Recent advances in quantifying chalk shore platform downwearing.

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Introduction

Chalk coasts are widely distributed throughout northwest Europe (Figure 1a). Direct measurements of their shore platform downwearing rates are available only for the coasts of Sussex and Kent, England, and Haute Normandie and Picardie, Northern France. Of these, the Cretaceous chalk platforms of East Sussex (Figure 1 b) have the longest available record (eighteen years) of downwearing rates measured directly using the Micro-Erosion Meter (MEM). In Kent there are a few direct measurements from engineering structures and also some studies where downwearing rates have been inferred from field surveys.

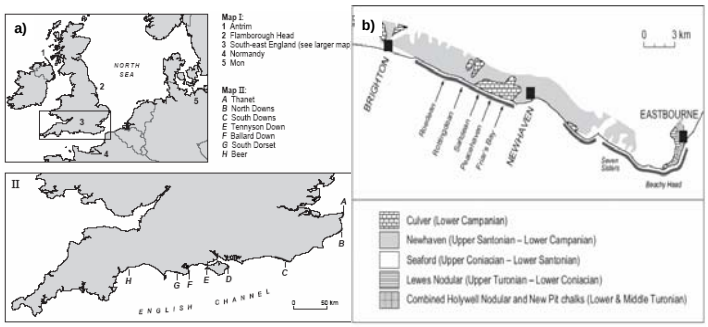


Figure 1 Location of chalk shore platforms: a) in Northwest Europe, b) in East Sussex

Characteristics of the chalk platforms of Sussex and Kent

The chalk platforms, which are present discontinuously along these coastal stretches, slope gently seawards at angles of up to approximately 1.5^0 and are backed by near-vertical cliffs. The cliffs are up to 160 m high, whilst the platforms reach a maximum width of 540 m. Much of the chalk coast is protected by sea defences comprising sea walls and groynes. Flint bands occur at regular intervals in the Cretaceous Chalk, the most notable being the Seven Sisters Flint which is present in the platform at Birling Gap and to the west and which rises into the cliffs to the east. Often, sheet flints are present on the platform surface and are released, by erosion of the surrounding chalk, to be broken into beach material. The platforms commonly descend by a series of steps of up to 1 m or more in height. The cliff-platform junction, in some places, is obscured by a narrow fringing beach composed predominantly of flint shingle (Figure 2a).

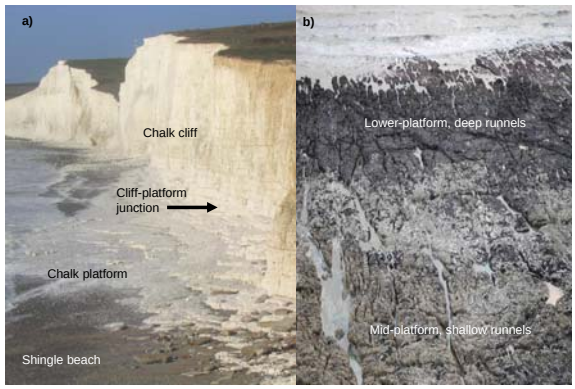


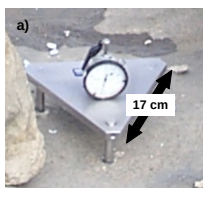
Figure 2. Shore platform characteristics
a) cliff-platform junction
b) mid – lower platform

The white zone, within about 5 m of the beach, is thought to result from intense abrasion of the soft chalk surface by the much harder beach material. Runnels generally increase in width and depth from the upper the lower platform reaching depths of >1m.

Platform downwearing: measurement techniques

Prior to the invention of the **Micro-Erosion Meter** (MEM; High and Hannah 1970; Figure 3 a) platform downwearing rates were either inferred from morphology or measured directly from structures such as sea walls that have their foundations in the platform (Table 1).

The **Laser Scanner**, which creates micro-maps of the rock surface, has recently been adapted to measure shore platform downwearing (Williams *et al.* 2000 and Swantesson *et al.* 2006; Figure 3 b). It has been deployed in Sussex at three of the same locations as the MEM transects reported in Foote *et al.* (2006); Peacehaven, Friar's Bay and Cuckmere Haven. At each of these field locations there were 17 - 20 MEM measurement sites and 4 - 5 Laser Scanner measurement sites. At each MEM measurement site only three readings, a few centimetres apart, were recorded. At each Laser Scanner measurement site readings were taken every 2 mm within an area of up to 25 x 25 cm, generating as many as 15,625 measurement values (Tables 2 and 3).



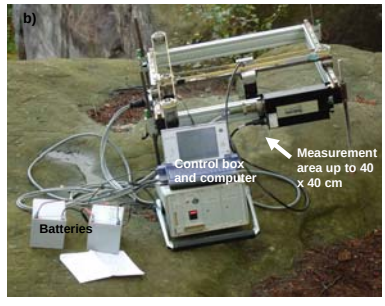


Figure 3.
a) Micro-Erosion Meter (MEM)
b) Laser Scanner

Table 1.
Chalk platform downwearing rates
a) measured from engineering structures.

Location	Downwearing rate (mm/yr)	Author and comments
Margate, Kent	24.5	Sewell 1959, cited in So 1965. Measurement period: 1938 – 1940. Measured by progressive surveys of sea defences.
Broadstairs, Kent	Just over 24.5	So 1965 Measurement period: 1904 - 1961. Measured from the height difference between the concrete/platform junction of Broadstairs Pier.
Brighton – Rottingdean	Mean annual rate of lowering: 3.5	Ellis 1986 Measured height between base of groyne/sea wall and platform surface. Groynes and sea walls constructed in the late 19th and early 20th centuries.
Brighton – Rottingdean	Mean annual rate of lowering: 3.0	Ellis 1986 Measured height between base of Volk's Railway foundation blocks and platform surface Volk's Railway constructed in the early 1890s and opened in 1896.
Peacehaven, East Sussex	Average downwearing around concrete groynes: Phase I: 3.1 Phase II: 3.0 Phase III: 2.77 Overall average: 2.96	Charman 2001. Groynes completed in three phases: Phase I – 1977 Phase II – 1980 Phase III – 1983 In 2001, measurements taken on three groynes per phase, at 8 m intervals along the groyne and on each side. Measured height between base of groyne and platform surface.

b) measured using MEM and Laser Scanner.

Location	Downwearing rate (mm/yr)	Average
Roedean	3.52[1]	3.52
Rottingdean	2.67[1]	2.67
Telscombe Cliffs	2.13[1]	2.13
Saltdean	3.94[2]	3.94
Peacehaven	2.08[1], 8.81[3], 1.49[4], 0.34[5]	2.55
Friar's Bay	2.71[1], 8.84[4], 6.69[5]	6.08
Cuckmere Haven	0.72[2], 0.68[4], 3.21[5]	1.54
Birling Gap	5.63[2], 1.08[4]	3.35
		3.22 ± 2.57

[1]Ellis (1986); [2]Andrews (2000); [3]Charman (2001) & Doyle (2002); [4]Foote *et al.* (2006) ; [5]Swantesson *et al.* (2006)

c) measured using MEM, Laser Scanner and photogrammetry.

Location	Downwearing rate (mm/yr)		
	MEM-measured	**Laser scanner-measured**	**Photogrammetry-measured**
Peacehaven	1.49[1]	0.34[2]	20-60[3] 4.98[4] 3.33[5] 4.19[6]
Friar's Bay	8.83[1]	6.69[2]	0.24[7]
Cuckmere Haven	0.68[1]	3.21[2]	0.71[8]

[1]Foote *et al.* (2006) ; [2]Swantesson *et al.* (2006); [3]Dornbusch *et al.* (2005); [4]calculated over 9000 m^2, the total area covered by the Foote *et al.* MEM transects; [5]calculated from an area of 640 m^2, centred on the western profile; [6]calculated from an area of 800 m^2, centred on the eastern profile; [7]calculated from an area of 5170 m^2, centred on the lower half of both MEM transects as the upper half is obscured by a rockfall; [8]calculated from an area of 6000 m^2, centred on two irregular polygons that cover three laser scanner sites and one MEM site.

The most recently developed technique for measuring platform downwearing is based on **softcopy photogrammetry** (Dornbusch et al. 2005, 2007). It has two key advantages over both the MEM and Laser Scanner: first, downwearing is measured over decades rather than a period of several years; second, downwearing can be measured across the entire platform rather than at discrete points. The latter means that downwearing hotspots and areas of block removal can be identified. Results are presented in Table 1c for downwearing rates calculated by photogrammetry for the same sites in Sussex where both the MEM and Laser Scanner have been deployed. The values are based on air photographs from 1973 and 2001.

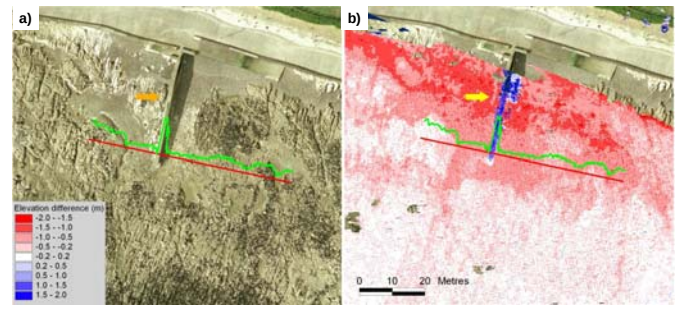


Figure 4. Chalk platform downwearing measured using soft copy photogrammetry.
a) Orthophoto showing the platform at Peacehaven (the green line shows the platform elevation in 2001 along the red profile line: groyne elevation is 2.2 m above the surrounding platform).
b) Elevation differences between 1973DEM and 2001DEM.

Platform downwearing: long term averages

The eighteen year dataset in East Sussex is discontinuous, but a combined average rate is 3.22 ± SD 2.57 mm/yr. At Peacehaven, the rate measured across the entire platform over a twenty three year period using photogrammetry is 26.25 ± SD 13.75 mm/yr (Dornbusch *et al.* 2005); the MEM-measured average rate over a three year period is 1.485 mm/yr (Swantesson *et al.* 2006) and the photogrammetry derived rate for the area covered by the MEM transect is 4.98 mm/yr.

Photogrammetry probably incorporates meso-scale processes such as step-backwearing, spalling caused by occasional severe frost action and removal of boulders by wave action, whilst the MEM and laser values do not. The long term data set is complicated by researchers using different sites and sampling strategies. It is possible to extract average figures for two chalk types from all of the studies: Newhaven Chalk Member 3.48 ± SD 1.44 mm/yr; Seaford Chalk Member 2.44 ± SD 1.28 mm/yr.

Platform downearing: comparison of techniques

Long term averages calculated by photogrammetry are valuable because they identify meso-scale processes that are missed by direct measurement techniques (MEM and Laser Scanner). For engineers this is useful information because it measures downwearing over the design life for sea walls and groynes. However, MEM and Laser Scanner measurements provide high resolution spatial and temporal data, i.e. seasonal and across platforms, that are masked by the averages presented in the tables on this poster.

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