

Pollen zonation problems

Palaeontologists are hoping to devise a methodology for determining the nature of change in species abundance in the past. Their data consist of fossil pollen compositions found at different depths in cores at different locations. A palaeontologist has given you data at three different locations A, B, C, and has asked you to investigate the nature of the change, if any, over the various depths.

At each location and at each depth there is available an seven-part composition consisting of the proportions of fossil pollens from seven different trees a, b, . . . , g. A main purpose of the study is to try to obtain from variability of the compositions an idea of how climate may have changed during the period covered by the core. A reasonably accurate date associated with each depth can be determined by carbon dating of other items found in the core but for the moment you have been asked to use depth as a surrogate for date.

Location A

Proportions ($10^{-3} \times$) of fossil pollens a – g at 55 'depths'

Depth no	a	b	c	d	e	f	g
1	71	42	161	285	74	199	169
2	53	39	183	228	88	161	250
3	151	53	107	273	69	79	268
4	105	47	162	277	154	107	148
5	150	73	166	263	70	118	160
6	134	47	151	301	50	102	215
7	132	77	157	278	79	121	157
8	89	59	182	285	52	101	232
9	106	45	161	248	76	170	194
10	65	45	256	244	72	76	242
11	73	54	252	213	84	121	203
12	82	47	190	245	57	130	249
13	98	58	94	215	87	163	285
14	53	35	175	233	54	222	228
15	58	35	125	216	89	263	216
16	107	52	112	249	111	155	215
17	144	47	151	231	144	125	158
18	118	48	177	270	96	117	175
19	90	48	150	263	81	99	270
20	118	74	162	300	103	76	167
21	111	48	126	277	89	136	214
22	176	91	75	224	111	149	173
23	97	41	96	255	71	181	259
24	141	71	108	254	96	123	207
25	93	35	128	243	72	157	271
26	75	35	161	241	79	201	208
27	105	46	150	232	85	138	244
28	144	65	102	256	100	119	214
29	64	61	218	257	88	134	179
30	71	42	180	248	50	171	238
31	150	147	138	179	63	155	167
32	93	73	216	203	87	143	185
33	183	138	207	178	70	86	137
34	68	105	292	177	71	169	118
35	230	155	139	222	52	90	113
36	88	79	235	192	108	94	204
37	127	76	182	278	68	119	151
38	71	95	302	205	109	76	142
39	54	73	239	212	124	164	134
40	89	70	225	221	111	113	171
41	104	96	283	191	130	44	152
42	132	164	114	210	84	101	195
43	54	66	224	202	150	165	137
44	57	72	186	222	187	142	134
45	84	105	136	213	75	218	168
46	98	86	242	212	112	73	178
47	192	90	145	209	114	73	177
48	94	78	200	236	108	142	141
49	98	99	198	205	93	148	158
50	134	86	177	232	98	91	182
51	88	114	194	222	103	104	175
52	54	59	221	163	139	159	206
53	61	70	188	228	119	102	231
54	139	114	175	219	116	93	144
55	98	79	196	180	91	197	158

Location B

Proportions ($10^{-3} \times$) of fossil pollens a – g at 50 'depths'

Depth no	a	b	c	d	e	f	g
1	126	67	208	38	244	101	216
2	191	106	148	31	216	118	189
3	121	58	221	60	185	127	228
4	150	84	208	54	240	100	166
5	177	100	150	88	131	93	261
6	122	62	190	57	291	94	183
7	99	49	217	49	255	99	232
8	144	82	209	38	195	105	227
9	137	71	232	72	191	116	180
10	196	116	140	49	229	80	190
11	142	71	185	85	190	109	219
12	140	70	165	64	230	89	243
13	177	94	155	69	178	101	224
14	145	85	201	44	205	96	225
15	118	65	205	51	276	90	195
16	190	109	153	44	206	102	195
17	134	77	193	37	229	85	245
18	132	76	171	29	306	74	212
19	151	91	213	29	239	114	163
20	131	59	185	71	210	146	198
21	107	56	219	46	256	101	214
22	183	92	155	45	169	118	238
23	144	67	198	84	140	143	224
24	193	115	182	53	191	103	163
25	172	95	165	42	234	86	207
26	168	98	178	58	163	99	236
27	188	96	151	39	164	122	239
28	200	128	178	61	125	101	207
29	166	84	190	54	164	130	211
30	148	95	199	43	221	65	228
31	177	99	151	61	245	81	187
32	166	81	153	52	205	103	240
33	195	105	162	70	150	107	211
34	134	69	188	58	189	92	270
35	116	66	196	39	306	78	200
36	119	55	192	64	176	112	282
37	116	65	234	33	268	102	182
38	146	77	180	49	225	98	224
39	133	66	218	36	241	132	175
40	154	70	196	52	161	139	229
41	177	101	200	41	174	102	205
42	133	65	160	76	193	92	281
43	126	63	214	50	207	120	219
44	180	105	172	37	238	105	163
45	147	78	192	50	242	99	192
46	168	105	191	32	250	101	153
47	218	143	105	34	283	62	155
48	169	114	218	49	145	93	212
49	186	107	146	50	231	87	192
50	120	65	208	39	261	92	215

Location C

Proportions ($10^{-3} \times$) of fossil pollens a – g at 45 'depths'

Depth no	a	b	c	d	e	f	g
1	121	28	192	48	158	28	427
2	126	31	188	53	160	28	414
3	123	32	177	53	178	29	407
4	128	36	171	60	174	31	401
5	129	39	177	59	158	31	408
6	132	41	188	65	162	32	380
7	133	43	194	66	162	34	368
8	133	48	170	68	160	36	386
9	135	54	156	71	152	38	394
10	133	58	141	74	157	39	397
11	131	59	149	77	144	41	399
12	133	63	153	75	144	44	387
13	130	63	163	74	152	46	372
14	128	64	163	77	164	47	356
15	133	70	167	81	163	49	337
16	134	76	171	80	160	48	330
17	136	80	178	80	163	48	315
18	136	85	173	86	153	51	315
19	130	85	175	80	151	54	324
20	128	88	177	79	143	55	329
21	128	92	189	77	152	54	308
22	130	99	185	82	156	56	291
23	130	104	187	89	147	57	287
24	130	109	196	90	141	59	275
25	130	114	195	92	145	62	262
26	127	118	196	92	147	65	255
27	128	128	178	101	145	68	251
28	128	139	165	109	144	72	243
29	124	137	177	117	126	74	245
30	123	138	190	133	116	72	229
31	121	141	187	143	114	73	220
32	123	152	191	146	120	75	194
33	121	163	172	146	127	79	191
34	117	158	180	163	125	76	180
35	118	169	174	165	136	75	162
36	112	162	187	159	135	78	167
37	110	169	174	174	144	81	147
38	107	181	150	187	144	79	151
39	104	179	159	194	133	80	151
40	103	187	157	194	134	85	140
41	102	192	160	205	128	84	127
42	99	192	161	207	134	86	121
43	97	200	159	210	128	84	122
44	98	220	149	210	122	81	120
45	98	228	152	207	130	76	109