Eastern desert ware : traces of the inhabitants of the eastern desert in Egypt and Sudan during the 4th-6th centuries CE

Barnard, H.

APPENDIX ELEVEN
Open Fire Temperature Measurements

Temperatures are usually recorded with alcohol or mercury thermometers, with thermistors or resistance temperature detectors (platinum resistance thermometers), or with a thermocouple. Alcohol and mercury thermometers are based on the fact that the volume of a liquid changes with its temperature. Such thermometers are suitable for most household and laboratory uses and accurately display temperatures between the freezing and boiling points of methanol, ethanol or mercury (Table 17-1).

	°F	°C
Methanol (CH_3OH)		
freezing	-143	-97
boiling	148	65
Ethanol (C_2H_5OH)		
freezing	-174	-114
boiling	173	78
Mercury (Hg)		
freezing	-38	-39
boiling	674	357

Table 17-1: Freezing and boiling temperatures of liquids commonly used in thermometers.

Themistors and resistance temperature detectors (RTDs) are based on the fact that the electrical resistance of metals depend on their temperature. Such thermometers require a small current to operate and an Ohmmeter to measure the electrical resistance in the system. Specific configurations have been developed for different applications and, in the form of digital thermometers, thermistors and RTDs have replaced most other temperature measuring devices. Given the large range and the high maximum reached, the temperatures required to fire pottery, in a kiln or in an open fire, are best measured with a thermocouple (Figure 17-1).

A thermocouple is based on the observation by Thomas Johann Seebeck (Tallinn, 9 April 1770-Berlin, 10 December 1831) that a circuit of two different metal wires produces a small, continuous electric current. The voltage of this current, known as the Seebeck voltage, depends on the metals used as well as on the temperature of the joints. If one of the joints is kept at a fixed, known temperature (for instance at 0°C or 32°F in melting ice), or is kept constant by an 'electronic ice point reference', the voltage in the system depends on the temperature of the second joint, which can now be used as a probe (Figure 17-2). It has to be kept in mind that the connection of the leads to the voltmeter, where different metals are connected, results in another thermocouple. If very accurate measurements are needed these connections should be placed in an 'isothermal block'. A large number of different thermocouples, comprising different combinations of metals, are commercially available. A K-type thermocouple, which consists of an alumel (nickel-aluminium alloy) and a chromel (nickel-chromium alloy) lead, is a general purpose thermocouple that is suitable to record the temperatures in an open wood fire, as well as in most pottery kilns. The correlation between the temperature of the probe and the current in the system (Figure 17-1) is given in Table 17-3 and Figure 17-3.

Two temperature scales are currently most frequently used (Tables 17-2 and 17-4), one developed by Daniel Gabriel Fahrenheit (Gdansk, 24 May 1686-The Hague, 16 September 1736) and another by Anders Celsius (Uppsala, 27 November 1701-25 April 1744). Fahrenheit identified the temperature of melting ice as 32°F and that of the human body as 96°F. His scale won great popularity because of the quality of the (mercury) thermometers (outfitted with his scale) that he produced. Celsius, on the other hand, was concerned with the universality of the units used in the sciences. He identified the temperature of boiling water as 0°C and that of melting ice as 100°C. How these figures were reversed remains unclear, although it has been suggested that this was done by Carolus Linnaeus (Carl von Linné) in 1745. The Celsius scale was chosen as the basis for the Kelvin scale (K = °C + 273.15), named after William Thomson, Baron Kelvin that places 0 K (without a °-sign) at 'absolute zero' (-273.15°C or -459.67°F), which is one of the seven base units of the International System of Units (SI).

°F	°C
-40	-40
0	-18
32	0
61	16
82	28
100	38
212	100
1000	538
1832	1000
°F = (°C x 1.8) + 32	°C = (°F – 32) x 0.56

Table 17-2: Correlation of °F and °C (cf. Table 17-4).

Appendix XI: Temperature Measurements

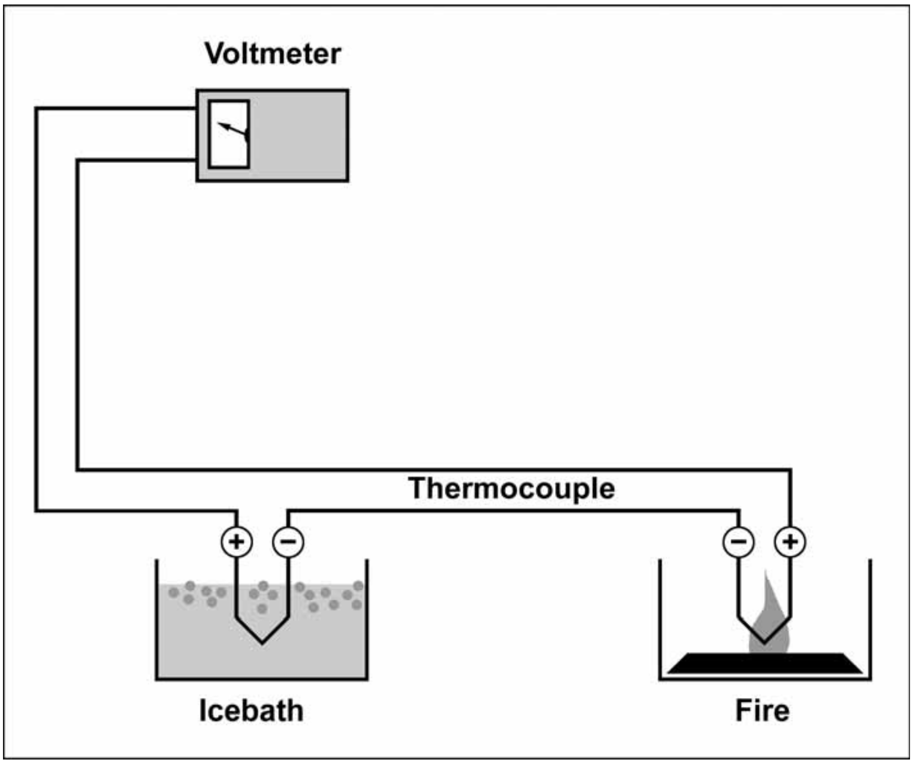

Figure 17-1: Theoretical lay-out of a thermocouple set to measure large temperature differences (cf. Figures 17-2 and 17-3).

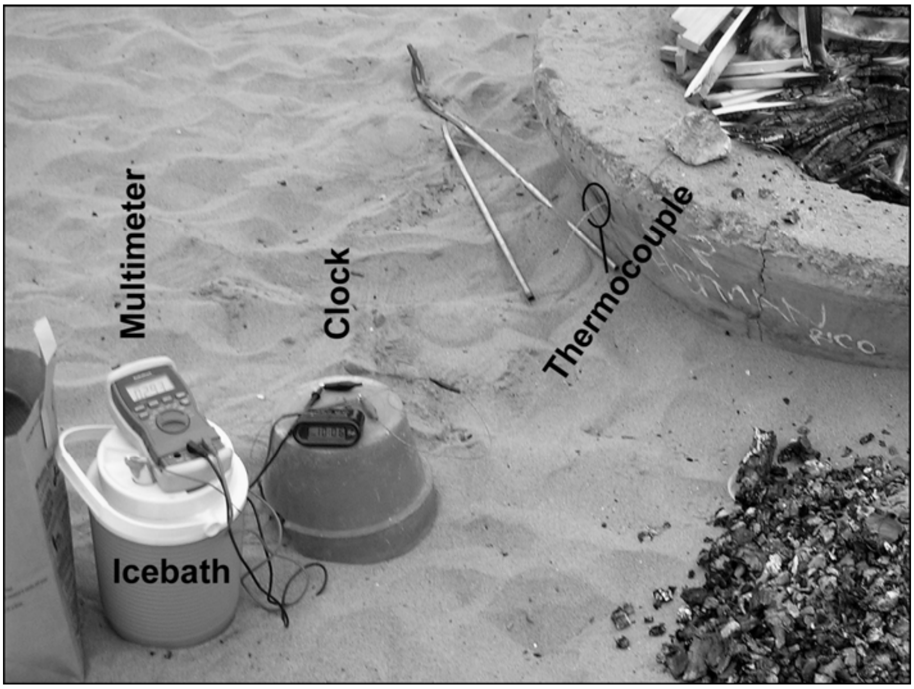

Figure 17-2: A K-type thermocouple employed to record the temperature of an open wood fire (cf. Figures 17-1 and 17-4).

mV	°F	°C	mV	°F	°C
0	32	0	20	905	485
1	77	25	21	948	509
2	122	50	22	990	532
3	165	74	23	1033	556
4	208	98	24	1074	579
5	252	122	25	1117	603
6	297	147	26	1159	626
7	342	172	27	1202	650
8	387	197	28	1245	674
9	432	222	29	1287	697
10	477	247	30	1330	721
11	520	271	31	1373	745
12	563	295	32	1416	769
13	608	320	33	1461	794
14	649	343	34	1504	818
15	693	367	35	1549	843
16	736	391	36	1593	867
17	779	415	37	1638	892
18	820	438	38	1683	917
19	864	462	39	1729	943
20	905	485	40	1774	968

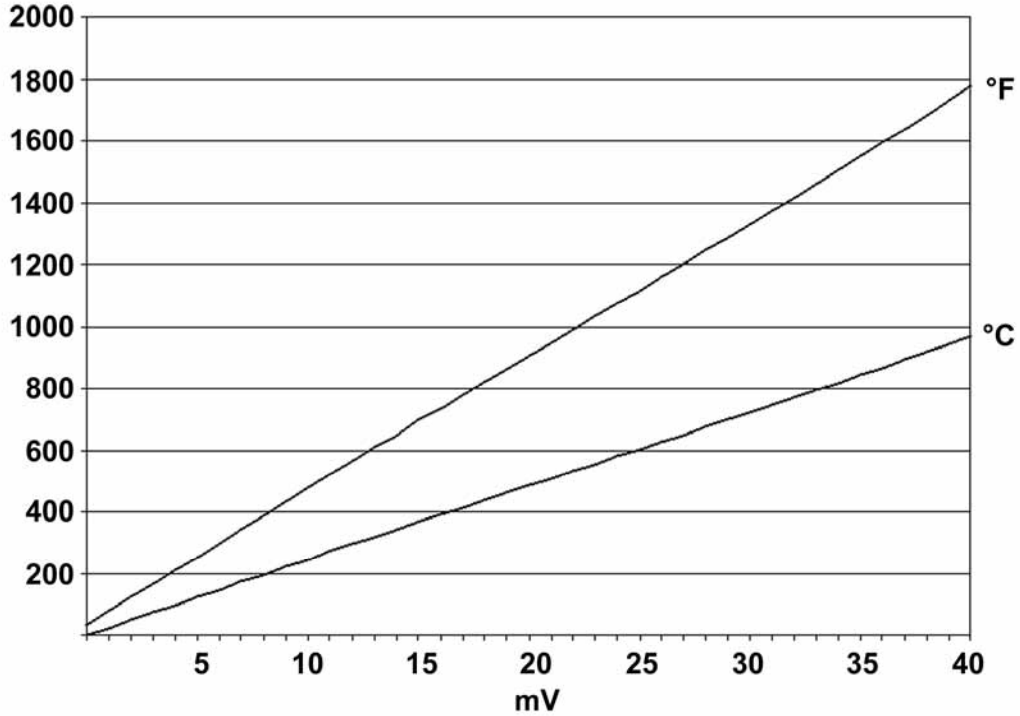

Table 17-3 and Figure 17-3: Correlation between the temperature and the voltage in a K-type thermocouple.

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
0		**100**		**200**		**300**		**400**	
5	41	105	221	205	401	305	581	405	761
10	50	110	230	210	410	310	590	410	770
15	59	115	239	215	419	315	599	415	779
20	68	120	248	220	428	320	608	420	788
25	77	125	257	225	437	325	617	425	797
30	86	130	266	230	446	330	626	430	806
35	95	135	275	235	455	335	635	435	815
40	104	140	284	240	464	340	644	440	824
45	113	145	293	245	473	345	653	445	833
50	122	150	302	250	482	350	662	450	842
55	131	155	311	255	491	355	671	455	851
60	140	160	320	260	500	360	680	460	860
65	149	165	329	265	509	365	689	465	869
70	158	170	338	270	518	370	698	470	878
75	167	175	347	275	527	375	707	475	887
80	176	180	356	280	536	380	716	480	896
85	185	185	365	285	545	385	725	485	905
90	194	190	374	290	554	390	734	490	914
95	203	195	383	295	563	395	743	495	923
100	212	200	392	300	572	400	752	500	932

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
500		**600**		**700**		**800**		**900**	
505	941	605	1121	705	1301	805	1481	905	1661
510	950	610	1130	710	1310	810	1490	910	1670
515	959	615	1139	715	1319	815	1499	915	1679
520	968	620	1148	720	1328	820	1508	920	1688
525	977	625	1157	725	1337	825	1517	925	1697
530	986	630	1166	730	1346	830	1526	930	1706
535	995	635	1175	735	1355	835	1535	935	1715
540	1004	640	1184	740	1364	840	1544	940	1724
545	1013	645	1193	745	1373	845	1553	945	1733
550	1022	650	1202	750	1382	850	1562	950	1742
555	1031	655	1211	755	1391	855	1571	955	1751
560	1040	660	1220	760	1400	860	1580	960	1760
565	1049	665	1229	765	1409	865	1589	965	1769
570	1058	670	1238	770	1418	870	1598	970	1778
575	1067	675	1247	775	1427	875	1607	975	1787
580	1076	680	1256	780	1436	880	1616	980	1796
585	1085	685	1265	785	1445	885	1625	985	1805
590	1094	690	1274	790	1454	890	1634	990	1814
595	1103	695	1283	795	1463	895	1643	995	1823
600	1112	700	1292	800	1472	900	1652	1000	1832

Table 17-4: Conversion table from 0 - 1000°C into °F (cf. Table 17-2).

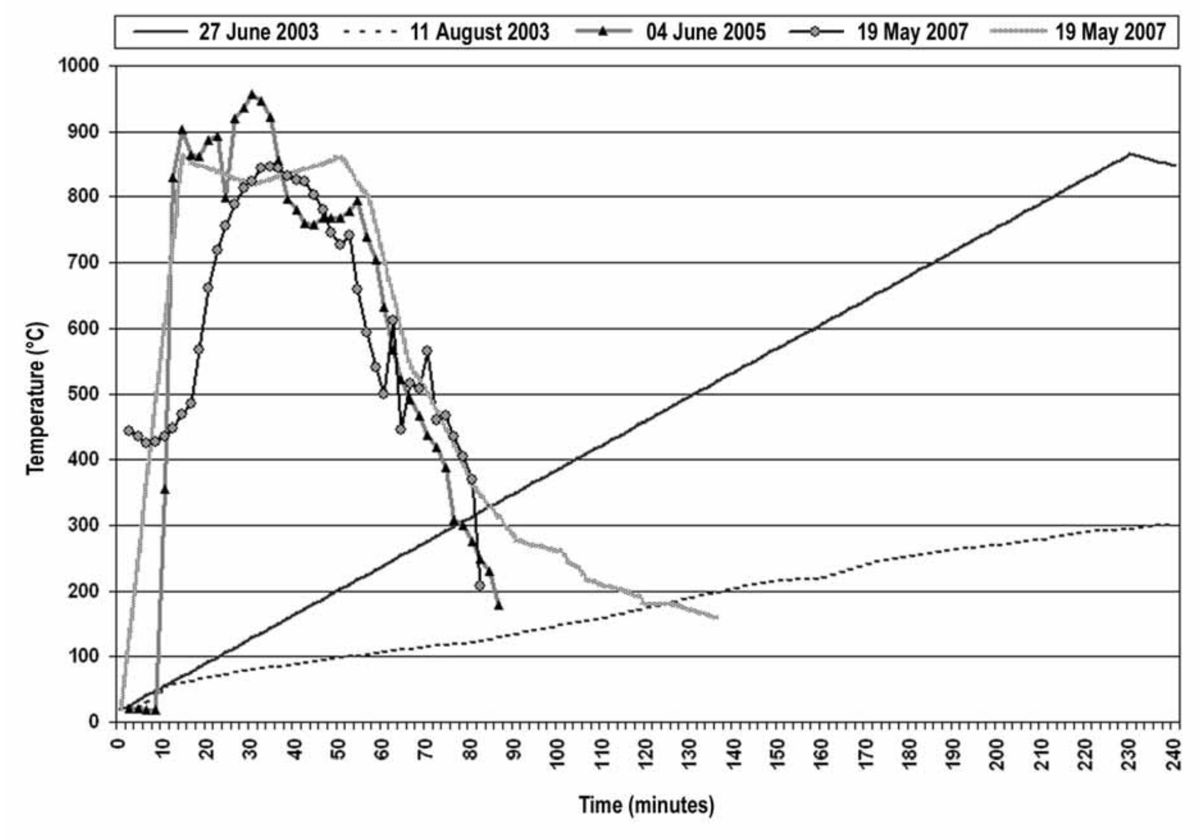

Figure 17-4: Temperature curves in an open wood fire (4 June 2005 and 19 May 2007, cf. Figure 17-2) compared to the temperature of the soil below a continuous wood fire (11 August 2003) and inside an electric pottery kiln, with kiln sitter 012, until just after it shuts off (27 June 2003).