Formation of St. John's Hill, Gruczno, Poland

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Abstract: The lower Vistula valley has provided an important trading route between the Baltic and the interior of Europe since the Neolithic. In antiquity east-west crossing places were few but at Gruczno, where the river was fordable, religious sites were established on hills on opposite sides of the bank. At Gruczno, this developed into a fort on top of St. John's Hill, and then the surrounding settlement seen today grew around it. There has been much discussion about the extent of anthropogenic modification of the hill at Gruczno due to its unusual shape. Investigations have shown that the hill is a natural feature largely formed by fluvial processes, including river capture, with limited anthropogenic intervention.

The Vistulan (Weichselian) ice sheet reached as far south as central Poland. Upon its retreat, a layer of sandy till, 50-100 m thick, covered the area north of the Berlin - Warsaw spillway. Into this, the lower part of the River Vistula has cut a channel, 10-20 m deep and of varying width (3-7 km), forming the present day flood plain, north to the Baltic Sea (Niewiarowski, 1990); the till now forms low plateaus on each side of this wide valley. Adjacent to Gruczno (Fig. 1) the river was fordable and allowed development of an important intersection between an east-west overland trade route and the River Vistula, which formed part of the amber trade route south from the Baltic. Here hill forts were constructed on two hills on the opposite banks. At Gruczno, the hill of St. John developed as a settlement site, down the hill and around the hill fort, and this eventually formed a Christian parish (Cholewscy, 2005). Although the archaeology of the hill was investigated in the early 20th century, the records were destroyed in the war and post-war investigations have concentrated on the hill fort. The unusual shape of St. John's Hill has been a source of discussion as to its formation and the extent of its anthropogenic modification.

St John's Hill

The hill forms a rounded elongated body trending NNE–SSW, decreasing in height from about 75 m a.s.l. at its SSW end down to below 50 m at its NNE end. The northern half has a rounded profile, while its southern end widens with steep slopes on the south-

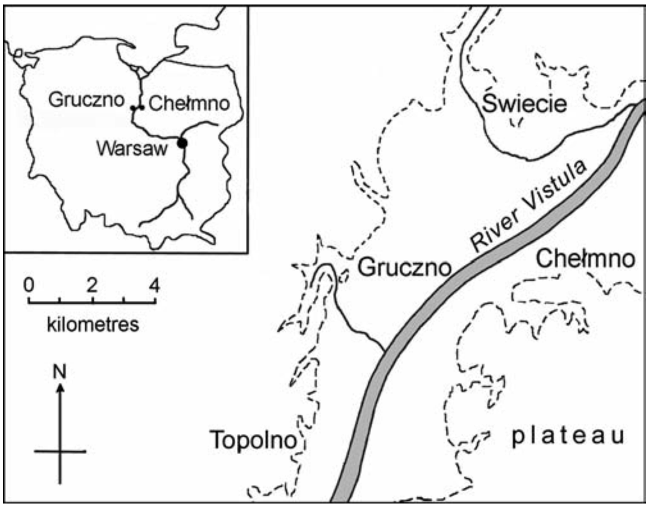

Figure 1. *Location of Gruczno in the lower Vistula valley.*

***Figure 2**. St. John's Hill, its hill fort and the village of Gruczno seen from the WNW. Dworcowa Street curves left of the hill and into the main village, while Młynska Street passes in front of the hill and into the wooded glen. The New Quarry had not been dug when this picture was taken. (From Cholewscy, 2005)*

west end. The flat top contains a semi-circular structure, enclosing a dished area that was the site of a wooden hill fort, in use until the 12th century (Fig. 2). The steeper slopes are obscured with trees, but there is a strong break of slope between the steeper fort side and the hill slope discernable on Figure 2.

Modern drainage is by a small stream, with tributaries shortened by post-glacial permeability, from the west of Gruczno, with elongation of the drainage basin parallel to the Vistula valley. The main stream flows east-south-east, before turning south around the western side of St. John's Hill, and then southeast across the alluvial fan and into a regulated course across the flood plain to the Vistula (Fig. 7c).

Geological Sections

The Old Quarry to the north of Dworcowa Street (Fig. 3 and Fig 7c) has cliffs exposing sandy till that is typical of the area; it has some evidence of stratification with a series of sandy horizons about 3 m from the base. The top part appears to show poorly sorted sand and gravel lenses, with some evidence of possibly cryoturbated deposits near the top.

The New Quarry at the NW corner of St. John's Hill, at the corner of Dworcowa and Młynska Streets (Fig. 3) is not accessible, due to an uncooperative owner, and is now obscured by buildings. The visible part of the N-S section (Fig. 4), comprises weakly stratified, sandy material. The left (north) part is capped with about a metre of a darker material above a distinct iron horizon. This may represent an anthropogenic deposit since it is thicker and abuts against the thinner soil horizons that are more common in the area. There is an in-filled channel feature, to the right, which may be natural, cutting into material that may have been contorted by natural processes. The return of the quarry face at its southern end, along a roughly W-E line shows near-horizontal stratification of sandy seams in the lower part of the till; these are truncated by the slope of the hill, but the west end is overlain by a thin wedge of slope debris marked by an iron-stained horizon.

On Dworcowa Street, near the New Quarry entrance, sand from excavated fence-post holes contained fragmented root casts (sample GT/PL.3).

A small exposure on the WSW corner of St. John's Hill (Fig. 3), sampled in 1996 (GT/PL.5), showed mid-grey-yellow, bedded sands with pale orange-brown horizons that were gently inclined.

Spring sapping with resulting cliff collapse was seen at Topolno, about 5 km south of Gruczno (Fig. 5). Groundwater flowing through the sandy till bluffs has undermined the cliff, resulting in collapse and cliff retreat. Within the till, sandy horizons, dipping gently to the south (seen as dark lines in Figure 5) probably assisted southerly sub-surface flow due to their higher permeability. Similar horizons are exposed within the till in the Old and New Quarries.

The Sands and their Interpretation

Statistical analysis of grain size distribution can be used, with other evidence, to determine possible origins of sediments. In cumulative frequency diagrams the accumulation of grain sizes, "% coarser", is plotted against the actual grain size measured on probability paper. This format is used because this matches most sediment distribution (Briggs, 1977). The steeper the graph the better sorted the sediment, the extreme being wind blown particles, and the most poorly sorted are usually glacial tills.

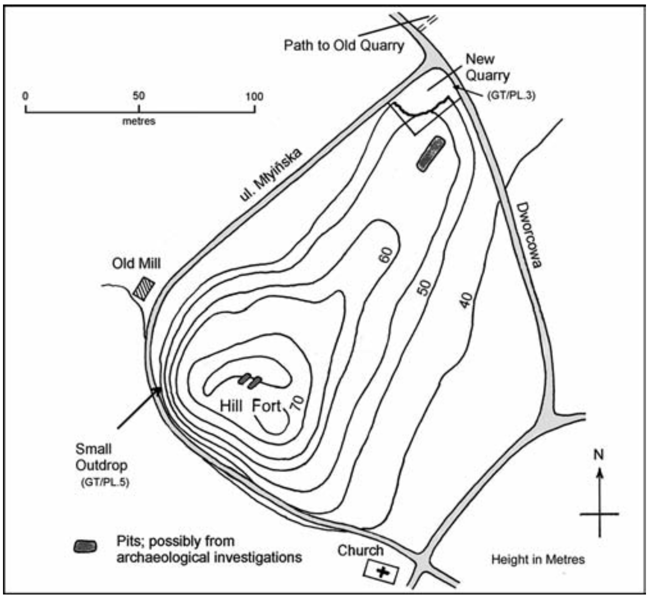

***Figure 3**. Sketch map of St. Johns Hill. Heights in metres.*

***Figure 4**. The new quarry N-S section cut into the NW corner of St. John's Hill; North is to the left. The upper dark layer to the left may be anthropogenic, and the channel infill lies to the right*

Figure 5. Spring sapped bank collapse at Topolno, 1995

There is some variation in the tills forming this part of the plateau (Fig. 6a). Aspects of this variation have been described elsewhere (Mojski, 1995). Sample GT/PL.1 contained pebbles of limestone which influence the multi-modal frequency distribution curve. Sample GT/PL.4 contained only a trace of limestone. Sample GT/PL.2 showed a slight bimodal frequency distribution, but is well sorted, and GT/PL.3 is similar (Fig. 6b). All the limestone in sample GT/PL.3 was authigenic, associated with the calcified root casts, and was removed prior to grain analysis.

The glaciofluvial nature of the till sample (GT/PL.4) (Fig. 6a), is seen elsewhere, at Topolno. Fluvial interbeds, possibly associated with sub-glacial streams, are distributed widely within the tills of this region. North of Gruczno, outwash terraces and a sandur are described by Drozdowski (1990) and Niewiarowski (1990) respectively.

The multi-modal distribution of GT/PL.2 probably reflects accumulation from variable flows, and its high carbonate content suggests a possible strong input of material from the bluffs to the west which are rich in limestone pebbles (GT/PL.1 in Table 1). The mono-modal distribution of GT/PL.3 suggests a non-variable fluvial deposit within the Dworcowa Valley gap, which later became vegetated.

	Location	*Date*	*Grain analysis*	*Limestone content*	*Origin*
1	Near top of plateau	June 1992	mainly sub-angular. some sub-rounded	pebbles, lmst forms ~60% grains 0.25-0.50mm	mainly glacial
2	Alluvial fan	June 1992	sub-rounded to sub-angular	~50% lmst, grains corroded	fluvial
3	New Quarry NW corner	June 2007	well polished sub-rounded	authigenic casts around rootlets	fluvial
4	Old Quarry	June 2007	sub-angular	trace	glacial or glaciofluvial
5	St. John's Hill SW corner	July 1996	sub-rounded some frosting	none	aeolian

***Table 1**. Sampled sediments, with locations, analyses and deposition modes; sample numbers are prefixed with GT/PL.*

Previous work by Niewiarowski (1990) suggested that the Vistula valley in this area had formed prior to the last glacial stage, possibly within the Older Dryas (Dimlington Glacial) and the Allerød (Windermere) Interstadial periods, though modified in the Younger Dryas (Loch Lomond Stadial). During the Allerød, large amounts of melt-water would have flowed off the bluff sides, and assisted by spring sapping from large amounts of sub-surface water from the sandy tills, supported by permafrost water tables, would have easily carved short channels, forming alluvial fans at their mouths. Many short channels exist to the north near Grudziądz (Drozdowski, 1990).

The village of Gruczno is located on alluvial fans that afforded a relatively dry settlement site. One fan, with Gruczno's church close to its apex, was fed by discharge through the Młyńska Channel, and the other lies below the Dworcowa Channel; each channel is now traced by a street of the same name.

The Dworcowa Channel

The lower gradient off St John's Hill towards the north, and the higher elevation of the Dworcowa gap compared to the Młyńska gap, suggest that the former was the original main channel, which was fed by outwash discharge and which cut much of the valley to the west. Palaeocurrent directions in the in-filled channel and other deposits in the New Quarry may confirm this. In which case, the low northerly gradient off St. John's Hill reflects the original valley profile, which has been destroyed by later spring sapping on the north side of the Dworcowa Channel valley (Fig. 7c). Reduced flow, may have resulted in vegetation developing on fluvial sand banks within the gap - the deposits seen near the New Quarry entrance. If dating of the Vistula formation is correct, this dry phase was probably the Younger Dryas. If the contorted deposits in the New Quarry are the result of cryoturbation, then this would confirm that the valley was already cut by the time of the Younger Dryas.

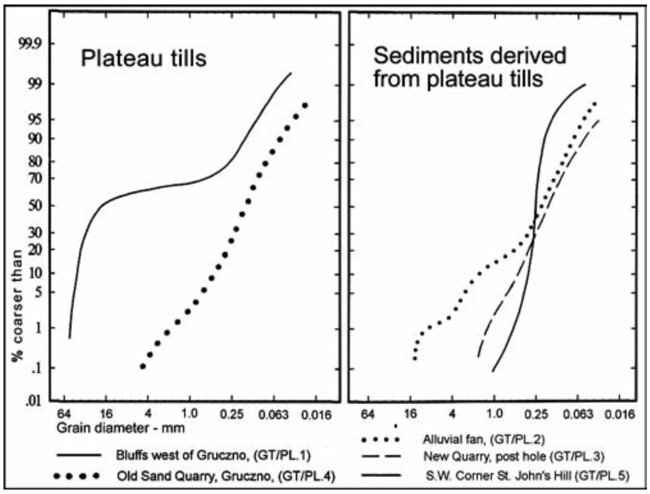

***Figure 6**. Cumulative frequencies of grain sizes within sampled sediments. The tills show variation in sorting, and are distinct from sediments reworked from the local till.*

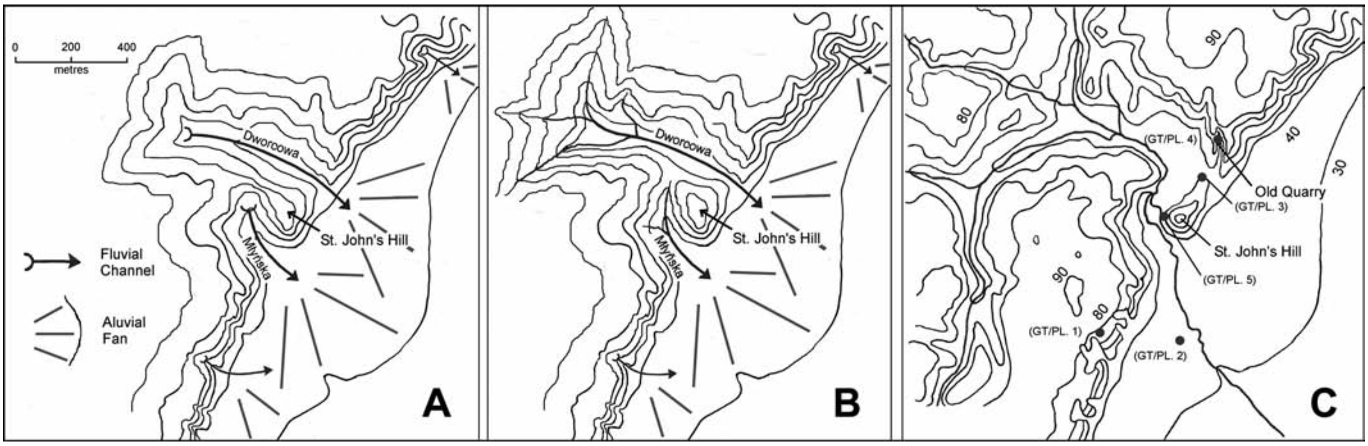

Figure 7. Evolution of St. John's Hill. A: The hill forms a spur between the Dworcowa and Młynska channels. B: The Dworcowa channels develop a dendritic drainage system and the Młynska Channel starts to cut back into the neck of the spur. C: The waters of the Młynska channel capture the drainage that originally flowed through Dworcowa gap.

The Młynska Channel

Although this outwash channel is much shorter than the Dworcowa system, it is no shorter than many other channels cut into the plateau edges south of Gruczno. The Młynska channel may have developed a tributary to the north and thereby started to separate St. John's Hill from the main bluffs (Fig. 7b). The Gruczno stream systems have developed marked tributaries parallel to the Vistula (Fig. 7c), which were probably initiated by sub-surface steams within fluvial sediments interbedded with the tills similar to those at Topolno (Fig. 5) and indicated by stratified sandy layers in the Old and New Quarries. Continued spring sapping and headward erosion eventually captured any flow in the Dworcowa channel. Increased flow after the Younger Dryas further modified the Młynska channel forming its present shape, leaving St John's Hill as a detached plateau remnant. The E-W section in the New Quarry shows no slumping of the strata, only erosion of stratified sands; this suggests that the valley is a fluvial feature that discharged onto the alluvial fan, and that St John's Hill is of natural origin.

Decreasing Holocene discharge has left the present small stream as an underfit in its valley. Spring sapping continues today, above several boggy areas at the base of the slope south-west of the church. Sandy horizons within the till, which would act as sub-surface conduits, were exposed at Topolno after its landslip Fig. 5). The north side of the Dworcowa gap (Fig. 7c) has also been cut back by former spring sapping, though excavation of the Old Quarry has interrupted the flow and the area is now relatively dry. It is likely that sub-surface flow within these horizons strongly influenced the development of the tributary streams shown in the west of Figure 7c. Evidence of present and former spring sapping can be seen in many locations along both sides of the Vistula river.

The aeolian sand in the SW corner of St. John's Hill (Fig. 3) may relate to dry conditions during the Younger Dryas, or earlier, suggesting that this part of the valley had formed by then. Aeolian dunes are recorded in the floor of the Vistula valley (Niewiarowski, 1990); St Laurent's Hill, Kaldus, on the east bank to Gruczno was modified by dunes prior to the late glacial, c.16,500 yrs BP (Chruścińska et al., 2004). Although the extent of the aeolian sands has not been assessed at St John's Hill, their presence suggests that the rounded southern end was not radically modified when the hill fort complex was built.

Conclusion

Although it is clear that the top of St. John's Hill was modified when the hill fort and settlement were constructed, the hill appears to be a largely a natural feature formed by fluvial processes and river capture. It is likely that the hill top was originally much more rounded and was then flattened to produce an area for settlement. The excess material was probably used to produce ramparts that may have reinforced the sharp edge to the southern part of the hill as well as supplying ramparts on the northern side. The thick dark soil at the top of the section in the New Quarry (Fig. 4) may well be the result of anthropogenic intervention when settlement spread down the hill.

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