185 (bc14\_294\_2)", 6260,40);

R\_Date("Poz-106052 (bc14\_294\_3)", 6240, 40);

First("house 70 first");

Last("house 70 last");

};

Phase("house 318")

{

R\_Date("GrM-12566 (bc14\_096\_2)", 6290,25);

R\_Date("GrM-12697 (bc14\_096\_1) 0.3%", 5890, 80);

Outlier();

};

Sequence()

{

Boundary("build 57");

Phase("house 57")

{

R\_Date("RICH-25443 (bc14\_198\_3 (b))", 6260, 34);

R\_Date("RICH-25444 (bc14\_200\_2)", 6206, 35);

R\_Date("GrM-12560 (bc14\_198\_3(a))", 6200, 25);

First("house 57 first");

Last("house 57 last");

Span("57 span");

};

Boundary("abandon 57");

};

Phase("house 29")

{

R\_Date("RICH-25442 (bc14\_401\_3)", 6211, 34);

R\_Date("RICH-25441 (bc14\_405\_4)", 6179, 34);

First("house 29 first");

Last("house 29 last");

Span("29 span");

};

Phase("house 34")

{

R\_Date("KIA-52748 (bc14\_340\_1) 3.9%", 6190, 26)

{

Outlier("collagen", 0.1);

};

R\_Date("GrM-12576 (bc14\_337\_7) 1.1%", 6130,30)

{

Outlier("collagen", 0.4);

};

R\_Date("RICH-25476 (bc14\_340\_1) <1% collagen", 6020, 36)

{

Outlier();

};

First("house 34 first");

Last("house 34 last");

Span("34 span");

};

Sequence()

{

Boundary("build 39");

Phase("house 39")

{

R\_Date("Poz-60638 1.1%", 6220, 35)

{

Outlier("collagen", 0.4);

};

R\_Combine("P30135-1 1.9%")

{

R\_Date("GrM-12574 (P30135-1) 2.0%", 6150, 30);

R\_Date("KIA-52816 (P30135-1) 1.8%", 6266, 27);

Outlier("collagen", 0.4);

};

R\_Date("GrM-14299", 6190,20);

R\_Date("GrM-14300", 6170,20);

R\_Date("GrM-14301", 6150, 20);

R\_Date("Poz-60611 1.1%", 6050, 35)

{

Outlier();

};

R\_Date("RICH-25472 (P30114) 1.4%", 6001, 32)

{

Outlier();

};

R\_Date("Poz-60637 0.8%", 6000, 50)

{

Outlier();

};

First("house 39 first");

Last("house 39 last");

Span("39 span");

};

Boundary("abandon 39");

};

Sequence()

{

Boundary("build 40");

Phase("house 40")

{

R\_Date("GrM-12562 (bc14\_143\_4)", 6240, 25);

R\_Date("RICH-25446 (bc14\_143\_2(a))", 6157, 35);

R\_Date("GrM-12559 (bc14\_143\_2(b))", 6155, 25);

R\_Date("GrM-12561 (bc14\_141\_3)", 6150, 25);

R\_Date("RICH-25440 (bc14\_143\_5)", 6097, 35);

R\_Date("RICH-25473 (bc14\_141\_5)", 6064, 34);

First("house 40 first");

Last("house 40 last");

Span("40 span");

};

Boundary("abandon 40");

};

Sequence()

{

Boundary("build 317");

Phase("house 317")

{

R\_Date("GrM-12784 (KNRC221146) 1.2%", 6170,25)

{

Outlier("collagen", 0.4);

};

R\_Date("RICH-25475 (KNRC221112-1) 1.2%", 6112, 32)

{

Outlier("collagen", 0.4);

};

R\_Date("GrM-12572 (KNRC221075-1) 2.3%", 6070,25)

{

Outlier("collagen", 0.2);

};

First("house 317 first");

Last("house 317 last");

Span("317 span");

};

Boundary("abandon 317");

};

Sequence()

{

Boundary("build 23");

Phase("house 23")

{

R\_Date("GrM-14305", 6200,20);

R\_Date("GrM-14303", 6170,20);

R\_Date("GrM-12570 (KNRC221312-2) 1.6%", 6125, 25)

{

Outlier("collagen", 0.4);

};

R\_Date("GrM-12571 (KNRC221329) 3.7%", 6125, 25)

{

Outlier("collagen", 0.1);

};

R\_Combine("KNRC221355")

{

Outlier("collagen", 0.1);

R\_Date("KIA-52818 5.5%",6101,26);

R\_Date("GrM-12569 (KNRC221355) 3.0%", 6115, 25);

};

R\_Date("Poz-98368 2.8%", 6100, 40)

{

Outlier("collagen", 0.2);

};

R\_Combine("KNRC221322")

{

Outlier("collagen", 0.2);

R\_Date("KIA-52749 (KNRC221322) 2.5%", 6091, 28);

R\_Date("RICH-25474 (KNRC221322) 1.6%", 6048, 32);

};

R\_Date("RICH-25487 (KNRC221358-1 3.9%)", 5875, 32)

{

Outlier();

};

R\_Date("Poz-98367 0.6%", 5860, 40)

{

Outlier();

};

First("house 23 first");

Last("house 23 last");

Span("23 span");

};

Boundary("abandon 23");

};

Phase("house 9")

{

R\_Date("GrM-12694 (bc14\_217\_4) 0.5%", 6060, 55)

{

Outlier("collagen", 0.8);

};

};

Span("duration SW settlement");

};

Boundary("SW end");

};

Sequence("SE settlements")

{

Boundary("SE start");

Phase("SE houses")

{

R\_Date("Poz-90171, house 112, charcoal", 6250, 40)

{

Outlier();

};

R\_Date("Poz-90167, house 135, charcoal", 6100, 40);

R\_Date("Poz-90138, east of house 132, grain", 6180, 40);

R\_Date("Poz-90137, east of house 132, grain", 6100, 40);

Sequence("132 before 133 and 131")

{

Sequence()

{

Boundary("build 132");

Phase("house 132")

{

R\_Date("Poz-87436, 0.2%", 6300, 50)

{

Outlier();

};

R\_Date("Poz-87446, 3.2%", 6270, 40)

{

Outlier("collagen", 0.1);

};

R\_Date("Poz-87448, 0.3%", 6220, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87453, 2.4%", 6190, 40)

{

Outlier("collagen",0.2);

};

R\_Date("Poz-87454, 0.3%", 6130, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87450, 2.7%", 6110, 40)

{

Outlier("collagen",0.2);

};

R\_Date("Poz-87451, 5.8%", 6110, 40)

{

Outlier("collagen",0.1);

};

R\_Date("Poz-87441, 1.7%", 6130, 40)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87437, 0.3%", 6070, 40)

{

Outlier();

};

R\_Date("Poz-87444, 0.07%", 6050, 50)

{

Outlier();

};

R\_Date("Poz-87438, 2.4%", 6000, 35)

{

Outlier();

};

R\_Date("Poz-87387, 0.3%", 5590, 120)

{

Outlier();

};

First("house 132 first");

Last("house 132 last");

Span("132 span");

};

Boundary("abandon 132");

};

Phase("133 and 131")

{

Sequence()

{

Boundary("build 133");

Phase("house 133")

{

R\_Date("Poz-87449, 1.2%", 6200, 40)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87439, 1.8%", 6140, 40)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87440, 3.8%", 6080, 40)

{

Outlier("collagen",0.1);

};

First("house 133 first");

Last("house 133 last");

Span("133 span");

};

Boundary("abandon 133");

};

Sequence()

{

Boundary("build 131");

Phase("house 131")

{

R\_Date("Poz-87443, 1.8%", 6170, 35)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87447, 1.6%", 6140, 35)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87445, 0.9%", 6100, 35)

{

Outlier("collagen",0.8);

};

First("house 131 first");

Last("house 131 last");

Span("131 span");

};

Boundary("abandon 131");

};

};

};

Sequence()

{

Boundary("build 105");

Phase("house 105")

{

R\_Date("Poz-60642, 0.5%", 6145, 30)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-60643, 0.8%", 6115, 35)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-60641, 0.7%", 6080, 30)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-60609, 0.9%", 5985, 35)

{

Outlier();

};

First("house 105 first");

Last("house 105 last");

Span("105 span");

};

Boundary("abandon 105");

};

Phase("house 127")

{

R\_Date("Poz-87477, 1.3%", 6110, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87472, 4.6%", 6080, 35)

{

Outlier("collagen",0.1);

};

R\_Date("Poz-87470, 0.15%", 5880, 40)

{

Outlier();

};

First("house 127 first");

Last("house 127 last");

Span("127 span");

};

Sequence()

{

Boundary("build 126");

Phase("house 126")

{

R\_Date("Poz-87456, 0.8%", 6130, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87475, 1.5%", 6115, 35)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87476, 2.0%", 6080, 40)

{

Outlier("collagen",0.3);

};

R\_Date("Poz-87455, 0.08%", 5860, 40)

{

Outlier();

};

First("house 126 first");

Last("house 126 last");

Span("126 span");

};

Boundary("abandon 126");

};

Phase("102")

{

R\_Date("Poz-60639, 0.1%", 6015, 35)

{

Outlier();

};

R\_Date("Poz-60610, 0.6%", 5920, 35)

{

Outlier();

};

R\_Date("Poz-60640, 0.2%", 5885, 35)

{

Outlier();

};

};

Span("SE span");

};

Boundary("SE end");

};

Sequence("N settlements")

{

Boundary("N start");

Phase("N houses")

{

Phase("house 245")

{

R\_Date("Poz-69565, 1.4%", 6260, 40)

{

Outlier();

};

R\_Date("Poz-69567, 0.8%", 6110, 40)

{

Outlier("collagen",0.8);

};

};

Sequence()

{

Boundary("build 262");

Phase("house 262")

{

R\_Date("Poz-69563, 0.5%", 6140, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-69571, 0.4%", 6130, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-69564, 0.4%", 6080, 40)

{

Outlier("collagen",0.8);

};

First("house 262 first");

Last("house 262 last");

Span("262 span");

};

Boundary("abandon 262");

};

Phase("house 244")

{

R\_Date("Poz-67229, grain", 6190, 40);

R\_Date("Poz-67228, macrofossil", 6180, 40);

First("house 244 first");

Last("house 244 last");

};

Phase("house 259")

{

R\_Date("Poz-69568, 0.5%", 6190, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-69566, 1.0%", 6080, 40)

{

Outlier("collagen",0.8);

};

First("house 259 first");

Last("house 259 last");

};

R\_Date("Poz-69570, house 258, 0.5%", 6100, 35)

{

Outlier("collagen",0.8);

};

Span("N span");

};

Boundary("N end");

};

Axis(-6600, -4600);

};

};

## Model B

The following CQL code will run in OxCal v4 (Bronk Ramsey 2009):

Plot("Model B")

{

Outlier\_Model("collagen",T(5),U(0,4),"r");

Sequence("Vrable settlements")

{

Boundary("Vrable start");

Phase()

{

Phase("SW houses")

{

Phase("house 70")

{

R\_Date("Poz-106185 (bc14\_294\_2)", 6260,40);

R\_Date("Poz-106052 (bc14\_294\_3)", 6240, 40);

First("house 70 first");

Last("house 70 last");

};

Phase("house 318")

{

R\_Date("GrM-12566 (bc14\_096\_2)", 6290,25);

R\_Date("GrM-12697 (bc14\_096\_1) 0.3%", 5890, 80);

Outlier();

};

Sequence()

{

Boundary("build 57");

Phase("house 57")

{

R\_Date("RICH-25443 (bc14\_198\_3 (b))", 6260, 34);

R\_Date("RICH-25444 (bc14\_200\_2)", 6206, 35);

R\_Date("GrM-12560 (bc14\_198\_3(a))", 6200, 25);

First("house 57 first");

Last("house 57 last");

Span("57 span");

};

Boundary("abandon 57");

};

Phase("house 29")

{

R\_Date("RICH-25442 (bc14\_401\_3)", 6211, 34);

R\_Date("RICH-25441 (bc14\_405\_4)", 6179, 34);

First("house 29 first");

Last("house 29 last");

Span("29 span");

};

Phase("house 34")

{

R\_Date("KIA-52748 (bc14\_340\_1) 3.9%", 6190, 26)

{

Outlier("collagen", 0.1);

};

R\_Date("GrM-12576 (bc14\_337\_7) 1.1%", 6130,30)

{

Outlier("collagen", 0.4);

};

R\_Date("RICH-25476 (bc14\_340\_1) <1% collagen", 6020, 36)

{

Outlier();

};

First("house 34 first");

Last("house 34 last");

Span("34 span");

};

Sequence()

{

Boundary("build 39");

Phase("house 39")

{

R\_Date("Poz-60638 1.1%", 6220, 35)

{

Outlier("collagen", 0.4);

};

R\_Combine("P30135-1 1.9%")

{

R\_Date("GrM-12574 (P30135-1) 2.0%", 6150, 30);

R\_Date("KIA-52816 (P30135-1) 1.8%", 6266, 27);

Outlier("collagen", 0.4);

};

R\_Date("GrM-14299", 6190,20);

R\_Date("GrM-14300", 6170,20);

R\_Date("GrM-14301", 6150, 20);

R\_Date("Poz-60611 1.1%", 6050, 35)

{

Outlier();

};

R\_Date("RICH-25472 (P30114) 1.4%", 6001, 32)

{

Outlier();

};

R\_Date("Poz-60637 0.8%", 6000, 50)

{

Outlier();

};

First("house 39 first");

Last("house 39 last");

Span("39 span");

};

Boundary("abandon 39");

};

Sequence()

{

Boundary("build 40");

Phase("house 40")

{

R\_Date("GrM-12562 (bc14\_143\_4)", 6240, 25);

R\_Date("RICH-25446 (bc14\_143\_2(a))", 6157, 35);

R\_Date("GrM-12559 (bc14\_143\_2(b))", 6155, 25);

R\_Date("GrM-12561 (bc14\_141\_3)", 6150, 25);

R\_Date("RICH-25440 (bc14\_143\_5)", 6097, 35);

R\_Date("RICH-25473 (bc14\_141\_5)", 6064, 34);

First("house 40 first");

Last("house 40 last");

Span("40 span");

};

Boundary("abandon 40");

};

Sequence()

{

Boundary("build 317");

Phase("house 317")

{

R\_Date("GrM-12784 (KNRC221146) 1.2%", 6170,25)

{

Outlier("collagen", 0.4);

};

R\_Date("RICH-25475 (KNRC221112-1) 1.2%", 6112, 32)

{

Outlier("collagen", 0.4);

};

R\_Date("GrM-12572 (KNRC221075-1) 2.3%", 6070,25)

{

Outlier("collagen", 0.2);

};

First("house 317 first");

Last("house 317 last");

Span("317 span");

};

Boundary("abandon 317");

};

Sequence()

{

Boundary("build 23");

Phase("house 23")

{

R\_Date("GrM-14305", 6200,20);

R\_Date("GrM-14303", 6170,20);

R\_Date("GrM-12570 (KNRC221312-2) 1.6%", 6125, 25)

{

Outlier("collagen", 0.4);

};

R\_Date("GrM-12571 (KNRC221329) 3.7%", 6125, 25)

{

Outlier("collagen", 0.1);

};

R\_Combine("KNRC221355")

{

Outlier("collagen", 0.1);

R\_Date("KIA-52818 5.5%",6101,26);

R\_Date("GrM-12569 (KNRC221355) 3.0%", 6115, 25);

};

R\_Date("Poz-98368 2.8%", 6100, 40)

{

Outlier("collagen", 0.2);

};

R\_Combine("KNRC221322")

{

Outlier("collagen", 0.2);

R\_Date("KIA-52749 (KNRC221322) 2.5%", 6091, 28);

R\_Date("RICH-25474 (KNRC221322) 1.6%", 6048, 32);

};

R\_Date("RICH-25487 (KNRC221358-1 3.9%)", 5875, 32)

{

Outlier();

};

R\_Date("Poz-98367 0.6%", 5860, 40)

{

Outlier();

};

First("house 23 first");

Last("house 23 last");

Span("23 span");

};

Boundary("abandon 23");

};

Phase("house 9")

{

R\_Date("GrM-12694 (bc14\_217\_4) 0.5%", 6060, 55)

{

Outlier("collagen", 0.8);

};

};

Span("duration SW settlement");

};

Phase("SE houses")

{

R\_Date("Poz-90171, house 112, charcoal", 6250, 40)

{

Outlier();

};

R\_Date("Poz-90167, house 135, charcoal", 6100, 40);

R\_Date("Poz-90138, east of house 132, grain", 6180, 40);

R\_Date("Poz-90137, east of house 132, grain", 6100, 40);

Sequence("132 before 133 and 131")

{

Sequence()

{

Boundary("build 132");

Phase("house 132")

{

R\_Date("Poz-87436, 0.2%", 6300, 50)

{

Outlier();

};

R\_Date("Poz-87446, 3.2%", 6270, 40)

{

Outlier("collagen", 0.1);

};

R\_Date("Poz-87448, 0.3%", 6220, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87453, 2.4%", 6190, 40)

{

Outlier("collagen",0.2);

};

R\_Date("Poz-87454, 0.3%", 6130, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87450, 2.7%", 6110, 40)

{

Outlier("collagen",0.2);

};

R\_Date("Poz-87451, 5.8%", 6110, 40)

{

Outlier("collagen",0.1);

};

R\_Date("Poz-87441, 1.7%", 6130, 40)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87437, 0.3%", 6070, 40)

{

Outlier();

};

R\_Date("Poz-87444, 0.07%", 6050, 50)

{

Outlier();

};

R\_Date("Poz-87438, 2.4%", 6000, 35)

{

Outlier();

};

R\_Date("Poz-87387, 0.3%", 5590, 120)

{

Outlier();

};

First("house 132 first");

Last("house 132 last");

Span("132 span");

};

Boundary("abandon 132");

};

Phase("133 and 131")

{

Sequence()

{

Boundary("build 133");

Phase("house 133")

{

R\_Date("Poz-87449, 1.2%", 6200, 40)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87439, 1.8%", 6140, 40)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87440, 3.8%", 6080, 40)

{

Outlier("collagen",0.1);

};

First("house 133 first");

Last("house 133 last");

Span("133 span");

};

Boundary("abandon 133");

};

Sequence()

{

Boundary("build 131");

Phase("house 131")

{

R\_Date("Poz-87443, 1.8%", 6170, 35)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87447, 1.6%", 6140, 35)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87445, 0.9%", 6100, 35)

{

Outlier("collagen",0.8);

};

First("house 131 first");

Last("house 131 last");

Span("131 span");

};

Boundary("abandon 131");

};

};

};

Sequence()

{

Boundary("build 105");

Phase("house 105")

{

R\_Date("Poz-60642, 0.5%", 6145, 30)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-60643, 0.8%", 6115, 35)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-60641, 0.7%", 6080, 30)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-60609, 0.9%", 5985, 35)

{

Outlier();

};

First("house 105 first");

Last("house 105 last");

Span("105 span");

};

Boundary("abandon 105");

};

Phase("house 127")

{

R\_Date("Poz-87477, 1.3%", 6110, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87472, 4.6%", 6080, 35)

{

Outlier("collagen",0.1);

};

R\_Date("Poz-87470, 0.15%", 5880, 40)

{

Outlier();

};

First("house 127 first");

Last("house 127 last");

Span("127 span");

};

Sequence()

{

Boundary("build 126");

Phase("house 126")

{

R\_Date("Poz-87456, 0.8%", 6130, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-87475, 1.5%", 6115, 35)

{

Outlier("collagen",0.4);

};

R\_Date("Poz-87476, 2.0%", 6080, 40)

{

Outlier("collagen",0.3);

};

R\_Date("Poz-87455, 0.08%", 5860, 40)

{

Outlier();

};

First("house 126 first");

Last("house 126 last");

Span("126 span");

};

Boundary("abandon 126");

};

Phase("102")

{

R\_Date("Poz-60639, 0.1%", 6015, 35)

{

Outlier();

};

R\_Date("Poz-60610, 0.6%", 5920, 35)

{

Outlier();

};

R\_Date("Poz-60640, 0.2%", 5885, 35)

{

Outlier();

};

};

Span("SE span");

};

Phase("N houses")

{

Phase("house 245")

{

R\_Date("Poz-69565, 1.4%", 6260, 40)

{

Outlier();

};

R\_Date("Poz-69567, 0.8%", 6110, 40)

{

Outlier("collagen",0.8);

};

};

Sequence()

{

Boundary("build 262");

Phase("house 262")

{

R\_Date("Poz-69563, 0.5%", 6140, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-69571, 0.4%", 6130, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-69564, 0.4%", 6080, 40)

{

Outlier("collagen",0.8);

};

First("house 262 first");

Last("house 262 last");

Span("262 span");

};

Boundary("abandon 262");

};

Phase("house 244")

{

R\_Date("Poz-67229, grain", 6190, 40);

R\_Date("Poz-67228, macrofossil", 6180, 40);

First("house 244 first");

Last("house 244 last");

};

Phase("house 259")

{

R\_Date("Poz-69568, 0.5%", 6190, 40)

{

Outlier("collagen",0.8);

};

R\_Date("Poz-69566, 1.0%", 6080, 40)

{

Outlier("collagen",0.8);

};

First("house 259 first");

Last("house 259 last");

};

R\_Date("Poz-69570, house 258, 0.5%", 6100, 35)

{

Outlier("collagen",0.8);

};

Span("N span");

};

Span("Vrable duration");

};

Boundary("Vrable end");

Axis(-6600, -4600);

};

};

Bronk Ramsey C. 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51(1):337-60.