Early Medieval/Viking Age Exchange Networks

Cattle Phalanx Gaming Pieces from Turku, Finland

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Abstract

Gaming pieces made from the first phalanges of cattle are relatively common finds in the medieval and post-medieval archaeological record in Northern Europe. A total of 32 worked cattle first phalanges have been recovered from the town of Turku, Finland, in archaeological excavations so far. In this article, we present a new study and interpretation of all known modified cattle first phalanges from the Turku excavation material as well as a comparison with the available ethnographic material. Modified cattle phalanges were recovered from seven archaeological sites across medieval Turku and from areas of various social standing. The results show variability in the modification of the cattle phalanges. Bones could be filled with e.g. wood, lead or an iron nail. Consistencies of metal fills were examined with a pXRF. In this study, X-radiography proved to be an effective method to examine these bones as all details are not visible otherwise. For example, in one bone there is a metal alloy object hidden inside, visible only in X-ray.

Introduction

Animal bones have been used to produce different gaming pieces in the past. One group of relatively common gaming pieces found in the archaeological material are those made from the first phalanges of cattle, anatomically located above hooves in both front and rear legs of cattle. These bones are naturally well suited for game use. They have been easy to obtain as one animal has eight of these bones. They are also small (approx. 50 mm tall), compact and their shape allows them to stand naturally upright. It is therefore not surprising that games using phalanges have been widely spread geographically and their use has survived until recently.

In this article, we present a new study and interpretation of all known modified cattle first phalanges from the archaeological material found in Turku (Sw. Åbo), Finland. Our aim is to analyse the function of the artefacts: can they be interpreted as gaming pieces? Furthermore, we examine whether archaeological material culture can be connected with ethnographic data of cattle phalanx use in gaming. Our method is to focus on the material and cultural aspects of these objects. The cattle phalanges included in this study were first examined through osteological analysis and the age of the animals, possible pathologies and signs of modification and use such as cutting marks or patina were noted. These artefacts were studied with X-radiography (X-ray) and the phalanges with metal filling examined with XRF (X-ray fluorescence) methods to reveal the details of their filling. In addition to the physical characteristics, we studied the archaeological context of the finds and ethnographic examples of games using cattle phalanges to help in interpreting the wider cultural context and the possible continuity of the tradition. This included similar archaeological finds in other regions as well as ethnographic data collected especially from Finland.

Modified cattle phalanges in the archaeological record

Modified cattle phalanges have been identified from archaeological assemblages dating from the Iron Age up to the 17th century from e.g. Finland (Turku), the Åland Islands (Kastelholm), Sweden (Örja, Malmö, Nyköping), Estonia (Tallinn, Viljandi, Lihula), Lithuania (Vilnius), Russia (Novgorod), Denmark (Roskilde), Germany (Rostock, Schwerin, Lübeck), the Netherlands (Amsterdam, Delft, Leiden, Reimerswaal), the British Isles (Orkney, Southampton), and Iceland (Alþingisreit) (Baart *et al.* 1977, 452 ff.; McGregor 1985, 134; Van Vilsteren 1987, 50; Åqvist 1989, 146; Poutiainen 1995, 16 f.; Gläser 2002, 119 f.; Luik 2002, 321, 35, 50; Koskinen 2004, 32 f.; Lehmkuhl & Schäfer 2005; Halonen 2007, 50 f; Blaževičius 2008, 97; Beronius Jörpeland 2010, 11; Schmidt Sabo *et al.* 2013; Lawrence 2014; Luik 2015, 94 f.; Luik *et al.* 2015, 151 f., pers. comm. Albína Hulda Pálsdóttir & Kirsti Pedersen). To make an exhaustive list of these artefacts is beyond the scope of this article, but this review demonstrates that the tradition of using cattle phalanges as gaming pieces was widespread and well known in Northern Europe for a long period of time.

However, even though modified cattle phalanges are a common find group in a wide geographical area, they have been a subject of very limited academic interest.[1] Many of the bones listed above were not initially recognized as gaming pieces. Some have been interpreted as handles of tools, or other toys, and some have not been interpreted at all. The list above includes bones exhibiting various modifications. Some have a decorative motif, some are filled with metal, some have a hole (or holes) and some bear signs of only light smoothing by cutting. Interpretation or classification of these artefacts is not always simple and they do not form a uniform group. In addition, not all modification found in cattle phalanges is related to game use. Phalanges can bear marks of skinning or butchery and they may have served as raw material for other types of artefacts.

Some of these artefacts have been studied in more detail. Baart *et al.* (1977, 452 ff.) have summarized the Amsterdam finds with a reference that these bones were used as gaming pieces. Luik *et al.* (2015, 151 f.) have summarized the Estonian find material with an interpretation as gaming pieces including ethnographic and archaeological comparisons. One cattle phalanx from Orkney has a motif of a standing man, dating perhaps to the Pictish (Iron Age) period (Lawrence 2014). It has been interpreted as a piece from a board game due to its elaborate design. Lead-filled cattle phalanges from Vilnius have been estimated to weigh about 50 g (Blaževičius 2008, 97 f.). This has led to the interpretation that these bones were thrown to hit targets from a ca. 7 m distance. Two of the phalanges have also been X-rayed to expose the lead fill (Blaževičius 2008, 97). Some of the finds from Turku have been examined as part of MA theses or bone reports (from Aboa Vetus: Poutiainen 1995, 16 f.; Koskinen 2004, 32 f., and from Åbo Akademi: Halonen 2007, 50 f.). However, none of these objects have been previously interpreted as gaming pieces.

The variety of games played with phalanges

These artefacts can relate to various types of games, which can be divided into three main categories: games for hitting targets, games for throwing the bones and seeing how they land, and board games. The most common game type associated with the cattle phalanges is a skittles-type of game (Sw. *kasta kota*), where a group of phalanges is standing up (like pins in bowling) and a metal-filled toe bone (or something else, see below) is used to knock them down. Children playing this type of game can be found in the painting called "Children's Games" dating to 1560 by the Netherlandish artist Pieter Bruegel. The elaborate sets of rules and unique vocabulary used in these games have been taken to indicate a long history of the phalanx games (Helanko 1975, 197 f.). Indeed, in light of archaeological finds and ethnographic data, it seems that variants of this game may have been known all over Europe. For example, a Scandinavian version is the Faroese game of *kasta kongar*, where a metapodial bone is used to knock the pin bones over (Jirlow 1931, 127; Göteborgs stadsmuseum 2018). Moreover, the "game of bones" or Bunnock in western Canada is a contemporary variant of the phalanx games using horse bones (*Farm Show Magazine* 1995; Cactus Ventures Ltd. 2018; IBA 2018). It is believed to have originated with the Russian cavalry. The game is still played actively in the area with horse phalanx shaped gaming pieces manufactured of plastic.

Another type of bone game is also seen in Bruegel's painting, using astragali bones from sheep, goat or cattle anatomical ankle (also called knuckle bones). In this game bones are thrown into the air and valued by the way they land. This game has a long history and is also associated with ritual use (De Grossi Mazzorin & Minniti 2013). While not usually associated with cattle phalanges, this type of game called *Päskksiõrr* played with reindeer phalanges is still known in Finnish Lapland among the traditional games of Sami people (MT 23 April 2017). Cattle phalanges have also been connected with a board game called *hnefatafl* (Lawrence 2014).

Playing *babka* – a geographically close ethnographic parallel

In 1975, Rafael Helanko wrote about a Karelian folk game called *babka* that was played with cattle phalanges (Helanko 1975). According to his article, the game of *babka* was well known at the time in the area north and north-east of Lake Ladoga in Olonets (Aunus) and Ladoga Karelia, and west of Lake Ladoga in South Karelia. The game was also known in some areas in Northern Finland, in Kainuu and Lapland (as *paaska*). According to Helanko's informants, the game had been frequently played up until the Second World War, after which it had become less popular. The name of the game, *babka*, is of Slavic origin, and Helanko mentions that it was also known by this name in other areas of the Soviet Union (Helanko 1975, 194).

Helanko explains that in the game, unmodified first phalanges of cattle were placed standing on their proximal end in specific formations and numbers that varied according to the variant of the game that was played. These were called *babka*, or sometimes also soldiers or sheep. These pins were then knocked over by throwing another object at them. This could be a round stone, an oval-shaped metal sheet called *bibka*, a larger phalanx, or a shinbone. The thrower could also be a cattle phalanx that was filled with lead or tin to become heavier. In order to improve the throwing quality of the bone, the tin was sometimes cast so that the metal would stick out from the bone by 1–2 cm. This piece was called *tinapersu*, tin bottom. When the pins were called sheep, the thrower was called a wolf. Sometimes the throwing phalanx could also be filled with small stones.

According to Helanko, the game was played by adult men and juvenile boys. The gaming pieces had value in terms of money, so gambling was an important aspect of the game. The players' throwing turns could be decided by the position in which the thrower landed during a preliminary throw. A player who managed to knock over the opponent's pins would win these for himself. Alternatively, a coin could be placed under each pin, and the player who knocked over the pin would win the coin under it. Throwing turns were important since a skilful player could "clear the table" before others got a chance to play. The gaming piece phalanges were acquired in connection with slaughter taking place at the homestead and more specifically when preparing soup from the hooves. The phalanges would easily come loose from surrounding tissue in the course of cooking the meal. Phalanx bones were also traded. One animal has eight of these bones, so during the time of small-scale household slaughter the monetary value of the pieces did not suffer from inflation.

Material: cattle toe bone finds in their archaeological context

A total of 32 worked cattle first phalanges have been so far identified in archaeological excavation from the town of Turku (Table I, Fig. 1). Turku was the most important town of the eastern part of medieval Sweden, present-day Finland, being the centre of commerce as well as of ecclesiastical and secular power (see e.g. Uotila 2002, 5; Harjula & Hiekkanen 2006; Haggrén 2015, 453). A total of 28 phalanges were recovered from medieval layers, three from mixed layers of uncertain dating, and one has no context information. Thus, none of the bones have a certain post-medieval dating. A total of 25 phalanges were complete or almost complete (over 90% of the bone present) and seven were fragments. These artefacts are not easy to recognize during the excavations due to the low modification rate of the bones. None of the cattle phalanges in our material was recovered *in situ*. Moreover, only ten of them were found during the sieving of excavated soil (nos. 10, 11, 13, 14, 15, 16, 19, 20, 23, 24). The rest of the bones were identified as artefacts only during the osteological analysis of the bone material. Thus, we do not know the exact location of the cattle phalanges within the contexts.

The modified cattle phalanges have been found in various contexts and sites (Table 1, Fig. 1). The Åbo Akademi site with wooden buildings represents an area of craftsmen but the Aboa Vetus and Katedralskolan sites, with stone houses near the market, was inhabited by wealthy merchants as was Itälaituri, their harbour area. Tuomiokirkontori is located near Turku cathedral and likely associated with ecclesial inhabitants. Rettinginrinne, and Kaupunginkirjasto are located on the outskirts of the medieval town area (Uotila 2003; Harjula & Hiekkanen 2006; Majantie 2007, 93 and references there; Pihlman 2007; Seppänen 2012a, 660 ff.; Haggrén 2015, 453

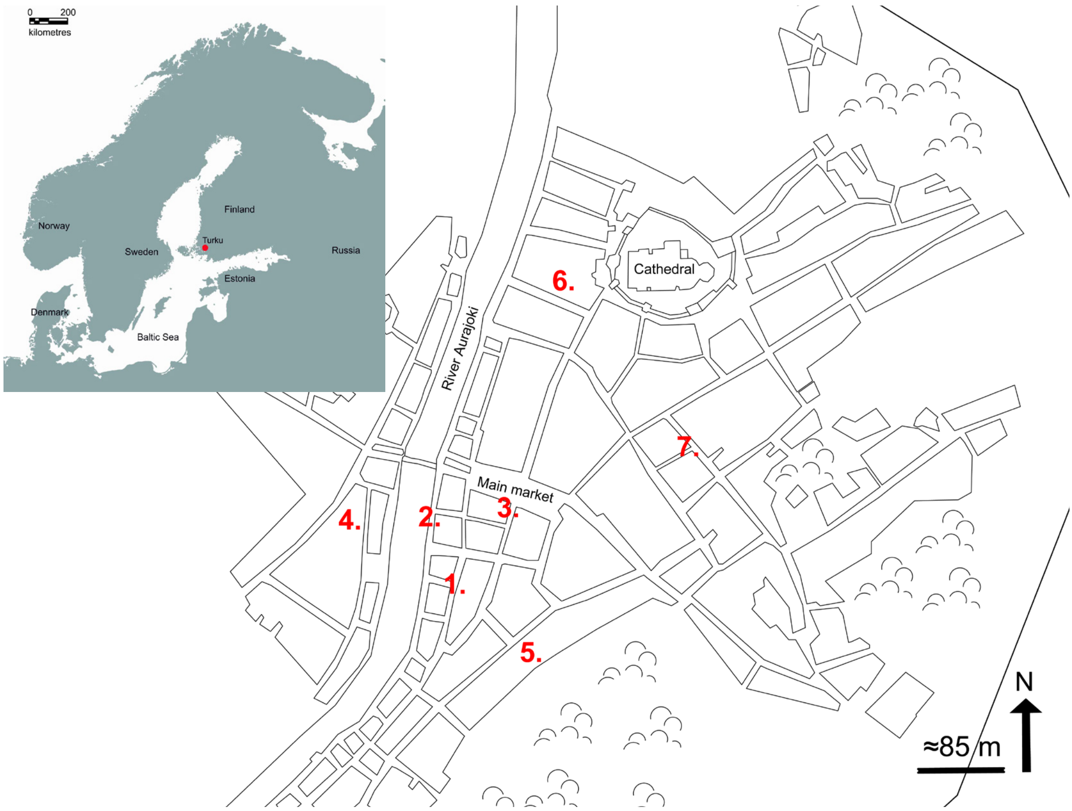

Fig. 1. The locations of the archaeological sites with the oldest map of Turku by Olof Gangius (1634) as background. 1) Aboa Vetus, 2) Itälaituri 2012, 3) Katedralskolan 2014, 4) Kaupunginkirjasto 2004, 5) Rettiginrinne 2001, 6) Tuomiokirkontori 2005, and 7) Åbo Akademi. Map by Sonja Hukantaival.

ff.; Saloranta 2019. Two of the phalanges were found in the bottom of the River Aura in a deposit that has accumulated over time (nos. 10 and 11, Itälaituri). Osteological analysis has been carried out on the bone material found in the context of bone no. 12 (Katedralskolan). The rest of the bone material was interpreted as a midden, with the majority of the bones related to kitchen (cooking and eating) activities. One has ended up in a context interpreted as a cabbage field (no. 13, Kaupunginkirjasto) and another in a possible cultivation or levelling layer with mixed household waste material (pottery, coin, glass) from the medieval period to the 16th century (no. 14, Rettinginrinne). No. 15 was found in a fill of a pit with iron nails, pottery fragments and another bone artefact. Most finds from the Åbo Akademi excavations come from large deposits interpreted as midden deposits, yards or cattle yards with few other characteristics.[2] Most of these layers typically consisted of much decomposed organic matter also containing wood chips, manure and clay, the find material consisting of fragments of pottery, glass and iron objects. Those related to foundations and insulation layers of the floors contained mostly sand (Seppänen 2012, 75 ff.). Osteological analysis has been carried out of the find contexts of artefacts nos.17, 18, 21, 22, 23 and 26–30. The amount of animal bones varies from 15.1 kg (M503E,

Table I. Modified cattle first phalanxes found in Turku archaeological excavations. No: as used in this publication. Epiphysis: F= fused, O= open. Hole: p= prox, d= dist, s= shaft. Smoothing: post=posterior, dist=distal, ant=anterior.

NO	Excavation, Year	Excavation nr	Catalogue nr	Completeness	Epiphysis	Hole	Smoothing	Other working	Patina	Material inside	Dating
1	Aboa Vetus	KM 95032	10917, L1889	Complete	F	p	post			Lump of soil?	Older than 1650
2	Aboa Vetus	KM 95032	10923, L1412	Complete	F	p, s	post, dist, ant	Two grooves			Older than 1827
3	Aboa Vetus	KM 95032	10939, L770b	Complete	F	s			x		Medieval
4	Aboa Vetus	KM 95032	10940, L799	Complete	F	p			x	Wood	Medieval
5	Aboa Vetus	KM 95032	10947, L1836	Complete	F	p		Notch			Medieval
6	Aboa Vetus	KM 95032	10949, L1880	Complete	F	p					Medieval
7	Aboa Vetus	KM 95032	10951, L1865b	Complete	F	p			x	Iron nail, perhaps wedged in place with other non-metallic material	Medieval
8	Aboa Vetus	KM 95032	10955, L 1909	Complete	F	p				Iron nail	Medieval
9	Aboa Vetus	KM 95032	10962, L1831	Complete	F	p				Iron nail	Medieval
10	Itälaituri 2012	TMM22882	LU023:003	Complete	F	p, d					Medieval
11	Itälaituri 2012	TMM22882	LU023:004	Complete	F	p	post		x		Medieval
12	Katedralskolan 2014	TMM23146	LU059:003	Fragment	F	p					Medieval
13	Kaupunginkirjasto 2004	TMM22237	LU325:001	Complete	F	p, s, d					Medieval

14	Rettiginrinne 2001	TMM22196	LU305:001	Complete	F	p					Medieval-17th century
15	Tuomiokirkontori 2005	TMM22367	LU3016:002	Fragment	F	p, s	post			Lead	Medieval
16	Åbo Akademi 1998	TMM21816	LU0691	Complete	F	p	post		x	Metal artefact, Iron nail	Medieval
17	Åbo Akademi 1998	TMM21816	LU0781	Complete	F		post			Lead	Medieval
18	Åbo Akademi 1998	TMM21816	LU1181	Fragment	F		post		x	Iron nail	Medieval
19	Åbo Akademi 1998	TMM21816	LU1201	Complete	F	p, d	post		x		Medieval
20	Åbo Akademi 1998	TMM21816	LU1381	Complete	F	p, s	prox		x		Medieval
21	Åbo Akademi 1998	TMM21816	LU1471	Complete	F	p	prox				Medieval
22	Åbo Akademi 1998	TMM21816	LU1472	Complete	F	p	post, ant			Iron nail	Medieval
23	Åbo Akademi 1998	TMM21816	LU1591	Complete	F		post		x		Medieval
24	Åbo Akademi 1998	TMM21816	LU1692	Fragment	F					Iron nail	Medieval
25	Åbo Akademi 1998	TMM21816	LU1693	Fragment	F	p?, d?			x		Medieval
26	Åbo Akademi 1998	TMM21816	LU5031	Half	F	p	post		x		Medieval
27	Åbo Akademi 1998	TMM21816	LU5042	Half	F	p	post				Medieval
28	Åbo Akademi 1998	TMM21816	LU5043	Complete	F		post				Medieval
29	Åbo Akademi 1998	TMM21816	LU5044	Complete	F		post	Knife marks			Medieval
30	Åbo Akademi 1998	TMM21816	LU5045	Fragment	F	p	prox, post				Medieval
31	Åbo Akademi 1998	TMM21816	LU5131	Fragment	F		post	Two depressions			Medieval
32	N/A		96 (?)	Complete	O	p					

no. 26) to 117.9 kg (M159, no. 23). The bone material consists of household waste mainly from cattle, sheep, goat and pig, with little variation (Tourunen 2008). Some of the bones were found in relation to structures. One was recovered in a demolition layer of a building, possibly in secondary contexts (no 16). One was stratified above or under a wooden yard pavement (no. 18) and two under/beside a fence and a wooden chute (nos. 20 and 31). Unfortunately, as the exact location of these bones is missing, we cannot be sure if they are in real relation to the structures or only recovered nearby. In nine cases phalanges were found in the layer under a building or under a wooden floor (nos. 19, 23–32), but again their excact location is not known. Due to the excavation methods, a similar detailed view of the contexts found in the Aboa Vetus & Ars Nova museum excavations in 1994 is not possible (see Sartes 2003, 78 ff.; Tourunen 2008, 48 ff.). However, most worked phalanges discovered there derive from the cultural layers older than the 15th-century stone houses of which some were demolished and filled in the mid-17th century and some after the fire of 1827 (Sartes 2003, 81; on the dating of the stone houses: Uotila 2003, 126 ff.; 2006, 352 f.; 2007, 25). The animal bone material consists of household waste of similar character to that at Åbo Akademi, but with slightly more elements from trunks and ribs, perhaps indicating a higher status of the site (Tourunen 2008, 135).

Research methods

The osteological analysis methods were limited because of the physical modification of the phalanges. As the bones were not complete, measurements could not be taken. Pathological changes (lipping, eburnation, exostosis) were recorded. In some cases, however, the cutting on the bones might have destroyed any signs of these changes. In addition, epiphyseal status (open, closing, closed) and types of modification (cutting, drilling, smoothing and polishing) and their location in the bone were recorded. X-radiography of the bones was carried out at the Museum Centre of Turku, to enable identification of further details not visible to the naked eye (exception: no. 12, which is just a small fragment, and 28–30, which were identified and added to the research material after the X-rays had been conducted). Furthermore, the portable X-ray fluorescence (pXRF) spectrometer was applied to examine the consistence of the metals attached to the bones. Niton XL3T GOLDD+ analyser of the Museum Centre of Turku was applied as the instrument.

X-ray fluorescence is a widely adopted method for material characterization in archaeology. One of the main reasons for its popularity is the non-destructive nature of the surface analysis (see Shugar & Mass 2012). In the XRF method radiation is used to provide a fluorescence phenomenon in the measured sample. The fluorescence waves typical for each element are then recognized by the detector of the instrument and results are obtained immediately. The detected elements are the ones present in the surface layers of the measured area but the depth of the measurement depends on the density of the object.

It is evident that the quality of the corrosion (influenced by the underground environment) on an artefact affects the XRF readings. Even so, in this study the aim was not to gain quantitative information on the metals used as filling materials for the bone artefacts and therefore it was not considered necessary to use reference materials. This kind of approach was found suitable for the instrument because the portable XRF device gives very reliable results for identification of metals. The Niton pXRF device offers

Fig. 2. Artefacts no. 21 and 22 (right and left, respectively). No. 22 with an iron nail, no. 21 with a hole drilled in the proximal end of the bone. Photo by Auli Bläuer.

different manufacturer calibration modes targeted for several purposes. As the primary goal of this study was to examine the metal additions in the bone artefacts, the General Metal mode was found appropriate. With this mode the small spot calibration gave a chance to allocate every measurement in a 3 mm area in radius. Three readings per object, with 120 seconds measurement time, were carried out during this study.

The XRF method was not originally created for archaeological purposes and so far, XRF studies of medieval objects in Finland are few (see Ratilainen & Kinnunen 2019). As stated above, the bone finds studied here have no detailed find contexts and the original soil layers do not exist anymore for sampling geochemical references. Moreover, the spatial relation to the other finds from the same unit is not known and the contexts do not constitute uniform underground environments. Thus, finding comparable reference for elemental analysis was not applicable. In this study the limitations of the portable XRF method were accepted and the research questions to be solved were kept simple.

Results

All but one of the objects were cattle phalanges from adult animals. The exception is a bone from unknown excavations (the context information has been lost) that derives from an animal under roughly 18 months of age since the proximal epiphysis is still unfused (no. 32, Silver 1969, 285). Bone no. 29 exhibits minor pathological changes, lipping on the proximal epiphysis. The bones were well preserved with shiny, hard surfaces and no surface abrasion. Two of the artefacts (nos. 24, 25) have been heavily gnawed by rodents, which makes identification of modifications challenging.

The modification of the bones was recorded (Table I). The most common modification is a hole made in the proximal end of the bone, present in 23 bones (Fig. 2). The marks on the holes' edges indicate the use of a knife or similar tool to carve the hole. Holes could also be sometimes found in the distal end of the bone or on the shaft. In two bones the holes are rectangular, perhaps made by a large nail (bones no. 3, 19). In one of these (no. 3) there are two holes in the shaft: one on the front and

Table II. Metal parts of the artefacts with iron nails were studied using the pXRF method with a Niton XL3T GOLDD+ analyser. In the tests the General Metals calibration mode was used. The percentage values referred to here are approximates of three individual measurements carried on for each artefact, except in the case of Object ref. 24, where the measurements (1–3) were taken from different parts of the nail surface and listed individually. See appendix for more details. * The measurements for this object had to be taken approximately 3 mm above the metal surface because the tip of the instrument could not reach into the depression at the end of the bone artefact, where the head of the iron nail was visible. This gap can have caused some error to the percentages.

Object ref.	Excavation, Year	Excavation nr	Catalogue nr	Iron (Fe) % (Error)	Other detected elements*	Specific features
7	Aboa Vetus	KM95032	10951, L1865b	96,112 (0,542)	Mo,Cu, Co, Mn, Cr, V, Ti, S, P, Si	
8	Aboa Vetus	KM95032	10955, L1909	77,431 (1,861)	Mo,Nb, Zr, W, Cu, Co, Mn, Cr, V, S, Si	Elevated silica (Si) values:19,289 %
9	Aboa Vetus	KM95032	10962,L1831	97,127 (0,424)	Mo, Co, Mn, Cr, V ,Ti, S, P, Si	
16	Åbo Akademi 1998	TMM21816	LU0691	86,058 (0,341)	Sb, Co, Zn, Cu,Co, Mn, Cr, V ,Ti, S, P, Si	Cu (0,021 %) and Zn (0,034 %) in average
18	Åbo Akademi 1998	TMM21816	LU1181	83,027 (0,382)	Sb, Sn, Cd, Pd, Co, Mn, Cr, V, Ti, S, P, Si	High sulphur value (14,399 %)
22	Åbo Akademi 1998	TMM21816	LU1472	81,823 (0,444)	Sn, Zr, Zn, Mn, Cr, V ,Ti, S, P, Si	* Avarage value of tin (Sn) 7,964 %
24	Åbo Akademi 1998	TMM21816	LU1692	80,802 (0,429)	Zn, Co, Mn, Cr, V ,Ti, S, P, Si	(1.) Measurement taken from the chipped-of surface piece with the corrosion layer consisting 14,76 % phosphorus (P)
24	Åbo Akademi 1998	TMM21816	LU1692	99,408 (0,209)	Mo, Cr, V, Ti, S, P	(2.) Measurement taken from the cleaved nail-head surface without corrosion products
24	Åbo Akademi 1998	TMM21816	LU1692	91,854 (0,249)	Mo, Zn, Cu, Co, Mn, Cr, V, Ti, S, P, Si	(3.) Copper (Cu) and zinc (Zn) were detected as trace elements in the measurement taken from the exposed shaft of the iron nail

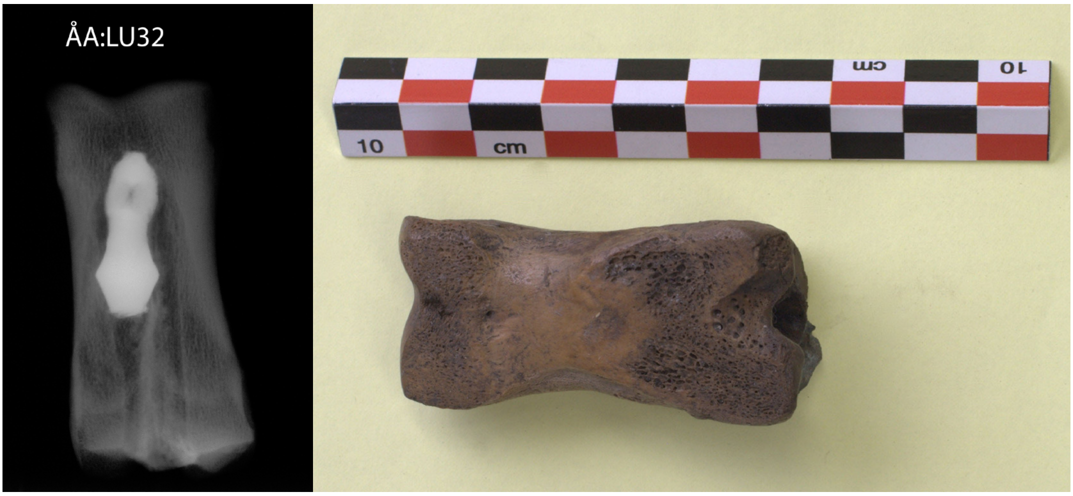

Fig. 3.1 and 3.2. Photograph and X-ray of artefact no. 16. The hidden metal object is only visible in the X-ray. Photo by Auli Bläuer.

the other on the back side of the bone. The holes are not, however, aligned and the other hole is asymmetrical, its edges perhaps broken.

Other types of modifications are also visible on the cattle phalanges. In 15 cases the surface of the bone has been cut in order to make it flatter or smoother. This cutting is most common on the posterior (back) side of the bone, but sometimes also present on the anterior (front side) and proximal or distal ends (Table I). In three cases special marks were made on the bone. In artefact no. 2 there are two shallow grooves carved on both sides of the hole made on the anterior distal shaft of the bone. Artefact no. 5 exhibits a notch on the anterior distal end of the bone. In artefact no. 31 there are two shallow depressions made on the posterior proximal side of the bone. In addition, bone no. 29 exhibits parallel knife marks on the anterior surface of the shaft on the frontal plane. A total of 11 phalanges exhibit a shiny, smooth surface, patina, likely to be a result of repeated handling of the bone (Table I).

Some of the cattle phalanges have additional material inside. These materials were examined visually and with a magnet, by X-radiography and with a pXRF. The pXRF results are divided into two tables according to the metals detected (summary in tables II and III, more complete results in appendices 1 and 2). The results show that visual examination alone is not a sufficient method for determining the possible fill in these artefacts.

In bone number 16 an inserted metal part was recognized during preliminary examination. Since the visible, corroded end of the metal part was not magnetic it was first interpreted as a possible lead fill. However, x-radiography of the object revealed that a pointed metal alloy object is placed inside the bone, near the distal end and wedged on place with an iron nail from the open end of the bone (Fig. 3). In contact with each other, the iron and metal alloy have formed an electro-chemical connection ending up with total rusting of the iron nail as an anode. With pXRF only small amounts of copper (Cu) and zinc (Zn) were traced on the outer surface of the bone artefact. The values are low and can be interpreted as matrix. Thus

Table III. Elemental compositions of the lead-alloy additions in the bone artefacts based on pXRF examination with the Niton XL3T GOLDD+ analyser, using the General Metals calibration mode. See appendix for more details. * Percentages of the other elements are listed in the appendix with values obtained from individual measurements with lowest and highest values of tin.

Object ref.	**Excavation, Year**	**Excavation nr**	**Catalogue nr**	**Lead (Pb) % (min - max)**	**Tin (Sn) % (min - max)**	**Other detected elements***
15	Tuomiokirkontori 2005	TMM22367	LU3016:002	68,189 - 89,207	4,465 -22,452	Sb, Cd, Cr, Zr, Bi, Cu, Ni, Fe, Al, P, Si
17	Åbo Akademi 1998	TMM21816	LU0781	80,05 - 84,413	3,202-9,614	Sb, Zr, Bi, Zn, Fe, Mn, V,Al, P, Si

the specific consistence of the hidden metal alloy object could not be identified with the pXRF-method.

According to the information from the X-ray pictures, there is an iron nail in six additional bones and in two cases there is lead inside the bone. In the initial visual inspection one of the rusted iron nails was interpreted as lead filling. In all cases, the iron nails are put into the bone from the proximal end. In three bones (nos. 8, 9, 18) the tip of the nail also comes through from the distal end and has been bent against the bone. In artefact no. 7 X-radiography showed that some non-metallic material, perhaps a wooden cone, might have been used to wedge the nail securely in place.

In two of the artefacts, no. 15 and no. 17, a lead-containing alloy was found already in the visual examination. In the X-radiography the fill material of artefact no. 17 appears as loose, asymmetrical granules, perhaps some scrap metal, whereas in the fragmented object no. 15 the fill is one solid clump of metal, probably cast inside the bone while the bone was still intact. In bone no. 17 the lead alloy pieces have been put inside through a hole in the middle of the shaft that has resulted from smoothing the shaft by cutting it. In the other bone (no. 15) molten lead alloy has been poured inside through the proximal hole. The conditions for surface examination in both cases were ideal since it was possible to take readings directly from the metal on different sides. A hole in the middle of bone no. 17 was large enough to enable careful removal of two single lead granules to be examined and afterwards put back in place. Artefact no. 15 has a plain metal surface visible due to the fragmented bone part.

Tin was found to be the major cast element with lead. According to the pXRF results the ratio of tin and lead varies substantially within the individual artefacts (Table III, Appendix 2). This is particularly evident with object no. 15, which also seems to have more tin in the cast material, although it cannot be well reasoned because of variation in the readings. The figures are thus not presented as averages of the measurements but as minimum and maximum values of tin and lead. Visual observation of the metal (artefact no. 15) also supports the results, since the cast seems to include clusters of both light and very dark coloured areas. Uneven compositions could be the result of poor or rough cast but part of the explanation can also be the uneven corrosion layer on the surfaces of the objects.

The other seven bone artefacts studied with pXRF all include an iron nail, and the measurements were taken from the parts where the iron was visible, from the head of the nail in most cases (Table II, Appendix 1). These results are averages of three individual tests carried out for each object in all cases, excluding one: artefact no. 24. In the case of the particular item the corroded surface layer of the nail head is disintegrated apart from its place. The cleft surface thus gave opportunity to study iron elements in the bulk of the nail and compare the information with the corroded (loose) surface. Since the object (no. 24) has a fragmented bone part, it was possible to examine the exposed shaft of the nail as well. The elemental variation in the different spots gives more information about the material and the underground environment (trace elements of corrosion products and soil minerals) since all three readings are listed.

Observations on X-radiography revealed that the iron nails from the Åbo Akademi site were in much less metallic condition than the ones from the Aboa Vetus collection. There seemed to be weak correlation between the metallic condition of the iron nail, since two of the better preserved finds gave more than 96% values of iron (Fe) on average. The third Aboa Vetus find had the lowest percentage of iron. This can be explained with the highest rate of silica, which means that there is a substantial amount of soil attached to the surface. All tests on Åbo Akademi finds gave a result of minimum 80% of iron as well. The highest rate of all was detected from object no. 24, where the measured spot under the cleft surface gave more than 99% iron as the result. The elemental variation of the particular reading was also more compact, apparently since it lacked the corrosion layer with attached soil minerals. Copper and zinc were present as trace materials in the shaft of the iron nail belonging to artefact no. 24.

Regarding material findings, the biggest surprise found was tin (Sn) addition in object no. 22, where almost 8% of the metal was detected with no visual evidence of the material. In the X-ray only a heavily corroded iron nail is visible. There is some light material also attached to the nail surface but this seems more likely to be expanded surface layer due to corrosion. The pXRF tests had to be shut with a slight air-gap because the instrument did not quite reach the visible nail surface in the depression of the bone end. However, the tin addition, whether in the surface (or body) of the iron nail or cast in the bone itself, is very likely (Table II).

In addition to the metal fillings, bone no. 4 has a little piece of wood inside the proximal hole and soil inside the cavity. Bone no. 1 has something non-metallic in the central cavity, perhaps a stone or a lump of soil.

Discussion

This study demonstrates the usefulness of a multisource approach – visual examination, X-radiography, X-ray fluorescence, archaeological contextual data and ethnographic data – in studying archaeological composite objects with a long cultural history. The methods used in this study offer the

Fig. 4. Artefact no. 8 in the pXRF analyser. Note the iron nail protruding from the proximal end of the bone. Photo by Auli Bläuer.

possibility to study the cattle toe bone artefacts from different perspectives. Combined together these facts contribute to the interpretation of these objects from their manufacturing methods to their use and cultural meaning.

X-ray fluorescence is useful in more detailed analysis of the fills but is limited to the exposed surfaces of the artefacts. Theoretically, a hidden object could be traced on the basis of elements leached to the surface material, but that would be unlikely. The identification and interpretation of the metals used as weight materials for the gaming pieces clarifies the details of their manufacture. The fills were easily accessible or leftover materials and their use did not require any special skills. In this context, object no. 22 remains an anomaly with the discovered tin addition. Tin plating on iron objects was a typical phenomenon in the medieval context but it also seems unlikely that the iron nail used as a weight needed a shiny surface. Fills could also include other materials than metals. Organic materials such as wood could have been used as wedges to secure the metal weight in place, and as they mainly consist of light elements, they are untraceable with the XRF.

Some of the modified cattle phalanges found in Turku could be interpreted with certainty as gaming pieces. Bones with metal filling (an iron nail, metal object or lead) are throwing bones in a skittles type of game (Sw. *kastben*, Fi. *tinapersu*, *bibka*). Leaving the head of the nail at some distance from the proximal end of the bone is described by Helanko as beneficial for balance. This practice can be observed in the Turku gaming pieces in either the proximal or the distal end of the bone (nos. 7, 8 and 9, Fig. 4). Bone no. 4 with a piece of wood in the proximal hole could be a throwing bone as well, and the piece of wood has been used as a plug or direct source of extra weight. These bones exhibit variety both in the materials used to gain extra weight and in the detail of how the filling was done. Lead filling could be scrap metal pieces or cast inside the object directly. Iron nails are always in the proximal end of the bone, however. The hidden metal alloy object (no. 16) could perhaps be a good luck charm known only by the owner. The other possibility is that the bone was used in cheating. From the outside artefact no. 16 looks just like an ordinary gaming piece with a nail inside. Perhaps that extra weight hidden from the other players gave this bone better throwing properties. The throwing bones sometimes exhibit other modifications as well, such as flattening of the posterior or anterior surface. This might be connected with the position in which the piece would land when throwing turns were decided. Helanko mentions that a throw landing on its "smooth right side" would grant the first turn in the game (unless someone's piece landed standing up, which was so exceptional it was remembered for a long time) (Helanko 1975, 197).

The rest of the artefacts are more difficult to interpret. They share a number of common features with the metal-filled bones – a hole in the proximal end, patina, smoothening of the shaft – which makes them appear as part of the same artefact group. The meaning of the proximal hole without any filling is a subject of interpretation. These bones could be unfinished throwing bones, but their high number makes this interpretation unlikely. Also, some of these bones have patina on them, indicating that they were frequently handled. It is also possible that these bones were filled with something that did not leave traces. Even small amounts of remaining metal should be visible in an X-ray, but wood certainly could have rotted away in certain conditions. Poor organic preservation could thus explain some of the empty holes. However, the preservation of the bone objects themselves is good, making this explanation unlikely. Also, bones with and without an iron nail (but with proximal hole) have been found in the same contexts (nos. 21 and 22, 24 and 25).

Bones with a decorative motif (nos. 2, 5, 31) could be *babkas*, bones that were thrown at. That applies also to other bones with flattening of the proximal end of the bone to make it stand better. However, *babkas* could be also without any decoration or modification. Thus, many of the unmodified phalanges found in the bone material could have been used in the game as well.

Flattening of anterior or posterior sides could also fit into another type of game, where phalanges are thrown in the air and the results are read by the way they fall down. The game is still played with reindeer phalanges in Finnish Lapland (MT 23 April 2017). Flattening one side makes the bone fall easier on that side. Whatever the reason for the flattening, this type is so common in the material that the modification must have had a certain meaning. As it is also found in many of the throwing bones, the reason for it could also perhaps be practical, to remove the remains of strong tendons attached to this side of the phalanx.

A total of 25 of the cattle phalanges found in Turku were recovered from medieval contexts and none are from certain post-medieval layers. It has to be noted, however, that much more medieval bone material has been analysed from Turku than post-medieval material. Also, medieval bone material tends to be better preserved than the post-medieval, and thus the identification of the modified phalanges is easier. Whether these gaming pieces were still used in Turku during the post-medieval period remains uncertain. The game was apparently still played after the Middle Ages, as the dating of gaming pieces from other countries and ethnographic examples demonstrates (see Luik *et al.* 2015, 151 f. for summary). In Finland information about the post-medieval use of the cattle phalanx games comes from ethnographic data from rural contexts, where most ethnographic data was collected. The research paradigm was interested in original forms of folk culture, and these were believed to have preserved better in peripheral areas (e.g. Krohn 1971, 119 ff.). Therefore, we do not have ethnographic information on the later gaming tradition in towns. The cattle phalanx gaming bones in ethnographic collections exhibit no visible modification in the bones, and the metal-filled *kastben* has been replaced by a stone, stick, metapodial bone or metal object shaped like a phalanx (Helanko 1975; Göteborgs Stadsmuseum 2018, Finna-database). Thus, the game tradition itself could have changed into a form that left only evidence that is difficult to identify in the archaeological material: just unmodified cattle phalanges and metapodials with some possible polishing. The data does not allow us to conclude that there was continuity in the cattle bone gaming tradition in Finland from archaeological medieval artefacts to the post-medieval ethnographic data. However, these gaming traditions are likely to belong to the same cultural group of games.

The context of the modified cattle phalanges in Turku is a medieval town area. They seem to be a relatively common find group, as they have been found in most of the major excavations in Turku. Moreover, as these bones are challenging to identify as artefacts due to the low modification rate, more of these artefacts are likely to be present in the unanalysed bone material from the town of Turku, which amounts to several thousands of kilograms. As none of the bones were recorded *in situ*, we lack detailed information on their deposition within contexts. However, most of the bones come from different layers associated with household waste. Two of the artefacts (nos. 24 and 25) from the same context exhibit rodent gnawing marks. This indicates they were discarded or deposited within the reach of rodents. It is possible that some of the bones associated with buildings or structures have been ritually deposited, but the lack of detailed contextual data prevents further interpretations. Modified cattle phalanges found in Turku derive from several different excavations that represent various social settings, from high to low status sites in both central and peripheral areas of Turku. In addition, these bones have previously been identified in the castle of Kastelholm, Åland, and in rural settlement (Örja, Sweden) (Åqvist 1989, 146; Schmidt Sabo *et al.* 2013, 50). Thus, archaeological evidence in Turku is in accordance with previous data that this gaming tradition is part of the widespread part of a medieval cultural tradition common in the Baltic Sea region and beyond.

Conclusions

Gaming pieces made of cattle phalanges are common finds in the archaeological material, but they have been previously often unrecognized. This study has demonstrated the value of combining different approaches (visual examination, X-ray, pXRF, ethnographic and archaeological data) to study material and cultural aspects of artefacts such as cattle toe bone gaming pieces. The bones do not form a uniform artefact group. Bones with metal filling can be identified as gaming pieces. Other similar modified cattle phalanges but without metal fillings are also likely to be game pieces as well as decorated bones. However, the ethnographic collections exhibit game pieces with no evident modification. Several different games may have been played with phalanges and even with similar games the required modification of the gaming pieces and rules may have varied. Thus, identification of the game tradition from the archaeological material might be challenging. This gaming tradition was well known in medieval Turku. This game is one of the cultural aspects Turku inhabitants shared with the neighbouring areas. It is uncertain whether medieval games played in Turku and those recorded in the ethnographic material decades later represent a continuous use of the game. However, they at least share the same common roots of the cattle phalanges gaming tradition.

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Notes

1 Cattle, goat and sheep astragali ("knucklebones") that have been widely used as gaming pieces or in rituals have been previously studied. However, as they belong to separate gaming traditions, their use is not discussed further here.

2 Åbo Akademi excavations were large scale rescue excavations with limited resources. Therefore the site was excavated partly with machinery and contexts could have been mixed in the process (Seppänen 2012, 50 ff.).

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Appendix 1

pXRF examination results on the artefacts with iron nail -additions. The instrument used is a Niton XL3T GOLDD+ analyser. The results were obtained using the General Metals calibration mode with the primary interest to find out how well the rusted metal is possible to identify and check if other weight-materials were used in making the objects. The percentage values cited here are approximates of three individual measurements carried out for each artefact, except in the case of Object ref. 24, where readings (1–3) were taken from different parts of the artefact and listed individually to compare the elements present in the corrosion and burial environment (nos. 843 and 845) with the readings from pure metal surface (no. 844).

Reading No	Units	Object ref.	Sb	Sb Error	Sn	Sn Error	Cd	Cd Error	Pd	Pd Error	Mo	Mo Error	Nb	Nb Error	Zr	Zr Error	W	W Error	Zn	Zn Error	Cu	Cu Error
685	%	7	<LOD	0,016	<LOD	0,014	<LOD	0,014	<LOD	0,014	0,02	0,002	<LOD	0,003	<LOD	0,003	<LOD	0,031	<LOD	0,015	0,024	0,01
669	%	8	<LOD	0,034	<LOD	0,022	<LOD	0,024	<LOD	0,024	0,029	0,003	0,006	0,002	0,009	0,002	0,054	0,026	<LOD	0,02	0,052	0,015
673	%	9	<LOD	0,015	<LOD	0,013	<LOD	0,013	<LOD	0,013	0,02	0,002	<LOD	0,003	<LOD	0,003	<LOD	0,027	<LOD	0,011	<LOD	0,02
832	%	16	0,023	0,01	<LOD	0,021	<LOD	0,017	<LOD	0,018	<LOD	0,004	<LOD	0,003	<LOD	0,003	<LOD	0,038	0,034	0,008	0,021	0,01
838	%	18	0,057	0,012	0,036	0,01	0,026	0,01	0,027	0,011	<LOD	0,004	<LOD	0,005	<LOD	0,003	<LOD	0,046	<LOD	0,017	<LOD	0,032
842	%	22	<LOD	0,043	7,964	0,072	<LOD	0,038	<LOD	0,031	<LOD	0,007	<LOD	0,006	0,016	0,003	<LOD	0,063	0,044	0,018	<LOD	0,049
843	%	24	<LOD	0,041	<LOD	0,022	<LOD	0,024	<LOD	0,024	<LOD	0,005	<LOD	0,004	<LOD	0,004	<LOD	0,04	0,055	0,011	<LOD	0,024
844	%	24	<LOD	0,013	<LOD	0,011	<LOD	0,012	<LOD	0,017	0,005	0,001	<LOD	0,002	<LOD	0,002	<LOD	0,025	<LOD	0,011	<LOD	0,016
845	%	24	<LOD	0,015	<LOD	0,013	<LOD	0,014	<LOD	0,019	0,009	0,002	<LOD	0,004	<LOD	0,002	<LOD	0,026	0,014	0,006	0,051	0,011
Reading No	Units	Object ref.	Co	Co Error	Fe	Fe Error	Mn	Mn Error	Cr	Cr Error	V	V Error	Ti	Ti Error	S	S Error	P	P Error	Si	Si Error		
685	%	7	0,42	0,074	96,112	0,542	0,068	0,022	0,047	0,005	0,024	0,004	0,017	0,005	0,655	0,061	0,206	0,075	2,387	0,125		
669	%	8	1,888	0,105	77,431	1,861	0,4	0,038	0,048	0,007	0,018	0,006	<LOD	0,012	0,747	0,288	<LOD	0,528	19,286	0,564		
673	%	9	0,466	0,067	97,127	0,424	0,081	0,02	0,036	0,004	0,027	0,004	0,018	0,004	0,207	0,04	0,487	0,042	1,511	0,09		
832	%	16	0,273	0,074	86,058	0,341	0,854	0,038	0,049	0,005	0,037	0,005	0,02	0,005	3,639	0,05	7,136	0,087	1,644	0,097		
838	%	18	0,429	0,092	83,027	0,382	0,285	0,036	0,024	0,006	0,024	0,006	0,02	0,006	14,399	0,104	0,317	0,055	1,315	0,085		
842	%	22	<LOD	0,219	81,823	0,444	1,206	0,069	0,053	0,009	0,044	0,009	0,057	0,011	1,264	0,047	6,276	0,111	1,176	0,123		
843	%	24	0,593	0,084	80,802	0,429	1,612	0,055	0,046	0,006	0,027	0,005	0,022	0,006	0,317	0,025	14,763	0,128	1,685	0,127		
844	%	24	<LOD	0,131	99,408	0,209	<LOD	0,036	0,033	0,003	0,033	0,003	0,022	0,004	0,206	0,017	0,216	0,02	<LOD	0,065		
845	%	24	0,266	0,069	91,854	0,249	0,414	0,028	0,053	0,004	0,04	0,004	0,027	0,004	0,673	0,022	5,402	0,073	0,965	0,078		

Appendix 2

Element compositions of the lead-alloy additions in the bone artefacts based on pXRF examination with the Niton XL3T GOLDD+ analyser, using the General Metals calibration mode. Of the two artefacts (Ref. nos. 15 and 17) readings with maximum and minimum values of tin based on the tests are listed below.

MAX Sn Reading No	Units	Object ref.	Sb	Sb Error	Sn	Sn Error	Cd	Cd Error	Zr	Zr Error	Bi	Bi Error	Pb	Pb Error	Zn	Zn Error	Cu	Cu Error
816	%	15	<LOD	0,059	4,465	0,062	<LOD	0,027	<LOD	0,018	<LOD	0,158	89,207	0,359	<LOD	0,015	<LOD	0,018
820	%	15	0,332	0,032	22,452	0,174	0,051	0,021	0,031	0,01	0,512	0,063	68,189	0,327	<LOD	0,022	0,038	0,015
823	%	17	0,064	0,021	9,614	0,099	<LOD	0,031	0,03	0,01	0,167	0,058	80,05	0,34	<LOD	0,018	<LOD	0,023
825	%	17	<LOD	0,041	3,202	0,052	<LOD	0,027	<LOD	0,018	0,11	0,054	84,413	0,336	0,019	0,008	<LOD	0,026
MAX Sn Reading No	Units	Object ref.	Ni	Ni Error	Fe	Fe Error	Mn	Mn Error	Cr	Cr Error	V	V Error	Al	Al Error	P	P Error	Si	Si Error
816	%	15	<LOD	0,039	0,297	0,038	<LOD	0,066	0,055	0,019	<LOD	0,03	0,785	0,326	0,767	0,078	4,316	0,125
820	%	15	0,064	0,028	0,799	0,066	<LOD	0,09	<LOD	0,043	<LOD	0,036	0,821	0,352	3,173	0,101	3,493	0,146
823	%	17	<LOD	0,04	0,581	0,051	<LOD	0,087	<LOD	0,04	<LOD	0,03	0,717	0,318	5,209	0,107	3,45	0,132
825	%	17	<LOD	0,036	1,208	0,058	0,153	0,042	<LOD	0,037	0,051	0,015	0,606	0,292	5,671	0,103	4,504	0,134