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RADIOCARBON DATING OF OSTRICH EGGSHELLS

JÜRGEN C FREUNDLICH, RUDOLPH KUPER, PETER BREUNIG
Institut für Ur- und Frühgeschichte
and
HANS-GEORG BERTRAM
Geologisches Institut, Universität zu Köln, West Germany

ABSTRACT. Unlike wood charcoal, as found admixed to other cultural remains, ostrich eggshells can be of more direct significance in ^{14}C dating, especially if they were processed to form, eg, eggshell beads. Normally the time span between laying the egg and working the shell beads is short enough to be negligible for ^{14}C dating purposes. Another advantage of eggshell dating is that the carbonate of the shell seems to keep exceptionally well over the millennia, whereas, especially in surface sites in a desert environment, organic material such as wood, charcoal or bone protein tends to decompose. With few comparative test samples, we thought ostrich egg samples would yield ^{14}C dates somewhat too young. The deviation is, however, balanced by performing ^{13}C analyses and a correction for isotope fractionation of ca 350yr.

Within the scope of diverse investigations on African prehistory (Kuper, 1988; Breunig, 1986; Gabriel, 1984) the question arose whether ostrich eggshells are as reliable as other customary materials for accurate ^{14}C dating (see also, Wendorf & Schild, 1984). This is an important consideration as, especially in desert environments, many samples come from surface sites where charcoal, bone, wood or other organic remains easily decay, whereas ostrich eggshells used in prehistoric settlements for manufacturing beads or water containers, have endured.

Along with a considerable number of ^{14}C dates from eight field seasons from 1980–1987 in the Eastern Sahara of Egypt and Northern Sudan (*cf*, Kuper, 1988), we analyzed >25 eggshell samples. By comparing the apparent ostrich eggshell dates (uncorrected for isotopic fractionation) with the dates of other concurrent material, the eggshell dates were ca 400 years too young (Table 1). We concluded that this may be due to an isotopic shift and reviewed our ^{13}C measurements which indeed established this effect (Table 2).

We then compared this deviation with the results for other carbonate dates, and inferred that possibly the isotopic shifts resembled those typical for carbonate materials (ca –10‰ for freshwater carbonate and ca 0‰ for carbonates of marine origin (Mook, 1968)). Taking a closer look at the $\delta^{13}C$ values of the eggshells, we found an apparent separation of the isotopic shift values into two groups; some seem to cluster ca -0.5 ± 1.5‰ and the rest ca -6.0 ± 1.5‰ PDB. If there is no $\delta^{13}C$ analysis, a tentative average correction for the ^{14}C age of 350 ± 60yr can be applied to normalize to $\delta^{13}C = -25$‰, based on a total $\delta^{13}C$ range of –7.0 to +1.0‰ for ostrich eggshell carbonate. We also tried to classify the two separated $\delta^{13}C$ intervals according to geographic or climatic parameters or age differences among the respective samples that failed, so far, to give a decisive clue.

The literature on isotopic effects on carbon shows that considerable interest in hens' eggs has led to the finding that the dominating factor is the ^{13}C level of the hens' food stuff, mirrored by the $\delta^{13}C$ values of their flesh.

TABLE 1

^{14}C results on ostrich eggshell *vs* concurrent other material

Location	Site	Eggshell dating KN no.	Eggshell dating ^{14}C age*	Mean	Age difference	Mean	Other material ^{14}C age	Other material KN no.	Material
Abu Ballas	Mudpans 85/56	–3693	7310±70	7310±70	150±140	7460±120	7550±160	–3720	Charcoal
							7370±170	–3721	Charcoal
							7550±80	–3634	Charcoal
Abu Ballas	Mudpans 85/56	–3692	7160±70	7160±70	360±90	7520±55	7500±80	–3635	Charcoal
							7500±1000**	–3722	Charcoal
Gilf Kebir	Wadi Akhdar 80/14	–2925	3860±60						
Gilf Kebir	Wadi Akhdar 80/14	–2926	3950±55	3990±40	210±1100	4200±1100**	4200±1100**	–3085	Charcoal
Gilf Kebir	Wadi Akhdar 80/14	–3173	4150±55						
Laquiya	Wadi Shaw 82/33	–3188	4010±60	4010±60	570±80	4720±40	4320±60	–3091	Charcoal
							4850±55	–3138	Charcoal
							4680±60	–3081	Charcoal
Laquiya	Wadi Sahal 82/38	–3189	4370±75	4300±45	420±70	4720±55	4990±150	–3144	Charcoal
Laquiya	Wadi Sahal 82/38	–3190	4240±55				5400±700**	–3330	Charcoal
Wadi Howar	Rahib 80/73	–2938	4850±60	4850±60	370±160	5220±140	5220±140	–2939	Bone
			Weighted mean age difference = 400±50						

* Uncorrected for isotopic effect

** Samples from surface sites in desert environments where charcoal, wood or bones are poorly preserved but eggshells keep well

TABLE 2

Ostrich eggshell values *vs* other concurrent material

KN no.	Location	Site	$\delta^{13}C$ ‰ PDB	Eggshell ^{14}C age*	Other material ^{14}C age	KN no.	Material
-3754	Qattara/Siwa	Sitra 85/05	-5.86	8070±80			
-3755	Qattara/Siwa	Sitra 85/05	-7.01	8150±60			
-3141	Sand-Sea	Abu Minqar 81/55	-2.41	6520±60			
-3142	Sand-Sea	Abu Minqar 81/55	-5.41	6380±60			
-3709	Sand-Sea	Abu Minqar 81/55	(-3)**	6740±100	6350±500†	-3140	Charcoal
-3710	Sand-Sea	Abu Minqar 81/55	(-3)	7060±100			
-3711	Sand-Sea	Abu Minqar 81/55	-4.2	6830±70			
-3552	Sand-Sea	Abu Minqar 81/55	-6.18	7240±70			
-3198	Sand-Sea	Abu Minqar 81/55	(-3)	6530±100			
-3783	Sand-Sea	Abu Minqar 83/16	-0.22	6600±60			
-3553	Sand-Sea	Abu Minqar 85/24	-1.18	6500±70			
-3836	Sand-Sea	Abu Minqar 85/28	-5.63	8450±70			
-3882	Sand-Sea	Abu Minqar 85/28	-4.28	8210±70			
-3197	Sand-Sea	Abu Minqar 81/61	(-3)	6410±100			
-3793	Gilf Kebir	Wadi Akhdar 80/32	-0.11	5440±60	6510±320†	-3191	Charcoal
-3636	Gilf Kebir	Wadi Akhdar 83/33	(-3)	6320±100			
-3525	Selima Sandsheet	Djebel Kamil 83/27	(-3)	8170±110			
-3526	Selima Sandsheet	Djebel Kamil 83/27	-7.13	8140±70			
					3660±55	-3105	Charcoal
-3143	Laqiya	Wadi Shaw 82/31	+1.37	3830±55	3670±55	-3169	Charcoal
					3820±55	-3362	Charcoal
					3850±55	-3439	Charcoal
-3755	NE Tibesti/Libya	Dj Eghei GA72/38	-3.81	5060±60	4600±600†	-3674	Bone
-3672	Gr Sandsee/Libya	S Calanscio GA70/26	-7.73	6790±70			
-3642	Brandberg/Namibia	Riesenhöhle RH 9	(-3)	5630±140			
-3775	Brandberg/Namibia	Amis 11/12	-5.32	1800±120			

* Normalized to $\delta^{13}C = -25$‰ PDB

** Values in parentheses are estimates

† See ** Table 1

TABLE 3

$\delta^{13}C$ values of chicken protein carbon

^{13}C (PDB)	Country
−15.9‰	USA
−14.4‰	Japan
−19.6‰	Germany

TABLE 4

Ostrich eggshell values quoted from the literature

Lab no	Ref	$\delta^{13}C$ ‰ PDB	Eggshell carbonate ^{14}C age*	Other material ^{14}C age*	$\delta^{13}C$ ‰ PDB	Lab no.	Material
A–2515	1	−3.4	6270±50	6660±320	−19.8	A–2516	Organic residue
–2517	1	–4.4	4780±50				
–2518	1	–4.4	6290±150				
–3106	1	–5.6	8280±60	8680±450	–21.8	A–3105	Organic residue
SMU–74	2		4510±70				
–734	2		7860±90				
–326	2	–3.7	7890±70				
–741	2		5450±80				
–257	2	–7.3	8270±80				
–191	2		7710±70	8130±60		SMU–255	Charcoal
–202	2	–4.6	8020±110	8040±90		–249	Charcoal
–189	2	–7.2	7890±100	8080±90		–252	Charcoal
				7970±70		–240	Charcoal
				7930±40		–208	Charcoal
				8010±80		–203	Charcoal
				8120±100		–199	Charcoal
SMU–273	2	–7.3	6980±80				
–494	3		8740±70	8740±90		SMU–489	Charcoal
–352	4	–4.6	6935±90	7120±150		–242	Charcoal

* Normalized to $\delta^{13}C$ = –25‰ PDB

References
1. Long, Hendershott and Martin (1983, Table 2)
2. Haas & Haynes (1980, Table A7.1, p 374/5)
3. Haas & Haynes (1980, p 376)
4. Wendorf & Schild (1984, footnote 1, p 411)

Hodges and Lörcher (1967) showed by infusion experiments with tracer-labeled $NaH^{14}CO_3$ and $^{45}CaCl_2$ that the carbonate of the eggshells is not derived from the hen's blood bicarbonate. They found an uptake of ^{45}Ca ions from the blood serum during shell formation but not the adequate bicarbonate uptake. More detailed studies (Lörcher & Hodges, 1969) suggest that the necessary CO_2 is taken from metabolic CO_2 generated in the hen's shell gland at the actual site of egg formation. The $\delta^{13}C$ values of this metabolic CO_2 are subject to the hen's diet. Table 3 shows the $\delta^{13}C$ values of the protein carbon of chicken flesh from different countries (Nakamura *et al,* 1982). The higher values from the United States and Japan are due to higher $\delta^{13}C$ values of C4 plants (especially maize) or fish-derived feed, respectively. In Germany, the diet contains more C3 plant material, hence, the chicken flesh is ^{13}C-depleted. In this case, the $\delta^{13}C$ value also of the hen's shell gland CO_2 would be ca –14‰ (Metzler *et al,* 1983). The CO_2 with $\delta^{13}C = -14‰$ (Sharma & Pillai, 1971) is in equilibrium at 30°C with HCO_3^- ions of $\delta^{13}C = -6.5‰$ (Mook, 1968); carbonates formed from these HCO_3^- ions show a $\delta^{13}C$ value of ca –5‰. $\delta^{13}C$ values of ca –6‰ can be readily explained by this mechanism. The higher $\delta^{13}C$ values close to 0‰ seem to point towards a higher amount of carbon derived from C4 plants.

^{14}C dates on ostrich eggshells have been reported by Haas and Haynes (1980), Wendorf and Schild (1984), and Long, Hendershott and Martin (1983) (Table 4). They normalized ^{14}C ages to $\delta^{13}C = -25‰$, and did not find significant age differences with concurrent samples of other materials.

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