DATA REPOSITORY DR2009086

Data repository item 2

DR2 – Study materials and analytical methods

The sample material was originally collected by S. Vartanyan, J. Karhu and M. Saarnisto for purposes of radiocarbon dating and oxygen isotope work during two expeditions to Wrangel Island in 1997 and 2000. Skeletal remains were gathered from the banks of Krasny Flag, Neizvestnaya and Tundrovaya rivers on the northern coastal plain, Gussinaya river in the west, and Neozhidannya and Mamontovaya rivers in the south west, coastal beaches and from slope and alluvial fan deposits (Fig. 1). In addition, specimens collected by S. Vartanyan in 1988 from northeast Wrangel Island were analysed.

Bioapatite samples

In order to remove possible diagenetic contamination the samples were pretreated by soaking the powders in 0.1N acetic acid (CH_3COOH) for 10 minutes, washing them with distilled and deionized water, and repeating the procedure. Prior to choosing this protocol, pretreatment effects were studied on sample aliquots of specimens Sr-6 and Sr-11 (Table DR2). Alongside the 2 × 10 min procedure, reaction time of 30 min was tested, but it did not result in a statistically significant change of the measured $^{87}Sr/^{86}Sr$ compared to the shorter procedure. The pretreatment experiments also included analyses of untreated sample aliquots.

Pretreated samples were dissolved in 4N HNO_3 and evaporated to dryness. Organic residues in some of the bone samples were decomposed with repeated additions of concentrated HNO_3 and evaporation to dryness. The dry samples were finally dissolved in 1N HNO_3. Strontium was extracted in microcolumns using Sr-spec resin (Eichrom Technologies, Inc.) and the Sr-containing solution was evaporated to dryness. Sr samples dissolved in 0.75N H_3PO_4 were loaded on Ta-filaments for measurement.

Water samples

The waters were filtered with a 0.45 µm filter, evaporated to dryness, and then taken up with 1N HNO_3 for Sr extraction. The analysis and measurement procedures followed those described for bioapatite samples.

Table DR1. Sr ratios of surface waters and mammal skeletal apatite from Wrangel Island. All radiocarbon dates (^{14}C yr BP) are from Vartanyan et al. (2008). Conversion of primary radiocarbon data to calendar ages: dates < 21 000 ^{14}C yr BP using Calib 5.0.2 software (Stuiver et al., 2005) and the IntCal04 dataset by Reimer et al. (2004); dates > 21 000 ^{14}C yr BP with Fairbanks (2005) coral data using the Fairbanks0107 calibration curve.

Sample	Species	Type	Location	^{14}C yr BP	^{14}C lab nr	Calendar age, years BP		^{87}Sr/^{86}Sr
water samples								
SRW-001		ice wedge	Mamontovaya river					0.71466
SRW-002		pond	Mamontovaya river					0.71383
SRW-003		river water	Mamontovaya river					0.71549
SRW-005		ice wedge	Neizvestnaya river					0.71245
SRW-006		river water	Neizvestnaya river					0.71584
SRW-007		ice wedge	Tundrovaya river					0.71216
SRW-008		ice wedge	Nasha river					0.71412
recent bioapatites								
Sr-51	musk ox	enamel	Gusinaya river					0.71441
Sr-52	musk ox	enamel	Neozhidannya river					0.71354
Sr-53	reindeer	enamel	Neizvestnaya river					0.71463
Sr-54	reindeer	enamel	Tundrovaya river					0.71372
Sr-55	reindeer	enamel	Mamontovaya river					0.71533
mid-Holocene bioapatites						*1σ range*	*median*	
Sr-1	mammoth	enamel	Mamontovaya river	3685 ± 60	Ua-13366	3930-4140	4024	0.71509
Sr-15	mammoth	enamel	NE Wrangel Island	4585 ± 70	Ua-17616	5060-5450	5274	0.71686
Sr-16	mammoth	enamel	Gusinaya river	4730 ± 65	Ua-13368	5330-5580	5468	0.71303
Sr-2	mammoth	enamel	Mamontovaya river	4860 ± 75	Ua-13376	5480-5710	5601	0.71508
Sr-17	mammoth	enamel	Gusinaya river	4985 ± 65	Ua-13357	5620-5880	5725	0.71591
Sr-18	mammoth	enamel	NE Wrangel Island	5185 ± 80	Ua-17628	5760-6170	*5951*	*0.71237**
Sr-19	mammoth	enamel	Gusinaya river	5285 ± 65	Ua-13359	5950-6180	6074	0.71511
Sr-20	mammoth	enamel	NE Wrangel Island	5375 ± 85	Ua-17631	6020-6280	6150	0.71501
Sr-21	mammoth	enamel	NE Wrangel Island	5470 ± 85	Ua-17627	6190-6400	6262	0.71826
Sr-3	mammoth	enamel	NE Wrangel Island	5475 ± 75	Ua-17629	6190-6390	6273	0.71600
Sr-22	mammoth	enamel	NE Wrangel Island	5570 ± 85	Ua-17626	6290-6440	6367	0.71544
Sr-23	mammoth	enamel	Gusinaya river	5875 ± 70	Ua-13356	6570-6790	6695	0.71398
Sr-24	mammoth	enamel	Gusinaya river	6090 ± 75	Ua-13371	6800-7150	6966	0.71452
Sr-26	mammoth	enamel	NE Wrangel Island	6245 ± 80	Ua-17625	7020-7260	7158	0.71376
Sr-25	mammoth	enamel	Gusinaya river	6260 ± 50	LU-2799	7030-7260	7194	0.71653
Sr-4	mammoth	enamel	Gusinaya river	6405 ± 65	Ua-13367	7280-7420	7338	0.71360
Sr-27	mammoth	enamel	Mamontovaya river	6410 ± 90	Ua-13374	7270-7420	7335	0.71664
Sr-28	mammoth	enamel	Gusinaya river	6530 ± 70	Ua-13360	7330-7560	7445	0.71444
Sr-29	mammoth	enamel	Gusinaya river	6560 ± 75	Ua-13361	7420-7560	7469	0.71416
Sr-30	mammoth	enamel	Wrangel Island	6765 ± 47†	†	7590-7660	7620	0.71658
Sr-31	mammoth	enamel	NE Wrangel Island	6910 ± 75	Ua-17634	7670-7830	7750	0.71459
Sr-32	mammoth	enamel	NE Wrangel Island	7060 ± 80	Ua-17622	7800-7880	7964	0.71387
Sr-33	mammoth	enamel	NE Wrangel Island	7130 ± 85	Ua-17621	7850-8020	7954	0.71660
Sr-34	mammoth	enamel	Tundrovaya river	7250 ± 60	LU-2809	8010-8160	8076	0.71391
Sr-6	mammoth	enamel	Wrangel Island	7510 ± 80	Ua-13372	8210-8390	8318	0.71321
Sr-39	mammoth	enamel	NE Wrangel Island	8445 ± 100	Ua-17615	9320-9540	9441	0.71273
Sr-36	mammoth	enamel	Mamontovaya river	8640 ± 80	Ua-13363	9530-9690	9627	0.71365
Sr-8	mammoth	enamel	NE Wrangel Island	8850 ± 95	Ua-17609	9780-10150	9932	0.71398
terminal Pleistocene bioapatites								
Sr-35	mammoth	enamel	Wrangel Island	12010 ± 110	LU-2823	13760-13980	13875	0.71212
Sr-38	mammoth	enamel	NE Wrangel Island	12415 ± 120	Ua-17611	14170-14690	14472	0.71210
Sr-40	mammoth	enamel	NE Wrangel Island	12505 ± 135	Ua-17633	14310-14880	14601	0.71260
Sr-9	mammoth	enamel	Krasny Flag river	12980 ± 80	LU-2792	15160-15480	15331	0.71318
Sr-46	bison	bone	Shumnaya river	12990 ± 95	Ua-21319	15160-15510	15347	0.71176
Sr-11	mammoth	enamel	NE Wrangel Island	14570 ± 140	Ua-17610	17320-17920	17571	0.71268
Sr-48	musk ox	bone	Wrangel Island	17670 ± 215	Ua-21321	20540-21140	20873	0.71241
Sr-41	mammoth	bone	Wrangel Island	18030 ± 130	LU-3510	21070-21650	21376	0.71271
Sr-45	bison	bone	Mamontovaya river	19400 ± 210	Ua-21318	22700-23400	23091	0.71116
Sr-13	mammoth	enamel	Wrangel Island	20000 ± 110	LU-2807	23800-24120	23959	0.71199
Sr-42	mammoth	bone	Wrangel Island	20660 ± 190	LU-3512	24480-25310	24819	0.71098
						mean ± 1σ		
Sr-43	mammoth	bone	Wrangel Island	22400 ± 200	GIN-8257	26930 ± 260		0.71199
Sr-44	mammoth	bone	Wrangel Island	37080 ± 1650	LU-3511	42180 ± 1470		0.71423
Sr-14	mammoth	enamel	NE Wrangel Island	38375 ± 2115	Ua-17618	43310 ± 1870		0.71306
Sr-37	mammoth	enamel	Gusinaya river	> 38000	Ua-13365	> 43000		0.71304

Sr-47	musk ox	bone	Wrangel Island	> 40000	Ua-21320	> 45000	0.70944
Sr-49	musk ox	bone	Neizvestnaya river	> 40000	Ua-21322	> 45000	0.71164
Sr-50	musk ox	bone	Neizvestnaya river	> 40000	Ua-21323	> 45000	0.71214

* Unstable measurement with high error (2σ 0.2085%), not included in handling of results.

†^{14}C date is a mean value (± 1 stdev of the mean) based on four determinations; GIN-8654 (6720 ± 50), GIN-6990 (6750 ± 30), LU-2736 (6760 ± 50), LU-3515 (6830 ± 40).

References for Table DR1:

Fairbanks, R.G., Mortlock, A., Chiu, T-C., Cao, L., Kaplan, A., Guilderson, T.P., Fairbanks, T., Bloom, A., Grootes, P., and Nadeau, M-J., 2005, Radiocarbon calibration curve spanning 0 to 50,000 years BP based on paired 230Th/234U/238U and 14C dates on pristine corals: Quaternary Science Reviews, v. 24, p. 1781-1796, doi: 10.1016/j.quascirev.2005.04.007.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Bertrand, C.J.H., Blackwell, P.G., Buck, C.E., Burr, G.S., Cutler, K.B., Damon, P.E., Edwards, R.L., Fairbanks, R.G., Friedrich, M., Guilderson, T.P., Hogg, A.G., Hughen, K.A., Kromer, B., McCormac, F.G., Manning, S.W., Ramsey, C.B., Reimer, R.W., Remmele, S., Southon, J.R., Stuiver, M., Talamo, S., Taylor, F.W., van der Plicht, J., and Weyhenmeyer, C.E., 2004, IntCal04 terrestrial radiocarbon age calibration, 26–0 ka BP: Radiocarbon, v. 46, p. 1029–1058.

Stuiver, M., Reimer, P.J., and Reimer, R.W., 2005, CALIB 5.0. [WWW program and documentation]. http://radiocarbon.pa.qub.ac.uk/calib/ [accessed 20 June 2008].

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Table DR2. $^{87}Sr/^{86}Sr$ results of pretreatment experiments.

Sample	Pretreatment	$^{87}Sr/^{86}Sr$
Sr-6		
	no pretreatment	0.71324
	0.1N CH_3COOH 10 min×2	0.71321
	0.1N CH_3COOH 30 min	0.71321
Sr-11		
	no pretreatment	0.71266
	0.1N CH_3COOH 10 min×2	0.71268
	0.1N CH_3COOH 30 min	0.71265