THE ECONOMIC GEOLOGY OF DEVON.

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THE fact will be admitted by all, though we may differ as to the degree of influence, that man is largely a creature of circumstances. By no set of material circumstances is he so influenced as by the geological conditions of the country in which he lives. The land shapes the people; its physical features mould their history. Our wealth, our enterprise, our skill, our character, spring from or are directed by our surroundings. Men vary in the use of their materials; some get a good return from that which is of little value, others starve in the midst of riches which they are too idle or too ignorant to realise; but the average man and the average nation are very much what the conditions of their existence make them.

To geological causes the world owes its configuration: its mountains and its plains; its rivers, lakes, and seas; its barren rocks and its fertile soils; the mineral wealth of certain strata, and the poverty of others. These things have ruled and do rule the destiny of man. Political divisions follow the lines of natural. Mountains have preserved freedom; coasts given birth to commerce; great rivers become the parents of busy cities. The volcano and the earthquake of the past have leagued with the more equably acting forces of Nature, to carve out the harbours from whose convenience our myriad-masted seaports have sprung. Men are sailors, or miners, or farmers, or factory hands, mainly because the physical conditions of the districts in which they live will it so, and make individual preference take the colour of overruling necessity. At the bidding of geological discovery the tide of population ebbs and flows. An English coal-field turns villages into workshop towns echoing with the din of manufacture. A mineral spring creates a centre of fashionable

life. Sands and cliffs, which sea, rain, and air have been forming and beautifying for ages, have their solitudes peopled with colonies of health-seekers. Diamond and gold fields change the currents of national life, and draw together the veriest medleys of races. Oil wells match a shoddy with a petroleum aristocracy. There is not a phase of human existence which geological conditions do not in some way influence. Hence there is a good deal more in geology than the theory and speculation to which many well-meaning, but not well-informed, people appear to consider its domain confined.

There is special interest for us in the geology of Devon. We are what we are, in race, character, calling, and social position, mainly because of the geological peculiarities of this western land. The proof is easy. Our tin mines brought the pioneers of civilisation earlier to these shores than to any other part of the kingdom. In the fastnesses of our moors and our hills the struggle for liberty was continued by Britons and Saxons when in more open districts the strife had long been over. Our extended coast line, broken by frequent harbours, gave birth to that spirit of adventure and enterprise which made Devon the foremost county in the land in the days of Elizabethan glory, and which has never failed us since. There, too, was commerce encouraged, and by commerce manufacture. Our buried riches, mild climate, and fertile soil, created and fostered mining and agriculture among us, and made them act and re-act upon each other. Still do our rugged uplands, with their rough roads and their sparse population, retain practices, and preserve old beliefs and superstitions, that have died out in less remote and more cultivated neighbourhoods. Thus the Devonshire man in his place, like the Englishman in his, like the inhabitants of other countries in theirs, is in no remote degree the product of the soil on which he lives. There is a deeper meaning in the words 'fatherland' and 'mother-country' than we are apt to imagine.

I do not intend, however, in this paper to discuss such questions of cause and effect. I wish simply to record the present economic relations of the geology of Devon, which are very wide and very important, dealing mainly with the mineral wealth of the county. We are far from recognising the extent of that wealth. In the days, not yet so distant as to be beyond living memory, when pack-horses were the sole means of traffic in our central districts, little advance could be made in its development. Good roads, rapid

and cheap locomotion, are the essentials of such progress. Our roads have for years been improving. Our canals were never very important—we have too many hills to permit the formation of an extended system of water-carriage—and have been elbowed out by the railways. The natural difficulties of the county have retarded the progress of the iron road; and there are yet large areas deficient in railway accommodation. The same geological causes that formed our mineral lodes, shaped in conjunction with others our hills and valleys; creating wealth on the one hand, increasing the difficulties of its attainment on the other. In railway extension, as in so many other matters, progress is attained only by conquering Nature for the object she supplies with the means she gives.

Cornwall excepted, no county in England presents a more varied field of economic geology than Devon. My object is to indicate the vast utilitarian debt we owe to the geological conditions of our county; possibly to forecast its increase. My materials are drawn from many sources, in addition to personal investigation; but I must specially express my sense of the value of that part of Sir Henry De la Beche's report on our western geology, which deals with this question. At the time he wrote it was hardly possible to have said more; but thirty-five years have made great changes; and his statements are no longer adequate. May I hope that this paper will supply the want which now exists of a full summary of the present condition of this important subject? Even at this time, when mining is by no means in a flourishing condition, our metallic minerals are worth as raised about £150,000 a year; and we cannot credit our earthy minerals—our building and paving stones, clays, and the like—with being of less value; whilst the possibilities of development in both are very great.

AGRICULTURE.

It would require far more space than can be devoted to this section, within the compass of my paper, fully to indicate the bearing of the economic geology of Devon upon its agriculture. Few counties have such variety of soils and subsoils, ranging from the almost barren sand, the product of the surface decomposition of the granite, which covers much of the higher ground of Dartmoor, to the rich deep alluvium of such river valleys as those of the Exe, the Creedy, the Culm, the Torridge, the Teign, the Dart, the Plym, and the Tamar. Taken as a whole, the most fertile district is that of the New Red Sandstone; and apart from Dartmoor some of the

poorest land in the county is to be found overlying Carboniferous shales, and the Cretaceous gravels. The Devonian districts occupy somewhat of a middle place. The limestone soils, though fertile, are comparatively thin, and apt to scorch in dry seasons. Some of the predominating clays are exceedingly heavy. But there is no better land in the county than is to be found on certain of the Devonian greenstones, to the decomposition of which it owes its fertility. With so many kinds of subsoil and substrata, and such continual variations of level and exposure, even in limited areas, there is of necessity a wide range in comparative fertility and in the measure of adaptation for different crops. Hence the many-sided character of Devonshire agriculture, and, mainly, its excellence. A large area of the county remains yet rough and unenclosed; but it by no means follows that improvement is stayed by natural conditions. Dartmoor is our local synonym for all that is barren and bare; yet year by year the girdle of cultivation encroaches more closely on the Moor; and the humid climate of that elevated region has been shown to confer great capabilities. A few summers since, when the lowlands were parched and burnt up by excessive drought, the hay crop on Dartmoor was luxuriant. And so, too, the debt of the agriculture of Devon to Dartmoor is great, even if we do not regard its own productive powers. From this central plateau descend most of the rivers which diffuse fertility through the vales of the south and west. To the Exmoor table-land the north of Devon is similarly beholden.

The fertility of alluvial soils depends upon the character of the rocks whence they are derived. The *débris* of the crumbling sandstone cliffs of Teignmouth and Dawlish comes at once into cultivation. Some of the shales degrade into an unprofitable clay. Disintegrated granite by itself is poor, but in mixture may have considerable fertility. These considerations will help to show why it is not every stream whose waters are adapted for that system of irrigation, which forms a special feature of the agriculture of the county.

MINERAL MANURES.

Fuller mentions among the mineral manures used in Devonshire in his day, blue and white marl, chalk, lime, and sea-sand. We have little clue to the character of the marl or the locality whence it came. Probably it was employed mainly in the north-eastern part of the county, to which also the practice of chalking must have been almost wholly confined; since

there alone were marl and chalk readily accessible. Marling has very much gone out of fashion.

We have abundant evidence that the use of lime in agriculture is of no very ancient date. Risdon* (and he is confirmed by Westcote) speaks of it as of recent adoption. But it came rapidly into favour; and was long used with very little discrimination as a kind of universal remedy. Even in the present day its manurial value has been the subject of much controversy. Devonshire, on the whole, is well supplied with lime, though there are localities in which it is scarce, the limestone occurring in isolated patches and the cost of carriage being high. The chief sources of lime supply are the districts of Plymouth and Torbay, where a great deal of lime is burnt and forwarded by rail. Limestone is also shipped thence to be burnt at other places, though less now than formerly. There are many lime quarries in and near Yealmpton, Totnes, Ashburton, Brixham, Newton, Drewsteignton, and Chudleigh; and the South Devon Railway passes through large quarries at Stonycombe. On the other side of Dartmoor we find quarries at Meldon, Lifton, Sourton, Bridestow, and South Tawton. In the north of Devon the chief supplies come from the Ilfracombe district; where, and at Coombe Martin, Challacombe, Berrynarbor, Castlehill, Bampton, and Swimbridge, large quantities have been raised. Chalk is burnt for lime at Beer and Branscombe.

Where lime is the scarcest—namely, in the district back of the coast-line between Bideford and Boscastle—the shell sand of Bude comes in as a substitute. It has been so used certainly for three centuries, since Carew refers to it in his *Survey*.† Thousands of cartloads are sometimes removed in a day; and De la Beche calculated that in 1839 5,600,000 cubic feet from Bude and elsewhere were used in Devon and Cornwall annually.‡ Its fertilizing qualities depend on the carbonate of lime contained in the shells of which it is mainly composed.

BUILDING STONES.

Devonshire abounds in building-stones of various kinds, though few of them have ever found their way beyond the limits of the county. Their use is chiefly confined to their own more immediate localities, for the supply of the wants of which hundreds, if not thousands, of quarries have been opened.

* *Survey of Devon*, p. 11. † First published 1602.
‡ *Report*, pp. 479-80.

Mr. R. Hunt, F.R.S., the Keeper of the Mining Records, in a *Report on the Building-stones of the United Kingdom* for the year 1858, published in 1860, enumerates sixty-five Devonshire quarries as having a more than merely local reputation and utility. There were granite quarries at Blackenstone and Westcott, Moretonhampstead; the Dewerstone; Heall, Dartmoor; Pewtor; Heckwood; and Lundy Island. One elvan quarry at Roborough. Two of trap at Pocombe and Dartmouth, the stone of the latter being used in London for roads. One of metamorphic rock at Sandquay, Dartmouth, employed for a similar purpose. Slate quarries at Burnshall, Longford, and Millhill, Tavistock; Coryton, Launceston; Cann, Plymouth; Claspery, Southmolton; Kingsbridge; Nethway, Brixham; Penricca and Rattery, Totnes; Woodland, Newton Abbot. Limestone quarries around Plymouth, Torquay, and Brixham; and at Chudleigh, Culm John, Drewsteignton, Ipplepen, and South Tawton. New Red Sandstone at Exminster, Heavitree, Pakeham, and Thorverton. Beerstone at Beer. Nearly half the quarries mentioned are of limestone, and fully half of these were worked principally for lime. The estimated total in tons of the stone returned (including a couple of small Cornish quarries) was 185,056, and the value £27,206. Mr. Hunt found the difficulties in the way of continuing these reports very great, and none have appeared since. The figures can only be regarded as approximate.

Granite.—The Dartmoor granite has been worked at several points, most extensively at Haytor; but the granite trade of Devon could never compare with that of Cornwall, and is now at a low ebb. Yet some of the Dartmoor granites would successfully rival the best Cornish. The absence of good roads partially accounts for the want of development; but while there is always a small demand for granite, it is only occasionally, and for special purposes, that this demand increases, and the Cornish granite has now almost entire possession of the field. The earliest railways of Devonshire were connected with its granite quarries. The first ran from the terminus of the Stover Canal, at Teigngrace, to the quarries at Haytor, whence came the granite for London Bridge. It consisted, however, simply of grooved blocks of granite, and was opened in September, 1820. The Princetown railway, from Princetown to Plymouth, has metal rails. It was projected about 1818, for the supply of the war prisons at Princetown, by Sir Thomas Tyrwhitt, and twenty-three of its twenty-four miles were opened in 1823. When the war

prisons were closed the line ceased to be of use except for the granite quarries at King Tor. The granite of Lundy Island is of good quality, and has been worked. The local name of granite—moorstone—arises from its association with the moorlands of the county. For ages it was procured from the surface blocks with which Dartmoor even yet is strewn.

ELVANS.—These are rocks of granitic character which occur in veins or dykes. They are in the main composed of the same constituents as granite, but differently arranged, and are often porphyritic. Some are admirably adapted for building purposes; others are worthless. The Roborough elvan, which crosses Roborough Down, near Plymouth, is the only noteworthy building elvan of Devonshire. It was a favourite material for dressings and carved work fully five centuries since, for it occurs in the ruins of the Carmelite Friary at Plymouth, which was founded in 1313. It has a felspathic base, with thinly disseminated crystals of limpid quartz, and numerous cavities, whence crystals have disappeared. The colour is a warm buff.

TRAPS.—The trappean rocks of the county are largely used for building purposes in their various localities. They vary widely in character; some are exceedingly hard and tough; others easily worked, but durable; others fairly adapted for rubble walling; others again decomposed and rotten. The best known building-traps of Devon are at and near Exeter. Rougemont Castle and many of the old structures in the city are built of a vesicular trap raised on the spot. A hundred years ago very similar stone was raised at Thorverton; and the felspathic traps of Pocombe and Posbury are still in demand. The stone is a dark ruddy brown with whitish veins. It forms the chief material of the Royal Albert Museum. The most compact stones are not always the most durable. Tavistock Abbey was built of a loose-textured, free-working trappean ash from Hardwick, about a mile from the town. It has proved exceedingly durable, and has a pleasing light-green tint. Tavistock New Hall is built of it, and the quarry is being re-worked extensively for the Kelly College. The greenstones are called locally dunstones; the blue and grey varieties being most valued.

METAMORPHIC.—The schists of the Bolt Head and Start Point district have been much used locally, and have weathered well, though not suited for fine work.

DEVONIAN.—The rocks of the Devonian system supply two chief classes of building-stone, the limestones and the slates, the sandstones being of more local occurrence and utility.

Centuries since, slate was very extensively employed for building; but it is now used for inferior work only; nor do the Devonian slates of Devon yield such good building-stone as the same rocks occasionally do in Cornwall.

The Devonian limestones are chiefly wrought in and around Torquay and Plymouth. Considerable progress has been made in their use since 1839, when Sir Henry De la Beche wrote: "They are rarely tooled highly for architectural purposes, though they would form a durable material where their gray tint would not be considered heavy."* The Plymouth limestones were certainly used for building over five centuries since, and have given abundant proof of their durability. These limestones are mostly crystalline, and not very readily wrought; but they look and last well. They range in hue from light grey to black, with different shades of red, and veins of white, red, yellow, and other colours; and admit, therefore, of effective chromatic treatment. The most important building in which they have been employed is the new Guildhall at Plymouth. They constitute the chief building material of the Three Towns, Torquay, and Newton. The objection raised to these limestones is, that they carry damp. Hence private houses built of limestone are generally stuccoed. Some of the Devonshire limestones are dolomitic, notably in the vicinity of Yealmpton. These, from their superior specific gravity, De la Beche considers peculiarly adapted for sea-walls.† The Plymouth Breakwater is of limestone from the quarries at Oreston.

The sandstones of the Devonian system have been occasionally used for building purposes, but their uses are purely local.

Carboniferous.—The rocks of the Carboniferous series quarried in the county do not call for much remark. They furnish a considerable quantity of rough building-stone; and "freestones" of fair quality have been worked in Clawton, Ashwater, Holwell, Beaworthy, and North Lew.

Trias.—The sandstones and conglomerates of the Trias present a wide range of adaptability, or the reverse, to building purposes. There are some notable exceptions, but as a class they are not distinguished for durability. They have been worked for centuries, and the products of certain localities have won considerable reputation. The conglomerates are the hardest of the series. At Heavitree they have long been quarried under the name of Wonford stone. They have been laid under contribution for the sea-wall at the bottom of

* *Report*, p. 491. † Ibid.

Torbay, for which purpose they are admirably suited. There are quarries at Exminster, Kenn, and Pakeham; and the sandstone from Ugbrook has obtained considerable local reputation for dressings.

CRETACEOUS.—This system supplies the most typically perfect building-stone of the county, such a stone being one easily raised from the quarry, obtainable in large blocks, of an even and agreeable colour, and fine grain, working readily, weathering well. These qualities are all found in the famous Beer stone, the great west-country mediæval rival of the Caen. It occurs near the little port of Beer, at the passage of the chalk into the greensand, and is chiefly composed of carbonate of lime. In colour it is white, and in grain fine and even. It was quarried so far back as Norman days, and used extensively in the building of Exeter Cathedral. Long neglected, it is now rising into fame again, and has been used in several places by Sir Gilbert Scott, R.A. Soft when first quarried, it hardens by exposure; and while its chief uses are in internal work, it possesses more than average powers of resistance to atmospheric influences. The flints of Devon are seldom used for building.

ORNAMENTAL STONES.

Associating Cornwall with Devon, it may be safely asserted that in ornamental rocks and stones no district of England is so rich. Devon supplies an almost endless variety of marbles; Cornwall equally varied stores of granites and porphyries, and a stone that surpasses all others in beauty—the serpentine.

In an ornamental sense, the granites of Devon are almost wholly undeveloped. De la Beche speaks of a white granite near Okehampton as resembling statuary marble,* and there is a red granite at Trowlsworthy, near Shaugh, worked by the Messrs. Freeman, of Penryn, which is the handsomest rock of its class in the West. Some of the Devonshire granites are porphyritic, containing large crystals of felspar, and susceptible of very effective treatment.

The greenstones have only been polished occasionally, though they would be of great service in relieving lighter stones, and might often work well with the marbles. The green trap of Black Head, Anstis Cove, has been mentioned by Mr. Appleton, F.R.I.B.A., as peculiarly adapted for this purpose.

Most of the Devonshire limestones are sufficiently hard to

* *Report*, p. 501.

receive a good polish, and are thus in effect marbles. Those of the Carboniferous system are chiefly black and grey, but have occasionally been wrought to advantage in chimney-pieces. It is with the marbles of the Devonian system that we have chiefly to do; they constitute the widely-known and well-characterised Devonshire marbles. The Chudleigh marbles were among the earliest worked in Devon for ornamental purposes; though Westcote * contains a reference to a couple of varieties of stone which he considers of a porphyritic character, but which can hardly be any other than the marbles of Ipplepen, then recently worked. One variety was of a "dunnish murrie colour, diapered with blue and green, with running veins of white;" the other was of a "marble dye, intermixed with white of diverse forms and fashions, very delightful to the spectator's eye." These, however, are only casual notices, and the value of those rocks for purely ornamental purposes is a comparatively recent discovery. Though long quarried for lime and building, the fact that throughout the mediæval churches of Devon wherever polished stone enrichments are introduced, Purbeck stone was almost universally employed, indicates to me clearly enough that the builders were unaware they had in the coralline marbles of Torquay and Plymouth a substance far more beautiful than the shelly marbles of Dorset.

Ninety years ago, Gilpin, in his *Observations on the Western Parts of England*, declared † that he thought the Plymouth more beautiful than any foreign marbles. Polwhele, a few years later,‡ directed special attention to the marble of St. Mary Church as "of superior beauty to any other in Devonshire, being for the most part either of a dove-coloured ground, with reddish-purple and yellow veins, or of a black ground, mottled with purplish globules." Within the past fifty years the fame of the Devonshire marbles has spread far and near, and they are now in very general request. They have found their way into every part of the kingdom, and have even been shipped to Italy.

The principal localities of the Devonshire marbles proper are Torquay, Ipplepen, and Plymouth. The Ipplepen marble is chiefly characterised by a roseate dove-colour ground, with reddish veins. The Plymouth and Torquay marbles closely resemble each other. The prevailing hue is grey, with veins of red, white, black, and brown; but the bases of some are red and yellow, and of others black; whilst others again are rendered exceedingly handsome by the "figure" of the fossil-

* *View of Devon in* 1630, pp. 66-7. † Page 203. ‡ *History of Devon*, p. 49.

shells and corals which they contain. Of the latter class are the madrepore marbles. The Devonshire marbles are chiefly employed for purposes of church decoration—for flooring, panelling, and even for columns. But there is a large trade done at Torquay, especially in small articles of jewellery and household knicknacks; in the manufacture of which a good deal of taste is displayed, alike in the selection and the arrangement of the pieces of which they are composed. There is an encrinital marble at Ilfracombe of which some use might be made.

Our minor decorative stones are numerous. Devonshire fluor spar has rarely if ever been adapted to ornamental purposes, for which indeed it is little fitted. The calcite which abounds in the limestone quarries has, however, been utilised. I saw recently a set of very handsome balusters which had been turned out of Plymouth calc spar by Messrs. Goad of that town. Jasper, though seldom worked, is by no means of infrequent occurrence. There are large blocks of the red variety near Brent Tor. Our rock crystals are sometimes cut and mounted in jewellery. The rarer materials of our local lapidaries are the calcedonies, jaspers, agates, carnelians, and silicified woods associated with the chalk and greensand of the north-east of Devon, fine examples of which are found on the beaches at and near Sidmouth. Some of these stones are very handsome, and well adapted for the purposes of personal adornment to which they are applied. Crystals of tourmaline have occasionally been cut and set; but our garnets and opals have only a mineralogical interest. Amber is said to have been found on the Devonshire coast, but this seems doubtful.

ROOFING SLATES.

There are many good quarries of roofing slate among the Devonian strata of the county; but they are not worked so extensively as was once the case, and the demand for their produce is now chiefly local, the slates of the Delabole district and of Wales being most frequently employed. The largest Devonshire slate quarries are at Millhill, near Tavistock; and considerable quantities were once raised at Cann Quarry, near the Marsh Mills station on the Tavistock railway. Other quarries have been or are now worked in the vicinities of Bickington, Ashburton, Buckfastleigh, Staverton, Rattery, Harbertonford, Ivybridge, Ugborough, Brixham, Leigham, Buckland Toutsaints, and elsewhere, small deposits of roofing slates of fair quality being by no means of unusual occur-

rence. From the Buckland Toutsaints quarries large quantities of slate were, before the Dutch war of 1781, exported to Holland.

ROAD AND PAVING MATERIAL.

Slabs of the local limestone are largely used for flagging in the limestone districts; but though durable they rapidly polish under the continual attrition of the feet. There is some compensation for the undue smoothness of their surface in the beauty of the appearance which they then present, after showers of rain. Seventy years ago a traveller recorded with surprise that the streets of Plymouth were paved with marble, and since then this has been a matter of constant remark with strangers. The limestone flags used in the Three Towns are squared; at Torquay they are worked in as irregular polygons.

Granite is occasionally used for flagging; but its expense militates against its general adoption. It has, however, of late come largely into favour for kerb stones, especially for footpaths which are not flagged, and being wrought in blocks nearly a foot broad is convenient to walk on for those who are not particular about keeping the wall.

The more schistose or laminated sandstones of the district supply a little flagging; and some of the quarries of roofing-slate furnish large and durable slabs, which are chiefly used for internal purposes, and the flagging of courtlages.

Limestone is occasionally used for pitching, but is not well adapted for the purpose. The best pitching stone in the district is the granite, which splits up easily into rhombs. The red-brown Devonian sandstone of Bovisand, near Plymouth, has been extensively used for pitching in the Three Towns. Like granite, it squares easily.

There is in the county an abundance of excellent macadamizing material, though many localities are badly supplied. Granite crushes too easily to make very good "road-metal;" and this is still more the case with the ordinary sandstones. Flints are largely used in the districts where they occur; and the cherty beds of the Carbonaceous series are also of much utility. The limestones answer well, though rather hard than tough. The best road metals of the county are derived from the trap rocks, some of which are not only very hard but very tough likewise, and while they last long and make hard roads cause little dust or mud.

For private and garden walks the finer gravel is frequently used, that from Aller, near Newton, being a fair example.

Sometimes crushed granite is employed, which has a very agreeable sparkle; and occasionally picked calcite from the limestone quarries, which looks well when broken small, though it will not stand heavy traffic.

CEMENTS.

Lime is the chief cement produced in the county. Its character and quality vary with those of the parent limestones. The calcareous beds of the Devonian system, as a rule, yield better lime than those of the Carboniferous. The chalk lime is inferior. Occasionally highly calcareous traps have been burnt for lime, and have yielded cement of fair quality. A bed of limestone at Oreston, near Plymouth, was found to yield a good hydraulic lime. The ordinary hydraulic lime of the district comes from the Lias limestone of Lyme Regis. This is just beyond the borders of Devon, in which the Lias is but sparingly represented; but the manufacture of the Lias cement is carried on at Plymouth and other places in Devonshire, to which the stone is shipped.

SAND.

The fine shell sand of the coast at Bude is much used, as stated heretofore, for manure. For mixing with lime to form mortar the river sands are employed where available; and in their absence, frequently, sea-sand is used, but is ill adapted for the purpose on account of the quantity of salt with which it is impregnated. Mine sand, which is produced in the operation of dressing the ores, holds a middle place. Granite sand is found at many points on Dartmoor, and is of considerable value; and there are occasional deposits of sand—the remains of old river beds—as on the Hoe, at Plymouth, that have some local importance. The sand of the Warren, near Dawlish, has been used for moulding purposes in foundries.

MILLSTONES.

The Heavitree conglomerate was formerly employed in the manufacture of coarse millstones for shelling clover, and for separating the wheat from the close husks taken off the ears in the process of thrashing.

WHETSTONES.

Whetstones have long been manufactured from indurated concretions found in the lower part of the greensand on the Blackdown Hills, which is wrought by means of levels. Under the name of Devonshire batts a considerable part of the south

of England was supplied with these stones; but the demand has fallen off with the introduction of artifical preparations, and of mowing and reaping machines. Scythe stones were also made at Kenn when Lysons wrote (1822).*

OILSTONES.

These are made from a stone which occurs near Wheal Friendship, Tavistock, and have considerable local repute.

CLAY.

The clays of Devon are among the most important of its commercial products. There are few districts in the county that do not yield clay of some kind, and in some places it literally abounds. Most of this clay is of inferior quality, but it has been frequently utilized for brickmaking. Other clays are well adapted for the manufacture of coarse ware, and there have long been potteries for this manufacture in the neighbourhoods of Bideford and Plymouth. At Fremington there is much red clay, and at Wear Gifford, white; and in these localities excellent sewage ware is made.

The most important clays of the county are those which are found in the vicinity of Bovey and Newton; the china clays of Dartmoor; and the terra-cotta clay of Watcombe, near Torquay.

Connected with the lignite deposit of Bovey Tracey, there are extensive beds of clay which reach as far as Aller. The ordinary varieties may be described as natural china clay, having been derived from the decomposed granites of Dartmoor, washed down into the bed of a lake which then occupied what is now Bovey Heathfield. These clays have long been known. They were used for many years in the potteries at Bovey and Indio, which were established about 100 years ago. The Bovey clays are now only employed for bricks and similar purposes. The clays at the other extremity of the deposits, Teigngrace, Kingsteignton, and Aller, are of very superior quality, and are largely exported. In 1800 the quantity shipped was about 2,000 tons; in 1873 it was 56,451.†

The Aller clay is worked up in a pottery on the spot into sanitary and architectural ware of excellent quality. The Bovey Pottery, employing about 250 hands, uses chiefly the

* *Magna Britannia*—Devonshire, p. ccxciv.

† *Mineral Statistics of the United Kingdom*, by Mr. R. Hunt, F.R.S. From this invaluable work most of the recent statistics concerning clays and metallic minerals are taken.

Dorsetshire clay, and makes the best descriptions of earthenware.

There are china clay works at several points on the west of Dartmoor, where large deposits exist. The oldest and the largest is that at Lee Moor, near Plympton, the property of the Messrs. Martyn. It is a noteworthy fact, that with china clay so close at hand, Cookworthy, the founder of the Plymouth pottery, and the first maker of true porcelain in England, should have gone so far as the west of Cornwall (Breage) for his supplies. At Lee Moor the refuse from the clay manufacture is burnt into bricks and tiles of high quality, both for fire-resisting and ordinary building purposes. The china clay raised in 1873—nine works in operation—amounted to 27,197 tons.

The terra-cotta clay at Watcombe is a recent discovery. It is perhaps the very finest terra-cotta clay in England, and is wrought in an art pottery on the spot into a ware of the finest texture, and of great beauty, the most beautiful in fact now made.

The clays of the county are employed for building purposes in other ways than in the manufacture of bricks. Houses have been built of "cob" in Devonshire from a very early date. "Cob" is a mixture of coarse clay and straw, and walls are built by its being rammed into a boarded framework. This shifts as the work proceeds in the manner of the modern concrete building apparatus, which so far simply follows the old lines. I have heard "cob" contemptuously called "mud." Much cannot be said in favour of its appearance, nor is there any reason why it should be retained in preference to brick or stone. Still it has the merit of forming, when properly treated, dry and comfortable cottages.

METALS.

Metal mining in Devon originated in a period of very remote antiquity. I have elsewhere given reasons* for holding that tin streaming in Cornwall was carried on far back in pre-historic times, when the general level of the West of England was at least some thirty feet higher than it is at present, and when the mammoth either still existed here or had not long disappeared. Though not so richly metalliferous as the sister county, Devonshire has many metallic lodes. Dartmoor and its borders constitute one great metalliferous district; Exmoor and its borders another. The chief mining

* Vide *Transactions Plymouth Institution*, 1874.

centre is Tavistock; but there are several mines around Ashburton. North Molton is a very promising locality, and there are many scattered mines of various kinds. Metal mining in Devon has been subject to a great many fluctuations, and at present is not too prosperous. The metallic ores raised in Devon in 1873 were of a value of £149,503 12s. 10d. In March last, according to the returns of the inspector, Dr. Foster, there were 63 metal mines in operation in the county. I give the details under the different heads. When a mine produces various metals in quantity (and there are nine worked for more metals than one) it is counted under each head.

ANTIMONY.—Various ores of antimony occur in Devon; and antimonite has been raised near Hennock and Bovey in small quantities.

ARSENIC.—Devon contains large quantities of arsenical pyrites; but it is only very recently that arsenic has been produced to any extent. In Cornwall white arsenic has long been manufactured in the process of calcining the tin ores; but the Devonshire mines neglected it until arsenic reduction works were established in connection with Devon Great Consols. These in 1868 produced 473½ tons; but they are now carried on far more extensively—the demand for arsenic having enormously increased—and are the largest arsenic works in the world. In 1873 the returns of arsenic, mostly refined, were 1,953 tons. In March last there were three arsenic-producing mines.

BISMUTH.—The ores of bismuth are found but rarely, and not in such quantity as to be commercially valuable.

COBALT.—Cobalt ores occur in several localities in Devon, but like those of bismuth, sparingly. 1,700 lbs. of ore of inferior quality were however raised and sold from Wheal Huckworthy, Sampford Spiney, in 1820.

COPPER.—Copper mining, in modern days at least—for it is probable that some of the bronze of the bronze period of Devonshire was manufactured on the spot—dates from early in the last century, though it was not until the commencement of the present that the copper mines of the county really became important. North Molton is one of the oldest centres of copper mining in Devon. A century and a half since copper ore was plentiful in that locality. Devon contains what was once the most productive copper mine in the kingdom—Devon Great Consols, which, on an original outlay of £1,024, in twenty-one years returned just a million profits; yielding £200,000 in dues to the mineral lord, the Duke of

Bedford. Copper mines are now worked in the vicinity of Tavistock, Buckfastleigh, and North Molton. The chief ore raised is the chalcopyrite or yellow ore; but gray and other ores occasionally occur in considerable quantities. The yield of copper ore in Devon has been subject to considerable fluctuation. In 1801, 1,078 tons were raised; in 1810, 3,747 tons (from seven mines); in 1820, 4,037; in 1830, 4,034. When Devon Great Consols was set to work it speedily sent up the produce, returning as much as 25,746 tons in one year. In 1857, with 19 mines at work, 39,069 tons were raised; 1860, 35,524; 1862, 41,513. In this year there were 24 mines at work, and the produce is the highest on record. Since then there has been a steady and almost continuous decrease. In 1870 the mines had fallen to 15 and the produce to 24,752, and in 1873 only 17,007 tons 11 cwt. were raised. In March last there were 16 copper mines in the county.

Gold.—This metal has been found at several localities in Devon; though, it is hardly needful to say, in very small quantities. It has chiefly occurred in the beds of the Dartmoor streams; but about fifty years since was discovered by Mr. Flexman in grains and small plates in a lode of hematite at North Molton. Both the Britannia and Poltimore mines were found to produce it; but the attempt to work for gold specially did not prove commercially successful.

Iron.—This metal was raised in Devon at a very early period; and there still remain abundant vestiges of pits sunk on the hills capped by the greensand at Blackdown, Dunkeswell, &c., for the extraction of the surface iron, which was probably smelted in bloomeries on the spot. The iron mines of Devon are more widely distributed than those of any other metal. Iron ores occur in workable quantities at Shaugh, Rattery, Sharpham, Brixham, Prawle, South Brent, Haytor, Ilsington, Smallacombe, Christow, North Molton, and many places in the Exmoor district. In fact the iron ores of Devon are almost undeveloped; though considerable attention has been turned of late to those in North Devon. Between 1796 and 1802, 9,293 tons of iron ore were raised at Coombe Martin and shipped to Wales. The principal varieties of ore worked are hematite, chalybite, limonite, and magnetite. A singular series of successive beds of the last mentioned ore occurs at Haytor. In the days of pounce, large quantities of micaceous iron ore were sent from the county to London and sold as Devonshire sand, realising £3 3s. to £8 8s. a ton. The production of iron ore in the

county has varied considerably. In 1857, 2,000 tons only were raised; in 1864 the yield had increased to 11,068; and in 1866 it was 40,671. The next year it fell back to 10,212; by 1872 it had again risen to 29,361; and 1873 sent it back again to 10,309. In March last Devon had 19 iron mines.

LEAD.—The lead mines of the county are of very great antiquity, dating back even to the Roman occupation. They were worked for the silver contained in the lead, for the Crown, certainly as early as the reign of Edward I., when they are recorded to have been very profitable. The two lead mining districts are around Beeralston and Coombe Martin. The latter mines were re-opened in the time of Elizabeth, and have been worked at various times subsequently. The most important lead mines of late years have been on the Tamar; but one of the most productive of these was stopped by the water of that river breaking into the workings. A considerable quantity of lead ore has been raised at Christow. The principal ore is the sulphuret—galena. The lead mines of the county are far less productive than formerly. In 1857, 15 mines produced 2,590 tons 11 cwt.; in 1868 there were only two which yielded 1,522 tons 12 cwt. In 1872 there were five mines producing 746 tons 9 cwt. In 1873 the produce was 676 tons 9 cwt. In March, 1875, there were ten lead mines.

MANGANESE.—Devon has long been the chief, and is now the only source of the manganese supply of the kingdom. About a century since manganese ores were first raised at Upton Pyne, and a little later, on the same lode, at Newton St. Cyres. These mines were considered exhausted about 60 years ago, and they have recently been re-opened without effect. Manganese was afterwards found at Doddiscombleigh, Ashton, and Christow; and about 1815 was discovered in what is now *the* manganese district of the county *par excellence*, the neighbourhood of Milton Abbot. The chief ores worked are the grey and black oxides, psilomelane and pyrolusite. Between 1803 and 1810 the produce of the county averaged about 3,000 tons annually. In 1837 Sir H. De la Beche reckoned it at 500 tons. In 1868, with a small supply from Cornwall, the total was 1,700 tons; and in 1873 it was 8,671 tons 6 cwt., of which 17 only came from Cornwall. In March last there were 10 manganese mines at work in the county.

MERCURY.—Much interest was excited last year by the reported discovery of native quicksilver in the rocks near the Head Weir at Exeter. Some was found, and mining was

suggested; but it seems certain that the metal had been thrown or placed there, so that we cannot, I think, much as we should have desired it, add mercury to the list of our Devonshire metals.

SILVER.—Native silver and several of its ores occur in Devonshire, but in very small quantities. Almost the sole source of Devonshire silver has therefore been its argentiferous galena. In 1293, 270 lbs. of silver were thence produced in the county. Some of the Devonshire lead ore is very rich in silver, ranging up to 140 ounces to the ton, and even beyond. Wheal Florence, near Tavistock, sold some silver lead ore at £90 per ton. Considerable quantities of silver have been produced in the county from time to time. In 1857, 50,262 ounces were raised; in 1868 the yield was 39,865 ounces. 1870 brought it to 24,706; 1873 to 6,510, from seven silver lead mines.

TIN.—There are vestiges of ancient streaming for tin to be found in almost every quarter of Dartmoor; and some tin is still raised on the moor. The old stannary towns of Devon were Tavistock, Ashburton, Chagford, and Plympton; the last-named so constituted in 1328; and the first three mentioned as such in a charter of 1305. They were the centres of the ancient tin mining districts. Devonshire at one time yielded more tin than Cornwall, and its coinage dues were farmed in 1213 at £200, whilst those of Cornwall were farmed at 200 marks only. In the next century, however, Cornwall attained that preponderance in the production of tin which she has since and increasingly maintained. Tin is found nowhere in Devon, save on Dartmoor and its borders; but explorations are in progress at Devon Great Consols in the hope that that famous copper mine may, like Dolcoath and many others in Cornwall, yield tin in depth. The only ore of tin raised is the oxide—cassiterite. The production of tin in Devon has long been small. In 1868 three mines raised 137 tons 15 cwt. In 1873 only 93 tons 8 cwt. were raised. There were 13 tin mines in Devon in March last.*

TUNGSTEN.—Wolfram (tungstate of iron) has been found in small quantities in the same locality.

URANIUM.—Pitchblende (proto-peroxide of uranium) has been found in the Tavistock district, but not to value.

ZINC.—Blende or blackjack (sphalerite) occurs in many of the mines of Devon, and is occasionally sold, but is not of much commercial importance. In 1857 three mines sold

* The number of mines in operation is taken from the report of Dr. Foster, F.G.S., inspector of the metalliferous mines of the district.

775 tons; in 1868 only 69 tons were sold; and in 1873 123½ tons. There is now only one zinc mine in the county.

SULPHUR.

The time may come when the sulphur-bearing ores of this county, at present of little note, may be of great value. They are by no means neglected, however, even now. Iron pyrites, or mundic, is the chief sulphur ore, and contains rather over 50 per cent. of sulphur. It is used in the manufacture of sulphuric acid and copperas; is widely distributed, and in some mines is found in very large quantities. Devonshire is producing an increasing supply. In 1858 the produce was only 685 tons; in 1867 it had risen to 2,758 tons; and in 1873 was 2,732 tons 8 cwt.—value, £2,881 14s. 11d. Two mines were worked for iron pyrites in March.

PAINTS.

Devonshire has produced, and still continues to do so, large quantities of mineral paints. The manufacture of black paint from the anthracite of Bideford is now of considerable standing. The anthracite is ground up finely, and then used in the ordinary way. For many years large quantities were consumed in the Government dockyards. Umbers and ochres were manufactured in North Devon—at East Down and Coombe Martin—nearly a century since; and more recently umber was raised at Berrynarbor and Ugbrook. Mr. Wolston, of Brixham, started a paint manufactory in connection with his iron mines, in which the softer parts of the ore were made into ochreous pigments, and similar paints are still manufactured there. Ochre is now manufactured, among other places, at Devon Great Consols; Laira, near Plymouth; and Aller, near Newton Abbot. At Devon Great Consols it is made from the iron oxide thrown down in the tanks in connection with the process by which the copper is precipitated from the cupreous water. There is a very large deposit of umber worked at Ashburton. The Mineral Statistics for 1873 state that 10 tons of ochre and 1,250 tons of umber were raised in Devonshire in that year, of a total value of £1,952 12s. 8d.; but the quantity of ochre must have been largely in excess of the amount stated.

HEAT AND LIGHT PRODUCERS.

Though so large an area of the county is occupied by rocks of the Carboniferous system, the coal measures are absent.

The belief, based upon the indications presented by the carbonaceous matter occasionally present, that coal was to be found, has led to several costly and of course fruitless searches, especially in the vicinity of Exeter, Bradninch, and Tiverton. There are, however, in North Devon several beds of anthracite or culm, which would seem, from the traces of ancient workings on their outcrops, to have been known at a remote period, and somewhat extensively wrought. The chief mines were near Bideford. One of the principal uses of the anthracite when it was raised was to burn lime, a purpose for which the Welsh anthracites have been largely imported into the county. No anthracite is now raised for fuel in Devon.

There is a very extensive deposit of lignite or brown coal at Bovey Tracey, which, with its accompanying clay beds, has been fully described by Mr. Pengelly, F.R.S., F.G.S.* This lignite is said to have been first worked early in the last century;† and it was at one time largely used in the potteries at Bovey Tracey and Indio, the latter no longer in existence. The lignite emits an unpleasant smell when burning, and therefore was never much used for domestic purposes, except in the poorer class of cottages. Moreover it is not a good fuel, and to be employed to the best advantage needs to be burnt soon after it has been raised. It has almost ceased to be of commercial or economic value; and is only used at Bovey to burn bricks, and to warm the drying-room in which the green ware is deposited, after it comes from the hands of the thrower or moulder, until it has hardened sufficiently to undergo the next process.

Dartmoor has an enormous and almost inexhaustible store of peat, which in some places is upwards of thirty feet deep, and which for ages has been a valuable source of fuel in the moorland and bordering districts. A peculiar form of peat, locally called blackwood, was formerly dried and charred, and used by the moorland smiths in tempering edge tools. Peat when distilled produces naphtha, paraffin, acetic acid, sulphate of ammonia, and other matters; and for some time the prisons at Prince Town were occupied by a company as peat naphtha works. The undertaking was not commercially successful; but during its continuance the works were lighted with peat gas. Under the present régime large quantities of peat have been cut by the convicts, and the prison was long lit in a similar way, the residuary charcoal being used for fuel and sanitary purposes, and the ashes as manure. The

* In a monograph, and also in *Devon. Assoc. Trans.* vol. i. p. 29, and elsewhere.

† Lysons' *Devon*, p. ccxcii.

use of peat for the manufacture of gas (in which it was sometimes used alone, sometimes with a little coal) has been discontinued from temporary causes. There are about one hundred patents for the manufacture of peat into a more concentrated fuel; and companies have been formed for carrying out some of these processes on Dartmoor. They could hardly be said to have reached the practical stage before they were abandoned, and the peat of Dartmoor therefore remains a vast mine of almost wholly undeveloped wealth. To a smaller extent the same may be said of Exmoor.

Petroleum shale was discovered to exist in the county last year at Barnstaple, and has been described by Mr. T. M. Hall, F.G.S.* Petroleum has likewise been observed in the neighbourhood of Chudleigh; but in neither case have there been any commercial results.

MINERAL SPRINGS.

The purest waters of the county are those which are derived from the granite. In the limestone districts the springs generally contain marked quantities of carbonate of lime, which makes them, in common parlance, "hard," and ill adapted for washing purposes. There are a good many springs in Devon of a chalybeate character, at, among other places, Lifton, Totnes, Ashburton, Ilsington, Ideford, Kingsteignton, St. Sidwell, St. Thomas, Cowley Bridge, Little Haldon, Swimbridge, Northmolton, Castlehill, and Anchorwood, Barnstaple. None of these are specially used for medical purposes, and the only instance of a medicinally-employed spring in the county with which I am acquainted was that which was once known as the Victoria Spa, at Plymouth, in connection with the Royal Union Baths. Neither Baths nor Spa now exist. The water came from a boring 360 feet deep, and the dry salts in a wine pint were: chloride of sodium, 96·64 grains; muriate of magnesia, 18·68; muriate of lime, 15·10; sulphate of soda, 9·55; sulphate of lime, 8·94; carbonate of lime, 2·06; carbonate of iron, 0·69—total, 151·66. The specific gravity was 1013·3, at 62°; and there were 8·1 cubic inches of carbonic acid gas per imperial wine pint. The spring never attained any note.

MISCELLANEOUS MINERALS.

BARYTES.—Barytes occurs in the county, but not in sufficient quantity to be of value.

* *Devon. Assoc. Trans.* vol. vi. p. 547.

FLUOR SPAR.—This spar occurs abundantly in some parts of the county, especially in association with the lead ores. It is used as a flux in reducing iron and copper ores, and for the manufacture of fluoric acid. The demand appears to vary considerably. In 1857, East Tamar Consols sold 1025 tons. No sales for Devon were recorded for 1873.

GRAPHITE.—This mineral is found in Cornwall, but not, so far as I am aware, in Devon. Vancouver, in his report on the agriculture of the county, states that plumbago had been found near Bovey, and sold in Exeter. No one else has recorded the occurrence of graphite in that locality, and in all likelihood Vancouver really refers to micaceous iron, which is found there.

GYPSUM.—Small quantities of gypsum are obtained from the red marl near Branscombe.

POWER.

Although deprived of coal, the physical peculiarities of Devonshire give it great, but little recognised, advantages in the production of power. Though once somewhat common, hardly a windmill now exists in the county, yet few localities are so well adapted for the utilization of these cheap and effective machines. Hills abound, and the sea-breezes sweep from one coast to the other; so that the slack times, with a judiciously-placed mill, would not be very frequent or prolonged. Windmills succeed elsewhere, and with our natural advantages I cannot see why they should not do so here also.

But it is the water-power of Devonshire to which I would direct special attention. This is literally enormous; but our water-wheels and other hydraulic machinery hardly encroach upon its borders. The rainfall of Devonshire for the eight years to and including 1873 averaged, according to the tables of Mr. Pengelly, F.R.S., published in our *Transactions* last year, 44·29 inches. This would make the total annual rainfall of the county, in round numbers, 260,000,000,000 cubic feet, or one billion six hundred thousand million gallons. In a flat county the rainfall is of comparatively little importance as a motive power; but in a county like Devonshire, where hills abound, where the centre of the district is occupied by a high table-land, forming a huge reservoir, whence rivers descend on all sides, the fact is very different. Let us see if we can form some approximate idea of what the yearly water-power is of Dartmoor alone—the power exerted by its rivers and streams as they flow from its hills to the sea. Dartmoor con-

tains about 130,000 acres. Its highest points are upwards of 2000 feet above the sea level, and its average height may be calculated at about 1200 feet. There are rainfall records from five Dartmoor stations, varying in height above the sea from 1500 feet to 650. For the eight years already mentioned the average rainfall was 66·466 inches; but inasmuch as the higher parts of the moor have a much heavier rainfall than the lower, and the highest station is 500 feet below the highest point, there can be no doubt that the average rainfall is considerably more than this. However, as we can only approximate, I will take it at 65 inches. This would give us 235,950 cubic feet of water per acre, or 30,773,500,000 over the whole of the moor; and if the whole of this water could be gathered into one stream flowing over a weir, it would make a river about eighty feet wide and three feet deep, pouring down from the moor without check or cessation day and night year after year. There is no great difficulty in calculating the motive power of such a stream as this. Let us see what could be got out of it by putting it to work a series of overshot wheels, so placed as to utilize the entire fall of 1,200 feet, which I have assumed as the average height of the moor above sea level. Taking the amount of work actually performed by a water-wheel at Wheal Friendship as a standard—one of a series of seventeen, which utilized an aggregate fall of 526 feet—we get the following results: An actual effective horse-power, calculated at 33,000 foot-pounds, of 90,000 horses, or, since the effective power of overshot wheels is to their theoretical as ·68 to 1, a total horse-power exercised of 120,000. These are startling figures; but if we compare them with actual horse labour, they will appear more astounding still; for it would require 400,000 horses working eight hours a day, raising 22,000 foot-pounds per minute, to do the same amount of work. In other words, the annual rainfall of Dartmoor, assuming that it all went through rivers to the sea, is equal to the performance of as much work as 400,000 horses, and expends as much power as would equal 550,000. And if we take the rest of the rainfall of Devonshire into account, assuming an average height above the sea of the non-Dartmoor portion of 300 feet, we find that the total effective power of the rainfall of the county is equal to something like 1,100,000 horses, and its expended power equivalent to about a million and a half. This, be it remembered, is on the presumption that the power is utilized in working overshot wheels. Applied to water-pressure engines, much higher results might be obtained.

I do not, of course, mean to assert that this amount of power, or anything approaching it, is available. Great part of the rainfall returns to the air by evaporation, and never enters the streams; the proportion that does so for Europe is calculated at about two-thirds. The evaporation of Dartmoor, however, is very much below that amount; for the great bulk of its rainfall either rushes off the rocks at once into the streams, or sinks into the peat-bogs, wherein it is stored as in huge sponges. So, too, it would not be at all possible to utilize the whole of the fall of every stream; but when every allowance is made, it will be seen that the fraction of realizable power at present utilized by our mills and water-wheels is so small as hardly to be appreciable in comparison with the possible aggregate. Devonshire has here an immense reserve of power, which, when our coal-fields are exhausted, may restore her to that manufacturing pre-eminence which she so long enjoyed. Granted that extensive works would have to be undertaken to equalize the supply, what places could be better suited for their construction than the valleys of Dartmoor, and in a smaller degree those of Exmoor?

Nor is this all. Devon, in common with all other maritime counties, possesses—but to an unusual extent—enormous means of developing power in the rise and fall twice a day of the tidal wave. Here, again, is a source of power almost wholly unrecognized, but of untold capabilities. Something is done at different points by throwing dams across little creeks, and thus forming tidal mill-ponds; but the aggregate is very small. Though Great Britain possesses more machinery than any other nation, it has been calculated that the force exerted by the tides daily along her coast is far more than sufficient to keep the whole of that machinery in motion without resort to steam. Some day we may be glad to realize this.

There are many ways in which the abundant rainfall of Devonshire has a high economic value apart from the question of power. In agricultural, mining, and manufacturing operations it is alike indispensable; nor, were proper means of storage and distribution devised and carried out, need there ever be much complaint in our humid climate of the effects of drought.