A Preliminary Study of Homefield Phosphorus Values at Vatnsfjörður, Vatnsfjarðarsel, and Sveinshús

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A program of coring, soil sampling, and soil phosphorus quantification of homefield deposits was conducted during the 2007 field season to assess the potential for a more intensive study of agricultural management and investment practices in the Vatnsfjörður area. Three farms were selected for the study: Vatnsfjörður, Vatnsfjarðarsel, and Sveinshús. Samples were collected on coring transects running through homefield areas. Soil phosphorus was measured using the Mehlich II extraction and colorometric quantification (Bolender 2006; Terry, et al. 2000). The initial evaluation indicates preserved agricultural horizons and evidence for homefield enrichment at Vatnsfjörður and Sveinshús. Vatnsfjarðarsel has areas elevated phosphorus but patterns of enrichment are significantly different from the two other farms.

Soil Sampling Procedures

Soil samples were collected using an Oakfield hand core with a peat coring tube. The 1¼" diameter coring tube (compared to the standard 13/16"). Soil profiles from core sections were recorded in the field, noting soil type, inclusions, tephra layers, and the presence of any cultural material. Samples were taken from the soil cores based on natural stratigraphy and with respect to tephra layers. Samples were labeled and stored separately for analysis. Core-hole depth was measured against the depth of soil profile recovered in the core section. In general, there was a close correspondence between the

reconstructed core profile and the actual depth of the core hole and in previous investigations a comparison of soil horizon depths between direct measurement in test trenches and extracted cores indicates that in-core soil compression is minimal and that soil profiles reconstructed from cores generally correspond closely to the depth of actual soil horizons (Steinberg 2002). Vatnsfjarðarsel proved an exception where the hummocky field resulted in large void spaces in soil profiles.

Mehlich II Soil Phosphorus Analysis

A Mehlich II based extraction adapted by the Hach Company for field testing was used to determine soil phosphorus levels (Bolender 2006; Mehlich 1978; Parnell and Terry 2002; Terry, et al. 2000). Mehlich II tests were conducted in Laboratory for Archaeological Chemistry in the Anthropology Department at Northwestern University under the supervision of Dr. Cynthia Robin. Phosphorus values are given in milligrams per liter (mg/L) instead of parts per million (ppm). In Icelandic soils the Mehlich II extraction is closely correlated with total phosphorus levels determined by ICP-MS but here the original mg/L are retained to distinguish the test results from phosphorus levels determined by other methods. Linear regression statistics and model for a comparison between Mehlich II and ICP-MS (total digestion) for 40 samples from Langholt (Bolender 2006) are shown in figure 1 and table 1.

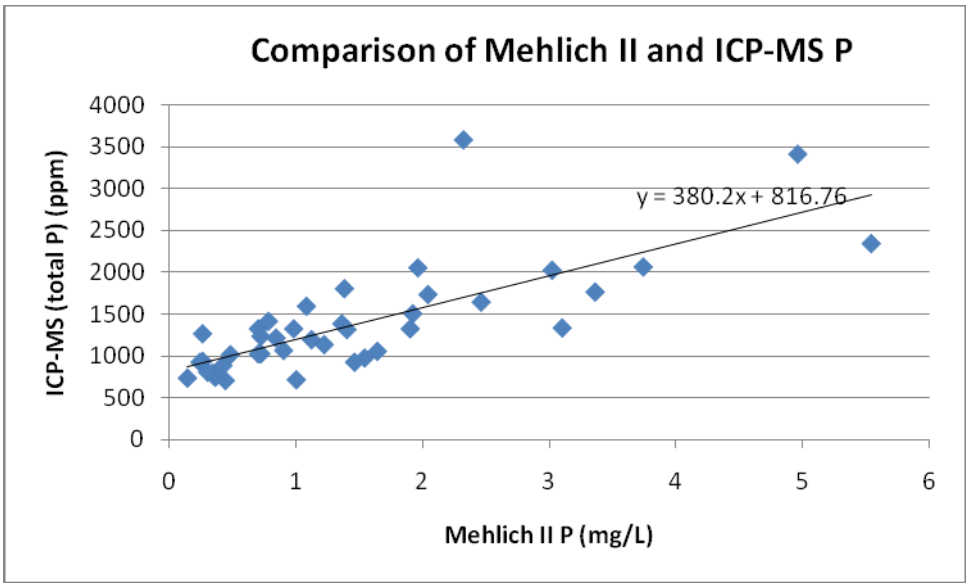


Figure 1. Comparison of Mehlich II and ICP-MS P.

Linear Regression Statistics, Mehlich II P and ICP-MS P	
Multiple R	0.752
R Square	0.566
Adjusted R Square	0.554
Standard Error	427.989
Observations	40.000

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	816.761	104.637	7.806	0.000
Mehlich II P	380.196	54.016	7.039	0.000

Table 1. Linear regression of Mehlich II and ICP-MS P.

Results

The soil samples have elevated phosphorus levels at all of the test sites (table 2). Sample number, mean, and standard deviation are provided for all samples and for samples taken from homefield areas. At Vatnsfjarðarsel the homefield area was determined by the existing boundary wall. At Sveinshús samples from inside farm outbuildings, outside the homefield wall, and unsmoothed areas at the inside edge of the homefield boundary were excluded from the homefield. At Vatnsfjörður coring profiles

that exhibited no evidence for P enrichment at the northeast end of the coring transect were considered to be outside the boundaries of the traditional homefield.

SITE	N	MEAN	SD
Vatnsfjörður (all)	25	0.903	0.798
Vatnsfjörður (homefield)	20	1.519	0.442
Sveinshus (all)	26	1.074	0.526
Sveinshus (homefield)	20	1.194	0.473
Vatnsfjardarsel (all)	17	0.525	0.463
Vatnsfjardarsel (homefield)	15	0.536	0.484
ALL	68	0.878	0.675

Table 2. Summary of Mehlich II phosphorus levels (mg/L).

Vatnsfjörður and Sveinshús have significantly higher P averages than Vatnsfjarðarsel. When considering all samples taken from the two farmsteads they are not significantly different; however, a comparison of homefield samples shows a significant difference between the two farms despite the smaller sample size (table 3). Both Vatnsfjörður and Sveinshús have enrichment patterns consistent with homefield deposits. While Vatnsfjarðarsel has enriched soils and a bounded homefield with better grass cover and deeper soils than the surrounding highland area, the enrichment levels and pattern clearly distinguish it from the other farms. Lower phosphorus levels and spatially inconsistent patterns of soil enrichment were associated with late medieval deposits (ca. AD 1300-1700) in the Langholt study (Bolender 2006) and may represent a late origin to the homefield at Vatnsfjarðarsel in addition to less intensive agricultural practices. The small pilot study demonstrates that significant differences between homefield intensification practices can be identified in the study area.

P(T<=t) two-tail	*Vatnsfjörður*	*Sveinshús*	*Vatnsfjardarsel*
Vatnsfjörður	n/a	0.260 (0.031)	0.000 (0.000)
Sveinshús	0.260 (0.031)	n/a	0.001 (0.000)
Vatnsfjarðarsel	0.000 (0.000)	0.001 (0.000)	n/a

Table 3. T-test of sample means among sampled farmsteads (parenthetical p values based on a comparison of samples taken from homefield areas).

Stratigraphic Reconstruction and Dating of Homefields

The Vatnsfjörður area has one historical tephra layer tentatively identified as the Hekla 1693 eruption (Sigurgeirsson 2005). This layer was present at all of the sampled farms and well preserved at Vatnsfjörður and Sveinshús. While providing limited chronological resolution the presence of the tephra indicates that homefield deposits have limited disturbance despite modern field leveling at the two sites and that a basic agricultural chronology is possible in the region.

Temporal differences in intensification practices were examined in two ways: a regression model of sample depth and sample phosphorus value and a comparison of pre- and post-1693 samples at individual farmsteads. At all farms there was a tendency for soil phosphorus levels to decrease with the depth of the sample. Again Vatnsfjörður and Sveinshús are distinguished clearly from Vatnsfjarðarsel. Vatnsfjörður and Sveinshús share identical slopes in the linear regression model (-0.044 mg/L per cm increase in depth from the surface) although the intercept is higher for Vatnsfjörður corresponding to the higher level of enrichment at the farm (figure 2). At both farms the depth of soil sample significantly affected the phosphorus value and had a strong affect on the regression model (Vatnsfjörður, $r^2 = 0.257$; Sveinshús, $r^2 = 0.321$). These are non-negligible effects and indicate either a real change over time or the possible interference of modern enrichment activity on phosphorus levels in earlier horizons (see discussion below). At Vatnsfjarðarsel there was tendency for phosphorus values to decrease with increasing depth; however, this tendency was not statistically significant ($p = 0.07$) and the effect was marginal.

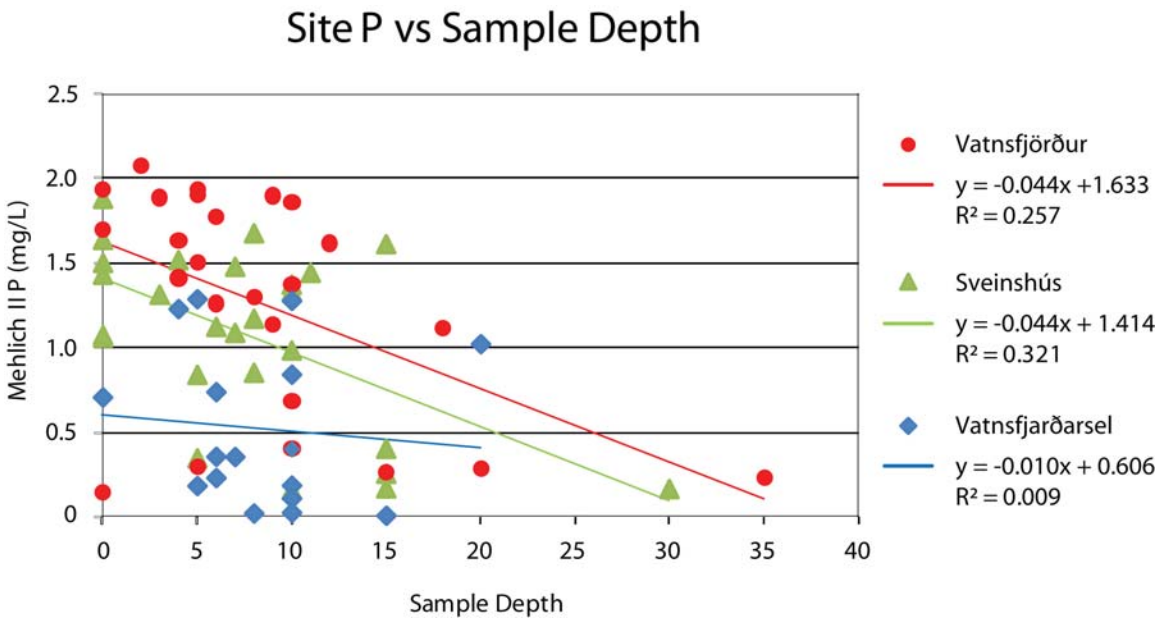


Figure 2. Effect of sample depth on phosphorus value.

Temporal change was also modeled by comparing the pre- and post-1693 samples where stratigraphic information was available. Overall the post-1693 soil horizons had higher P values than the pre-1963 horizons. Although sample sizes were small these differences were moderately significant at individual farms: Vatnsfjörður (p=0.025) and Sveinshús (p=0.073) (table 4). At Vatnsfjarðarsel there were not enough samples with tephra layers to do a stratigraphic analysis.

	All Samples†		**Vatnsfjörður**		**Sveinhús**	
	POST	*PRE*	*POST*	*PRE*	*POST*	*PRE*
Mean	1.584	1.025	1.750	1.264	1.483	1.086
Variance	0.090	0.315	0.054	0.251	0.098	0.140
Observations	14	19	7	9	5	7
Df	29		12		10	
t Stat	3.681		2.569		2.000	
P(T<=t) two-tail	**0.001**		**0.025**		**0.073**	
t Critical two-tail	2.045		2.179		2.228	
† Includes Vatnsfjörður, Sveinshús, and Vatnsfjarðarsel.						

Table 4. T-test of sample means between pre- and post-1693 soil horizons (assuming unequal variances).

One of the most significant complications in quantifying relict agricultural investments is the impact of modern farming activity, specifically fertilization, on phosphorus levels in lower horizons. Previous research in the Langholt region of Skagafjörður showed a diminishing but nonetheless significant effects of modern agricultural activity on buried horizons at a depth of up to 30 centimeters (Bolender 2006) (figure 3). Preserved homefield horizons are shallow in the Vatnsfjörður area. In most cases soil cores only penetrated to 10-20 centimeters before arresting on rocky soils and modern farming enrichment may have a significant impact on medieval agricultural horizons.

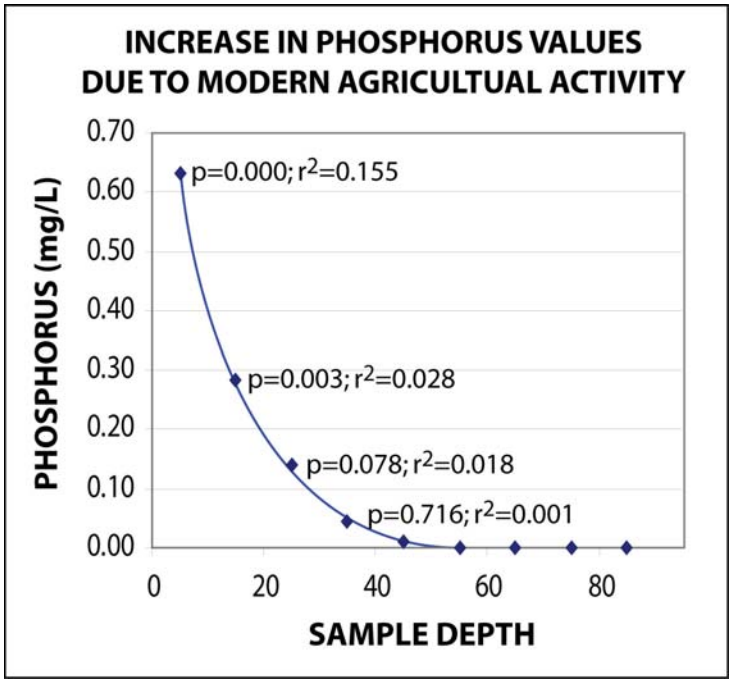


Figure 3. Effect of modern agricultural enrichment on phosphorus values by depth in the Langholt region of Skagafjörður (from Bolender 2006).

Appendix 1: Soil Sample Register and P Values.

FARM	CORE#	SAMPLE#	SAMPLE DEPTH (cm)	MEHLICH II P (mg/L)	HOMFIELD?	HORIZON
Sveinshús	206.01	1.2	8-17	1.678	YES	
Sveinshús	206.02	2.1	3-7	1.315	YES	post-1693
Sveinshús	206.02	2.3	7-10	1.480	YES	pre-1693
Sveinshús	206.02	2.4	10-15	1.333	YES	pre-1693
Sveinshús	206.03	3.1	0-8	1.061	YES	post-1693
Sveinshús	206.03	3.3	8-11	0.853	YES	pre-1693
Sveinshús	206.03	3.4	15-20	0.403	YES	pre-1693
Sveinshús	206.04	4.1	0-7	1.502	YES	
Sveinshús	206.04	4.2	7-11	1.089	YES	
Sveinshús	206.04	4.3	11-14	1.444	YES	
Sveinshús	206.04	4.4	15-20	1.614	YES	
Sveinshús	206.05	5.1	0-6	1.639	YES	post-1693
Sveinshús	206.05	5.3	8-14	1.173	YES	pre-1693
Sveinshús	206.06	6.1	0-8	1.882	YES	post-1693
Sveinshús	206.06	6.3	10-15	1.374	YES	pre-1693
Sveinshús	206.07	7.2	4-9	1.519	YES	post-1693
Sveinshús	206.07	7.4	10-14	0.985	YES	pre-1693
Sveinshús	206.08	8.2	6-10	1.124	YES	
Sveinshús	206.08	8.3	15-20	0.255	YES	
Sveinshús	206.08	8.4	30-35	0.165	YES	
Sveinshús	206.09	9.1	5-10	0.347	NO	
Sveinshús	206.09	9.2	10-12	0.159	NO	
Sveinshús	206.09	9.3	15-20	0.169	NO	
Sveinshús	206.10	10.2	5-10	0.841	NO	
Sveinshús	206.11	11.1	0-10	1.433	NO	
Sveinshús	206.12	12.1	0-10	1.075	NO	
Vatnsfjarðarsel	204.01	1.2	10-15	1.277	YES	
Vatnsfjarðarsel	204.02	2.2	10-15	0.181	YES	
Vatnsfjarðarsel	204.03	3.1	10-17	0.840	YES	
Vatnsfjarðarsel	204.04	4.2	10-15	0.020	YES	
Vatnsfjarðarsel	204.05	5.2	5-9	1.288	YES	post-1693
Vatnsfjarðarsel	204.05	5.4	10-20	0.105	YES	pre-1693
Vatnsfjarðarsel	204.06	6.2	6-10	0.736	YES	
Vatnsfjarðarsel	204.07	7.1	4-7	1.229	YES	post-1693
Vatnsfjarðarsel	204.07	7.3	10-15	0.397	YES	pre-1693
Vatnsfjarðarsel	204.07	7.4	15-20	0.002	YES	pre-1693
Vatnsfjarðarsel	204.08	8.2	6-10	0.352	YES	
Vatnsfjarðarsel	204.09	9.1	8-12	0.016	YES	
Vatnsfjarðarsel	204.09	9.2	20-25	1.021	YES	

FARM	CORE#	SAMPLE#	SAMPLE DEPTH (cm)	MEHLICH II P (mg/L)	HOMEFIELD?	HORIZON
Vatnsfjarðarsel	204.10	10.2	7-11	0.351	YES	
Vatnsfjarðarsel	204.11	11.2	6-10	0.226	YES	
Vatnsfjarðarsel	204.12	12.1	0-5	0.705	NO	
Vatnsfjarðarsel	204.13	13.1	5-10	0.179	NO	
Vatnsfjörður	205.01	1.2	5-10		NO	
Vatnsfjörður	205.02	2.2	5-10		NO	
Vatnsfjörður	205.02	2.3	10-15		NO	
Vatnsfjörður	205.02	2.4	20-25		NO	
Vatnsfjörður	205.03	3.1	0-6	0.143	NO	
Vatnsfjörður	205.03	3.3	10-15		NO	
Vatnsfjörður	205.03	3.4	20-25		NO	
Vatnsfjörður	205.04	4.2	6-12		NO	
Vatnsfjörður	205.04	4.3	15-20		NO	
Vatnsfjörður	205.04	4.4	30-35		NO	
Vatnsfjörður	205.05	5.2	5-10		NO	
Vatnsfjörður	205.05	5.3	15-20	0.258	NO	
Vatnsfjörður	205.05	5.4	35-40	0.230	NO	
Vatnsfjörður	205.06	6.2	5-10	0.290	NO	
Vatnsfjörður	205.06	6.3	20-25	0.281	NO	
Vatnsfjörður	205.07	7.1	3-8	1.886	YES	post-1693
Vatnsfjörður	205.07	7.3	10-15	0.681	YES	pre-1693
Vatnsfjörður	205.08	8.1	4-9	1.412	YES	post-1693
Vatnsfjörður	205.08	8.3	10-14	0.404	YES	pre-1693
Vatnsfjörður	205.09	9.2	6-9	1.776	YES	post-1693
Vatnsfjörður	205.09	9.4	9-12	1.133	YES	pre-1693
Vatnsfjörður	205.09	9.5	12-14	1.616	YES	pre-1693
Vatnsfjörður	205.09	9.6	18-23	1.118	YES	pre-1693
Vatnsfjörður	205.10	10.1	5-9	1.502	YES	post-1693
Vatnsfjörður	205.10	10.3	10-15	1.371	YES	pre-1693
Vatnsfjörður	205.11	11.1	2-7	2.074	YES	post-1693
Vatnsfjörður	205.11	11.3	9-14	1.898	YES	pre-1693
Vatnsfjörður	205.12	12.1	4-9	1.630	YES	
Vatnsfjörður	205.13	13.1	0-5	1.932	YES	
Vatnsfjörður	205.14	14.1	5-10	1.938	YES	
Vatnsfjörður	205.15	15.2	6-11	1.262	YES	
Vatnsfjörður	205.16	16.2	5-8	1.901	YES	post-1693
Vatnsfjörður	205.16	16.4	8-12	1.298	YES	pre-1693
Vatnsfjörður	205.17	17.1	0-6	1.695	YES	post-1693
Vatnsfjörður	205.17	17.4	10-15	1.860	YES	pre-1693

Appendix 2: Coring Locations

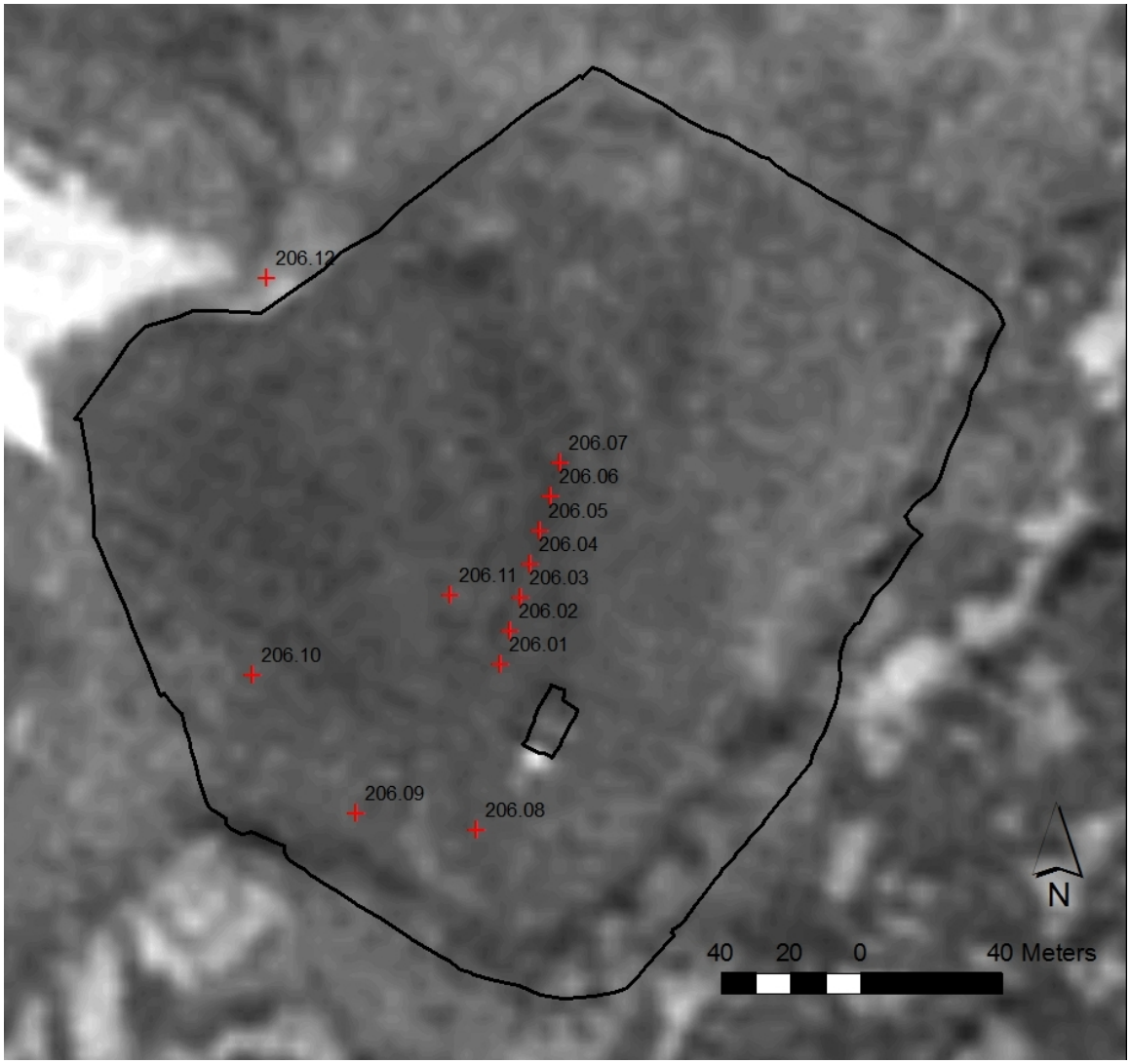


Figure X. Homefield and Coring Locations at Sveinshús.

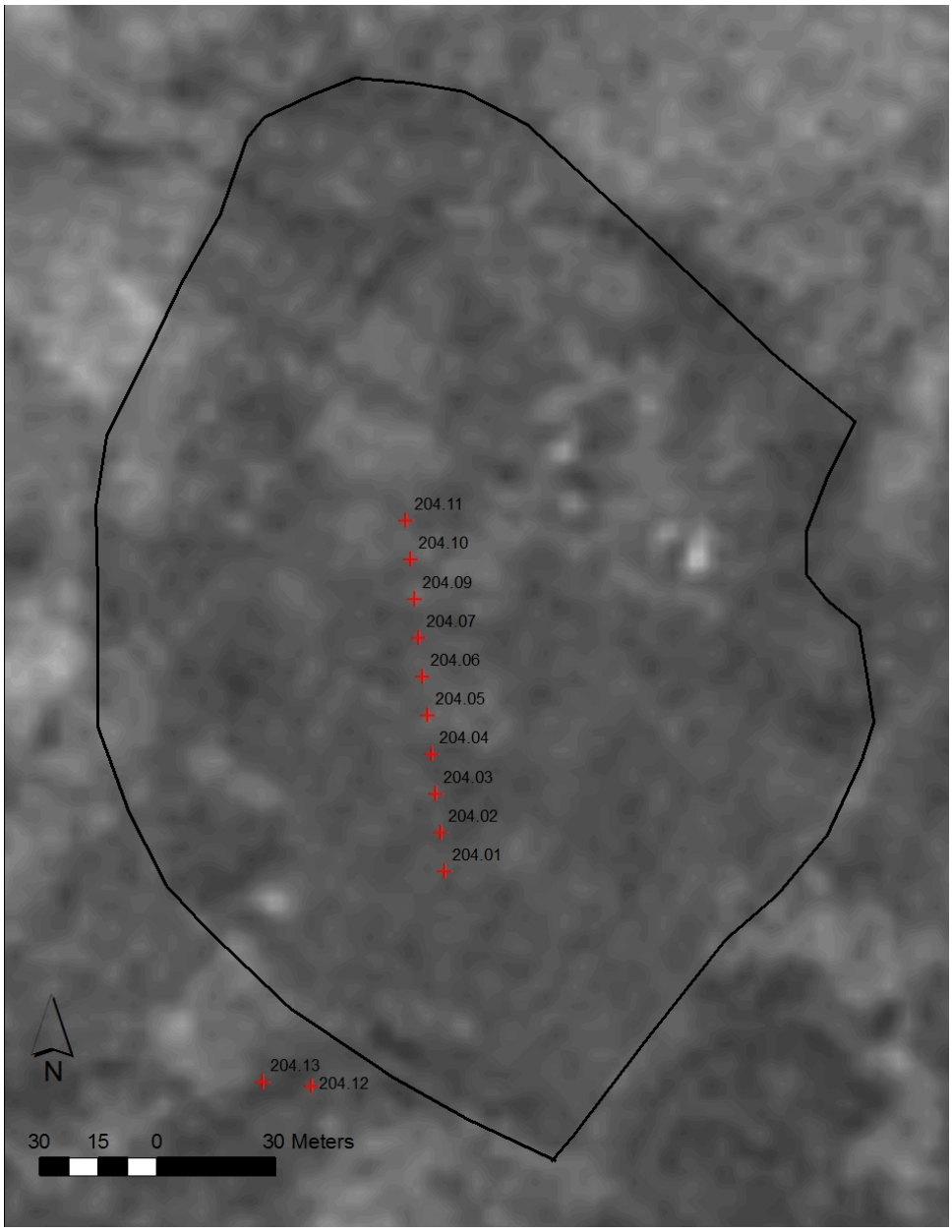


Figure X. Homefield and Coring Locations at Vatnsfjarðarsel.

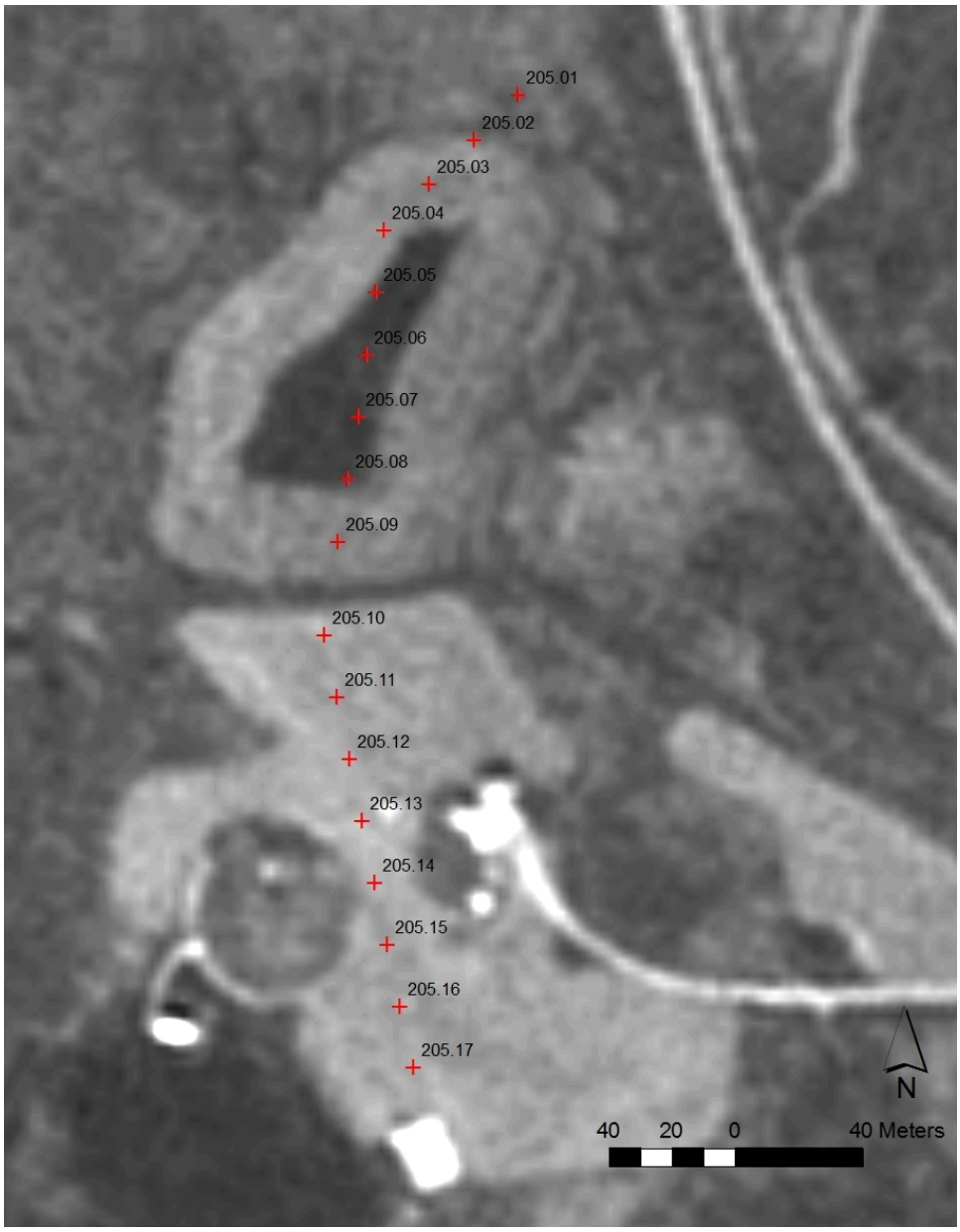
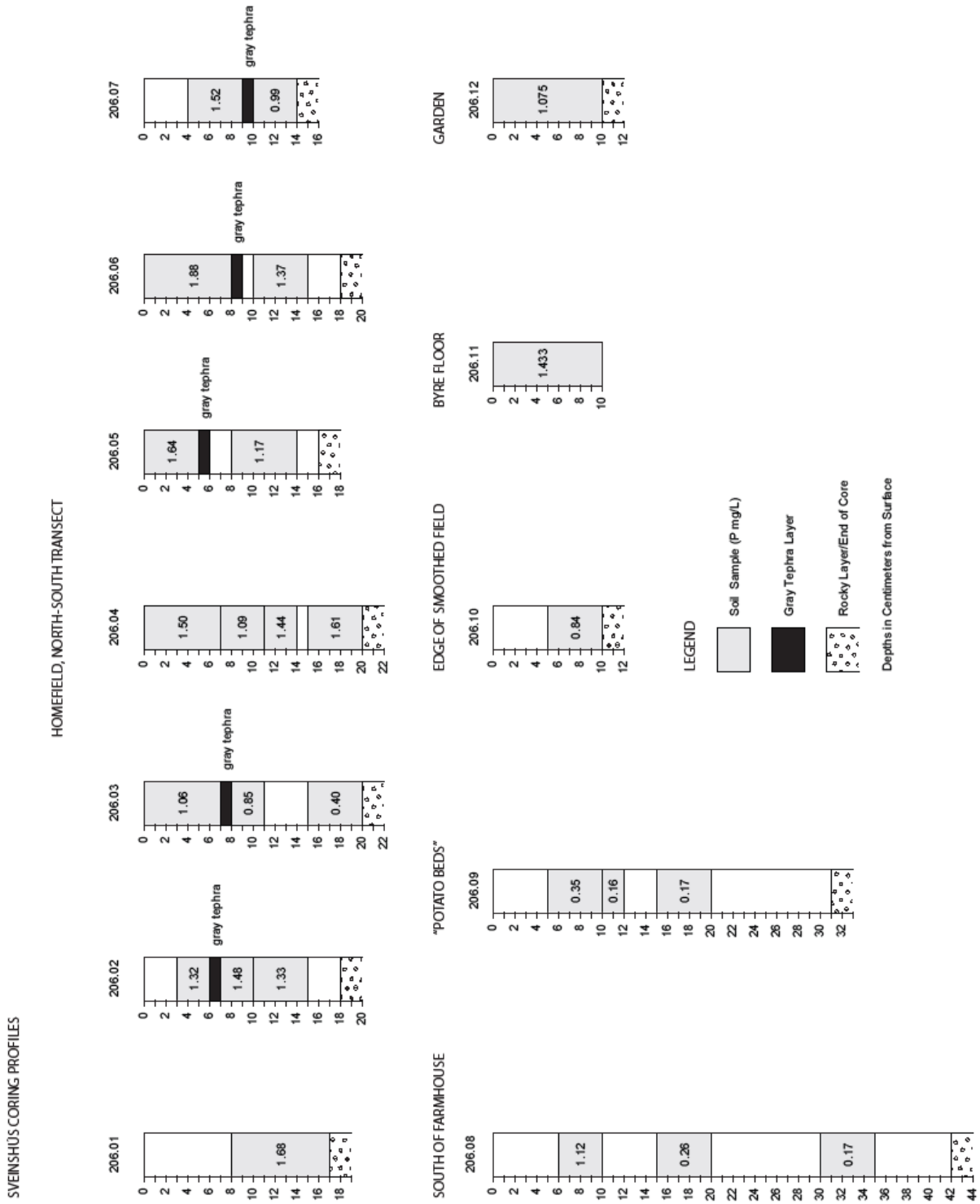


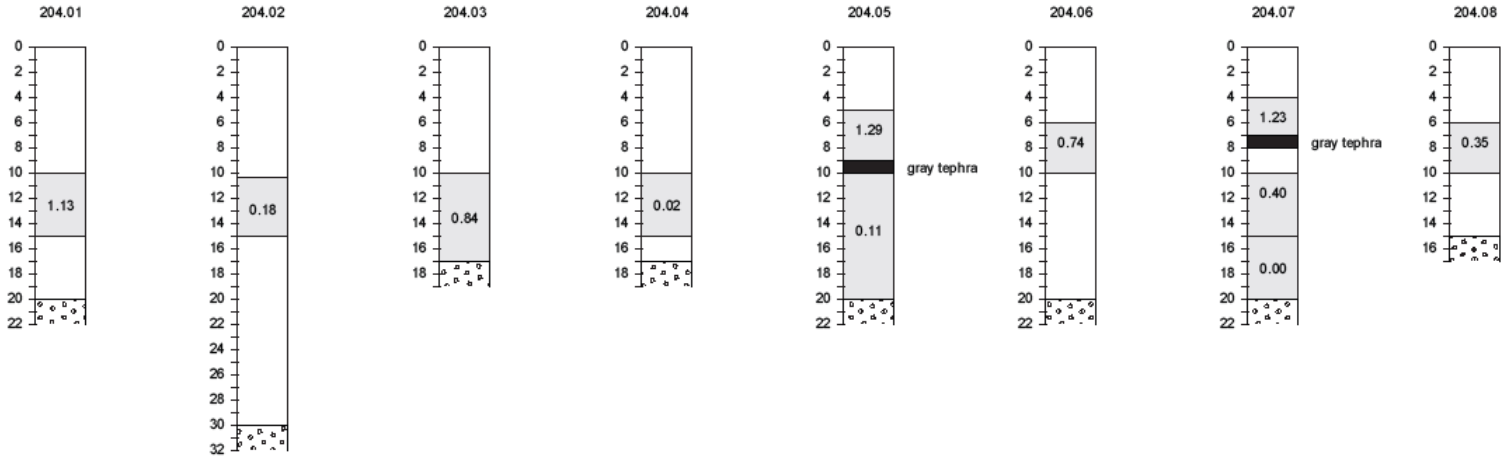
Figure X. Homefield and Coring Locations at Vatnsfjörður.

Appendix 3. Stratigraphic schematic of corign profiles and soil samples.

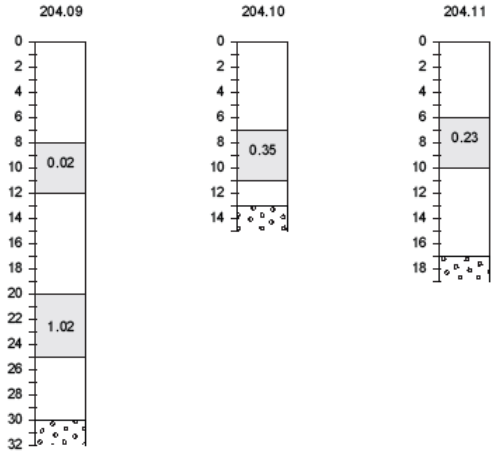


VATNSFJARÐARSEL CORING PROFILES

NORTH-SOUTH TRANSECT

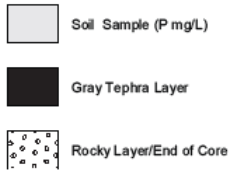


NORTH-SOUTH TRANSECT (CONTINUED)



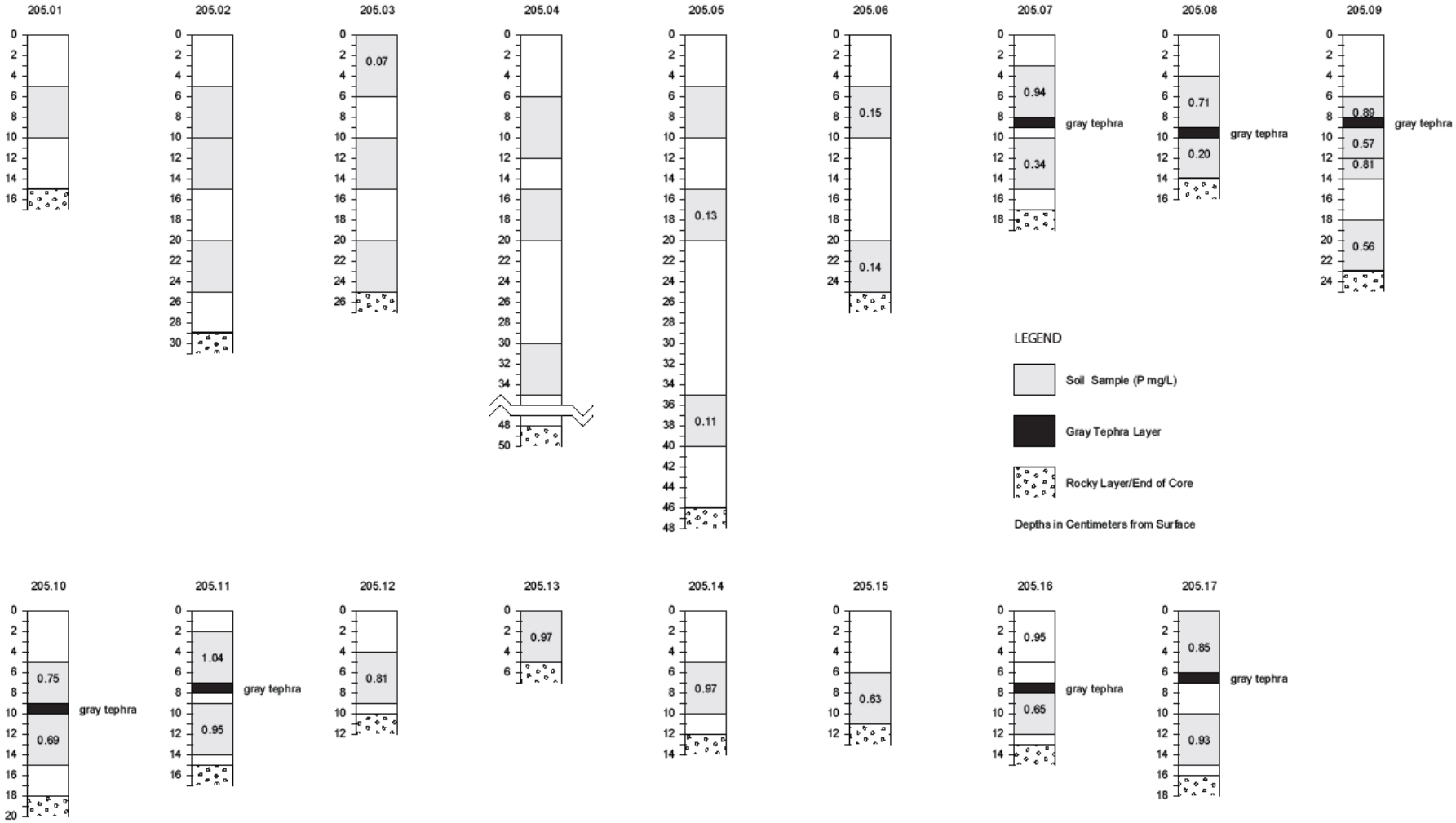
CONTROL SAMPLES OUTSIDE FIELD BOUNDARY

LEGEND



Depths in Centimeters from Surface

VATNSFJÖRÐUR CORING PROFILES



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