Detrital Andalusite in Tertiary and Post-tertiary sands.[1]

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UNTIL quite recently, in spite of its characteristic features, andalusite had not been met with in the younger detrital rocks of Britain; a few years ago, however, I remarked on its relative abundance in the older Pliocene sands of St. Erth and St. Agnes in the west of Cornwall.[2] Its presence in these deposits, in which it is associated with pink garnet and cyanite, is easily explained by the close proximity of the areas of deposition to the metamorphic aureoles of the west of England granite-masses, in which andalusite of identical character is exceedingly common. It also occurs in fair quantity in the Pliocene sands of Lenham in Kent accompanied by cyanite, and together with cyanite and garnet in the Red and Norwich Crags and the Chillesford Beds in the east of England.[3] It is said to be rarely present in the Chalk of Beer Head, Dorsetshire,[4] but I have failed to find it in the residues which I have examined.

Records of detrital andalusite in the unaltered state from foreign localities are quite few, the most noteworthy being those made by R. Bréon and E. Artini. R. Bréon[5] mentioned it as being fairly common in the sea-sands of the Île-de-Groix (Brittany) and as of rare occurrence in the dune-sands of Pointe-de-Grave (Landes), in both cases associated with garnet, but cyanite, its usual companion, is not recorded. E. Artini[6] has noted it in the sands of the Ticino, near Pavia, with cyanite, garnet, and many other minerals; and, with the same associates, from the sands

[1] Communicated by permission of the Director of H. M. Geological Survey.

[2] H. H. Thomas, Quart. Journ. Geol. Soc., 1902, vol. lviii, p. 620.

[3] Ibid., 1900, vol. lvi, pp. 38–43.

[4] W. F. Hume in 'Cretaceous Rocks of Britain,' vol. ii (Mem. Geol. Surv.), 1903, p. 510.

[5] R. Bréon, Bull. Soc. Min. France, 1880, vol. iii, p. 46.

[6] E. Artini, Giorn. Min. crist. Ital., 1891, vol. ii, pp. 1–19, also p. 177; Riv. Min. crist. Ital., 1898, vol. xix, pp. 33–34.

of the river Adige in northern Italy. It has also been mentioned as occurring in the marine monazite-bearing sands of the neighbourhood of Penang in the Malay States.[1]

Recently my attention has been drawn to masses of glacial sand and gravel which cap many of the minor elevations in western Carmarthenshire and the counties of Pembroke and Cardigan, as well as to some of the drift-sands of north Wales and the beach- and blown-sands of the same districts. Many of the masses of drift-sand were mapped by my colleagues Mr. T. C. Cantrill, Mr. E. Dixon, and Mr. O. T. Jones, who kindly furnished me with samples. In almost every case, andalusite, in a perfectly fresh condition, proved a fairly common constituent, but more especially of those samples of sand collected from south-west Wales.

It is an interesting point that, with the possible exception of the Chalk of Beer Head, all the known records of unaltered detrital andalusite are from beds of comparatively recent date, and that it as yet remains undetected in any sedimentary rock of greater antiquity than the Pliocene. Considering the work that has been done on the Cretaceous and older Tertiary rocks by Cayeux, Dick, Hume, and others, it would be most surprising that this mineral, had it been present, should have remained unidentified. It therefore appears that andalusite has not survived as such in the Cretaceous and Lower Tertiary rocks of the London and Paris basins. In all the older British sediments that I have examined, including the Old Red Sandstone, Carboniferous, Permian and Triassic sandstones, as well as Jurassic sands, no unaltered grain of this mineral has been detected.

It is, therefore, highly probable that andalusite cannot remain in a sand without decomposition for more than a limited period, after which its place is taken by certain micaceous aggregates, such as are of frequent occurrence in the Triassic sandstones of the west of England.

It may, I think, be taken for granted that the presence of unaltered andalusite in a glacial or recent sand means that much of the detritus has been furnished either directly by some metamorphic area, or indirectly by Tertiary sediments derived in part from similar or identical metamorphic masses.

Andalusite-bearing rocks are of restricted occurrence in the British Isles and the presence and distribution of detrital andalusite in recent sedimentary rocks should point more or less clearly to some special area of metamorphic rocks. In the case of the drift-sands of west Wales two near sources are available—either the granitic regions of Cornwall and

[1] Bull. Imp. Inst., 1906, vol. iv, p. 301.

Devon or those of the east of Ireland. It is not, however, my purpose in this short note to discuss the source of the mineral or its associates, but merely to put on record those sands and those localities in which detrital andalusite has been found.

In the superficial sands of west Wales it occurs as slightly elongated, somewhat angular grains averaging 0·43 mm. in length, 0·25 mm. in breadth, and 0·12 mm. in thickness.[1] Occasionally there are some signs of rounding.

The elongation is that usually met with in andalusite, namely parallel to the a-axis, while the grains are bounded by the good cleavages parallel to the prism {110}. The sign of the zone of elongation is always negative, and this forms a ready means of distinguishing andalusite from certain members of the rhombic-pyroxene group with which it might possibly be confused. The pleochroism exhibited by some grains is most intense, reaching occasionally a blood-red colour for light vibrating parallel to the axis of elongation (a) and pale greenish-blue at right angles. This latter tint is produced by the mixture of the tints due to rays vibrating parallel to b and c, as the normal to the plane of the cleavage makes an angle of approximately 45° with the points of emergence of those axes.

A few grains viewed in convergent light show a positive bisectrix (Bx_o) and are evidently tabular parallel to the less perfect cleavage {100}. They usually show the characteristic rose-pink colour for light vibrating parallel to a and the pale green parallel to b. The pleochroism, however, is far from a constant feature, for many grains which have a similar orientation and thickness to those showing strong pleochroism are almost colourless for all positions of the polarizer. The intensity of the pleochroism often varies abruptly in the same grain, causing deeply coloured layers ranging up to 0·07 mm. in thickness, which evidently represent zonal layers in the original crystals.

Almost every grain possesses rod-like and granular, dark, opaque inclusions, arranged parallel to the vertical axis.

The associates of andalusite in the sands of west Wales are pink garnet, sometimes in well-formed dodecahedra, greenish-brown augite, cyanite, zircon, rutile, tabular anatase, staurolite, brown and more rarely blue tourmaline, green hornblende, bright green epidote, rare cordierite, iron ores, and in some cases glaucophane.

[1] The thickness of the grains was obtained by measuring the retardation on the cleavage-plane, assuming that for andalusite $\gamma - \alpha = 0{\cdot}011$, which gives the value 0·0086 for the birefringence on (110).

The sands and localities from which andalusite has been recognized in Wales are as follows:—

Glacial sands from Castle-tôch and Ebenezer, near Llansadurnen,[1] and Red Roses in Carmarthenshire; Pen-cnwc near Llandissilio East, Colby Moor near Llawhaden, Carew Cheriton, Carew Newton, and Bubbleton in Pembrokeshire; and about two miles south-east of Mount Church in Cardiganshire. It is present, but extremely rare, in the glacial sands of Bagillt in Flintshire. It occurs in the beach- and blown-sands of Laugharne in Carmarthenshire, Newgale in Pembrokeshire, and Mount Church in Cardiganshire.

In putting forward the above records and description of detrital andalusite in England and Wales, I do so with the suggestion that a detailed study of the distribution of this highly characteristic mineral will throw additional light on the source of the glacial deposits of south and west Wales, or indicate the possible extension of the younger Tertiary deposits beyond the limits at present recognized.

[1] These sands are described in 'The Country around Carmarthen', Mem. Geol. Surv. (in the press).