WAS THE AD 1607 COASTAL FLOODING EVENT IN THE SEVERN ESTUARY AND BRISTOL CHANNEL (UK) DUE TO A TSUNAMI?

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INTRODUCTION

Extensive coastal lowlands known as Levels border the Severn Estuary and Bristol Channel in southwest Britain. The Levels are the result of many years of salt marsh reclamation, apparently initiated during the Roman Period, through a programme of sea bank construction. The altitude of the Levels is typically between 5-6 m Ordnance Datum (OD), an altitude that is below the current Mean High Water Springs level in the Severn Estuary. Therefore, the Levels are vulnerable to flooding, not only from river sources, but also from the sea at times when sea banks are overtopped and/or breached. A number of significant historic coastal flooding events have affected the Levels, but the event attributed with causing the greatest devastation occurred on 20th January 1607, and is the subject of this study. This flood event is often cited as being caused by a storm, alternatively however, we consider that some evidence suggests that the flood may have been the result of a tsunami, and that a reassessment of the cause is required. In this note, our intention is to discuss the existing literature, whilst results from our recent fieldwork in the area will be prepared for future publication.

The area affected by the 1607 flood extended from Barnstaple (Devon) and the Carmenthenshire coast in the Bristol Channel to the head of the Severn Estuary at Gloucester (Anon undated; Morgan 1882; Boon 1980), but most of the documentary evidence refers to Somerset and Monmouthshire. Some local churches record the event with commemorative plaques, such as at Kingston Seymour in Somerset (Bailey 1965), and in Monmouthshire at Goldcliff (Boon 1980), St. Brides (Coxe 1904 reprint), Redwick (Anon undated), and Peterstone (Haynes 1986). Boon (1980) reports that the height attained by the floodwater at Goldcliff and Petestone, indicated by the plaques, has been surveyed to 7.14 m OD, whilst at Kingston Seymour the flood reached 7.74 m OD (Williams 1970). It therefore appears that the flood was of considerable extent and depth. The event is dated as 1606 on the plaques, as it was the convention at the time to change the year in March.

HISTORICAL ACCOUNTS

There are a number of contemporary accounts (CA) of the event. (CA1) A chap-book dated 1607 and entitled *A true report of certaine wonderfulle overflowings of Waters, now lately in Summerset-shire, Norfolke and other places of England*, printed in London by W. I. for Edward White. Excerpts are included in Anon (1762), Bailey (1965) and Williams (1970). (CA2) A pamphlet entitled *God's warning to his people of England*, also included in the *Harleian Miscellany* (Anon, undated). Excerpts are included in Anon (undated) and Mee (1951). (CA3) A pamphlet dated 1607 and entitled *Lamentable newes out of Monmouthshire in Wales*. The pamphlet was reproduced in 1829 by Charles Heath of Monmouth, which is itself reproduced by Nichols (1977). Extensive excerpts are also given in Morgan (1882), who also includes an extract of (CA4) an account of a visit to the area by Camden (1607) at the time of the flood.

The connection of the flooding with a storm appears to stem from Camden's (1607; CA4) account who states that 'the Severn Sea after spring tide being driven back by a strong south-west wind that blew three days without intermission, rose to such a height with a most violent sea wind that the swell broke in upon the low ground .... with the greatest violence' (Morgan 1882, 3). CA3 also makes a meteorological connection, stating briefly that the sea was 'very tempestuously moved by the windes' (Morgan 1882, 4). However, CA1 makes no mention of the weather, stating that the flood occurred without warning, and indeed, CA2 is quite contradictory in that it portrays a tranquil scene, 'for about nine of the morning, the same being most fayrely and brightly spred, many of the inhabitants of these countreys prepared themselves to their affayres' (Mee 1951, 131). CA2 goes onto describe the event 'then they [the inhabitants of these countreys] might see and perceive afar off as it were in the element huge and mighty hilles of water tombling over one another in such sort as if the greatest mountains in the world had overwhelmed the lowe villages or marshy grounds. Sometimes it dazzled many of the spectators that they imagined it had bin some fogge or mist coming with great swiftness towards them and with such a smoke as if mountains were all on fire, and to the view of some it seemed as if myriads of thousands of arrows had been shot forth all at one time ....' (Anon undated, 3; Mee 1951, 131). This collection of apparently eye witness accounts has led a number of popular and local history writers to refer to the flood as being caused by a 'tidal wave' (Anon undated; Phillips 1951; Haynes 1986). This is not surprising given the similarity to descriptions of more recent tsunami, such as the tsunami associated with the eruption of Krakatau in 1883, where accounts refer to the sea as being 'hilly', and the reference to dazzling, fiery mountains, and myriads of arrows, is reminiscent of accounts of tsunami on the Burin Peninsula (Newfoundland) in 1929, where the wave crest was shining like car headlights, and in Papua New Guinea in 1998 where the wave was frothing and sparkling (Bryant 2001).

If a hypothesis is developed, that the flood could have been caused by a 'tidal wave' or tsunami, a number of passages from the other CA's could be seen as corroborative. For example, dissection of Camden's (1607; CA4) report suggests a sequence that (a) 'the Severn Sea after spring tide' appears to suggest that the flood occurred after a high spring tide (perhaps the tide was at least falling, so unlikely to pose an immediate flood risk), (b) 'being driven back by a strong south-west wind', 'driven back' is curious as it might suggest the tide retreated (perhaps excessively) from the shoreline, rather than being driven forth towards the shore, followed by (c) '[the tide] rose to such a height ..... that the swell broke in upon the low ground' referring to perhaps a single wave (cf. swell) inundating the Levels (CA3 also refers singularly to the 'wave's furie'; Morgan 1882, 5). The occurrence of an exceptionally 'low tide' is a well-known precursor to an approaching tsunami (Smith and Dawson 1990; Haslett 2000).

A second example comes from CA3 whereby the account of 'one Mistress Van .... is vouched before she could get uppe into the higher rooms of her house, having marked the approach of the waters, to have been surprised by them and destroyed, her house being distant above four miles in breadth from the sea' (Morgan 1882, 5). This suggests that the flood occurred very rapidly to cover a considerable distance, and CA3 supports this further in stating that the flood waters are 'affirmed to have runne .... with a swiftness so incredible, as that no gray-hounde could have escaped by running before them' (Morgan 1882, 4). Bryant (2001) states that the velocity of a tsunami is solely a function of water depth such that once on dry land the wave height equates with water depth. Water depth of the 1607 flood is marked on the commemorative plaques mentioned above, and these are generally 1.5 m (5 ft) above the ground surface. If the event was caused by a tsunami, it is likely that the wave height was greater than this as it travelled across the Levels, but a depth of 1.5 m provides an approximate minimum that may be used in equation 2.27 of Bryant (2001) to arrive at a minimum velocity of 7.6 ms^{-1} for a hypothetical 1607 tsunami. These accounts imply a wave crest moving faster than those that have been associated with storm surges. For example, the storm surge generated by the 1938 hurricane that inundated Long Island, New York took several minutes to flood the coastline and penetrated no more than 2.5 km (1.5 miles) inland across flat topography despite reaching a height of 6 m (20ft) above sea level (Bryant 1991).

The maximum inland penetration of the floodwaters of the 1607 event in the area appears to have been approximately 22 km, as indicated by accounts of the flood reaching the foot of Glastonbury Tor in Somerset (Williams 1970). In Gwent, Boon (1980) considers the flood to have invaded the Usk Valley at least as far upstream as Caerleon where he speculates a layer of sediment was deposited, so raising the ground surface there to the same altitude as the commemorative plaques in the churches of the Gwent Levels. Bailey (1965) considers the Yeo Valley was also inundated to submerge Congresbury on the North Somerset Levels. The rapidity with which such extensive flooding was achieved is perhaps more likely due to tsunami rather than under storm conditions. Backwash of the possible tsunami wave could have been eliminated by the sea-defences that trapped the invading water landward. Only at Burnham (Somerset), has documentary evidence been found that indicate the sea-defences were breached (CA1; Green 1872; Williams 1970), either by the inundation or by tsunami backwash; elsewhere the defences must have simply been overtopped.

PHYSICAL EVIDENCE

Some existing physical evidence also corroborates evidence for a tsunami from the historical accounts, although at this point, the evidence is rather circumstantial and requires detailed field and laboratory investigation in the future. Tsunami possess long wave periods of several minutes duration, rather than seconds as in storm waves, making them capable of significant erosion related to their sustained high velocity flow (Bryant 2001). Significant erosion that we consider may be related to a hypothetical 1607 tsunami is postulated in Allen and Fulford (1992). They discuss two areas 15 km apart along the Gloucestershire shore of the Severn Estuary, one southeast of Oldbury Flats and the other along the shore opposite English Stones and Gravel Banks. In both these areas, the extant reclaimed wetlands lack classical ridge and furrow, instead possessing younger ridge and furrow. The position of these areas within the wetland, and at the modern shoreline, is problematical and leads Allen and Fulford (1992) to suggest two possible explanations: (1) the wetlands may in the past have extended over rockhead now exposed in the intertidal zone 'before some environmental change forced a substantial south-easterly retreat of the edge of the alluvial outcrop' (pp. 96-97); or (2) that the wetland extended out to the lee of a low island that has since disappeared, and that the coast has subsequently retreated south-easterly. Regardless of which explanation may be correct, Allen and Fulford (1992) state it is clear that the alluvial sediments, and wetlands they supported, 'once extended substantially to the north-west of the present coastal mud cliff' (p. 97) at both Oldbury Flats and Gravel Banks, and that significant erosion has occurred. Allen and Fulford (1992) prove that the sea-defences here were reset inland in response to coastal erosion early in the seventeenth century, therefore, providing a chronological link to the 1607 event.

Although erosion appears to have been dramatic near Oldbury Flats and Gravel Banks, there is less-dramatic but more widespread evidence of erosion at the same time throughout the Severn Estuary, which was followed by the deposition of a pre-Industrial salt marsh sediment unit known as the Rumney Formation (Allen 1987). This Formation appears to be diachronous, depositing earlier at its type-site near Cardiff, perhaps in response to earlier localised erosion, rather than associated with the widespread early seventeenth century erosion that is encountered throughout the greater part of the Severn Estuary. Near Cardiff, substantial sand sheets up to 0.6-0.8 m thick occur in the Rumney Formation at four localities, some continuously exposed in the cliff over a distance of more than 80 m, and Allen (1987) suggests that three of the sand sheets may be of the same age. He goes on to speculate that it may 'prove possible to link some of these buried sand bodies to major storm surges, those of 1607 and 1703 being obvious candidates' (p. 179). Bryant (2001) states that the commonest signature of tsunami is the deposition of sandy units. Storms may deposit sand lenses up to 10-20 m wide, but tsunami-emplaced sand sheets are more continuous and extend over longer distances. Allen (1992) also maps a large near-surface sand sheet at Hill that is curved with the horns pointing down-estuary. Although Allen (1992) suggests it may have been emplaced by the convection of tidal waters onto the reclaimed marsh surface via a creek, in the context of a hypothetical tsunami, it could be interpreted as akin to a flood-tide delta deposited by a tsunami propagating up-estuary.

We do not know the exact deathtoll of the 1607 flood - apparently there were many thousand fatalities (CA1) - but it may also have had an impact on infrastructure. A number of small harbours, such as at Peterstone (Gwent) and Colhuw Port (Glamorgan), disappeared after 1594 (Davies and Williams 1991). Also, Phillips (1951) goes so far as to speculate that the listing of St. Brides church (Gwent) may have been caused by the 1607 flood. In 1624, the Lord Treasurer of England was asked by Rumney tenants to pay towards the repair of coastal structures (Rippon 1996), which, if damaged by the 1607 flood, remained unrepaired 17 years afterwards.

CONCLUSION

This note has sought nothing more than to raise the possibility, given the ambiguity in historical accounts and the major contemporary coastal changes that the 1607 coastal flooding event experienced in the Bristol Channel and Severn Estuary may have been caused by a tsunami. Certainly the evidence for a storm surge is contradictory because several historical accounts note a sudden flooding of the coastline under fair weather conditions. There has been in recent years a growing appreciation of the contribution made by tsunami events to coastal evolution (eg Bryant *et al.* 1996) and that coastlines should be reassessed on an individual basis. In order to evaluate the hypothetical Severn tsunami muted here, a detailed study of the complete historical accounts should be undertaken, archaeological sites that may have some association with the event should be examined, and sites of potential geomorphological and sedimentological significance should be investigated.

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