Part III.—Nature Lore.

THE STORY OF THE ROCKS.

"Sermons in Stones."

STONE quarry is a common enough object in Orkney—so common, indeed, that we may never have taken any interest in it. Yet this common quarry is a place where we may learn some strange facts about the making of our islands, if we visit it in the spirit of one who

> "Finds tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything."

The quarrymen begin their work by clearing away the "redd" from the rock beneath. First they remove the soil. This is dark in colour, not very rich or deep, perhaps, and not so black as the more fertile soils of other lands. Yet it contains the plant-food which nourishes our crops, and thus nourishes ourselves. The particles are fine and loose, and the soil is traversed everywhere by the small rootlets of plants. The dark colour is due to the decayed substance of past crops of plants, which largely consists

of carbon. We must try to find out how this soil, which is so precious to the farmer, has been formed.

Every one knows the difference between the appearance of a new house and that of an old one: in the former the stones of the walls are clean and sharp, in the latter they have a weathered, time-worn look. In graveyards the headstones recently put up have their inscriptions sharp and clear; the older stones have their surfaces pitted, and the letters carved on them are indistinct. Compare the old carvings and tracery on the outer walls of our cathedral, made hundreds of years ago, with the clean-cut masonry of new buildings which stand near it, and you will see that stones decay with time and moulder away; they crumble into dust under the winter's frost and rains and the heat of the summer sun.

So it is with all the rocks of which the surface of our islands is made up. Year by year they moulder away. The dust or earth into which they break down forms a soil in which plants take root and grow. The plants push their root fibres downwards, helping to open up the cracks in the rock; and when these roots die and decay their substance mingles with the soil, giving it that black colour which marks old fertile soils that have long been cultivated.

Under the soil lies the subsoil—that is, rock which is half decayed and partly broken up. In course of time it will become as fine as the soil itself; for the subsoil gradually changes into soil. In wet weather the rain, and in dry weather the wind, carry away the fine particles of earth from the surface of the fields, and would sooner or later take away all the fertile soil; but the continual action of the weather on the

subsoil supplies fresh material. Hence, while the old soil is constantly being removed, new soil is forming to take its place.

As we see in the quarry, under the soil and the subsoil there is rock. This is true of all parts of our country; there is a rocky skeleton beneath the thin layer of fertile soil which supports the plants and animals. In the rocky skerries which are common along the shores we see the nature of the rock-built framework of the islands. If the soil and subsoil were swept away, as the waves have swept it from the skerries, it would be plainly seen that the islands are built up of rocks.

All the rocks of our islands, almost without exception, were laid down under water. They consist of three different substances. One is sand, in small rounded white or yellow grains. Another is clay, dark gray in colour, very close grained and soft. The third is lime.

A rock which consists mostly of sand is called sandstone. The Eday freestone, which is much used for putting round the doors and windows of shops and large buildings, is a sandstone. The common blue flagstone contains clay mixed with more or less sand. The sandy beds are coarse, gritty, and hard; the fine-grained flags contain more clay, and are darker in colour, softer, and smoother on the surface. Nearly all the fine flags contain lime; often it is seen in white shining crystals on the joint-faces of the stones used in building. The presence of lime in a soil improves it considerably.

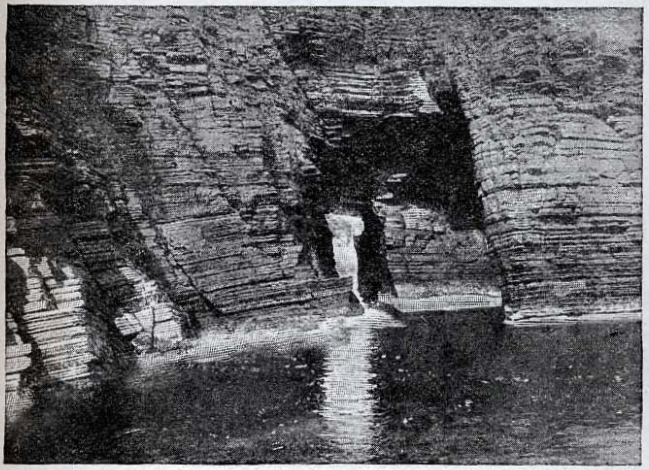
In different parts of Orkney the rocks differ much in appearance. In one place we find yellow and red

sandstone, in another blue and gray flags, in another pudding-stone and granite. What is the meaning of this? It shows that while the whole area of our islands was covered with water, gravel was being laid down at one place, sand or muddy silt at another, and so on. We can even make out the order in which the different layers or strata were laid down.

It is done in this way:—Usually the beds of rock are not now flat but tilted, and show their edges turned up in a more or less sharp slope. If we walk along any bare rocky shore we shall find that bed succeeds bed, each resting on the top of all those which underlie it. No place could be found to show this better than the shore of Hoy Sound from Stromness to Breckness. We go on and on, crossing over bed after bed of rock, till we have passed over the edges of a pile of flagstone which must be several thousand feet thick. The same thing can be seen to the east of Kirkwall, or, in fact, almost anywhere in the islands.

Sometimes the beds dip or slant in different directions at different parts of the shore. Then again they may be broken by cracks or faults which bring different kinds of rock up against one another. If one could visit the whole of Orkney and examine all the rocks, making out in what order they follow one another, how often they are interrupted or repeated by faults, and what is their inclination or dip, one could tell exactly the order in which the rocks of each district were laid down on the bottom of the old lake where they were formed. This is one of the tasks which the geologist undertakes; and though it looks very difficult, yet in Orkney it is quite possible to do so with pretty fair accuracy.

What is the result? At the bottom of the whole we place the granite of Stromness and Graemsay. This represents part of the floor of the old lake on which the gravel and sand and mud were laid down—a part which stood up above the water as an island. Next to this we find a thin layer of pudding-stone. This is formed of the old gravel which gathered on the beaches and shores around the granite island as it



Cliff showing horizontal strata.

was slowly covered over. Above that were laid down the flagstones of the West Mainland; then those of Kirkwall, the East Mainland, and the North Isles; then the yellow and red sandstones of Eday, Shapinsay, the Head of Holland, Deerness, and South Ronaldsay.

The whole series of these rocks must be thousands of feet thick, and how long they took to form we cannot conceive.

Then there is a gap in the series. This means that for a time the lake was dry land and instead of mud and sand being laid down, the rocks which had been formed were partly washed away by rain and streams. After a long time had passed, another lake was formed, and in it were laid down the yellow sandstones of Hoy, which are quite different from the other yellow sandstones of Orkney.

When you think that each thin flagstone or layer of sandstone in our quarry was once a sheet of mud and sand, and that it took months, no doubt, or even years, to gather on the lake bottom, you can understand how vast a space of time is represented by the old red sandstone of Orkney.

"Books in the Running Brooks."

Let us now take a stroll along one of the little burns which flow between their green or heathery banks in any of the valleys of our native islands. These little burns are very small in comparison with the mighty rivers of the world, yet they are quietly performing a great task, and in the long past ages the amount of work which they have done is far greater than you have ever imagined.

It is summer, and the burn runs shallow and slow; the pebbles and sand show clearly in the pools. The burn enters a little bay, and as it flows across the shore it breaks up into several streamlets, each working its way through the gravel. Brackish water plants grow here; the shore is muddy, and the seaweed is often soiled with fine sediment. The burn has brought this down, and has dropped it where it enters the sea.

We follow the channel upwards, through flat, rich meadows, which may be tilled, and covered with corn and other crops. In the meadow the burn winds to and fro, and in each loop the outer side is steep, often overhanging: under the grassy bank the trout lie hid. The inner side of the bend is shallow, slopes gradually down to the water, and is covered with small broken stones and gravelly pebbles. We can see that the current is eating away the steep outer bank by undermining it, while on the inner side the small stones are gathering.

The meadow through which we are passing is flat, and covered with wiry grasses which love wet situations. The stuff of which it is made can be seen on the banks of the burn. It is a soft, dark-brown earth, almost without stones, or with here and there a layer of pebbles. How has this meadow been formed? The stream has done it.

To find out how the stream made the meadow we must visit it in winter after several days of heavy rain. Then a sheet of water covers the meadow, making it a shallow lake. The water is very still except near the channel of the burn; it is brown and full of mud. For some days the lake remains, then the water begins to fall. The stream is clearer now, though still dark with mud; good water this for the trout-fisher. A few days more and the lake has vanished; the stream keeps within its banks, though it is still full.

Now look at the meadow. It is covered with a very thin film of grayish-brown mud. In spring the grasses will grow quickly, and will be greener than ever. The meadow is a little—ever so little—

higher for the new sheet of mud it has acquired. Winter after winter this goes on. The brown earth which forms the meadow is flood mud. Its flat configuration is due to its being laid down in a little temporary lake.

Let us follow the stream still farther, and leave the meadow behind. The channel gets steeper, and the water flows along quite merrily, faster than in the level meadow below. The bends in the burn disappear. It is in a hurry here and flows straight; in the flat meadow below it loiters and swings lazily to and fro. The channel is shallow, and there are few pools. The banks are often bare rock, or the stony clay which is produced by the weathering of rock. The stream is washing away the clay; it even attacks the hard rocks.

To see how this is done you must come when the burn is swollen with heavy rains. Then you will hear it rolling the stones along. They grind on one another, and thus they get their rounded shape, or are broken up into small fragments. As they are rolled along they wear away the rocks and deepen the bed of the stream. Loose pieces are swept away, soft layers are planed down. Many of the cracks and joints are opened and loosened, ready for fresh attacks during the floods of next winter.

This is where the gravel comes from. In the lower part of its course the stream cannot move large stones, but in floodtime the smaller pebbles are carried downwards. The big stones lie in the upper stream; they must be broken smaller before they can be carried away. After rainy weather you will often find that a rapid branch stream has shot a big heap of pebbles into the main stream. When the

floods rise above the surface of the meadow they may strew sheets of little stones here and there over the grass.

After a big flood, if you know the stream well, you will find many changes. Here a bank of gravel has been carried away; there a new one has gathered. At every bend the bank shows undermining, and pieces have been swept away. The fine stuff makes mud: part of this is laid down on the meadow, but much of it is carried right out to sea.

That running water will wash away sand, gravel, and mud is not new to you. You have often seen it on the roads and in the roadside ditches, in the little runnels around the farmhouses, or in the ploughed fields. The burn is always doing the same thing, according to its powers. In dry weather it does little, for its current is weak; in floods it works rapidly. For perhaps two dozen days in a year every burn is in great strength, and is a powerful agent in changing the form of the land. This leads you to grasp the fact that the stream has dug out its own channel, and that it carries rock material to lower levels, and at last to the sea. If you know some of our burns well, and study and watch them closely, you will find a world of interest in them. Every feature of their channels is due to the work the flowing water is doing, and shows the manner in which it is done.

But what of the wide valley in which the burn flows? Other agencies have been at work here besides the water: ice has left its mark on every part of our valleys. But the burn has done most. On either side it is joined by branches. Each of these

is cutting its own channel, and thus gradually deepening the valley. Each branch has its lesser branches; together they cover the whole valley with an intricate system of water channels.

Between these channels, heather and grass are growing in the stony soil. The soil, as you have learned already, is due to the decay of the rocks. Frost and rain begin the work, and the growth of plants hastens and helps it. Over the whole of the sloping valley sides the rocks are being broken up into finer and finer particles. When heavy rain comes it washes away the smaller particles, and little runnels appear which carry away the surface water.

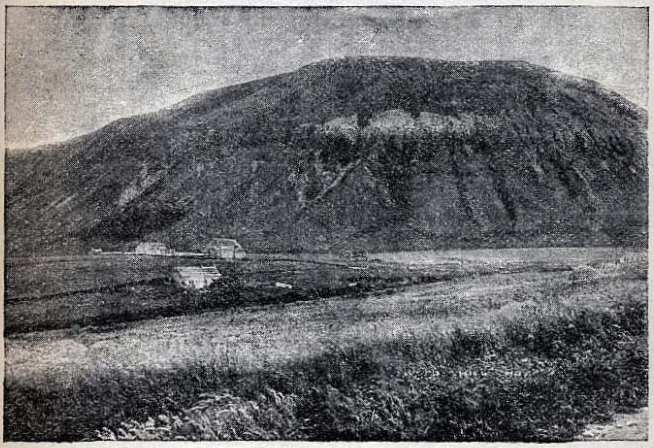
Every year a portion of the soil is swept away to the meadows, or to the mud sheets which floor the shallow sea below. None of this ever comes back; it is sheer loss—a little at a time, but if the time be long enough it amounts to a very great quantity. Every day since that burn began to flow it has carried downwards a greater or smaller burden of soil.

It took a long time for people to grasp the fact that running water is a great earth-shaping agent. Every valley you have ever seen was made in this way. Other things helped, but the stream was the main cause. A valley is only a great groove eaten out of the rock. It is not due to any earthquake or rending apart of the rocks; it is not an original feature of the country. There was a time when there was no valley there; but from the day the stream first began to trickle over the rocks it has gone on deepening its channel and excavating the valley, and it is still doing so.

The stream not only made the valley; it shaped

the hills also. We sometimes speak of "the everlasting hills." No doubt the hills are very old, and will last a long time. Yet the little stream is older and mightier than they. It shaped them and brought them into being; in time it will remove them and level them with the plain.

Let us climb the side of a hill, and see what we can learn about it by patient observation and inference.



The Ward Hill, Hoy.

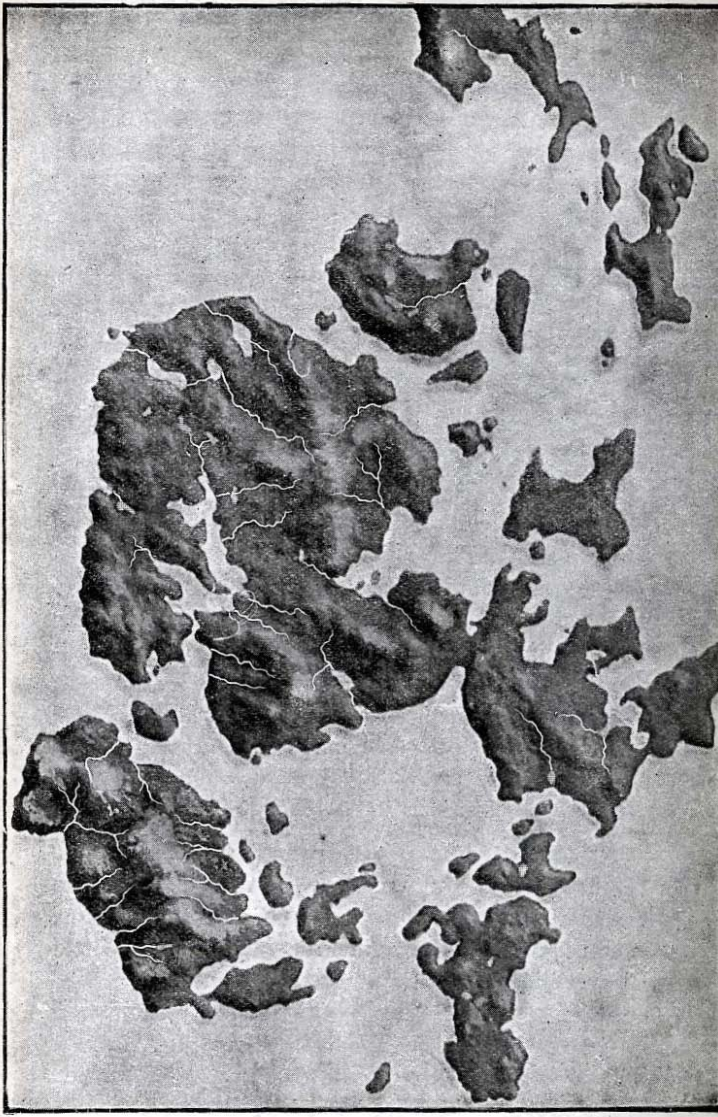
Any one of our flat-topped, round-shouldered Orkney hills will do. They were all formed in the same way, and teach the same lessons.

The ascent is gentle at first as we leave the plain or the bottom of the valley. Then it gets steeper and steeper. Often it is like a series of great steps—a sharp rise for a little, then a flat ledge; another sharp rise, followed by a gentle slope, and so on. These terraces are formed of beds of hard stone,

which weather down very slowly. The softer rocks crumble fast, and form the steep slope. All our flagstone hills show these steps or terraces. They prove that the slope of the hillside is determined largely by the rate at which the different rock beds wear away.

After our stiff climb we get near the top. Many of our hills are broad-backed. When we get above the steep part we find a flat top, and it is often difficult to say where the actual summit is. In many places there are great groups of hills, all of about the same height, but separated by valleys. The Orphir, Firth, and Harray hills, the Rousay, Evie, and Birsay hills, and the hills of Walls are all of this kind. Even the Hoy hills show the same feature, though less clearly. In all these cases the hilltops look like the remains of one continuous stretch of high ground, which has been cut up into pieces by the digging out of the valleys. The hills are the remnants of a plateau.

This is not a mere supposition, but can be proved quite clearly. In many Orkney hills there are beds of rock which can be identified by the geologist by certain marks. They may contain peculiar fossils, or they may be of a special colour or structure. In Firth and Orphir, for example, there is a band of flagstone which yields roofing slabs. You can follow this band from hill to hill for several miles, often by the quarries in which it was extensively worked in former years. It occurs at much the same level in all the different hills, though sinking somewhat to the north according to the dip or slope of the rock bed. It is found on both sides of the valleys, as, for example, at Finstown, at much the same height.



The Hills of Orkney. Photographed from a Relief Model based on the Ordnance Survey.

The Orkney hills, then, consist of a great pile of beds of flagstone which once spread unbroken over the whole country. Out of this great mass of flagstones and sandstones the running water of the burns has carved the valley systems. The hills are the remnants which the streams have not yet removed. As time goes on the valleys deepen and broaden, and the hills get less and less.

> "The hills are shadows, and they flow
> From form to form, and nothing stands."

It has taken vast ages to do this work, and the work is still going on. It is very slow. The oldest man hardly notices any visible change in the configuration of the country. But wind, rain, frost, and running water are ever at work. Every day sees some loss, some material swept away never to return. What becomes of it? It reaches the sea, and there forms mud and sand. Time will change these into solid rock again, and may ultimately use them in building new continents. The hills crumble into dust, but it is "the dust of continents to be."

Cliffs and Beaches.

On looking at a map of Orkney or Shetland we are struck with the irregularity in the shape of the islands and the winding nature of the coast line. There must be some reason for this, and a little reflection will bring it to light. If you look at the larger valleys you will notice that most of them end in salt-water bays, while the hills or ridges between the valleys run out into points or "nesses." This is especially the case in Shetland; but in Orkney, too,

there are many instances of it. The shape of the land extends beneath the water—the deep bay continues the land valley, the point and the skerry mark the position of the watersheds.

We have seen that the valleys were eaten out by running streams. At one time the land stood higher, and the burns flowed where now the salt water covers the bottom of the bay. Thus the land was shaped. Then the ground sank a little, and the sea flooded the lower grounds. The hilltops remained above water as islands; the valleys and flat grounds were changed into bays and sounds and firths. Think what would happen if the land sank another hundred feet. Many of the present islands would become shoals, and new islands would be made where the sea flowed round the higher ground, winding out and in among them in narrow sounds and straits, just as it does among the islands of the present day.

Long ago Orkney and Shetland were much larger than they are at present. Most of the North Sea was dry land, covered with trees. In several parts of Orkney we can see trunks and roots of trees uncovered after heavy storms have shifted the sand on the beach. These trees did not grow beneath the sea, of course; but the land sank, and the salt water covered the site of the old forest.

Our wild animals, such as hares and rabbits, mice, voles, and shrews, were not imported in boats. They were here probably before man arrived, and they walked in on their own feet when the sea bottom was still part of the dry land of Europe. Those who have studied this question think the land is still sinking, or at any rate has not yet begun to rise. If it were

rising, we should find gravels and shells and sea-beaches above the level of the present shores. Such raised beaches are found in many parts of Scotland, but not in Orkney or Shetland.

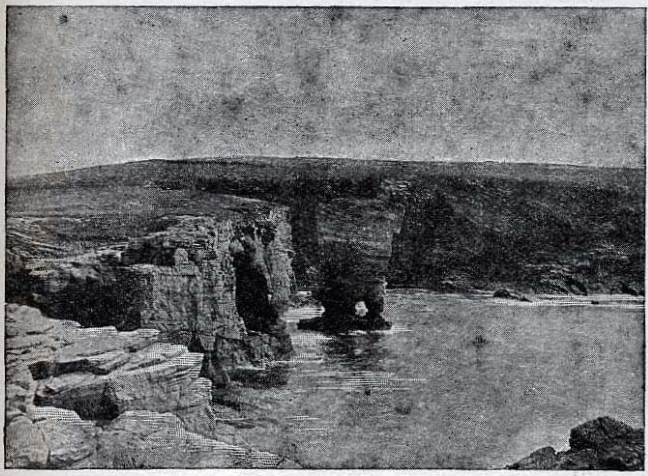
The shores are always changing, and every part of them bears evidence of constant alterations. Where there are high banks or cliffs, you will often find that pieces have fallen down; this is especially the case where the bank consists of clay. Our Orkney rocks are very hard and our cliffs very lasting, but in some parts of England there are villages and churches now standing on the very edge of the cliffs which a few centuries ago were at a considerable distance from the sea.

It is the sea that wears away the cliffs by hammering at the rocks; during storms the big stones on exposed beaches are rounded and worn by the billows tossing them about and driving them against the rocks. On the west coasts of our islands the great winter waves have enormous power; no breakwater could resist them, and a ship which is driven ashore soon goes to pieces. The cliffs are undermined at their base by the formation of caves; the soft parts are eaten out into geos. Frost and rain open the seams of the rocks and great masses tumble down; these are then tossed to and fro until they are converted into heaps of boulders. The boulders get less and less, and become pebbles; last of all they are ground down to fine shingle and sand.

Every kind of rock has its own characteristic type of cliff scenery. When pieces are detached they separate along natural cracks which are called "joints," and these joints have a different arrangement in

sandstone, in granite, in serpentine, and in schist. Weathering then acts on the exposed surface, and, if the rock is bedded, some beds are eaten away more rapidly than others. There is much to interest us in our cliffs; there is not a detail in their form which has not a meaning.

On wild shores where storm-waves are high we find large boulders; the smaller ones are washed away



A sandstone cliff.

and swept out to sea. Sometimes there is no beach, but the cliff plunges down into deep water, for there the waves are so powerful that they clear away all the broken rock. On sheltered beaches we find small rounded pebbles. If we look at the stones on the shore of a small fresh-water loch we find them scarcely rounded at all, for the little waves cannot toss them about and rub them against one another.

The tear and wear of pebbles produces sand, and the sand is driven to and fro by currents and by storms. It rests for a time in some of the bays, but is not a fixture. A high wind drives some of it ashore to cover the grass of the sandy links. A heavy storm may drag a great deal of it out to sea. Unless it is held fast by bent or other plants, sand is always moving.

Even the stones travel along the shore, driven by the beat of the waves in bad weather. There are stone beaches common in Orkney and Shetland which are often called ayres, and which have behind them a salt lagoon or oyce. The oyce opens to the sea at one end of the ayre, and a strong tidal current flows out and in through the opening. An ayre is really an army of stones on the march, constantly moving forward. In every bay there is one direction from which the biggest waves come, and the stones of the ayre have come from that direction. The opening of the oyce is at the other end of the ayre.

At first there was a bay with a shallow inner end. When the big waves reach shallow water they turn over and have their speed checked. Stones carried along the shore are dropped at the edge of the shallow water, forming a bar. The bar goes on stretching across the bay as the storms fetch more stones, and in time the oyce is nearly walled in. But as the opening gets narrower and narrower the tidal flow gets stronger and stronger. There is a combat between the tidal currents and the storm currents, and in time things are adjusted so that the speed of the outflow is just enough to keep the opening from being closed up.

The Age of Ice.

Along the burns and the seashores, and in stone quarries, we often see banks of clay. Usually this clay is full of stones. In some places the clay is merely the softened, crumbling top of the rock, and the stones in it are of the same kind as the solid rock below. In other places the clay contains stones which are quite unlike any rocks in the neighbourhood. Sometimes these stones are very large, and they must have been carried from some distant place, for they are of a kind of rock which is not found in the islands. What is the history of this clay with travelled stones, or "boulder clay," as it is called?

Boulder clay may be recognized by several marks. It is tough and sticky; it shows no bedding or layers; and it may be only a few inches thick, or it may form cliffs thirty or forty feet high. Pick a few stones out of it: you will notice that they are not all of the same kind. Wash them carefully in the sea or the burn. Their ends are blunt and worn, but they are not rounded like sea-pebbles. Their surfaces are smooth, and are covered with fine scratches, as if some one had drawn a needle or the point of a knife along them. Nowhere except in this clay will you see stones with these curious scratches.

If you find the place where the bottom of the clay rests on the hard rock, you should carefully remove a little of the clay and lay bare the rock surface beneath. Wash it with a little water, and you will see that it is covered with fine scratches exactly like those on the stones. Now this smoothing and scratching of the stones and of the rock

might be explained by imagining that the clay at one time was in motion, pushed forward by some immense force, and that the stones rubbing on one another and on the rocky floor produced these scratches.

Among the Alps, in Norway, in Greenland, and in other places where there are high snow-clad mountains or a very cold climate, the snow gathers in the valleys till it forms thick masses, and is compressed by its own weight into ice: these masses are known as glaciers. Glaciers are really slow-moving rivers of ice; they slip very slowly down the valley slopes, travelling usually only a few inches in a day. When they reach the warmer region at the base of the mountains, they melt away, leaving behind them heaps of clay which they have swept down from the hills. The stones in this clay are worn and smoothed and scratched exactly like those in the boulder clays of Orkney and Shetland, and the rocks over which the glaciers have moved are smoothed and scratched likewise.

The boulder clay, then, is clearly a glacial deposit, formed at a time when our islands were covered with moving sheets of ice. These ice sheets were travelling from the North Sea towards the Atlantic, in a west or north-west direction, for the scratches on the rock surface always have that trend. We can often prove also that the boulders found in the clay have travelled from the south-east. Thus at the Mont, near Kirkwall, the boulder clay is full of red sandstone from the Head of Holland and Inganess Bay. In Shetland stones have been carried from the east side of the mainland right over the hills to the west shores.

When we piece together all the evidence about this Ice Age or Glacial Period, not only in Orkney and Shetland but in all the north-west of Europe, we learn that it lasted a very long time, and that the North Sea was filled with a great sheet of ice which must have been several thousand feet thick. This ice was pushed out of the basin of the North Sea westwards into the Atlantic by the pressure of the deep snow-cap which covered the mountains of central Europe, and on its way it passed over Orkney and Shetland. The broken stones and rubbish which gathered below it formed the boulder clay. This may seem a very strange tale, but every kind of evidence that is needed to prove its truth has been found by those who have studied the boulder clay and the scratched rocks beneath it.

After the great ice sheet melted, the climate was still cold, and there were times when snow and ice gathered on our hilltops and little glaciers flowed down the valleys. These also have left traces behind by which you can know where they were. In every one of the higher glens in the Orkney hills you will find mounds of clay and stones, often forming a crescent or bow running from side to side of the valley. They are very well seen in Harray, Birsay, Orphir, and Hoy; but even in the East Mainland the hills, though low, gave rise to little glaciers. In Shetland they are almost as common as in Orkney. In many parishes there are clusters of large and small mounds, some of them grassy and others covered with heather, lying near the mouths of the main valleys. When these mounds have been cut into by streams or by

roads, we see that they are not rocky hillocks but consist only of clay and stones, and that the stones are often scratched like those in the stiff boulder clay. These mounds are the "dumps" or moraines where the glaciers which filled the valleys melted and dropped their rubbish. At that time our islands must have resembled Spitzbergen, where to-day most of the hills have an ice-cap and nearly all the valleys are filled with glaciers, some of which reach the sea and give birth to icebergs, while others melt away and deposit lumpy moraines over the valley bottoms.

Orkney Fossils.

You cannot examine many of our Orkney flagstones carefully without finding fossils. The most common are scales and bones of fishes. In the rock these often appear as coal-black specks. When a fossil has weathered for a long time, as in a stone dyke or on the seashore, it often becomes bright blue, like a splash of blue paint. Sometimes whole fishes are found in the gray flagstones, with every fin and every scale perfect. Of course you will not find these every day or every year, but there are many quarries in Orkney where you may get them occasionally. When the quarryman uncovers a bed of rock, he often finds it sprinkled over with great numbers of fossil fishes.

We can picture to ourselves that, at some time long gone by, when these flagstones were being laid down in the old Orcadian lake as sheets of sandy and muddy silt, the fishes were suddenly killed by a volcanic eruption, or by a period of drought, and their dead bodies covered the muddy bottom for

miles. Fresh mud then came down and buried them, and preserved their remains. In process of time their bones and scales were changed into the pitch-black substance which we now find in the rocks. But we can still see that these specks and scales are really parts of fishes. If we examine them under the microscope, we find that they have all the marks of structure that the same parts of certain fishes have at the present day.

In almost every parish in Orkney there is at least one quarry which contains good fossils, and there must be many others which we do not yet know of. But no person who knows what a bit of fossil fish is like need search very long among the flagstones of the shore without finding a scale, a jaw bone, a tooth, or other relic of the fishes which lived in Orkney at the time the flagstone muds were gathering. A heap of stones thrown down by the roadside, for building a dyke or for mending the roads, often contains fragments of dozens of fishes.

It is not difficult for us to picture what these fishes were like when alive. Some of them were about the size of sillocks or herrings, others were as large as a big cod. They had scales all over their bodies, and fins, supported by bony rays, just like living fishes. But though many of them were of the same shape and general outline as a trout or a herring, they differed from these in many ways.

Their scales were often hard and bony, with a smooth, shining outer layer of enamel like that which covers a tooth. Those fishes are called *ganoids*. On their heads they had bony plates with the same hard covering, often showing ridges and furrows, knobs,

and other markings. You may see these beautifully preserved in many of the fossil bones which occur in the gray and blue flagstones. Those fishes belong to species which are no longer living on the earth's surface, but closely allied kinds of fish are still found in a few rivers in Africa, America, and Europe. The royal sturgeon is one of these.

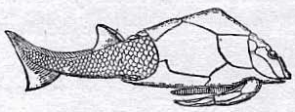
None of the fishes which are common in our seas at the present day are ever found as fossils in rocks as old as the Orcadian flagstones. The water of the Orcadian lake was fresh water. We know this because we find no marine shells, and no crabs or cuttle-fishes in the flagstones, though these kinds of animals peopled the sea at that time, and would have been preserved as fossils if they had inhabited the lake.

Some of the fishes in the lake were very grotesque and oddly-shaped creatures. One of them had two curious bony arms or wings which stuck out from its sides. It is not very common in Orkney, but is sometimes found in quarries near Stromness, and a smaller fish of much the same shape may be got in Deerness occasionally. They are called "winged fishes," and are quite unlike any fishes now living. So strange is this fossil that when first found it was thought to be a curious beetle.

Another strange fish was of great size; its head bones are a foot or more in length. Pieces of the head of this fish may be seen in many parts of Orkney, but the bones of the body were soft and rotted away after the fish died. The back of its head was somewhat like a shovel in shape, and the bones are often half an inch in thickness. There were two great holes for the eyes near the corners of this

shield. The back of the neck was protected by another large plate. A specimen of this fossil can be seen in the Stromness museum; it was called by Hugh Miller the *Asterolepis*, or "star-scale fish," of Stromness.

Besides the fishes, other fossils occur in the flagstones, but not of many kinds. At Pickaquoy, near Kirkwall, and in several other places, very small shells, like tiny mussel shells, often cover the surface of the beds of rock. Pieces of wood may also be seen in the flagstones; they are flattened out and form black strips of a coaly substance, but as they must have drifted a long distance from land, and sunk to the bottom only when they became water-logged, they do not tell us much about the nature of the plants which clothed the islands and the shores of the lake. Yet we know that there were no flowers then, no grasses, or sedges, or trees like those that now live, but only great reeds and tree-like plants belonging to the same groups as the horse-tail that grows in watery places and along roadsides, and the little green scaly club moss that creeps through the heather, sending up its fruit-bearing spikes. There were also many kinds of ferns. In the forests and swamps there were land-snails and insects, but no frogs or lizards, still less any birds or other warm-blooded creatures. The fishes are the highest types that then existed; they were the "lords of creation" in that day.



"*Winged fish*" (*Pterichthys*).