Scotland can be most effectively explored. It is quite true that hitherto our evidence for the stages of land- and sea-level adjustment prior to the formation of the 25-ft. beach remain largely unexplored; but the new dating techniques, applied to situations where the field geology is adequately known, should give us the means of extending this knowledge to the earlier stages. I believe that it is against the background of this kind of information that Dr. Baden-Powell's most valuable analyses of the inter-glacial littoral faunas should be viewed.

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Prof. Godwin's discussion of my article on the isostatic recovery of Scotland is most welcome, and I am grateful to him for raising several points of interest. But I must start by assuring him that I am not considering this isostatic recovery as "a single process extending over a period of time which embraces that of the Tyrrhenian beaches" as he puts it. On the contrary, I am only discussing crustal movement which has occurred since the last glaciation in Britain, emphasizing the effect this movement would have on the very much earlier Tyrrhenian beaches. (The possibility mentioned by Prof. Godwin of isostatic recovery during interglacial periods raises interesting theoretical questions, but I have never yet seen evidence for such a thing in the field, though of course this does not mean that such events have not taken place.)

As regards Prof. Godwin's reference to the so-called 25-ft. raised beach of Scotland and its relative height farther south, it is well known that the Sub-Department of Quaternary Research in Cambridge has been working hard on this problem for some time; but the height of the 25-ft. beach is not exactly what I was discussing in my article. The point I was trying to make was that W. B. Wright, in his original work reported in the *Geological Magazine* (1911), emphasized the distribution of the 100-ft. beaches in Britain as an important part of his theory about isostasy, believing these beaches to be "grouped round a centre in the Scottish Highlands"; but the work described in my article shows that part of Wright's theory was based on incomplete evidence. For example, according to Wright's map (p. 99), the distribution of both the 'preglacial' and the 'late glacial' 100-ft. beaches is restricted to Scotland, indicating that there is no such thing as a '100-ft. beach' in England. One look at such deposits as the Sussex raised beaches and the Nar Valley clay shows us that we have evidence which was never used by Wright; in this case he was wrong in thinking that a 100-ft. beach ('preglacial') in Scotland descends abruptly to a 10-ft. 'preglacial' beach in southern England.

A minor point made by Prof. Godwin rather mystified me, when he writes that beaches formed during warm interglacial periods could have similar heights in relation to present sea-level, and that this does not invalidate the theory of isostatic elevation. How can this be? Surely uneven uplift of the 25-ft. beach must also tilt the earlier beaches, and the answer must be that so far the measurements of the Tyrrhenian beaches have been too coarse to show the relatively slight movements which have taken place since the 25-ft. beach was formed.

In conclusion, I agree with Prof. Godwin that there has been some differential movement between Scotland and parts of England during the Holocene. I must stress this particularly, as we know that the 25-ft. beach of Scotland is a common feature in the north, whereas this beach is conspicuously absent at that height in southern England.

The single point which I was trying to make in my article was that whatever crustal movement has taken place during the Holocene has been much less than the 100 ft. or so suggested by Wright. It may seem strange to divide a problem like this into parts and try to solve each part in turn, but this seems the best way to set about this complicated subject.

Sir Archibald Geikie once wrote an article with the amusing title: "The Raised Beach of Britain and how Scotland has risen in the World". Perhaps what we are really discussing is whether Scotland has been going up or whether parts of England have been sinking. Presumably W. B. Wright and others have been too ready to assume that both movements have occurred at the same time. As I understand it, Depéret thought that Scotland is at its normal level, with the '25-ft. beach' re-appearing at that height in neighbouring parts of Europe and in the Mediterranean area. In that case a slow abnormal sinking of part of England may be nearer the truth than an extensive rise in the north.

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MINERALOGY

Strength and Structure of Flint

In view of the widespread prehistoric use of flint for making tools and weapons, it is of interest to compare its structure and strength with those of present-day ceramic materials. The physical properties of stone tool materials have been investigated by Mary Ellen Goodman[1], who examined and compared the relative density, toughness, resilience and hardness of limestone and a number of siliceous materials. However, the transverse bending strength, needed for quantitative comparison with ceramic materials, was not determined.

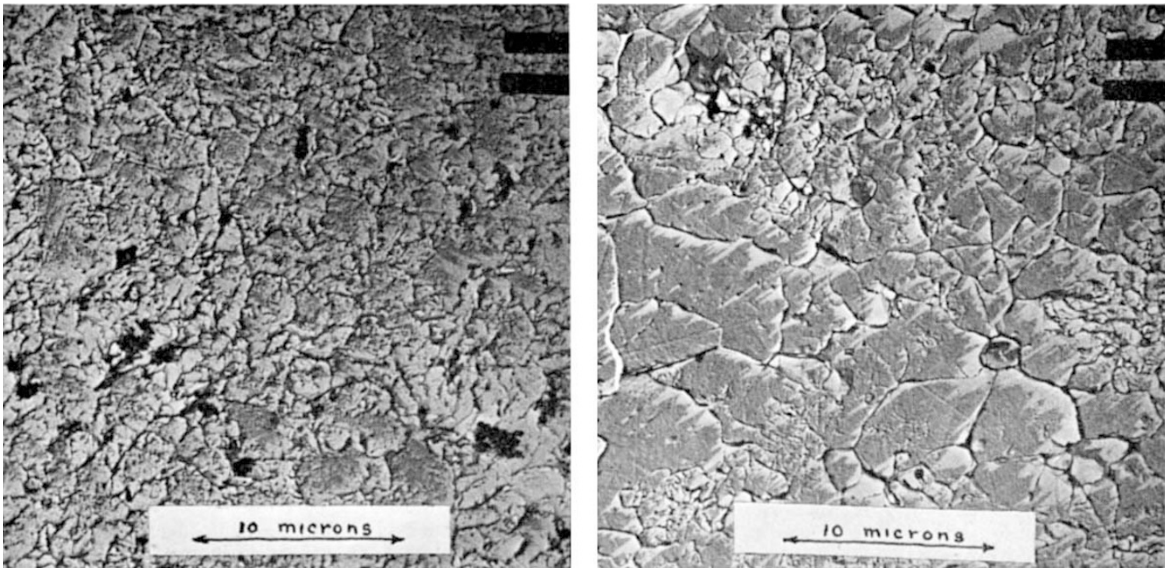
Flint is described as a "tough, very compact, microcrystalline material"[2]. The colour varies from light, almost transparent, to grey or black. Weymouth[3] has shown that flint has a typical density of 2·62 g/c.c., and shows only the X-ray diffraction pattern of quartz. Since the density of quartz is 2·65 g/c.c., the material was estimated to have a porosity of about 1 per cent by volume. Microscopic examination showed that flint was similar to chalcedony. The colour was believed to be the result of light scattering from extremely fine pores.

I have myself examined flint cut from the most homogeneous appearing sections of a boulder of English flint obtained through a commercial source; also chalcedony taken from a geode which was almost filled with a brownish, nearly transparent, dense, homogeneous-appearing silica, kindly furnished by Alvin B. Stiles. For comparison, fused silica of the transparent optical-grade, as well as of the opaque type used for laboratory ware, were tested.

Test bars 0·070 in. square, 0·75–1·5 in. long were cut with a '180 grit' diamond saw of 20 mils thickness on a wafering machine; this gave an almost optically smooth finish. Transverse bending strength was measured by applying the loading at a single point at the centre of a test span 0·75 in. long.

Microstructure was examined by embedding specimens in plastic, polishing, etching with dilute hydrofluoric acid, and examining with a metallurgical microscope at a magnification of 500. For electron micrographs, polished sections, etched with hydrofluoric acid, were replicated in two stages with cellulose acetate and carbon, then shadowed with chromium.

Observed transverse rupture strengths of flint and chalcedony are compared in Table 1 with those of some typical ceramics and natural stone materials. It will be noted that the translucent types of chalcedony and flint are about equally strong and that both are stronger than the ceramics, fused silica and porcelain. They are much stronger than the other natural stone materials that are



A *B*

Fig. 1. Electron micrographs of replicated surfaces of English flint. *A*, dark brown translucent region; *B*, light brown, opaque region

listed. Flint is almost as strong as modern micro-crystalline ceramics made by devitrification of glass.

The structure of the dark translucent flint was compared with that of the light brown opaque type. The opaque material occurred as clearly defined, more or less spherical regions within the matrix of the darker translucent mass of the boulder. The translucent regions appeared darker in colour because light penetrated more deeply and was thus absorbed. The spherical shape of the opaque zones suggested that a process of recrystallization might have occurred as though the masses of crystals were radiating from nuclei. This is sometimes seen in the partial devitrification of silica glass.

X-ray diffraction patterns of English flint showed only the presence of quartz. The diffractometer curves showed marked line-broadening in the case of the stronger, dark-brown, translucent specimens, for which an average crystallite size of 120 mμ was estimated. The weaker, light, opaque flint gave sharp lines with no measurable broadening, indicating that the crystal size was more than 500 mμ.

Optical micrographic examination of polished sections in reflected light indicated that the grain size, after etching with hydrofluoric acid, was of the order of 2–10μ in the light opaque areas, but less than 1μ in the dark translucent areas. Electron micrographs of the surfaces of the dark, translucent (*A*) and light, opaque areas (*B*) are shown in Fig. 1. Although the density of these materials ranged from 2·55 to 2·61 g/c.c., suggesting 1·5–4·0 per cent porosity, no pores could be clearly identified. These electron micrographs confirm that the stronger, more translucent type of material has a finer grain structure.

Table 1. Transverse Rupture Strengths

Material	Type	No. of test bars	Strength (lb./in.²) Average	Maximum
English flint	Dark brown, translucent	7	27,000	30,100
English flint	Light brown, opaque	6	17,100	19,800
Chalcedony	Light, translucent	5	23,500	29,100
Chalcedony	Dark, translucent	6	24,000	29,400
Fused silica	Transparent	4	18,400	21,000
Fused silica	Opaque	8	10,300	12,200
			Range	
Porcelain (ref. 4)	Electrical grade	-	5,000 to	15,000
'Pyroceram' (ref. 4)	Code 9606		32,000	
Common stone materials (ref. 5)				
Limestone			500 to	2,000
Marble			600 to	4,000
Serpentine			1,300 to	11,000
Slate			6,000 to	15,000
Granite			1,380 to	5,500
Sandstone			700 to	2,300

Specimens of dark and light regions of chalcedony were both translucent; this indicates that the colour is related to impurities rather than recrystallization. Electron micrographs of the chalcedony showed a fine grain structure indistinguishable from that of the translucent flint. Also, X-ray diffraction indicated a quartz crystallite size of about 200 mμ. Thus the translucent forms of chalcedony and flint appear to be identical.

It is thus concluded that the high strength of flint is a result of its very fine grain structure. The choice of flint by primitive man was undoubtedly based on its outstanding strength in comparison with other stones, as well as its characteristic cleavage behaviour.

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PHYSICS

A Ready Method for finding Eccentric Dipole Time

Eccentric geomagnetic dipole[1] time at an observatory (O) is defined for present purposes as the difference in eccentric dipole longitude (φ') of the Sun (as distinct from the sub-polar point) and the observatory being measured eastwards from the Sun to the observatory, that is:

$$t_{ecc.} = \varphi'_o - \varphi'_{sun} \quad (1)$$

Elsewhere[2,3] it has been shown by different approaches that $t_{ecc.}$ runs parallel to ordinary geomagnetic time (a centric system) differing by a constant C_o, which is a characteristic of the observatory for the particular epoch of the Earth's magnetic field. Thus, also: