A SHATTERED TOMB OF SCATTERED PEOPLE

The Alvastra Dolmen in Light of Stable Isotopes

Elin Fornander

Skeletal remains from the dolmen in Alvastra are approached from the perspective of isotope analyses, providing insights into dietary and residential patterns. Radiocarbon dates from the interred individuals provide evidence of long-lasting burial practices which were still active when the Alvastra Pile Dwelling was built. The isotopic record indicates dispersed geographic origins among the buried individuals. It is suggested that Alvastra, with the dolmen as a focal point, was established as a meeting place and sacred space already several centuries before the time of the Pile Dwelling.

Keywords: Megalith, Alvastra, stable isotopes, interaction, ^{14}C, Neolithic, Funnel Beaker culture

INTRODUCTION TO A SHATTERED TOMB

When the farmer J. Ingvarsson in the spring of 1916 decided to blast away three stone blocks obstructing tillage on his field at the foot of Mount Omberg, little did he know that he was about to reveal and damage an originally monumental collective tomb of the Stone Age. Startled by the exposed and now partly scattered human remains, Mr Ingvarsson contacted the National Heritage Board, where archaeologist Otto Frödin was assigned to investigate the site (ATA dnr 53/1916). According to local folk traditions the field in question hid the execution site of the assassin of a medieval king, Sverker the Elder, a belief that was to heavily influence early interpretations of the exposed remains. Frödin, who considered the site a medieval place of execution and hence named it "Gallows Hill", conducted a small excavation and documentation of the exposed ground plan of the monument (Frödin 1918).

Frödin's "Gallows Hill" interpretation was soon challenged by archaeologist Ture J. Arne, who perceived the monument as a Stone Age tomb. Animated discussions commenced, with Arne arguing in favour of regarding the monument as a mass grave from the end of the Neolithic, combining elements from a megalithic passage grave and a slab cist (Arne 1923, 1924; Frödin 1923). In the 1980s Arne was, at least in part, posthumously proven correct when excavations of the site (Janzon 2009) identified the monument as a megalithic dolmen. The Alvastra dolmen to this day remains the only documented Neolithic megalithic tomb in the province of Östergötland.

Although we cannot know for sure whether other, now destroyed, megaliths have been present in the area, the Alvastra dolmen still stands out as an isolated occurrence, especially in comparison with the megalithic core area at Falbygden on the other side of Lake Vättern. Undisputed remains of dolmens and passage graves in Sweden are, apart from Alvastra and a few tombs on Öland and Gotland in the Baltic Sea, only present at Falbygden, in Scania and along the Swedish west coast. This raises questions as to who were buried in the Alvastra tomb and who made use of it. What inspired the building of the monument and the activities related to it? Were the buried members of a local community, or did they originate from other geographical regions? How extensive was the economic impact of farming activities among the buried population? The rich natural resources and fertile soils at hand imply that Alvastra was no less suitable for occupation and cultivation than the Falbygden region, and given the frequency of documented Early to Middle Neolithic activities in the area, population density cannot explain the differences in megalithic traditions between the two regions. A highly intriguing aspect of the Alvastra dolmen is the geographic proximity to the renowned Alvastra Pile Dwelling, which possibly evolved while the megalith was still in use. Insights into the longevity of burial practices in the dolmen, and its role in the social landscape of the time, can potentially shed some light on the relation between this monument and the Pile Dwelling.

In the present study, skeletal remains from the Alvastra dolmen are analysed with respect to stable carbon, nitrogen and sulphur isotopes in order to investigate dietary and residential patterns among the buried individuals. In addition, radiocarbon dates, complementing those presently available from the tomb (Janzon 2009), are obtained and discussed.

THE NATURAL AND CULTURAL LANDSCAPE OF ALVASTRA

The Alvastra dolmen (Raä 12:1) is found in Västra Tollstad parish in the western parts of Östergötland, figure 1. The landscape surrounding the tomb, situated at the southern foot of Mount Omberg and overlooking Lake Vättern directly to the west, presents dramatic topographical features. Mount Omberg is locally renowned for the clouds of vapour it gives off on damp days (see further Janzon 2009:83). Although the panoramic view over Lake Vättern offered today may not mirror Neolithic, more forested, conditions, the proximity to the shoreline is still likely to have influenced the location of the tomb. The shoreline displacement at Alvastra since Neolithic times is estimated to only about 3 m, which is why the present-day relation between the dolmen and the shores of Lake Vättern is rather reminiscent of Neolithic conditions (Norrman 1964). An undulating plain extends south and north of the site, encompassing Broby spring mire and containing the Alvastra Pile Dwelling, less than 2 km to the northeast. The geology of the Alvastra region, figure 1, is complex with Precambrian granites reaching about as far north as Mount Omberg and Lake Tåkern. To the north, the Östergötland Cambro-Silurian plain is comprised of limestones, shales and sandstones (Loberg 1999; Janzon 2009).

The Alvastra Pile Dwelling comprises a wooden construction in the Broby mire and contains finds of Funnel Beaker culture character as well as abundant Pitted Ware culture pottery. Dendrochronology shows that the construction was built in several phases during a period of just over 40 years (Browall 1986; Malmer 2002). The archaeological evidence indicates repeated acts of feasting during the summer months, although during its last years the Pile Dwelling rather functioned as a place for the dead. The timber structures in the Alvastra Pile Dwelling have been radiocarbon dated to c. 3300–3010 cal. BC (2σ, see further Browall 1986; Skog 2009). Other Early to Middle Neolithic activities in the region include a partially excavated TRB settlement site at Charlottenborg (Väversunda parish) west of Lake Tåkern, with pottery typologically dated to c. 3300 BC. Stray finds of TRB character indicate the presence of further settlements around Lake Tåkern as well as in present-day Ödeshög parish further to the south (Browall 2003:35ff).

A HISTORY OF THE SITE

The excavation following the discovery of the site in 1916 identified a floor of water-polished stones in an open space between the preserved

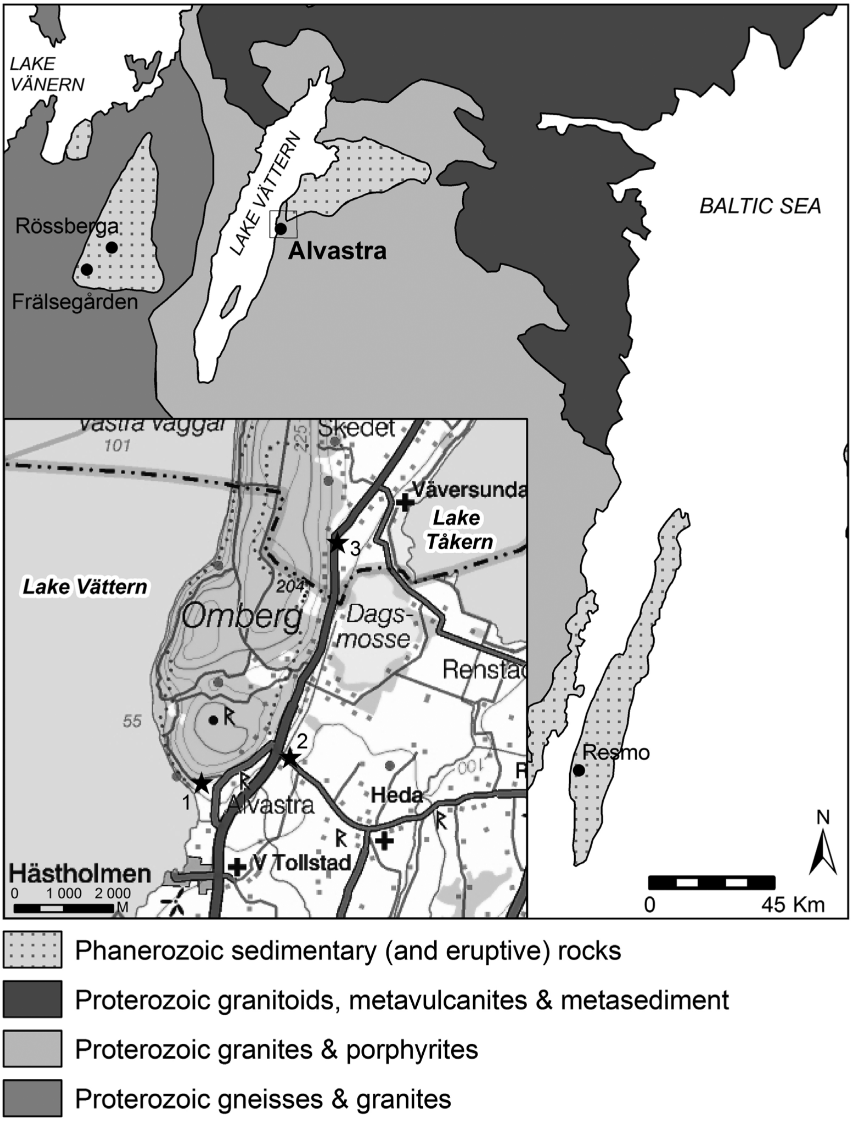

Figure 1. Geological map of southeast Sweden, indicating megalithic sites mentioned in the text. Revised after Loberg (1999). Enhanced section: natural features and archaeological sites in the Alvastra region mentioned here. 1) The Alvastra Dolmen, 2) Alvastra Pile Dwelling, 3) Neolithic dwelling site at Charlottenborg. © Lantmäteriet Gävle 2001. Medgivande I 2011/0094.

bases of larger stone blocks. Bone material was found scattered over the site, although an approximately 10 cm thick layer of sediments with commingled bone fragments directly above the stone paving remained seemingly undisturbed. A concentration of skulls mixed with vertebrae and extremity bones was identified in the northwest corner between two blocks (Frödin 1918:112; Janzon 2009).

Excavations in 1979–1983, led by Gunborg O. Janzon, were initiated following the hypothesis that the site represented the remains of a megalithic tomb (During 1980; Janzon 1984, 2009). As a result of these investigations the original ground plan of the monument is now fairly well understood. The tomb comprises a rounded chamber with a stone-paved floor and a diameter just less than 2 m. A probable capstone of granite has been identified, and the tomb has been surrounded by a stone kerb with a diameter of approximately 6 m. An entrance is indicated in the SSE by increased frequencies of pottery and flint finds (Janzon 2009).

The osteological material from the tomb has been analysed in several stages (Frödin 1918; During 1980; Wilhelmsson & Ahlström 2009. See further Janzon 2009), with Carl M. Fürst performing the initial identification of the bones retrieved in 1916 (Frödin 1918). In 1997, a box that Fürst had labelled "Alvastra" and that contained skeletal remains was found at Lund University (see Janzon 2009:68f). This material, together with all other human remains from the tomb, has recently been analysed by Wilhelmsson and Ahlström (2009).

The number of interred individuals is estimated to over 30 (Wilhelmsson & Ahlström 2009). Among the eight ^{14}C dates from human remains available prior to the present study, three yielded consistent Neolithic dates falling around 4500 BP. Bones from two different individuals, however, produced Iron Age dates and one individual, a male aged over 60 years represented by three radiocarbon dates, belonged to the Mesolithic period. Since these chronologically deviating individuals all come from the box rediscovered in Lund it has been suggested that either all three, or at least the Iron Age individuals, originate from the nearby Iron Age cemetery at Smörkullen. Fürst worked with the skeletal remains from this site prior to his analysis of the dolmen material (Janzon 2009:69; Wilhelmsson & Ahlström 2009:96f).

The diverse faunal assemblage, comprised almost entirely of unburned bones, includes 25 identified species. Represented domestic species include dog, pig, sheep/goat, cattle and horse. Eight published radiocarbon dates from faunal bones range from the Bronze Age to the Early Middle Ages, and it is uncertain which, if any, of the bones are of Neolithic origin (Janzon 2009:68ff).

Recovered pottery finds include a number of sherds from a pedestalled bowl with vertical comb-stamped bands, typologically dated to MN I (early MN A). The remains of this vessel were found near the presumed entrance to the dolmen. A ring-shaped eye or sun pattern places another identified sherd stylistically in MN III–IV (second half of MN A). Only undecorated sherds have been recovered inside the chamber itself. Other finds include a fragment from a polished flint axe, amber bead fragments and grindstone/whetstone fragments. Two slate pendants imply Late Neolithic activities in the tomb. The occurrence of quartz is notable, since this material is extremely rare in megalithic contexts. Apart from scattered pieces, quartz was retrieved from underneath the cultural layer of the tomb (Janzon 2009). Further, a bifacial reduction method has been identified in the material, and these two circumstances imply a Mesolithic presence at the site (Ahlbeck 2009). Although we cannot say whether these finds correspond chronologically to the disputed Mesolithic man from Alvastra, the evidence for Mesolithic activities at the site is worth noting. About 1–2 m north of the tomb a hearth of Viking Age date has been identified.

AN INTRODUCTION TO STABLE ISOTOPE ANALYSIS

Stable isotopes in collagen provide information on the protein component of the diet (DeNiro & Epstein 1978; Ambrose & Norr 1993). The stable carbon isotopes, $\delta^{13}C$, discriminate between terrestrial and marine environments (Schoeninger & DeNiro 1984). The $\delta^{13}C$ end values for marine and terrestrial consumers in the Balitc Sea region have been estimated to approximately -15 and -20‰, respectively (Lidén & Nelson 1994). Since the nitrogen isotope value, $\delta^{15}N$, increases by approximately 3‰ for each step up the food chain (Minagawa & Wada 1984; Schoeninger & DeNiro 1984), different trophic levels can be identified. Further, marine food chains are longer than terrestrial ones, which is why marine top predators exhibit higher $\delta^{15}N$ values. It should be noted that since plants have lower protein contents than meat, they will be under-represented in the isotopic data.

Stable sulphur isotopes, $\delta^{34}S$, provide insights into geographical origin, since the $\delta^{34}S$ values in plants are dependent on the average composition of the underlying bedrock (Peterson *et al.* 1985; Richards *et al.* 2003). European granitic rocks exhibit $\delta^{34}S$ values between approximately -4 and +9‰, whereas sedimentary rocks are known to display a much wider range of values, albeit locally consistent. The $\delta^{34}S$ values in marine environments average +21‰ (Krouse 1980; Peterson & Fry 1987; Faure & Mensing 2005. For a more in depth presentation of the methodology of stable isotopes, see e.g. Fornander *et al.* 2008).

In bone, collagen is continuously remodelled with turnover rates of between 5 and 30 years (Lidén & Angerbjörn 1999; Hedges *et al.* 2007), which is why isotopic data represent the average diet of the last years in life. In contrast, the isotopic record in teeth is fixed at the time of tooth formation. Thus, by comparing data from teeth and bone, potential intra-individual changes in diet and provenience can be identified (Sealy *et al.* 1995). We can also study patterns of breastfeeding via deciduous teeth, since the child will develop elevated $\delta^{15}N$ values relative to the mother (Fogel *et al.* 1989).

THE ANALYSED MATERIAL

With the aim of identifying intra-individual patterns, analysed human samples include only jaws and associated teeth. Since a double sampling of lower and upper jawbones from the same subject cannot always be excluded, the minimum number of individuals for the analysed human population represented by the lower jaws amounts to eleven. The human individuals have been arbitrarily numbered, where subjects 1–11 represent the lower jaw and subjects 12–15 the upper jawbones. Subjects 1, 2, 5 and 9 include both the upper (not analysed) and the lower jaw and thus represent unique individuals. Subject 2 has previously been dated to the Mesolithic, and an available radiocarbon date for subject 9 falls within the Iron Age (Wilhelmsson & Ahlström 2009). The selected samples include adults as well as children. The total number of human samples amounts to 35. From 13 of the analysed individuals, collagen was submitted for radiocarbon dating.

Faunal samples were included as local isotopic reference data. Further, sulphur isotope analysis of domestic species can potentially shed light on interaction and mobility patterns among the human population. The total number of faunal samples, including wild as well as domestic species, amounts to 38. Ten collagen samples from domestic species were further radiocarbon dated.

Collagen quality criteria include C and N concentrations (Ambrose 1990) and C/N ratios (DeNiro 1985). One sample each of cattle, pike and perch did not produce sufficient amounts of collagen. The bone samples from subjects 3 and 8 were excluded due to high C/N ratios. For sulphur, S concentrations of 0.14–0.60 and C/S ratios of 200–800, are assumed to represent unaltered mammal collagen sulphur, provided that the criteria for C and N are fulfilled as well (Fornander *et al.* 2008). Four samples, of sheep/goat and pig together with the bone samples of subjects 2 and 14, presented C/S ratios below the accepted range and are excluded from further discussion regarding sulphur isotopes, table 1.

Table 1. Stable isotope and radiocarbon data for the analysed samples. Struck-out samples are excluded since they failed to meet the quality criteria (continues on the next pages).

Individual	Age	^{14}C BP	^{14}C id.	Element	Lab#	Collagen (mg)
Subject 2/Ind. A*	>60 ys	7088±62	Ua-38179	M2	ALM 04	1.0
				Mandible	ALM 03	5.1
Subject 3	Adult	4667±41	Ua-38181	M1	ALM 46	6.1
				M2	ALM 07	5.4
				M3	ALM 08	5.7
				Mandible	ALM 45	10.0
Subject 13/Ind. R*	c. 8-10 yr	4635±48	Ua-39638	dm2	ALM 58	1.5
				M1	ALM 25	3.0
				M2	ALM 59	2.5
				Maxilla	ALM 24	2.0
Subject 7	c. 5-8 yr	4537±41	Ua-38182	Mandible	ALM 51	6.6
Subject 14/Ind. Q*	c. 10-11 yr	4523±36	Ua-38187	dm1	ALM 60	0.5
				dm2	ALM 61	0.6
				M1	ALM 62	4.1
				M2	ALM 63	3.0
				Maxilla	ALM 26	2.9
Subject 5/Ind. P*	c. 3 yr	4522±37	Ua-38180	dm1	ALM 49	0.8
				dm2	ALM 50	1.2
				Mandible	ALM 12	5.6
Subject 4	c. 12±3 yr	4474±49	Ua-39637	M1	ALM 10	5.5
				M2	ALM 11	9.0
				Mandible	ALM 09	1.4
Subject 11	Adult	4384±35	Ua-38185	Mandible	ALM 22	10.9
Subject 12	Adult?	4370±35	Ua-38186	M1	ALM 56	1.4
				M2	ALM 57	1.9
Subject 10	Adult	4334±36	Ua-38184	M1	ALM 54	1.6
				M2	ALM 55	1.5
				Mandible	ALM 53	1.4
Subject 6	c. 5-8 yr	4290±35	Ua-38188	Mandible	ALM 42	4.0
Subject 9/Ind. C*	c. 10-11 yr	1884±33	Ua-38183	M2	ALM 52	2.3
				Mandible	ALM 20	10.6
Subject 1	Adult	1236±31	Ua-39636	M2	ALM 02	2.6
				Mandible	ALM 01	6.6
Subject 15	c. 5-8 yr	Undated		C max	ALM 28	1.6
Subject 8	Child	Undated		Mandible	ALM 19	0.9
Dog				Molar	ALM 78	1.9
Dog				Molar	ALM 76	0.4

Collagen (%)	δ13C (‰)	δ15N (‰)	%C	%N	C/N	δ34S (‰)	%S	C/S
2.6	-18.4	11.3	41.7	14.6	3.3			
2.0	-18.2	11.6	41.6	14.4	3.4	7.3	0.31	179
4.4	-20.4	10.9	40.7	13.8	3.5	8.7	0.23	236
4.1	-19.4	12.2	44.0	15.4	3.3	10.6	0.21	279
5.1	-19.6	11.2	43.2	15.2	3.3	8.9	0.23	250
3.9	-19.9	12.1	40.1	12.7	3.7	9.8	0.23	232
2.0	-20.3	12.5	43.8	15.0	3.4			
2.6	-20.7	10.7	43.2	14.8	3.4			
2.5	-20.9	10.9	44.3	15.1	3.4			
4.1	-20.6	11.1	42.5	14.9	3.3			
6.3	-19.9	10.0	44.0	15.4	3.3	7.7	0.20	293
2.2	-19.8	12.7	41.4	14.2	3.4			
2.0	-20.4	11.7	41.0	13.7	3.5			
4.0	-20.2	10.9	44.9	15.8	3.3	6.2	0.20	299
3.9	-20.1	10.5	44.8	15.6	3.3	6.3	0.20	299
3.9	-20.4	10.2	42.4	14.6	3.4	6.9	0.31	182
2.4	-19.7	11.9	40.1	13.8	3.4			
2.7	-19.4	12.1	42.9	14.9	3.4			
4.7	-19.6	11.9	44.0	15.3	3.3	6.9	0.24	245
4.4	-19.9	12.1	44.1	15.3	3.4	4.4	0.23	255
6.4	-20.1	10.8	44.1	15.4	3.3	5.0	0.27	218
0.9	-20.3	10.6	38.1	12.9	3.4	6.7	0.21	242
5.1	-21.1	9.4	43.6	15.0	3.4	10.1	0.21	277
2.7	-20.6	10.9	39.7	13.9	3.3	8.4**	0.26	204
2.7	-20.5	10.8	41.8	14.7	3.3			
4.2	-20.5	9.5	41.8	14.6	3.3	9.5***	0.26	214
3.6	-21.1	8.9	42.1	14.7	3.3			
1.3	-18.5	12.2	42.9	15.1	3.3			
2.8	-20.2	10.0	42.7	15.0	3.3			
5.3	-20.0	13.3	42.9	15.1	3.3	5.6	0.27	212
6.4	-20.2	13.4	43.4	15.3	3.3	5.5	0.20	290
4.1	-20.1	14	42.3	14.9	3.3			
2.7	-20.2	14.3	42.6	15.1	3.3	3.9	0.25	227
3.0	-20.6	11.0	42.7	14.1	3.5			
0.5	-20.5	10.2	40.2	12.8	3.7			
2.1	-20.0	9.7	42.8	16.0	3.1			
1.9	-19.9	9.3	37.1	13.6	3.2			

Table 1 continues.

Individual	Age	^{14}C BP	^{14}C id.	Element	Lab#	Collagen (mg)
Dog				Mandible	ALM 77	3.6
Dog				Femur	ALM 75	3.2
Cattle				Molar	ALM 85	5.2
Cattle				Molar	ALM 84	0.2
Cattle		3894±34	Ua-39645	Carpal bone	ALM 88	5.1
Cattle				Premolar	ALM 86	5.8
Cattle				Talus	ALM 89	3.6
Cattle		2695±30	Ua-39644	Humerus	ALM 87	18.3
Sheep/Goat				Molar	ALM 70	3.6
Sheep/Goat				Mandible	ALM 72	5.5
Sheep/Goat		1247±30	Ua-39642	Molar	ALM 73	3.4
Sheep/Goat		991±30	Ua-39643	Tooth	ALM 74	4.0
Sheep/Goat				Phalanx	ALM 68	2.9
Sheep/Goat				Coxae	ALM 69	1.4
Sheep/Goat		1269±30	Ua-39641	Premolar	ALM 71	7.1
Sheep/Goat				Phalanx	ALM 67	6.7
Pig		1214±30	Ua-39646	Talus	ALM 92	7.5
Pig				Talus	ALM 93	5.7
Pig				Talus	ALM 91	2.5
Pig				Tibia	ALM 97	14.4
Pig		1197±30	Ua-39648	Mandible	ALM 96	14.2
Pig				Mandible	ALM 95	6.2
Pig		1192±30	Ua-39647	Molar	ALM 94	8.0
Pig				Incisor	ALM 90	3.8
Horse		1274±31	Ua-39639	Molar	ALM 65	5.3
Horse		1271±30	Ua-39640	Radius	ALM 66	4.4
Lynx				Claw	ALM 83	12.8
Polecat				Coxae	ALM 81	2.6
Polecat				Femur	ALM 82	4.8
Pike				Vertebra	ALM 101	0.2
Pike				Vertebra	ALM 99	1.0
Pike				Praeoperculare	ALM 102	0.4
Perch				Cranial bone	ALM 103	0.5
Salmon/trout				Tooth	ALM 98	0.4
Salmon/trout				Vertebra	ALM 100	1.3
Common scoter				Ulna	ALM 80	4.6

* Individuals assigned by lettering in Wilhelmson and Ahlström (2009).
** Sulphur data from pool of ALM 56+57.
*** Sulphur data from pool of ALM 54+55.

Collagen (%)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	%C	%N	C/N	$\delta^{34}S$ (‰)	%S	C/S
1.3	-20.4	7.5	42.2	15.6	3.2	12.3	0.26	217
6.0	-19.3	8.3	44.8	16.1	3.3	11.8	0.23	260
1.4	-21.0	8.7	41.8	16.1	3.0	8.3	0.24	232
0.1								
1.9	-22.1	5.5	39.3	15.3	3.0			
2.9	-21.4	5.8	43.2	16.6	3.0	11.1	0.27	213
1.1	-21.3	6.8	41.5	16.8	2.9	7.7	0.23	241
5.6	-20.9	6.2	44.1	17.3	3.0	2.2	0.21	280
5.2	-20.9	10.2	44.2	15.9	3.2	5.3	0.22	268
1.8	-21.4	5.8	43.3	15.2	3.3	10.9	0.30	193
3.0	-21.3	7.5	45.1	15.9	3.3			
2.3	-21.5	7.5	44.1	16.4	3.1			
8.8	-23.1	7.2	43.2	16.3	3.1	10.7	0.21	274
2.0	-19.8	9.9	41.6	14.8	3.3			
3.3	-21.5	10.3	45.2	16.1	3.3	5.8	0.22	274
7.4	-21.4	11.6	45.0	16.8	3.1	6.5	0.22	273
2.8	-21.8	11.4	41.6	16.4	3.0	7.0	0.20	277
4.2	-21.4	8.8	44.3	17.8	2.9	2.6	0.20	295
2.6	-21.2	9.2	43.8	17.3	2.9	6.4	0.30	194
8.6	-21.8	10.0	45.4	15.9	3.3	6.8	0.23	263
4.0	-22.0	10.7	45.5	15.9	3.3	7.1	0.23	264
4.2	-21.0	11.0	45.4	15.7	3.4	7.2	0.22	275
5.3	-21.3	10.9	44.6	17.6	3.0	6.8	0.22	270
6.2	-21.3	15.8	43.7	17.8	2.9	6.8	0.22	265
2.3	-22.1	6.3	43.4	16.1	3.1			
1.7	-22.0	7.9	43.7	16.1	3.2			
6.1	-20.2	7.8	44.2	17.0	3.0	9.4	0.20	294
3.8	-19.8	6.2	43.5	16.0	3.2			
3.3	-20.4	4.4	42.6	16.3	3.1	9.8	0.18	316
0.1								
0.4	-14.7	9.3	34.0	11.6	3.4			
0.2	-15.7	9.2	31.3	10.3	3.5			
0.1								
0.3	-16.9	8.8	38.1	13.6	3.3			
0.3	-16.7	8.9	33.7	12.2	3.2			
8.4	-13.1	12.8	44.2	16.7	3.1	14.1	0.27	218

OBTAINED RADIOCARBON DATES

The radiocarbon data are reviewed in tables 1 and 2 and figure 2. Among the 13 human samples, ten fall within the range 3628–2876 cal. BC (2σ), roughly corresponding to the end of EN and early to middle MN A. Subject 2, the old man, and subject 9, a child, display ^{14}C dates in line with those previously published, falling within the Mesolithic and Early Iron Age, respectively. Further, the adult subject 1 is dated to the Late Iron Age, that is, cal. AD 687–878 (2σ).

Among the dated faunal samples, none is contemporaneous with the Neolithic inhumation activities in the dolmen. The only sample yielding a Neolithic date, a specimen of cattle, had been placed in the tomb somewhere around the transition to the Late Neolithic several hundred years later. With the exception of a second specimen of cattle displaying a Late Bronze Age date, the remaining faunal radiocarbon dates all fall within the Late Iron Age and, in one case, the Early Middle Ages.

Table 2. Obtained calibrated radiocarbon dates (OxCal v4.1.7 Bronk Ramsey (2010)).

Species/ Individual	^{14}C BP	Cal. BC/AD (1σ)	Cal. BC/AD (2σ)
Subject 2	7088±62	6021–5901 BC	6072–5839 BC
Subject 3	4667±41	3516–3371 BC	3627–3362 BC
Subject 13	4635±48	3510–3359 BC	3628–3139 BC
Subject 7	4537±41	3361–3116 BC	3368–3097 BC
Subject 14	4523±36	3352–3114 BC	3361–3098 BC
Subject 5	4522±37	3351–3114 BC	3361–3098 BC
Subject 4	4474±49	3334–3035 BC	3356–2944 BC
Subject 11	4384±35	3078–2905 BC	3096–2909 BC
Subject 12	4370±35	3017–2922 BC	3091–2906 BC
Subject 10	4334±36	3011–2901 BC	3081–2891 BC
Subject 6	4290±35	2920–2885 BC	3014–2876 BC
Subject 9	1884±33	70–209 AD	57–226 AD
Subject 1	1236±31	693–859 AD	687–878 AD
Bos taurus	3894±34	2461–2345 BC	2473–2243 BC
Bos taurus	2695±30	894–810 BC	902–805 BC
Ovis capra	1247±30	688–805 AD	680–870 AD
Ovis capra	991±30	996–1148 AD	988–1154 AD
Sus scrofa	1214±30	775–870 AD	693–890 AD
Sus scrofa	1197±30	780–875 AD	715–939 AD
Sus scrofa	1192±30	780–881 AD	720–941 AD
Equus caballus	1274±31	685–771 AD	662–852 AD
Equus caballus	1271±30	687–771 AD	664–854 AD

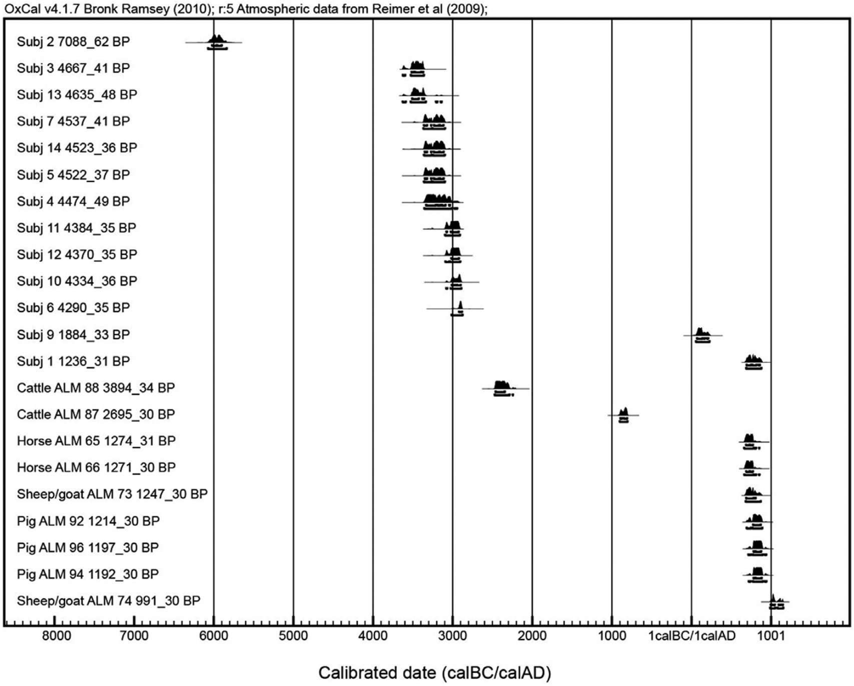

Figure 2. Radiocarbon dates obtained in this study. Calibrated using OxCal v4.1.7 Bronk Ramsey (2010).

SOME CHRONOLOGICAL CONCERNS

The results presented here, as well as previous publications regarding the Alvastra dolmen, imply that activities surrounding the monument are not restricted to the Neolithic period. Before embarking on a discussion of the main trajectory of this study, the Early to Middle Neolithic events, some remarks on the identified remains from other periods in time are in order.

When contesting the accuracy of attributing the Mesolithic man to the Alvastra dolmen find material, Wilhelmsson & Ahlström (2009) emphasise the differing patina on the bones together with the fact that the other remains in the rediscovered box represent two Iron Age subjects. However, in a letter to Frödin, Fürst describes some morphological features which can only refer to the Mesolithic skull among the assembled cranial material from the dolmen (Fürst ATA). From this Janzon (2009:67f) concludes that these remains were demonstrably found together with other skulls from the tomb. Further, the identified quartz material attests to Mesolithic activities at the site. Thus, it is quite possible that someone, while building or using the megalith, may have stumbled across a 3000-year-old burial in the vicinity of the site. The location of the tomb on top of an older site and the inclusion of a Mesolithic skeleton in the chamber may very well have comprised deliberate acts of relating to a distant, mythical past.

As regards the Iron Age individuals, the origin of which also Janzon questions, the results presented here confirm the presence of Iron Age burial activity in the tomb. Remains that are dated to the Late Iron Age did not originate from the rediscovered box discussed above. The Viking Age hearth produced ^{14}C dates analogous to that of the subject in question (Janzon 2009:71), further attesting to Late Iron Age activities at the site. To discard the previously identified Iron Age individuals solely on the basis of their dating is therefore questionable. Unfortunately, this issue may never be definitively solved.

The oldest date obtained for a domesticated animal, and indeed for any faunal sample, from the Alvastra dolmen represents a cattle bone deposited around the transition to the Late Neolithic. The results from Alvastra illustrate the problem of evaluating the presence of domesticates in megalithic tombs. According to Sjögren (2003), remains from domesticated animals of Middle Neolithic date are generally burned and deposited at the entrance to the tomb. Unburned animal bones from within the chamber, on the other hand, often represent later periods. A suggested exception from this pattern concerns unburned pig bones, most notably phalanges, which comprise one of the most common animal bone categories in megalithic chambers (Sjögren 2003:134ff). Animal bones in megaliths are rarely radiocarbon dated since the human remains are prioritised. From a passage grave in Resmo on Öland ^{14}C-dates for two sheep/goats and one specimen of cattle, all unburned, indicate an absence of deposited domesticate bones predating the Late Neolithic (Eriksson *et al.* 2008). More data on this subject are certainly desirable, and without having radiocarbon dated the material, inferences on megalithic mortuary practices involving animal bones are highly problematic.

EVALUATING THE ANIMAL ISOTOPE DATA

The following section comprises an account and evaluation of the animal isotope data presented in table 1 and figures 3 and 4.

Among the five cattle samples, all but one display low $\delta^{15}N$ values (mean 6.1±0.6‰) well in line with what can be expected from terrestrial herbivores. The elevated value of 8.7‰ represents a tooth sample possibly affected by the trophic level effect that occurs while suckling. The more diverse values reported for sheep/goat imply that the animals had been provided with different fodders ($\delta^{13}C$ range -23.1 to -19.8‰, $\delta^{15}N$ range 5.8 to 11.6‰, n=8). Since the three radiocarbon dates all fall within the Late Iron Age or Early Middle Ages, these isotope values are unsuitable to use for inferences on Neolithic human diet. A similar call for caution concerns the pig samples, where the three dates are correspondingly late. Here, a suckling pig is indicated by an elevated $\delta^{15}N$ value of 15.8‰ in a tooth sample. Nitrogen isotope data for the remaining seven pigs imply a contribution of meat to the diet (mean 10.3±1.0‰), similar to that reported for dogs ($\delta^{15}N$ 9.7±1.0‰, n=4).

The relatively low $\delta^{15}N$ values for the terrestrial carnivores lynx and polecat, 4.4–7.8‰ with lynx representing the highest value, are somewhat puzzling. These animals are rather expected to produce values similar to the Alvastra dogs.

All fish samples display $\delta^{13}C$ values in line with a marine origin (-14.7 to -16.9‰). The fact that salmon/trout represent the two lowest values can probably be attributed to the anadromous nature of the salmonidae family, migrating between freshwater and marine environments. The common scoter displays values expected for a carnivorous migratory marine feeder ($\delta^{13}C$ -13.1‰, $\delta^{15}N$ 12.8‰).

To estimate the local sulphur isotopic range on the basis of faunal values from the Alvastra dolmen proves to be problematic. The only two $\delta^{34}S$ values available from wild fauna imply that a local signature includes values around 9–10‰. However, the varied diet of polecat, which includes frogs and birds, together with the often extensive home ranges of lynx, makes this estimation highly uncertain. When turning to the domestics, none of which need to be local or Neolithic, pigs display rather consistent values between 6.8 and 7.2‰ (n=6) if one excludes an obvious outlier of 2.9‰. Sheep/goat, after excluding one deviating value of 10.7‰, range between 5.3 and 6.5 ‰ (n=3). Markedly higher values are exhibited in two dog samples, whereas the four cattle values are widely dispersed. Hypothetically, the more consistent values found among pigs and sheep (if excluding the outliers) could indicate a local origin. If so, a resulting local sulphur isotopic range would land around 5.3–7.2‰ (mean 6.6 ± 0.6‰, n=9). The $\delta^{34}S$ value for common scoter (14.0‰) is in line with Baltic Sea marine consumers (Fornander *et al.* 2008; Linderholm *et al.* ms.).

HUMAN DIET AND PROVENIENCE

The human isotope data are reviewed in detail in table 1 and figures 3 and 4. Given the somewhat problematic animal dataset discussed above,

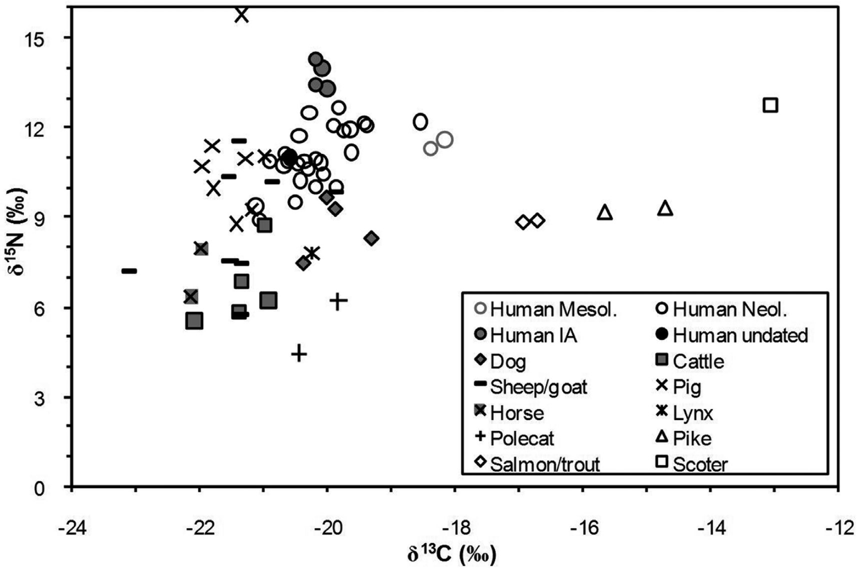

Figure 3. $\delta^{13}C$ and $\delta^{15}N$ data for human and animal samples from Alvastra.

interpretations of the isotopic data are further aided by previously published human and faunal isotope data from Neolithic Sweden (Eriksson *et al.* 2008; Fornander *et al.* 2008).

The consistent $\delta^{13}C$ and $\delta^{15}N$ values in the second molar (-18.4 and 11.3‰) and lower jaw (-18.2 and 11.6‰) from the Mesolithic subject 2 indicate some contribution of marine protein to a predominately terrestrial diet. No intra-individual dietary change can be observed for this individual.

The ten subjects dated to the Neolithic period display $\delta^{13}C$ values from -21.1 to -18.5‰ (mean -20.2 ± 0.6‰, n=26), and $\delta^{15}N$ values of 8.9 to 12.7‰ (mean 11.0 ± 1.0‰). The results correspond to a terrestrial diet, with the exception of the jawbone sample of the adult subject 10 where some contribution of marine protein is likely. The majority of high $\delta^{15}N$ values can be attributed to the trophic level effect of breastfeeding discernible in deciduous teeth and infant bone. However, there is also a representation of samples reflecting a juvenile or adult stage among these higher values, possibly implying some proportions of freshwater fish and/or suckling animals contributing to the diet. The undated subject 15, a child, displays stable isotope values corresponding to the Neolithic human samples.

The above-mentioned subject 10 further displays the most notable intra-individual variation observed, showing an increase in the consumption of marine foods between childhood and adulthood. Minor

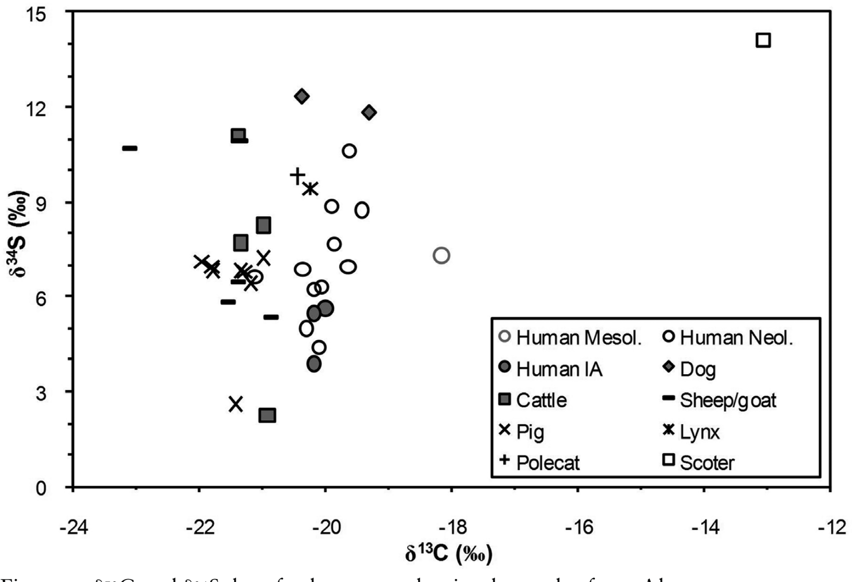

Figure 4. $\delta^{13}C$ and $\delta^{34}S$ data for human and animal samples from Alvastra.

variations possibly connected to dietary change are further detectable for the adult subject 3 and the child/juvenile subject 4. Intra-individual dietary patterns for subjects 13 and 14, both children, are related to breastfeeding and subsequent weaning. Subject 5, the youngest child, has consistently high nitrogen isotope values in both teeth and bone implying a continuation of breastfeeding until death or at least up until a very late stage in life.

The two Iron Age subjects exhibit the highest measured $\delta^{15}N$ values, 13.3–14.3‰ (n=4), implying substantial consumption of freshwater fish and/or suckling animals. Correspondingly high values are represented in several adult individuals from the nearby Iron Age cemetery of Smörkullen (Lindberg 2009). None of the Iron Age individuals display any signs of experiencing dietary changes.

Sulphur isotope data for the Neolithic human samples range from 4.4 to 10.6‰ (mean 7.7 ± 1.9‰, n=13), whereas the three Iron Age samples produce values between 3.9 and 5.6‰. In light of the evaluation of faunal $\delta^{34}S$ values above, non-local values seem to be represented in both time periods. For the Neolithic subjects 3, 4 and 14 it is possible to trace life histories in terms of $\delta^{34}S$. The two values from subject 14, an older child, are highly consistent. Both the adult subject 3 and the child/juvenile subject 4 display some intra-individual variations which could indicate a change of residence. For subject 3, intra-individual changes in $\delta^{34}S$ co-vary with changes in $\delta^{13}C$ and $\delta^{15}N$.

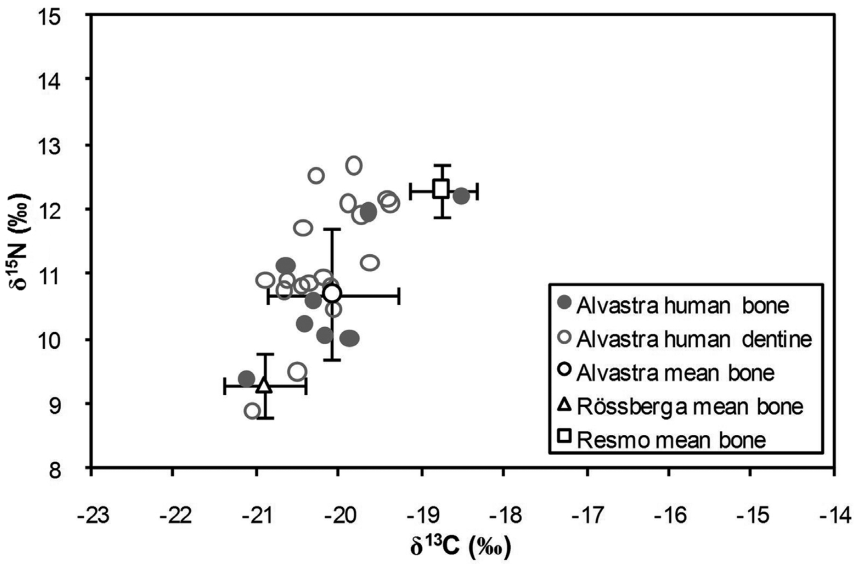

Figure 5. $\delta^{13}C$ and $\delta^{15}N$ data for Neolithic human samples from Alvastra, together with mean values ± 1 s.d. for human bone samples from Alvastra (n=8), Rössberga (n=30, Linderholm *et al.* 2008) and MN A Resmo (n=8, Eriksson *et al.* 2008).

NEOLITHIC FOOD HABITS

When comparing the Neolithic human dietary data with results from a passage grave in Rössberga at Falbygden (Linderholm *et al.* 2008), where the majority of the interred individuals date to the Early Neolithic or MN A, the people from Alvastra in general seem to have consumed food sources of a somewhat higher trophic level, figure 5. Further, the variation in isotopic values is larger among the Alvastra population. The data imply a land-based, possibly rather meat-oriented diet with varied but limited contributions of freshwater fish or suckling animals. The abundant fishing opportunities in the area thus seem to have been rather moderately utilised. Only in one case can the diet be said to have been complemented with limited proportions of marine resources. Direct inferences on the economic impact of farming activities cannot be made based on stable isotope data, since we cannot discriminate between wild and domesticated terrestrial resources. However, it is quite possible that people in the Alvastra region at this period in time were fully established as pastoralist farmers. The dietary pattern, with only a few possible exceptions, further seems to have been rather consistent throughout life.

An interesting contrast to the land-based economies of people buried at Rössberga or Alvastra was presented in a previous study dealing with a passage grave at Resmo on Öland (Eriksson *et al.* 2008). Here, the economy of MN A individuals was considerably more varied and comprised of a mixture of marine and terrestrial resources, figure 5. A transition to a more strictly land-based diet on Öland seems to take place no sooner than the Late Neolithic or Early Bronze Age. The prevailing strategy at Alvastra, to refrain from any substantial exploitation of the resources at hand in the surrounding lakes, is thus not paralleled here.

THE CONTINUITY OF A SACRED SPACE

A central question for understanding the location and use of the Alvastra dolmen concerns its relationship with the Pile Dwelling. Knowledge of the duration of Middle Neolithic burial activities in the megalith is thus essential. In the following, all BC ranges refer to a calibrated 2σ range (OxCal v4.1.7 Bronk Ramsey (2010)).

Whereas the three previously available Neolithic dates displayed a rather narrow chronological range (4540±80, 4490±95 and 4450±80 BP, with a range of 3496–3101 BC), the picture is somewhat altered by the supplementing ^{14}C data obtained here, ranging from 3628 to 2876 BC, table 2 and figure 2. Hence, not only can we stretch the initiation of burial activities in the tomb further back in time to at least between c. 3630 and 3360 BC, but the evidence also further supports a longer duration of burial activities than previously implied. With respect to a 2σ interval, the longevity of Neolithic burial practices in the tomb can be estimated to more than 350, and possibly as long as 750, years. The occurrence of pottery typologically attributed to early versus late MN A (Janzon 2009:77ff) suggests that not only burial practices in the chamber but also ritual activities outside the tomb have a fairly long duration.

Arguing that ^{14}C dates from the western, middle and eastern trenches of the Alvastra Pile Dwelling are statistically contemporaneous, Göran Skog (2009) attempts to statistically test the hypothesis of simultaneity between the dwelling and the dolmen. Comparing the three then available Neolithic dates with ^{14}C dates from pole sapwood in the dwelling, Skog concludes that since the probability distributions comprise approximately the same time span, the two objects date within a common interval of about 350 years. The data are thus inconclusive as regards potential contemporaneity between the two sites. A central premise in these calculations is that the dated individuals from the dolmen and the sapwood samples from the dwelling are contemporaneous and that Skog's analyses of pooled means from the different groups are statistically tested and justified. However, given the dataset now at hand, it is

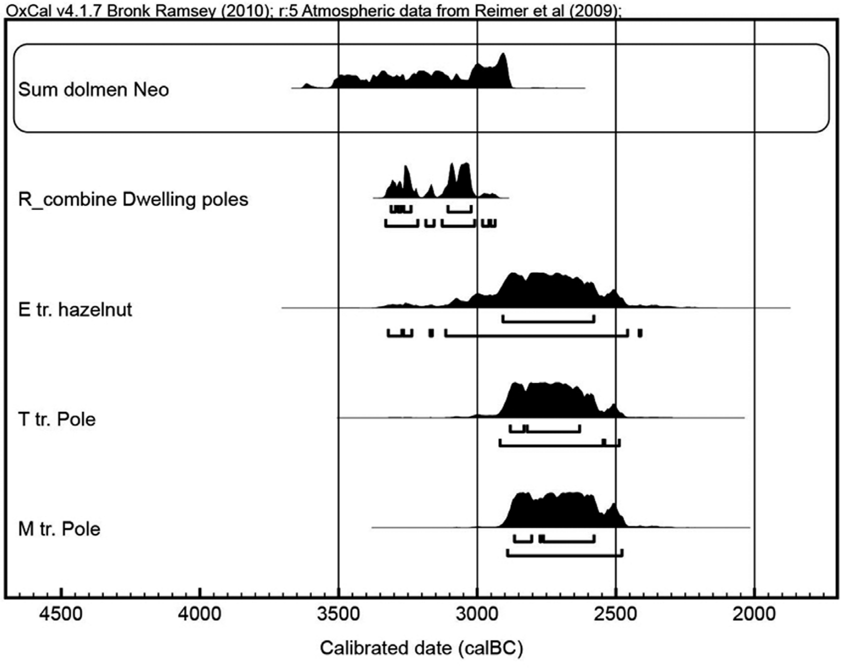

Figure 6. Comparison of Neolithic ^{14}C dates from the dolmen (total range of Neolithic human samples, n=10) and the Pile Dwelling (pooled means of consistent dates from pole sapwood samples from the eastern, western and middle trenches (n=12), and three individual samples of later date). Pile Dwelling data from Browall (1986).

questionable to presuppose that the dolmen burials took place at more or less the same time, regardless of the statistic significance of such a hypothesis. Burial practices in the tomb are to be perceived of as a continuous tradition rather than an instantaneous event.

In his estimations, Skog leaves out a deviating sapwood value of 4120±90 BP from the middle trench, since this is clearly not contemporaneous with the bulk of Pile Dwelling dates. Interestingly, two further late dates are available from the site, 4165±90 (pole sapwood, trench T) and 4190±130 (hazelnut, cultural layer in the eastern trench), figure 6. The first ^{14}C analyses done in 1957 on samples from Frödin's trench (Browall 1986:26f) have a very wide confidence interval and were performed on materials (unspecified wood and turf) hard to evaluate, which is why these correspondingly late dates are disregarded here. The high standard deviation of the hazelnut shell is unfortunate, and when excluded the two remaining late dates range from 2918 to 2479 BC. There is thus hardly any overlap with the earlier Pile Dwelling dates.

The latest Neolithic human date from the dolmen ranges from 3014 to 2876 BC, so the tradition of burying members of the community in the monument was in use until at least around 3000 BC. Following Skog's calculations of dates from the Pile Dwelling, the pooled mean represents a range of c. 3330–3010 BC, figure 6. A more or less corresponding date for the oldest timber floors of c. 3360–2930 BC is suggested by Hans Browall (1986:26f) using the dates from the western trench, exhibiting the earliest mean value among the trenches.

In light of the above discussion, some interesting finds from the Broby spring mire are worth mentioning. In the technological analysis of ceramics retrieved from the Pile Dwelling excavations, Birgitta Hulthén identifies some megalithic pottery sherds of the same production and ornamentation as sherds from the Alvastra dolmen. The sherds were found in association with the timbered causeway, either where it leads up to the Pile Dwelling from the south or, in a few cases, by the western edge of the dwelling construction itself (Hulthén 1998:55ff, 2008:30f). Janzon, hypothesising that the causeway represents one of the mire's primary structures, suggests that these sherds reflect votive acts in the wetland predating the dwelling (Janzon 2009:79). This implies a close conceptual connection between the megalith and the wetland, where both featured as focal points in the ritualized space of the community. The later emanation of the Pile Dwelling can be perceived as a continuation of this ritualized space. If one follows the practice-oriented understanding of ritualization formulated by Catherine Bell (1992) as a strategy of distinguishing certain acts from others, thus making them privileged and powerful, it can be problematic to identify remains of ritualized acts in the archaeological material. Here, an interesting archaeological and interpretive parallel can be found in Åsa Berggren's (2010) study of the Hindby fen in Scania, where acts of deposition of, for example, flint and stone artefacts, pottery sherds, and small amounts of human and animal bones have been carried out for thousands of years, from the Late Mesolithic to the Early Bronze Age. Drawing on the works of Bell, Berggren emphasises the delimited space of the fen, as well as the historicity, as central in the strategy of ritualization (Berggren 2010; Berggren & Nilsson Stutz 2010). The misty mountain overlooking the Alvastra dolmen and the bubbling mire surrounding the Pile Dwelling set these two spaces, as well as the related acts, apart from the surrounding environment. Uniting features for the dolmen and the Pile Dwelling further include the dealing with the dead, suggesting, in combination with the striking natural features, that the ritualized acts had some sacred connotations. A structural parallel between the Pile Dwelling and megalithic monuments in general has further been suggested to be found in the high frequency of deposited artefacts by the entrance to the Dwelling, which is placed in the southeast (Carlsson 1998:55). However, the absolute lack of typological or technological correspondence between Pitted Ware pottery material from the Pile Dwelling and ceramics from the dolmen (Hulthén 1998, 2008) suggests that the Pile Dwelling marks a disruption in the traditions surrounding the mire. A discussion of the relation between the people associated with the Pile Dwelling, their abundant Pitted Ware pottery and the dolmen reaches beyond the scope of this study. Here it will suffice to say that a continuity in the perception of the sacred landscape, regardless of by whom this landscape was perceived and utilised, seems apparent.

Conclusively, a plausible scenario can be outlined as follows: somewhere around 3600–3400 BC a round dolmen was erected at the foot of mount Omberg close to the shore of Lake Vättern. Although we do not know where the people building the tomb came from, they were hardly pioneers in this dramatic landscape which had already been utilised for several thousand years. The practice of burying selected individuals in the tomb continued for several hundred years, accompanied by activities including depositions of pottery at the entrance and by the kerb. Meanwhile, the nearby spring mire was the object of votive offerings of pottery sherds and possibly other items; these offerings took place from a timbered causeway that provided a passage through the wetland. The dolmen was still actively in use around 3350–3000 BC, when ritual activities in the mire intensified with the building of a large timber dwelling. Although the duration of the Pile Dwelling *per se* might have been rather limited, activities in the mire possibly carried on for some hundred years, or were re-activated a few hundred years later, as indicated by the radiocarbon dates. During this later stage, the dolmen no longer functioned as a burial site.

But what, then, inspired the erection of this seemingly isolated megalith? And who were the people buried within the chamber of the tomb?

A LONG-LASTING PLACE FOR MEETING?

When reflecting over the sulphur isotope results, the above-mentioned Rössberga megalith can again serve as an illustrating comparison. This tomb occupies a central location within the Västergötland Cambro-Silurian region whereas the Alvastra dolmen is situated at the border zone between sedimentary and crystalline rocks. Since the local $\delta^{34}S$ signature is dependent on the geological setting, one might expect to find more homogenous values in local food sources at Rössberga than in Alvastra. However, sulphur is incorporated into plants and animals via the soil, which in the Alvastra region is comprised primarily of Cambro-Silurian

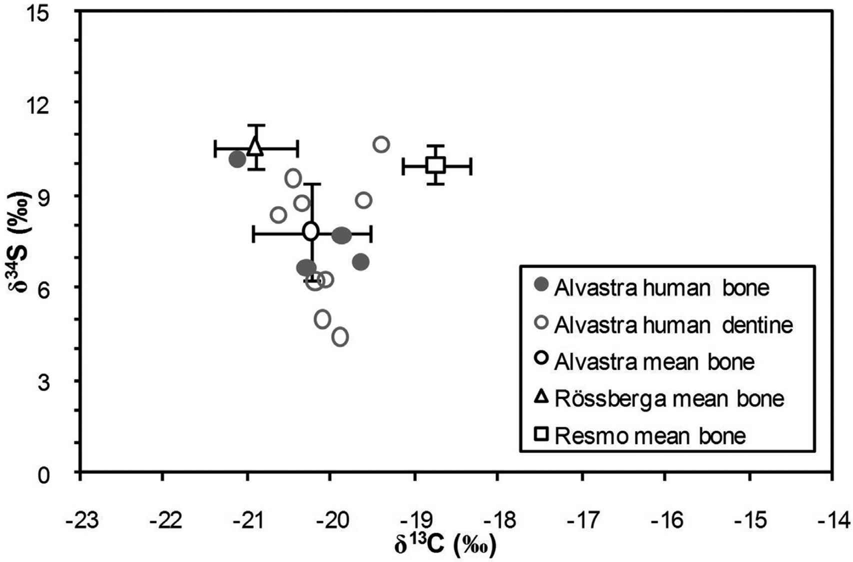

Figure 7. $\delta^{13}C$ and $\delta^{34}S$ data for Neolithic human samples from Alvastra, together with mean values ± 1 s.d. for human bone samples from Alvastra (n=4), Rössberga (n=30, Linderholm *et al.* 2008) and MN A Resmo (n=8, Linderholm, Fornander *et al.* ms.).

material (Janzon 2009). Glacial and postglacial processes of sediment transportation even out the sulphur isotope values in soil compared to the more sharp delimitations of the underlying bedrock. Comparing $\delta^{34}S$ variations in the Rössberga and Alvastra materials is thus considered both justified and fruitful. Figure 7 illustrates the variation in bone sulphur isotope values, in terms of mean and standard deviations, among the human populations from Rössberga, Neolithic Alvastra and MN A Resmo, respectively. All data points on bone and tooth elements from Alvastra are also included in the figure. Some highly interesting observations can be made from this graph. Firstly, values from Alvastra and Rössberga are hardly coinciding, with the exception of one or possibly two overlapping data points from Alvastra. Secondly, the variation is higher in Alvastra compared to Resmo and Rössberga. But what does this mean?

The Rössberga individuals have such concurrent $\delta^{34}S$ values that the tomb must be perceived as only including members of a highly local community (Linderholm *et al.* 2008). A similar pattern is evident in the bone samples from Resmo. However, it should be noted that at least two of these individuals display deviating molar tooth sulphur isotope values, not included in the graph, indicating a movement into Öland from other regions that took place at a later stage in life (Linderholm *et al.* ms.).

In Alvastra, the comparatively large standard deviation in the bone isotope data can be explained by the low number of samples (n=4), where one sample deviates markedly from the rest. Unfortunately, the remaining Neolithic bone samples did not produce sufficient amounts of collagen for $\delta^{34}S$ analysis. When taking both bone and tooth samples into account, however, the range in values is rather wide. Here, food sources probably emanate from a wider geographical region, which is why several subjects seem to have spent at least early parts of their lives some distance away from the direct vicinity of Alvastra. Several potential scenarios could account for this variation; a higher level of mobility in general compared to the Rössberga population, interaction patterns in terms of, for example, marriage alliances including more distant communities, or sedentary people living their whole lives in other regions. Regardless, this enlarged area of origin and interaction hardly includes the region surrounding Rössberga, since the $\delta^{34}S$ values from Rössberga and Alvastra show very marginal correspondence. In light of the discussion on soil sulphur isotope values presented above, we can assume that the values from Rössberga are more or less representative for the entire southern parts of the Falbygden region. This assumption is strengthened by recently produced isotope data on skeletal material from the Frälsegården passage grave in southwest Falbygden, where $\delta^{34}S$ values are very similar to those from Rössberga and the variation is equally low (Hinders 2011). Further, data from both bone and tooth elements from the same individuals show no variations, which is why the wider geographic representation evident in the early ages of the Alvastra individuals has no correspondence in this community. Only people native to the Falbygden region, with its dense frequency of megalithic monuments, seem to have been buried at Frälsegården. Clearly, something different was happening at Alvastra.

The isolated location of the Alvastra dolmen must be regarded as more or less reflecting a Neolithic reality. Even if, hypothetically, other megaliths were present somewhere east of Lake Vättern, they must have comprised a very rare feature. The Alvastra dolmen, especially when taking into account the dramatic landscape in which it is situated, would have been perceived as a special place, serving as a focal point in the landscape. The significance of Alvastra during the Neolithic is further evident in the emanation of the Pile Dwelling, quite possibly bringing together people from geographically dispersed communities. In light of these aspects, it is close at hand to interpret the diversity in residential patterns among the people buried in the dolmen as reflecting a function of the site as a meeting place for one or several communities from a wider geographical region. That the buried came from different places within a wider region is a plausible scenario given the isotope data, and even more so when taking into account the natural and archaeological context in which the tomb is situated. Alvastra thus might have functioned as a place of meeting, at least in connection with ritual activities of burials and depositions, for several hundred years prior to the construction of the Pile Dwelling.

But what inspired the building of a megalithic tomb in this region in the first place? From a geographical perspective the Falbygden area with its dense frequency of megalithic tombs is the closest, and possibly most likely, source of inspiration and know-how. It is worth noting that in a discussion of Neolithic communication routes Janzon (2009:84) identifies a plausible landing place for journeys on Lake Vättern at Hästholmen only a few kilometres south of the dolmen. This easily accessible low-lying shore has served as a harbour in recent times, and Bronze Age rock carvings of ships have been documented at the site. A highly interesting result from Hulthén's analyses of megalithic pottery is an identified close correspondence between the ceramic assemblages from Alvastra and Rössberga. In part, the two materials are so alike both typologically and technologically that Hulthén assumes a common origin. The tempering with a doloritic rock common in Västergötland but not native to Östergötland suggests that the origin lies west of Lake Vättern (Hulthén 1998:56). Close contacts with the megalith builders at Falbygden can thus be assumed, although none, or only a few, of these people seem to have been buried at Alvastra.

SOME CONCLUDING REMARKS

Ultimately, the picture of Alvastra emerges as a meeting place of long continuity. In a topographically dramatic setting a monumental tomb operated as a central place for the surrounding communities, and now and then a deceased member was granted access. The isolated occurrence of this megalith may have enhanced rather than weakened its significance, leading to the longevity of the monument as a focal point in a sacred landscape that further included the nearby spring mire. Probably actively used simultaneously during the tomb's later stage, the dolmen and the dwelling are perceived as interwoven in terms of occupying the same ritualized space.

Elin Fornander
Archaeological Research Laboratory, Stockholm University
SE-10691 Stockholm, Sweden

Acknowledgements

I would like to thank the EU Sixth Framework programme "Cultaptation" and Helge Ax:son Johnsons stiftelse for financial support. I am further grateful to Heike Siegmund at SIL, Maria Olander and the National Historical Museum.

TECHNICAL APPENDIX

Bone and tooth dentine samples were obtained using a dentist's drill or were pulverised in an agate mortar. Tooth samples were taken from the crown of the tooth. Collagen extraction was carried out following a modified Longin method (Brown *et al.* 1988) including filtration in 30 kDa ultra-filters (see further e.g. Fornander *et al.* 2008). The isotope analyses were performed using a Carlo Erba NC2500 elemental analyser connected to a Finnigan MAT Delta V (carbon and nitrogen isotopes) or Finnigan MAT Delta+ (sulphur isotopes) isotope ratio mass spectrometer at the Stable Isotope Laboratory (SIL), Stockholm University. The precision of the measurements was ±0.15‰ or better for $\delta^{13}C$ and $\delta^{15}N$, and ±0.2‰ or better for $\delta^{34}S$.

REFERENCES

Ahlbeck, M. 2009. Vain quartz? In: Janzon, G.O. *The Dolmen in Alvastra*. Pp. 127–134. Stockholm: Kungl. Vitterhets-, historie- och antikvitets akademien.

Ambrose, S.H. 1990. Preparation and Characterization of Bone and Tooth Collagen for Isotopic Analysis. *Journal of Archaeological Science*. Vol. 17. Pp. 431–451.

Ambrose, S.H. & Norr, L. 1993. Experimental Evidence for the Relationship of the Carbon Isotope Ratios of Whole Diet and Dietary Protein to Those of Bone Collagen and Carbonate. In: Lambert, J.D. & Grupe, G. (Eds.). *Prehistoric Human Bone – Archaeology at the Molecular Level*. Pp. 1–37. Berlin: Springer-Verlag.

Arne, T.J. 1923. Avrättningsplatsen vid Alvastra – en stenåldersgrav. *Fornvännen*. Vol. 18. Pp. 81–84.

Arne, T.J. 1924. Avrättningsplatsen vid Alvastra – en stenåldersgrav. *Fornvännen*. Vol. 19. Pp. 101–105.

Berggren, Å. 2010. *Med kärret som källa. Om begreppen offer och ritual inom arkeologin*. Lund: Nordic Academic Press.

Berggren, Å. & Nilsson Stutz, L. 2010. From Spectator to Critic and Participant: A New Role for Archaeology in Ritual Studies. *Journal of Social Archaeology*. Vol. 10. Pp.171–197.

Browall, H. 1986. *Alvastra Pålbyggnad: Social och Ekonomisk Bas*. Stockholm: Theses and Papers in North-European Archaeology.

Browall, H. 2003. *Det Forntida Alvastra*. Stockholm: Statens Historiska Museum.

Brown, T.A., Nelson, D.E., Vogel, J.S. & Southon, J.R. 1988. Improved Collagen Extraction by Modified Longin Method. *Radiocarbon*. Vol. 30. Pp. 171–177.

Carlsson, A. 1998. *Tolkande arkeologi och svensk forntidshistoria. Stenåldern*. Stockholm: Stockholm Studies in Archaeology.

DeNiro, M.J. 1985. Postmortem Preservation and Alteration of In Vivo Bone Collagen Isotope Ratios in Palaeodietary Reconstruction. *Nature*. Vol. 317. Pp. 806–809.

DeNiro, M.J. & Epstein, S. 1978. Carbon Isotopic Evidence for Different Feeding Patterns in Two Hyrax Species Occupying the Same Habitat. *Science*. Vol. 201. Pp. 906–908.

During, E. 1980. En mellanneolitisk grav från Alvastra. Undersökning av "Sverkergårdens" s.k. avrättningsplats. Unpublished essay. Department of Archaeology and Classical Studies. Stockholm University.

Eriksson, G., Linderholm, A., Fornander, E., Kanstrup, M., Schoultz, P., Olofsson, H. & Lidén, K. 2008. Same Island, Different Diet: Cultural Evolution of Food Practice on Öland, Sweden, from the Mesolithic to the Roman Period. *Journal of Anthropological Archaeology*. Vol. 27. Pp 520–543.

Faure, G. & Mensing, T.M. 2005. *Principles of Isotope Geology*. New York: John Wiley & Sons.

Fogel, M.L., Tuross, N., & Owsley, D.W. 1989. Nitrogen Isotope Tracers of Human Lactation in Modern and Archaeological Populations. In: *Annual Report from the Director of the Geophysical Research Laboratory at the Carnegie Institution of Washington 1988–1989*. Pp. 111–117. Washington: Carnegie Institution.

Fornander, E., Eriksson, G. & Lidén, K. 2008. Wild at Heart. Approaching Pitted Ware Identity, Economy and Cosmology through Stable Isotopes in Skeletal Material from the Neolithic Site Korsnäs in Eastern Central Sweden. *Journal of Anthropological Archaeology*. Vol. 27. Pp. 281–297.

Frödin, O. 1918. Från det medeltida Alvastra. Undersökningarna åren 1916 och 1917. *Fornvännen*. Vol. 13. Pp. 105–198.

Frödin, O. 1923. "Avrättningsplatsen vid Alvastra – en stenåldersgrav". Ett genmäle. *Fornvännen*. Vol. 18. Pp. 183–200.

Hedges, R.E.M., Clement, J.G., Thomas, C.D.L. & O'Connel, T.C. 2007. Collagen Turnover in the Adult Femoral Mid-Shaft: Modeled form Anthropogenic Radiocarbon Tracer Measurements. *American Journal of Physical Anthropology*. Vol. 133. Pp. 808–816.

Hinders, J. 2011. Dödsrikets livshistorier. Artikulerade och icke-artikulerade individer i Frälsegårdens gånggrift i Falbygden. Unpublished essay. Department of Archaeology and Classical Studies. Stockholm University.

Hulthén, B. 1998. *The Alvastra Pile Dwelling Pottery*. Stockholm: Historiska Museet. Lund: Keramiska Forskningslaboratoriet.

Hulthén, B. 2008. *Middle Neolithic Burial Traditions in an Alvastra Ceramic Context. A Ceramological Investigation of Pottery from the Alvastra Dolmen*. Lund: Monographs on Ceramics.

Janzon, G.O. 1984. A Megalithic Grave at Alvastra in Östergötland, Sweden. In: Burenhult, G. (Ed.). *The Archaeology of Carrowmore*. Pp. 361–366. Stockholm: Theses and Papers in North-European Archaeology.

Janzon, G.O. 2009. *The Dolmen in Alvastra*. Stockholm: Kungl. Vitterhets-, historie- och antikvitets akademien.

Krouse, H.R. 1980. Sulhpur Isotopes in our Environment. In: Fritz, P. & Fontes, J.C. (Eds.). *Handbook of Environmental Isotope Geochemistry I, The Terrestrial Environment*. Pp. 435–471. Amsterdam: Elsevier.

Lidén, K. & Angerbjörn, A. 1999. Dietary Change and Stable Isotopes: A Model of Growth and Dormancy in Cave Bears. *Proceedings of the Royal Society of London: Series B*. Vol. 266. Pp. 1779–1783.

Lidén, K. & Nelson, E.D. 1994. Stable Carbon Isotopes as Dietary Indicator, in the Baltic Area. *Fornvännen*. Vol. 89. Pp. 13–21.

Lindberg, T. 2009. Smörkullen – the Forgotten Cemetery: Dietary Studies of a Roman Iron Age Cemetery in Västra Tollstad Parish, Östergötland. Unpublished essay. Department of Archaeology and Classical Studies. Stockholm University.

Linderholm, A., Fornander, E., Eriksson, G., Mörth, C.M. & Lidén, K. ms. Increased Mobility from the Neolithic to the Early Bronze Age – Sulphur Isotope Evidence from Öland, Sweden. Manuscript.

Linderholm, A., Mörth, C.M., Richards, M. & Lidén, K. 2008. A Case Study of Stable Isotopes ($\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$) on Human and Animal Bones from the Passage Tomb at Rössberga in Cental Sweden. In: Linderholm, A. *Migration in Prehistory. DNA and Stable Isotope Analyses of Swedish Skeletal Material*. Stockholm: Theses and Papers in Scientific Archaeology.

Loberg, B. 1999. *Geologi. Material, Processer och Sveriges Berggrund*. Stockholm: Prisma.

Malmer, M.P. 2002. *The Neolithic of South Sweden: TRB, GRK and STR*. Stockholm: The Royal Swedish Academy of Letters, History and Antiquities.

Minagawa, M. & Wada, E. 1984. Stepwise Enrichment of ^{15}N Along Food Chains: Further Evidence ant the Relation Between $\delta^{15}N$ and Animal Age. *Geochimica et Cosmochimica Acta*. Vol. 48. Pp. 1135–1140.

Norrman, J.O. 1964. Vätterbäckenets senkvartära strandlinjer. *Geologiska Föreningens i Stockholm Förhandlingar*. Vol. 85. Pp. 391–419.

Peterson, B.J., Howarth, R.W. & Garritt, R.H. 1985. Multiple Stable Isotopes Used to Trace the Flow of Organic Matter in Estuarine Food Webs. *Science*. Vol. 227. Pp. 1361–1363.

Peterson, B.J. & Fry, B. 1987. Stables Isotopes in Ecosystem Studies. *Annual Review of Ecology & Systematics*. Vol. 18. Pp. 293–320.

Richards, M.P., Fuller, B.T., Sponheimer, M., Robinson, T. & Ayliffe, L. 2003. Sulphur Isotopes in Palaeodietary Studies: a Review and Results from a Controlled Feeding Experiment. *International Journal of Osteoarchaeology*. Vol. 13. Pp. 37–45.

Schoeninger, M.J. & DeNiro, M.J. 1984. Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals. *Geochimica et Cosmochimica Acta*. Vol. 48. Pp. 625–639.

Sealy, J., Armstrong, R. & Schrire, C. 1995. Beyond Lifetime Averages: Tracing Life Histories through Isotopic Analysis of Different Calcified Tissues from Archaeological Human Remains. *Antiquity*. Vol. 69. Pp. 290–300.

Sjögren, K.-G. 2003. "*Mångfalldige Uhrminnes Grafvar.*" *Megalitgravar och samhälle i Västsverige*. Göteborg: GOTARC. Series B. Gothenburg Archaeological Theses.

Skog, G. 2009. The Alvastra Projects Concerning the Pile Dwelling and the Dolmen – An Evaluation of the ^{14}C Datings. In: Janzon, G.O. *The Dolmen in Alvastra*. Pp. 135–137. Stockholm: Kungl. Vitterhets-, historie- och antikvitets akademien.

Wilhelmsson, H. & Ahlström, T. 2009. An Analysis of the Bone Material from the Alvastra Megalithic Tomb. In: Janzon, G.O. *The Dolmen in Alvastra*. Pp. 95–126. Stockholm: Kungl. Vitterhets-, historie- och antikvitets akademien.

Unpublished sources from the Anthropological Topographical Archive (ATA)

Frödin, O. Originalplan med fältanteckningar från undersökningen 13.7–14.7. 1916.

Fürst, C.M. Brev till Frödin den 10 Februari 1918.

Ingvarsson, J. Brev till Riksantikvarien den 28 april 1916. Dnr 53/1916.