

Non-invasive dendrochronological analysis of four book bindings 'Missale Nidrosiense', Norway.

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Fig. 1. 'Missale Nidrosiense' book 4 with the back and front of book 1, ready for CT-scanning at NGI, Ullevål, Oslo (photo Nina Hesselberg-Wang).

Introduction

Non-invasive dendrochronological analysis has proved successful in recent years, both through CT-scanning of oak objects and through analysis of exposed tree-rings on objects, when possible (Bill et al 2012, Daly & Streeton 2017). In this study, four printed books, missals for the church in Norway, have been CT scanned to gain

access to the tree-rings of the oak book-binding boards. This report outlines the results of the analysis.

In order to obtain tree-ring measurements for analysis, the books have been CT-scanned by Heidi Debreczeny Wilkinson at the facility at the Norwegian Geotechnical Institute. Nina Hesselberg-Wang placed the objects upright on a wooden stand (designed by Jan Bill, UiO), and positioned in the scanner in such a way as to optimise the resolution and to enable the maximum number of tree-rings to be visible (figs. 1 and 3). The object rotates slowly and the X-ray images are then compiled into a 3D model through the object. Virtual cross-sections of the object (figs. 2 and 4) can then be extracted for tree-ring measurement. Measuring was carried out from these images using the program Able Image Analyser, and for the analysis and the calculation of the t -value ("t-test"), the programs "DENDRO" (Tyers, 1997) and "CROS" (Baillie & Pilcher, 1973) are used. An extensive network of master and site chronologies for Northern Europe were consulted to find the dating for the tree-ring series. To estimate the felling dates of the oak trees that were used for the boards a sapwood average for Northern Poland (15 years (-6 +9) (Wazny 1990)) is used.

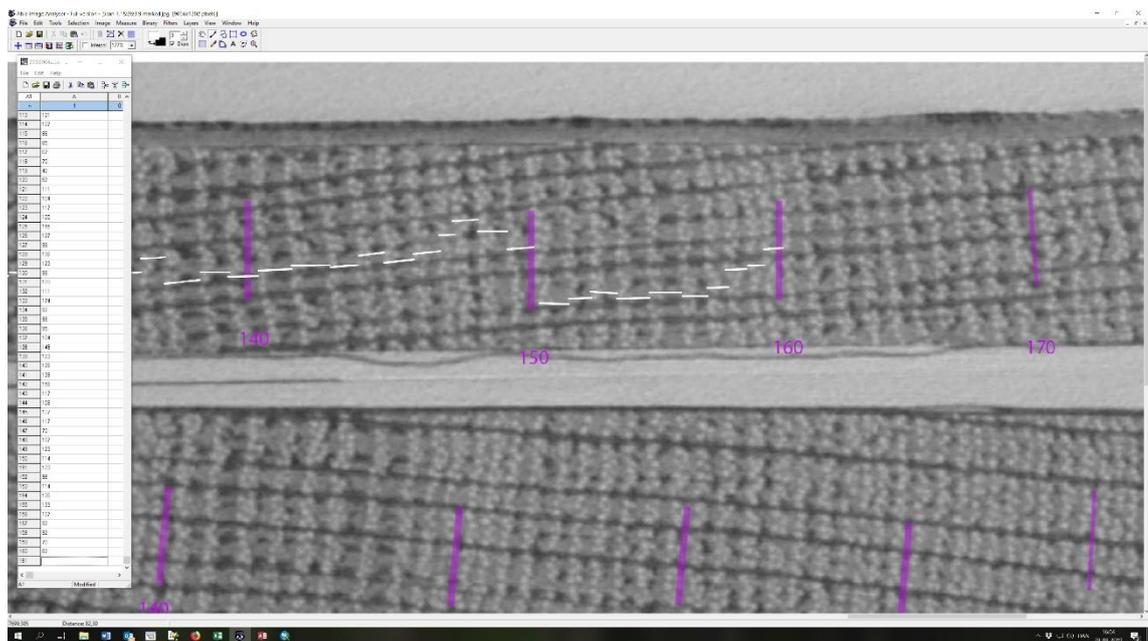


Fig. 2. 'Missale Nidrosiense' book 1. A virtual section through the wood clearly shows the oak tree-rings (image produced at NGI, Oslo; markings Aoife Daly).

Book 1

The two boards of book 1 were no longer attached to the book so these could be placed alongside book 4 for the scanning (fig. 1). The scans did not reach the full width of the boards, so an unknown number of inner and outer tree-rings are not measured or counted. Both boards are radially converted from the parent tree. Board 1 (Z256004a) has 213 measured rings while board 2 (Z256003a) has 230. The correlation between the tree-ring curves of these two boards are so similar, both statistically ($t = 16.93$) and visually, it is most probable that they are manufactured from the same tree.

The tree-ring curves are dated. The outermost measured tree-ring is on board 2, and it was formed in AD 1476. No remains of sapwood have been observed. Allowing for missing sapwood we can estimate that the tree for the two boards for book 1 was felled after AD 1486 (see fig. 5).

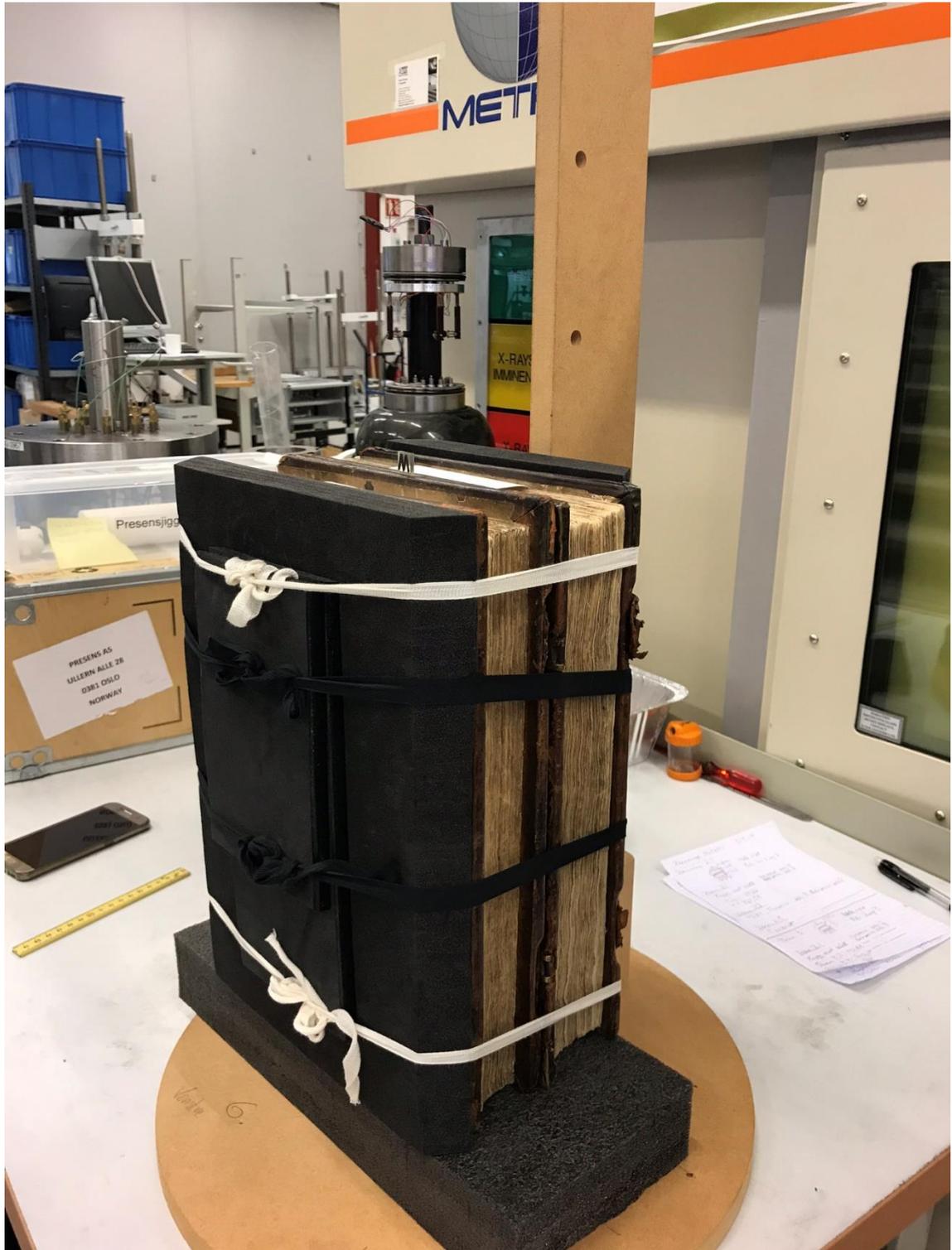


Fig. 3. 'Missale Nidrosiense' books 2 and 3, ready for CT-scanning at NGI, Ullevål, Oslo (photo Nina Hesselberg-Wang).

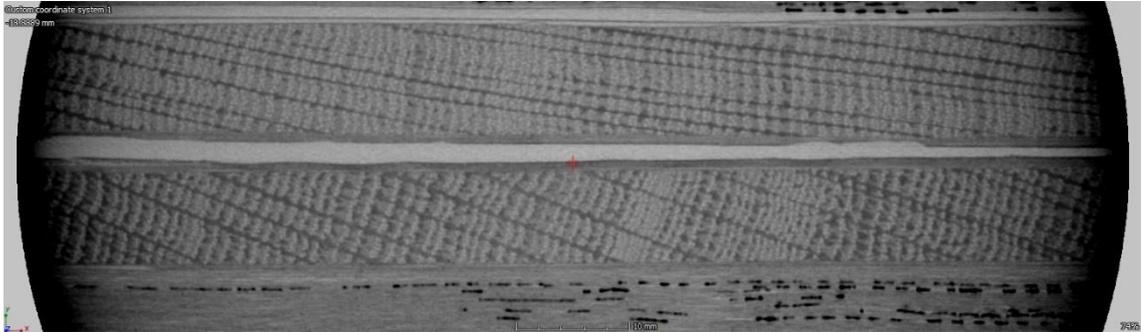


Fig. 4. ‘Missale Nidrosiense’ books 2 and 3. A virtual section through the wood clearly shows the oak tree-rings (image produced at NGI, Oslo).

Book 2

The two boards of book 2 were scanned alongside book 3 (fig. 3). The scans reach the outer edge of both boards, but no sapwood is observed. Both boards are tangentially converted from the parent tree. The back board (Z2560069) has 125 measured rings while the front board (Z256008a) has 198.

The tree-ring curves are dated. The outermost measured tree-ring is on the front board, and it was formed in AD 1452. Allowing for missing sapwood we can estimate that the tree for the back board was felled after AD 1452 while that for the front was felled after AD 1462 (see fig. 5).

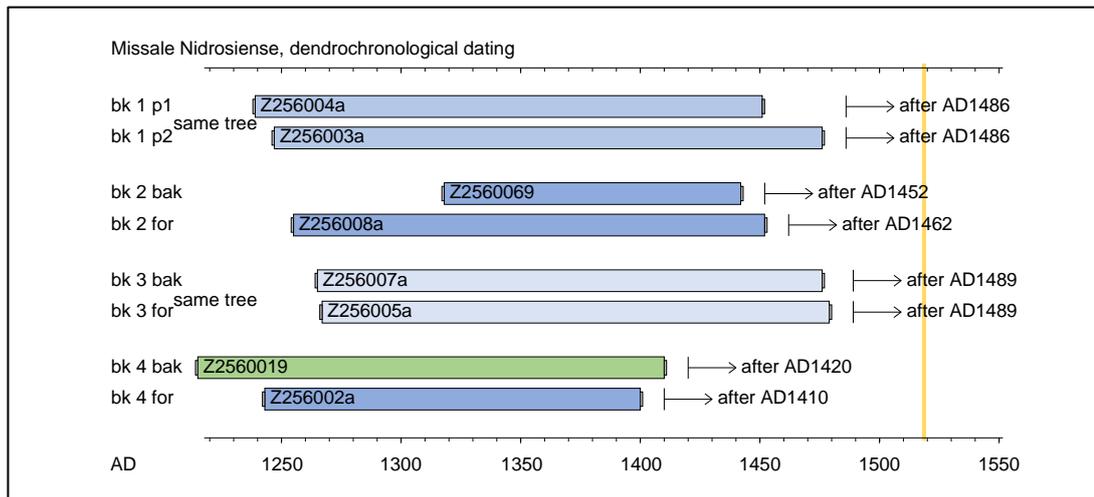


Fig. 5. ‘Missale Nidrosiense’. The diagram illustrates the chronological position of the dated wood elements. The blue and green shading corresponds to the highlighting in tables 1 and 2. The yellow vertical line marks the date of the printing of the books – AD 1519 (illustration Aoife Daly).

Book 3

The two boards of book 3 were scanned alongside book 2 (fig. 3). The scan of the front board (Z256005a) reaches the outer edge while that of the back board (Z256007a) misses just the very outer edge. No sapwood is observed. Both boards are tangentially converted from the parent tree. The front board has 213 measured

rings while the back board has 212. The correlation between the tree-ring curves of these two boards are so similar, both statistically ($t = 15.53$) and visually, it is most probable that they are manufactured from the same tree.

The tree-ring curves are dated. The outermost measured tree-ring is on the front board, and it was formed in AD 1479. No remains of sapwood have been observed. Allowing for missing sapwood we can estimate that the tree for the two boards for book 3 was felled after AD 1489 (see fig. 5).

				Z2560019	Z256002a	Z256003a	Z256004a	Z256005a	Z256007a	Z2560069	Z256008a
		Book 4 back	Z2560019	*	2.66	2.94	2.44	3.43	3.88	3.66	1.04
Average Z256M001		Book 4 front	Z256002a	2.66	*	5.97	5.79	6.92	6.28	5.83	3.81
	Same tree	Book1 p2	Z256003a	2.94	5.97	*	16.93	5.91	7.68	6.73	4.02
		Book 1 p1	Z256004a	2.44	5.79	16.93	*	7.06	7.17	7.16	5.13
	Same tree	Book 3 front	Z256005a	3.43	6.92	5.91	7.06	*	15.53	7.11	6.54
		Book 3 back	Z256007a	3.88	6.28	7.68	7.17	15.53	*	6.8	7.35
	Book 2 back	Z2560069	3.66	5.83	6.73	7.16	7.11	6.8	*	7.42	
	Book 2 front	Z256008a	1.04	3.81	4.02	5.13	6.54	7.35	7.42	*	

Table 1. 'Missale Nidrosiense'. Result of the correlation (t -value) between the tree-ring curves from each board with each other.

Book 4

Book 4 was scanned alongside the two loose boards of book 1 (fig. 1). The scans do not reach the outer edge of these boards. No sapwood is observed. Both boards are tangentially converted from the parent tree. The back board (Z2560019) has 196 measured rings while the front board (Z256002a) has 158.

The tree-ring curves are dated. The outermost measured tree-ring is on the back board, and it was formed in AD 1410. Allowing for missing sapwood we can estimate that the tree for the back board was felled after AD 1420 while that for the front was felled after AD 1410 (see fig. 5).

Provenance

The tree-ring curves from the boards from the four books cross-match with each other as shown in table 1. A strongly correlating group can be defined including seven boards, representing five trees (highlighted in blue). These are averaged to form a mean curve (Z256M001) of 241 years in length.

In table 2 the correlation values (t -values) between this average curve and a selection of Northern European chronologies are shown. The material is dating strongly with Southern and Eastern Baltic oak tree-ring datasets.

The back board from book 4 (Z2560019) falls outside the clear group (highlighted with green). This board is also dating with Southern and Eastern Baltic datasets, but it might be from a tree that grew in a different area to the trees in the main group.

As many of the Baltic tree-ring chronologies are built from oak that was exported to Western Europe, it has not as yet been possible to say where, precisely, that these trees grew in the extensive Southern Baltic region. In the extensive corpus of dendrochronologically analysed oak, used as supports for fine art and for ecclesiastical sculpture in the c. 15th to 17th centuries, it is possible to distinguish between different groups of the Southern Baltic timber, (named Baltic 1, Baltic 2 and Baltic 3 (Hillam & Tyers 1995)) and these groups most probably represent forests in different areas within the region. The strong correlation of the book boards with recently built chronologies for oak from Klaipeda, however, allows the suggestion that this material is from trees from Eastwards in the region, rather than from the Southern Baltic.

Filenames	-	-	Z2560019	Z256M001	
-	start	dates	AD1215	AD1239	
-	dates	end	AD1410	AD1479	
Site and master chronologies					
klaipeda-oak	AD1247	AD1552	4.14	11.09	Klaipeda (Puckiene pers comm)
BALTIC1	AD1156	AD1597	6.74	9.91	Baltic 1 64 timbers (Hillam & Tyers 1995)
Memel Klaipeda	AD1288	AD1580	-	7.44	Memel Klaipeda (Brazauskas 2006)
P802001m	AD1209	AD1401	-	6.14	Poland Krupy (Wazny pers comm)
vilnioak	AD1202	AD1530	3.73	6.02	Vilnius Castle oak 20 timbers (Puckiene pers comm revised Daly unpubl)
PP111M01	AD1136	AD1399	-	5.92	PL Gdansk St Nikolaus 11 timbers (Wazny pers comm revised Daly 2007)
StJM2	AD1342	AD1514	-	5.86	St Jakobs Church Riga 12 timbers (Zunde & Daly unpubl)
PP106M01	AD1110	AD1399	-	5.76	PL Gdansk Parc.6 14 timbers (Wazny pers comm revised Daly 2007)
P676001m	AD1084	AD1393	-	5.61	Poland Kolobrzeg (Wazny pers comm)
PP118M01	AD1112	AD1399	-	5.59	PL Gdansk various 31 timbers (Wazny pers comm revised Daly 2007)
PP122M01	AD1006	AD1359	-	5.11	PL Elblag 114 timbers (Wazny pers comm revised Daly 2007)
PP133M01	AD1111	AD1408	-	5.08	PL Puck Kirche 9 timbers (Wazny pers comm revised Daly 2007)
cesis_c4	AD1398	AD1536	\	4.93	Cesis Castle Cesu pilseta Latvia (Zunde pers comm)
0628002M	AD1225	AD1445	4.70	3.45	Torun Joh. K. (Wazny pers comm)
Ship chronologies					
Z2261M01	AD1098	AD1522	8.85	8.53	Køge ship planks 18 timbers (Daly 2019)
Z2261M03	AD1264	AD1537	5.09	7.47	Køge ship double planks 7 timbers (Daly 2019)
00751M01	AD1113	AD1463	7.56	6.96	Vejdyb ship 14 trees (Daly 1997)
Z084M001	AD1152	AD1437	4.12	6.15	Skaftö wreck barrels 9 timbers (Daly 2013)
Chronologies from Baltic exports					
stirlingdoorsM1	AD1270	AD1524	3.16	8.21	Stirling Castle doors 10 timbers (Crone pers comm)
H11EOM01	AD1260	AD1495	5.20	7.06	Bordesholmer Altar 10 timbers (Hamburg Uni revised Daly 2007)
Z002M002	AD1121	AD1391	-	5.79	Avaldsnes cog Norway 4 timbers (Daly 2004)
Z054m001	AD1235	AD1448	5.76	5.46	Ostsee VII planks 5 timbers (Daly 2010)

Table 2. 'Missale Nidrosiense'. Result of the correlation between the average curve Z256M001 and the tree-ring curve Z2560019 and diverse Northern European site and master chronologies. The source of the chronologies is given. The grey tone highlights the high *t*-values.

Discussion

It has previously been shown that CT scanning as a non-invasive technique for dendrochronological analysis is a very viable technique, when suitable equipment and settings are used (Bill et al 2012; Daly & Streeton 2017). In the case of this study the images produced for tree-ring analysis were of a clarity that allowed confident reliable tree-ring measurement, resulting in successful dating of the oak in all four books.

In terms of the wood used for the books the resulting dating and provenance determination indicate that the majority of the boards might be seen as a homogeneous group. Perhaps the blue group represents a single shipment. Where we see that both boards in two of the books come from the same tree, we might envisage that the raw material was a longer board that the book binder sawed into two identical halves.

It is a period where we see extensive trade of Baltic timber to western Europe, especially of long, straight boards and planks of knot-free oak, so the provenance of the wood does not indicate where the binding of the books might have taken place.

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Catalogue

Filename	sample title and number	rings	start yr.	end yr.	pith	sapwood	bark?	Conversion	extra end	Average ring width (mm.)	Interpretation / felling
Boards											
Z2560019	Missale Nidrosiense CT bok 4 bakperm QUSP	196	AD1215	AD1410	F	0	N	T	H1	1.14	after AD1420
Z256002a	Missale Nidrosiense CT bok 4 forperm QUSP	158	AD1243	AD1400	G	0	N	T	H1	1.08	after AD1410
Z256003a	Missale Nidrosiense CT bok 1 perm 2 QUSP	230	AD1247	AD1476	G	0	N	R	H1	0.97	after AD1486
Z256004a	Missale Nidrosiense CT bok 1 perm 1 QUSP	213	AD1239	AD1451	G	0	N	R	H1	1.04	after AD1486
Z256005a	Missale Nidrosiense CT bok 3 for perm QUSP	213	AD1267	AD1479	G	0	N	T	H1	1.07	after AD1489
Z2560069	Missale Nidrosiense CT bok 2 bak perm QUSP	125	AD1318	AD1442	G	0	N	T	H1	1.29	after AD1452
Z256007a	Missale Nidrosiense CT bok 3 bak perm QUSP	212	AD1265	AD1476	G	0	N	T	H1	1.06	after AD1489
Z256008a	Missale Nidrosiense CT bok 2 for perm QUSP	198	AD1255	AD1452	G	0	N	T	H1	1.11	after AD1462
Same tree											
Z256003&4 st	Missale Nidrosiense CT bok 1 perms 1&2 QUSP	238	AD1239	AD1476	G	0	N	R	H1	0.99	after AD1486
Z256005&7 st	Missale Nidrosiense CT bok 3 both boards same tree QUSP	215	AD1265	AD1479	G	0	N	T	N	1.06	after AD1489
Averages											
Z256M001	Missale Nidrosiense CT 5 timbers QUSP	241	AD1239	AD1479						1.08	
Conversion: R = radial split plank, T = tangential plank, W = whole timber, S = squared whole timber, H = half timber, Q = quarter timber, O = other conversion. Pith: C = centre, V = less than 5 rings, F = 5 – 10 rings, G = greater than 10 rings.											
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