CONTRIBUTION OF FLINT SHINGLE FROM CLIFF RETREAT AND SHORE PLATFORM EROSION

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1 Summary

Retreat of chalk cliffs and erosion of the shore platform releases flint from the chalk that contributes shingle to the beaches of the BAR coast. The amount of flint contributed depends on the rate of retreat and amount of flint present in the chalk. Measurements of the flint in the chalk for the whole BAR coast have been carried out using photographs of the chalk cliffs to calculate flint content. Flint content varies significantly along the BAR coastline ranging from 11% near Etretat to less than 1% on part of the Isle of Thannet. The differing lengths of coastline, rates of retreat and flint content lead to differing contributions that are in the order of 8,500 $m^3 y^{-1}$ for the English side and 47,000 $m^3 y^{-1}$ for the French side.

2 Aims

Calculate the flint shingle contribution from cliff retreat and shore platform erosion.

3 Introduction

Both chalk cliff retreat and erosion of the chalk shore platform produce flint shingle that contributes to the volume of shingle forming the beaches of the BAR coast. An assessment of the present day and historic input puts into perspective the geological evolution of the BAR coastline which on the UK side includes large shingle accumulations at Dungeness and the Crumbles, that are unlikely to have formed solely from shingle derived from the cliffs by present day processes.

4 Method

Flint content has been measured using digital photographs of the cliff face as detailed in (Dornbusch, 2002, pages 10-11; Dornbusch et al., in press). These were either taken in 2x2m sections along the cliff foot in East Sussex, or with appropriate tele-lenses (East Sussex and Kent). The resolution of the photos is greater than 0.5 cm on the ground and allows the flint to be clearly identified on screen in the photographs.

Flint content values are combined for multiple photographs of a range of representative sites. Based on the geology as exposed along the cliffs in East Sussex (Figure 1) flint percentage have been calculated for individual chalk members and from their distribution within the cliff for distinct stretches of coastline. The low inclination of the Chalk in Kent (Shephard-Thorn, 1988) and the higher number of profiles sampled means that the flint content shown in Figure 4 is the flint content directly measured.

If the two-dimensional area occupied by flint is assumed to be representative of the three-dimensional content of flint in the cliff then this can be calculated as a percentage from the area of the photographic image occupied by flint.

Data for France has been obtained from photographs by LCHF (1972) and is reported in Costa (1997) together with alternative data by Costa et al. (1996) and Laignel (1993).

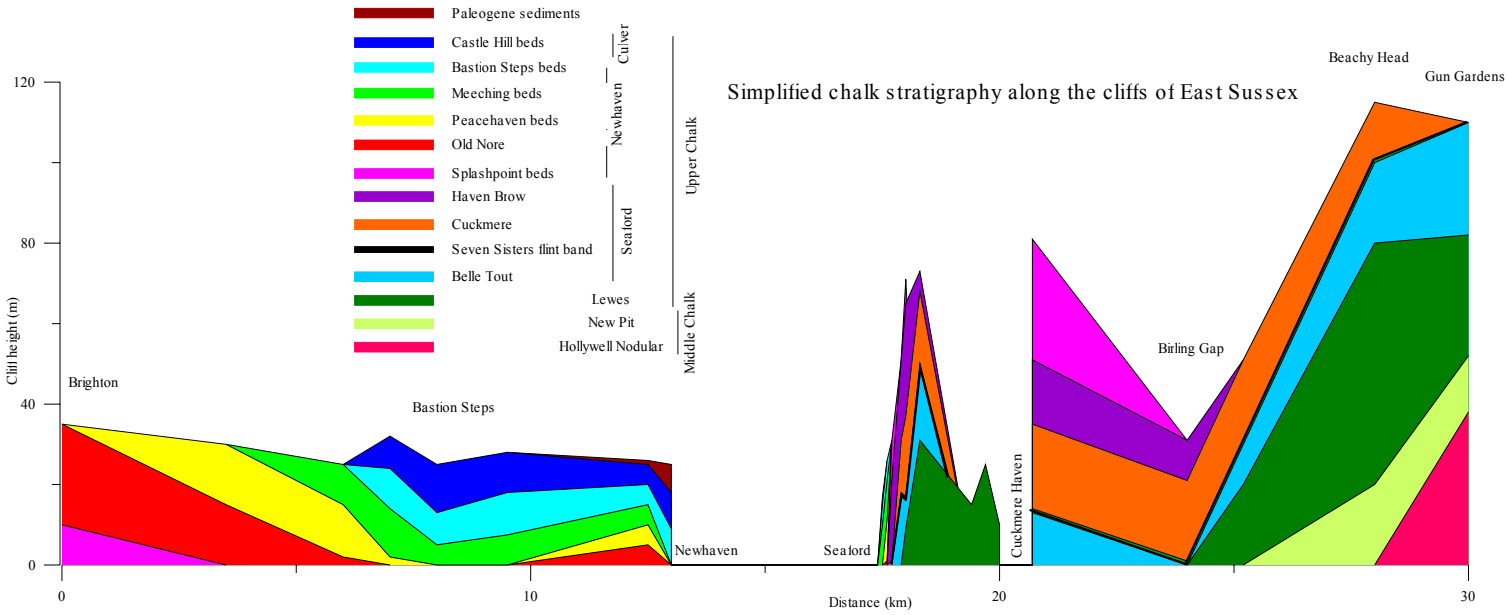

Figure 1 Simplified profile of the chalk stratigraphy along the Sussex coast (stratigraphic sources: Mortimore, 1997; Mortimore et al., 2001; Young and Lake, 1988),. Vertical scale exaggerated.

5 Flint content

Flint content for Chalk in East Sussex is shown in tabular form in Figure 2. Figure 4 shows the spatial pattern of varying flint content along the BAR coastline. In France, flint content declines from southwest to northeast, while in England the picture is more fragmented but overall the flint content is significantly less. Flint content increases from west to east in East Sussex and is low on the Isle of Thanet. Around South Foreland a 'hot-spot', with high flint content, is found at St. Margarets with low flint contents on either side.

Chalk Member	Flint content (%)
Upper Newhaven & Culver	1.5 ± 0.5
Newhaven	2 ± 0.5
Seaford	3.5 ± 0.5
Lewes	4.5 ± 0.5

A

Coastal stretch	Flint content (%)
Saltdean to Newhaven	1.5 ± 0.5
Seaford Head	3.5 ± 0.5
Cuckmere Haven to Belle Tout	2.5 ± 0.5
Belle Tout to Beachy Head	4.5 ± 0.5

B

Figure 2: Flint content for A) different Chalk members, B) different stretches of coast in East Sussex

Chalk Member	Flint content (%)
Turonian inferior	0,9
Turonian moyen	4,1
Turonian superior	4,7
Coniacien	12
Santonien	14,2
Campanien	15

Figure 3: Average flint content for the French cliffs taken from table 4 in Costa (1997)

However, high flint content does not necessarily mean high flint input as this will also depend on the rate of cliff retreat. Figure 5 shows the relationship between the flint content and cliff

retreat rate for the French coast, Figure 6 the same for the English coast. In France, the highest flint content coincides with the lowest rates of cliff retreat and higher rates of cliff retreat generally coincide with lower flint content.

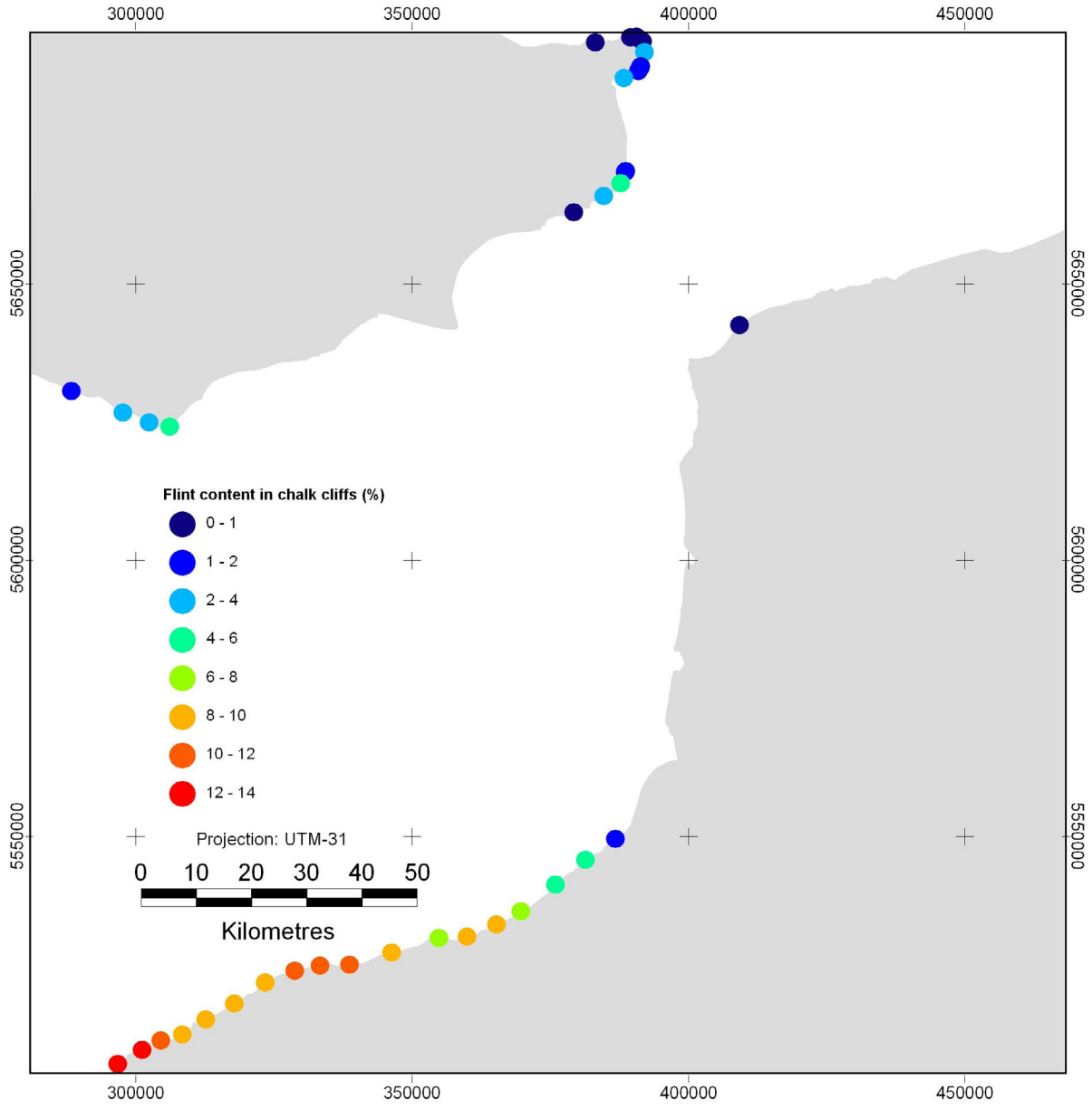

Figure 4: Flint content for the BAR coast showing for representative locations the percentage of flint in the chalk found in the cliff face.

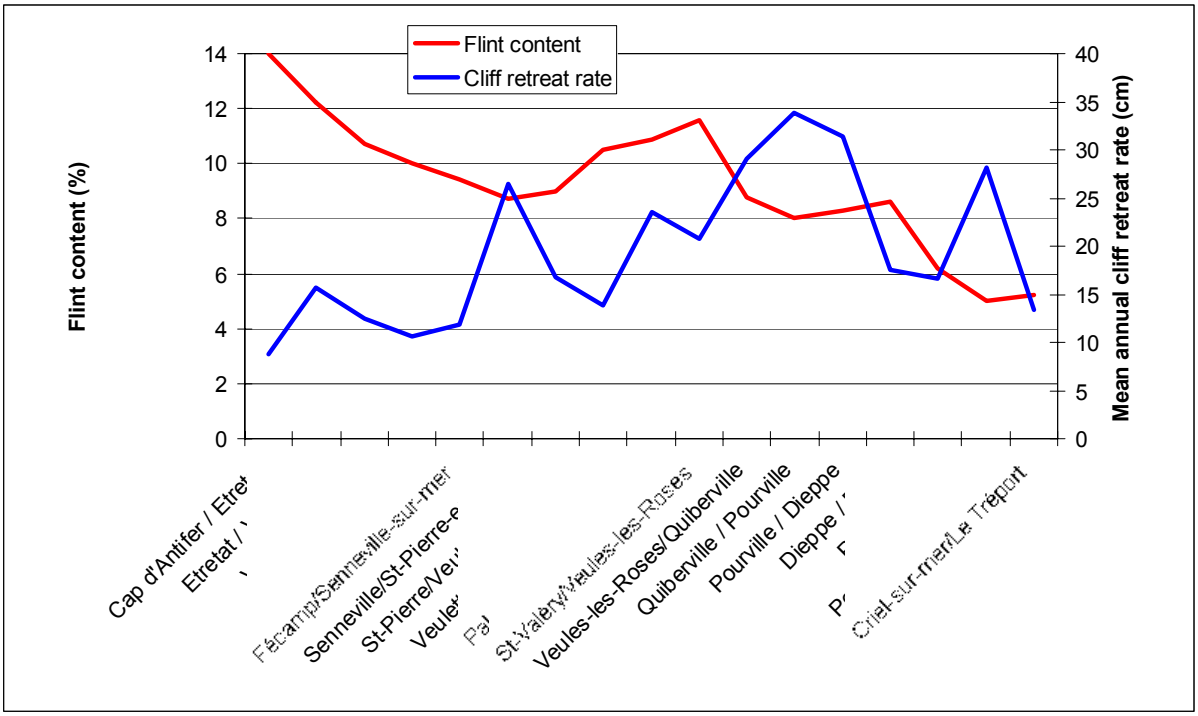

Figure 5: Relation between cliff retreat rate and flint content for the French coast.

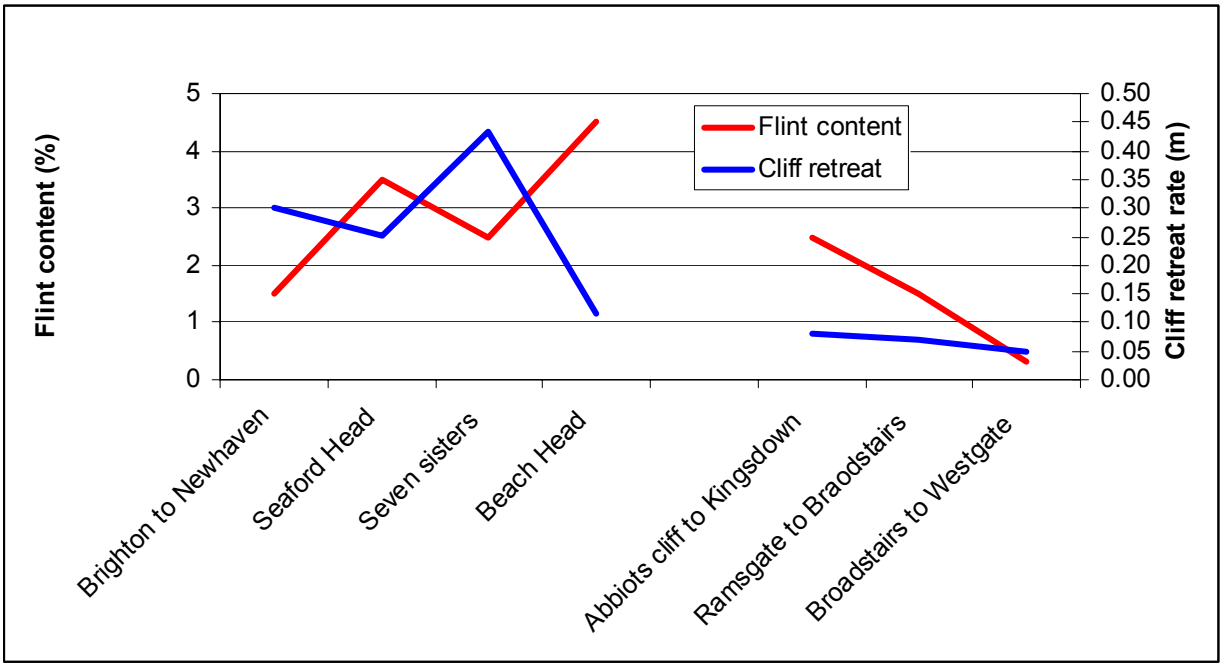

Figure 6: Relation between cliff retreat rate and flint content for the English coast.

On the English side, if East Sussex and Kent are considered together, the relationship is less clear. In East Sussex the highest flint content coincides with the lowest rates of cliff retreat but in Kent both retreat rates and flint content are variable and low.

The annual volume of flint contributed from cliff retreat is tabulated in Figure 7. The total volume of 6000 $m^3 y^{-1}$ for the English coast is one fifth of the annual contribution on the French side. The report on cliff retreat and shore platform erosion suggests that to allow 10% of the rate of cliff retreat for the shore platform erosion would probably be a reasonable,

possibly an overestimate of the contribution from this source. Taking this into account, both processes will probably contribute ~6500 $m^3 y^{-1}$ of flint shingle on the English side and ~35000 $m^3 y^{-1}$, on French side.

	Annual cliff retreat (m)	Flint content (%)	Annual flint production (m^3)
Brighton to Newhaven	0.30	1.5	600
Seaford Head	0.25	3.5	1200
Seven sisters	0.43	2.5	2600
Beach Head	0.12	4.5	1000
Abbots cliff to Kingsdown	0.08	2.5	500
Ramsgate to Broadstairs	0.07	1.5	50
Broadstairs to Westgate	0.05	0.3	0
Sum			**6000**
Cap d'Antifer / Etretat	0.09	14	1500
Etretat / Vaucotte	0.15	12.2	4000
Vaucotte / Yport	0.12	10.7	400
Yport / Fécamp	0.10	10	1400
Fécamp / Senneville-sur-mer	0.12	9.4	900
Senneville / St-Pierre-en-Port	0.26	8.7	5000
St-Pierre / Veulette-sur-mer	0.17	9	3200
Veulette / Central de Paluel	0.14	10.5	700
Paluel / St-Valéry-en-Caux	0.24	10.9	3300
St-Valéry / Veules-les-Roses	0.21	11.6	2500
Veules-les-Roses / Quiberville	0.29	8.8	2100
Quiberville / Pourville	0.34	8	2000
Pourville / Dieppe	0.32	8.3	1600
Dieppe / Puys	0.17	8.6	100
Puys / Penly	0.17	6.2	800
Penly / Criel-sur-mer	0.28	5	1300
Criel-sur-mer / Le Tréport	0.13	5.2	400
Le Tréport / Ault	0.21	1.5	500
Sum			**31700**

Figure 7: Summary table of cliff retreat rates, flint content and mean annual flint production.

Given that the volumes calculated are for solid flint, the contribution to the volume of beach will be higher as the flints will become part of the beach with a void space of ~35%. Therefore the contribution to beach volumes is likely to be 8,500 $m^3 y^{-1}$ for the English side and 47,000 $m^3 y^{-1}$ for the French side.

6 Discussion

The flint shingle contribution to the beach system needs to be related to the amount of shingle present in the system to assess its importance. On the English side it is estimated

that about 200,000,000 m³ of shingle are locked in the accumulation at Dungeness alone. Volume measurements on the French side calculate the total beach volume between Cap d'Antifer and Le Hourdel at 17,000,000m³ (this does not include shingle buried beneath urban development at places such as Dieppe or Le Treport). If one makes the bold assumption that cliff retreat has occurred at the present rate over the past 2000 years, the production on the English side would amount to 17,000,000 m³ and thus be less than 10% of the shingle at Dungeness. On the French side, the same retreat would have produced 94,000,000 m³, almost five times more than is present in today's beaches. The calculation for the French side shows, that the assumption of continuous retreat over millennia at today's rates is highly unlikely.

In fact, at the present rate, the shingle on the French coast could have been produced in less than 400 years which appears to be an equally bold assumption.

7 Outlook for Phase 2 of BAR

From the perspective of geological time, the contributions of the present day cliff retreat to the shingle budgets of the BAR coast provides a mixed picture by, on the one hand failing to provide the material that is seen in Holocene deposits on the English side, and on the other hand by producing more material that can be found on the French side. As a Holocene transfer of shingle from the French to the English side is impossible, rates of cliff retreat must have been very different during the Holocene from those observed today.

Assessing the trend in cliff retreat rates for the last 130 years is important for our understanding and prediction of future rates of cliff retreat.

8 References

Costa, S., 1997. Dynamique littorale et risques naturels : L'impact des aménagements, des variations du niveau marin et des modifications climatiques entre la Baie de Seine et la Baie de Somme. Thèse de doctorat Thesis, Université de Paris I, Paris, 376 pp.

Costa, S., Laignel, B. and Quesnel, F., 1996. Les facteurs de localisation des entonnoirs de dissolution dans les craies de Seine-Maritime (Normandie, France), Colloque Formations superficielles et géomorphologie. 19-20 Mars 1996. BRGM, Rouen.

Dornbusch, U., 2002. BERM Final Report - Technical report, University of Sussex, Falmer, Brighton.

Dornbusch, U., Robinson, D.A., Moses, C. and Williams, R.B.G., in press. Chalk coast erosion and its contribution to the shingle budget in East Sussex. Zeitschrift für Geomorphologie.

Laignel, B., 1993. Les matériaux résiduels à silx de lar marge occidnetale du Bassin de Maris. Caractérisation, bilan des transformations minérales au cour de leur génèse et utilisation potentielld comme granulat. DEA Thesis, Université Orléans, Orléans, 45 pp.

LCHF, 1972. Etude de la production des galets sur le littoral haut-normand, Laboratoire Central d'Hydraulique de France.

Mortimore, R.N., 1997. The chalk of Sussex and Kent. Guide 57. Geologists' Association, London.

Mortimore, R.N., Wood, C.J. and Gallois, R.W., 2001. British upper cretaceous stratigraphy. Geological Conservation Review Series, 23. Geological Society, London.

Shephard-Thorn, E.R., 1988. Geology of the country around Ramsgate and Dover. Memoir for 1:50 000 geological sheets (England and Wales). Her Majesty's Stationery Office, London.

Young, B. and Lake, R.D., 1988. Geology of the country around Brighton and Worthing, British Geological Survey, Memoir for 1:50,000 geological sheets 318 and 333.