One or two he found in Ayrshire, and also one on the banks of the Lyne Water, a tributary of the Tweed.

The question naturally arises, When were those channels scooped out? To what geological period must those ancient rivers be referred? It will not do to conclude that those channels must be pre-glacial simply because they contain boulder-clay. Had the glacial epoch been one unbroken period of cold, and the boulder-clay one continuous formation, then the fact of finding boulder-clay in those channels would show that they were pre-glacial. But when we find undoubted geological evidence of a warm condition of climate of long continuance, during the severest part of the glacial epoch, when the ice to a great extent must have disappeared, and water began to flow as usual down our valleys, all that can reasonably be inferred from the fact of finding till in those channels, is that they must be older than the till they contain. We cannot infer that they are older than all the till lying on the face of the country. The probability however, is, that some of them are of pre-glacial and others of inter-glacial origin. That many of these channels have been used as watercourses during the glacial epoch, or rather during warm periods of that epoch, is certain, from the fact that they have been filled with boulder-clay, then re-excavated, and finally filled up again with the clay.

III. *On the Discovery of a "Sand-dyke" or Old River Channel running north to south, from near Kirk of Shotts to Wishaw, Lanarkshire.* By ROBERT DICK. (Illustrated with map of Midland Valley of Scotland, fig. 1, and relative section, fig. 3, Plate XVI.)

Any one who has been engaged in mining matters for any lengthened period, or whose duty it has been to open up new mineral fields, must in the course of his experience have met with what are termed in *mining* phrase, "*sand-dykes*," or "*clay-dykes*." They are, I believe, not confined to any particular district, though rarely met with, and that only in those fields where the seams that are being worked do not exceed 40 or 50 fathoms in depth. It is one of these sand-dykes that I propose to make the subject of my remarks.

When I first heard of the sand-dyke as having been found in the mineral field which was under my charge, I had no distinct idea of what it was. There was a local tradition that two extinct pits, which had been worked fifty or sixty years previous, named the Spatchall and the Mutton pits, were sunk through the dyke. Whence the first of these pits derived its name, I do not know, but the second owed its title to the fact of bones having been found in it while sinking, which were supposed to be those of

sheep. The first time I had an opportunity of meeting with this dyke, was in the Virtuewell coal-workings of No. 27 pit, connected with the Ormoa ironworks. The level going to the north-west had not been driven far from the pit-bottom, when the coal was observed gradually getting more and more "rusty." The "*backs*," or joints, as they are familiarly called, became quite open and disjointed, and were covered with a red crust, somewhat similar to that which coal takes on when found cropping out exposed to the open air in any burn or deep glen. The roof became exceedingly brittle or "*frush*," and was coloured with the same reddish hue. These indications were well known; and as this field had been partially excavated in olden times, it was naturally concluded that we were about to emerge into some of the old workings, although the symptoms shown by the coal, the roof, the pavement, and the breadth of the rents or seams, together with the dryness of the coal, were unusually marked. At length the coal came to an end, the level went through upon the "*boss*," but instead of an old waste, there appeared a bed of the finest sand. The pavement was now dug out, and the roof was pierced. But it was found that both were cut in the same manner as the coal.

It is probable that the working would have terminated here, and no farther light been thrown upon the presence of the sand, had the level been a greater distance from the bottom of the pit. But as the wall cut out was extremely short, it was necessary to attempt to get through the obstruction, the coal being known to be lying on the other side, at nearly the same level. The inference therefore, was, that this was not a slip in the ordinary sense of that term, but in so far as the coal was to be found in the opposite side, on nearly the same plane, it was called a *dyke*, in the absence of any better definition. Accordingly, a mine was arranged to be driven through the sand-bed, for the sake of the coal which lay on the other side. When it was completed, and the coal got, the dyke was found to be from 90 to 100 feet broad. No unusual difficulties were met with in the excavation, but the sides and the roof had to be very carefully timbered and secured. The same fine sand continued throughout its whole breadth. The coal presented the same red, dry, and open appearance on the further side as it did when first obtained; but this gradually disappeared as the mine pierced into the solid seam, until at length the coal assumed its ordinary appearance—black, compact, and firm.

Not having any kind of notion at this time of the nature of the space which had been filled with sand, I did not pay the same attention to it as I would have done had its true character been known to me, and unfortunately I never had an opportunity of seeing it again under the same favourable circumstances. It was, indeed, met with afterwards, at several other parts, but at a

higher level, where the solid pavement and the bed of sand lay at some distance lower down, a bed of coarse boulder-clay being now found opposite. .

In the mine I have already described as having cut through the sand, the thickness of the bed was ascertained to be from 9 to 10 feet; above were pebbles and gravel, while beneath the fine sand rested on the solid pavement. The mine was cut through the very bottom of the trough, for immediately under the pavement or floor of the coal, the floor of the trough was found; the timbering required for the support of the sides and roof of the mine was planted in the solid rock. I observed that the pavement was irregular, several parts of it appeared striated and furrowed, as if it had been planed out by the action of running water. The sand was of the finest description, and passed through a small sieve, leaving only a very small percentage of egglike or oval-shaped pebbles, like those mixed with the sand of the brink of rivers or larger sized streams. The sand was used for mixing with lime, and forming moulds for holding the cast-iron, for which purposes it was admirably adapted. It was not pure rock-sand, but contained a little clay. I cannot say whether it contained any shell or other organism, it never having occurred to me to look for anything of that kind, and I have not had a chance of seeing the same stratum since.

Although it was not again seen under such favourable circumstances, yet in the course of mining operations the dyke became my constant companion for years. It never was mined through again, but for a mile and a half of its course the coal and iron-stone were stripped off the edge of it, except at the part where the roof became so brittle that it was considered more economical to leave part of the mineral in than to take it out. When the edge of the "dyke" was bared off and exposed it did not present the same appearance as it did when first observed. The materials which composed it were,—a mixture of sand, clay, pebbles, and boulders. The fine bed of sand already mentioned lay some distance beneath. Sufficient was learned, however, from the course in which it ran to determine that its character differed from that of the ordinary slip, which the miner familiarly terms a *dyke*. It was found not to run far in any given direction, but to twist itself about from north to south and east to west, so that the common rule which miners employ to ascertain the run of ordinary dykes and slips did not apply in this instance.

After these earlier explorations I left this district for a time. In the interval the management was carried on by others, and a new pit was opened nearly a mile to the south of this pit (No. 27), in which the "sand-dyke" had been found. Considerable difficulty was encountered in the upper part of the new pit. The "surface" continued very deep, but held no water. When a

depth of upwards of 30 fathoms had been reached a bed of fine sand was sunk into, with a free run of water. A number of fathoms above this, strong timbering had to be used in lining the sides of the shaft, to preserve the pit from collapsing. But when the watery sand was struck, the difficulty was increased, and the pit seemed to run some risk of being totally lost. Fortunately it was not very thick, 10 feet more and the rock was bared. The sides of the pit were secured with strong timber, but were in a very imperfect state. It is the fashion for the practical miner to ignore all help from Geological science when pursuing his occupation; but in the present instance, had any of those connected with the management known anything about the nature of the thick surface through which they were sinking, they would have removed the pit a short distance either east or west, and the rock would have been got a few feet from the surface, saving a large amount of expenditure both of time and money. The only attention the subject attracted at the time was occasioned by the amount of money which had been required to sink through so deep a "surface." As I afterwards discovered, this pit was sunk in the centre of the ravine or "sand-dyke" already seen in the workings of pit No. 27.

Several years after this, when looking over the mineral plans at Wishaw Ironworks, I observed a large area which had been left unworked underneath the furnaces. On making inquiry as to the reason of this being left, I learned that the seam of coal, which was there about 40 fathoms deep, had been cut off on both sides by a sand or clay "dyke" running from south to north (see Plate XVI. fig. 1, at C). I did not at the time suppose that this had any connection with the one I had seen in the Cleland Field, as it lay about four miles to the south. I first endeavoured to find out the bearing of its course, and to ascertain, if possible, whence it came and whither it went. By means of the various underground workings and pits I traced its course to the north, pursuing an irregular line, and found that the road which leads from the low end of Wishawtown to Cleland descends into the site of the ancient river channel at about half a mile from the town, and threads its way through its course until near the bridge which spans the Calder water. The high walls of sand and mud, partly in a laminated state, which line each side of this road, are evidently the *debris* and wreck under which the ravine lies buried. The hollow into which this road descends when it enters the heart of the ancient ravine is evidently the work of the small rivulet which flows at its side. The road continues in this valley until the Calder is reached, when it turns to the right, and rapidly ascends to its former level as it leaves the track of the ravine. It was my impression at this time that this ancient channel had flowed into the Calder at this

point, and had formed at some remote period one of its tributary streams. A short time afterwards, however, I obtained a sight of the plan of Glen-Cleland coal workings, and to my surprise found that it crossed the Calder at right angles, cutting off the Ell coal workings of this colliery, which were bared along its side, and continuing its course still in the same northerly direction, bending sometimes to the east, sometimes to the west, but pursuing its way still to the north. Further investigation showed me that it crossed the Tillon Burn in like manner at right angles, crossing in the same direction, proving its identity with the one down which the pit was sunk that had cost so much money. Further reference to bores and other explorations which had been made from the surface in the tract of ground that lay between the pit and the one in which the mine was driven through the sand, showed me that the dyke found at Spatchall, Nos. 27 and 35 pits, and at Wishaw Ironworks, were one and the same. For its direction and position reference is made to fig. 1 of the accompanying Plate.

It was my next duty to examine the places where the Calder Water and the Tillon Burn flowed over this ancient bed, to ascertain if their bed was on the same level with that of this ancient river, or which of them flowed lowest—the modern or the ancient streams. At the Calder Water it appeared on the south side the valley which I have already described, through which the Wishaw road runs. On the north side, on the site of the ravine, was the flower-garden of the late Lord Belhaven. In the bed of the stream the rock was cut off at nearly right angles; above this severance the water ran on the clear rocky bottom, beneath it was a channel composed of rock, stones, gravel, and shingle. In the edge of this rock I recognised the edge of the ancient stream, and saw that its bed was still lower down. At the Tillon Burn an indented hollow on each side of its course marked the place where the ancient river had flowed. The rocky bed of the stream could not be seen except at a considerable distance above and below. At the place of crossing, the water ran over a channel composed of slag and *debris* washed from the ironworks, so that no decided conclusion could be arrived at here as to the relative position of the respective river-beds; but if it is not on the same level, it is evident that it must be lower.

From a point, then, a few hundred yards to the south of the Wishaw Ironworks, and only from this point, because, so far as I know, there have been no mining or boring operations carried on further in that direction, I had found a wide ravine, varying from 100 to 150 feet wide at the bottom, its side slope falling back with an easy incline of from 1 or $1\frac{1}{2}$ to 1, until the surface or the clay is reached. From the Spatchall pit, the *northernmost* point at which it has been proven to exist, to beyond Wishaw

Ironworks, the furthest point *south* is a distance of between six and seven miles, measured along the windings of the watercourse. At Spatchall pit the depth of its bottom is 30 or 40 yards; at No. 27 pit it is 47 yards; at No. 35 pit it is 60 yards; and at Wishaw Ironworks fully 80 yards. The three first named places are nearly level on the surface, the ironworks considerably lower. These figures go to prove that the floor of this ravine falls with a gradual and easy descent from the north towards the south of not more than 1 in 200. This long and extensive space is filled up with sand, clay, boulders, gravel, and every description of debris, so as to be level with and unobservable from the surrounding surface. Taking all these facts into account, its circuitous windings; its gradual fall; the width of its upper part as seen at the deep glen, through which the road called the Low Road wanders from Wishaw to Cleland; together with the marks shown upon the coal, and crumbling red strata that line its sides, as seen in No. 27 pit, with the water-worn appearance and tracings which its floor exhibited, I had hardly a doubt that there was here preserved the channel by which some ancient river poured its waters into the Clyde or the ocean of that day. One piece of information more was desirable. One link only was wanting to complete the chain of evidence, and that was to obtain a cross section of the whole ravine from its surface down to the bottom, or near its bottom. That link came sooner than I anticipated. The new railway from Holytown to Mid-Calder, which is now completed, revealed this part of the evidence. The reality confirmed all the anticipations I had formed of what its nature should be.

The Mid-Calder branch of the Caledonian Railway passes a short distance to the north of No. 27 pit (at "C," fig. 1, Plate XVI.), and has a cutting of more than usual depth at that place. This I have given in detail in figure 3, Plate XVI. The whole section exhibits a total depth of more than 20 fathoms, but the railway cutting extends to little over 60 feet of this depth. Had it been somewhat deeper it would have opened up the mine already alluded to as having been cut through the sand. It crosses nearly at a right angle this ancient ravine, of which a cross section was opened up, and seen to great advantage. On each side the rocks and shales were dried, weatherworn, fragmentary, crumbling, rusty, and open, precisely as may be seen along the sides of any modern ravine or deep glen, where the strata are exposed to the action of the atmosphere. At the surface the old river course was very wide; but gradually narrowed as it descended. Where the strata consisted of shale, the slopes were flatter, and where they were of sandstone, the sides were more precipitous and steep. I carefully examined the slopes in order to detect any traces of vegetation, but without success. Occasionally there was a thin layer of coal along the edge, but

it appeared as if it had been imported; it did not seem to have been fossilised upon the spot. My attention was also directed to the material with which the ravine had been filled up, and the order in which it had been deposited. Uppermost was about 20 feet of clay with large boulders, very similar in texture and composition to the clay overlying the rock-material on either side of the ravine. The structure, composition, and thickness of the two deposits were so alike, that one could not help thinking that they must have been laid down during the same period of time. Beneath the clay with boulders was a finer kind of clay, containing stones of a much smaller size; and near the sides of the ravine it was well mixed with sand on fine mud, laid out in layers, rising gently to the edge of the rock at an angle of from 1 in 15 to 20. Lower down it contained more sand and less mud, sloping in the same bedded form to the sides, while in the centre there was no kind of stratification or order, the material consisting of large boulders intermixed with coarse clay and sand. Lower still, the section presented beds of small gravel and fine sand, with thin layers of coal, all finely stratified towards the edges, and rising with a gentle slope. The centre was composed almost wholly of gravel beds and sand, but having no appearance of stratification. The railway cutting showed material similar to this throughout its whole depth, which must be a considerable number of yards above the mine already referred to as having been cut through the sand beneath, at the bottom of the ancient ravine. The rocks which composed the sides of the ravine have been detailed on the margin of the Plate (fig. 3).

It may not be unimportant to say a word or two upon the configuration of the surface at this point. It would be natural to expect here a more or less marked hollow, but it is in reality the highest portion of the ground in the immediate neighbourhood; the land falling on either side both towards the east and the west. Nowhere, on any part of its course, are any indications of the presence of the old ravine to be derived from the form of the present surface. The general inclination of the district is from east to west—from the summit at the Shotts Hills to the valley of the Clyde; and the rivers and streamlets generally flow in the same direction. The two streams of any consequence are the Tillon Burn and the Calder Water, already noticed; these both cross, at nearly right angles, this ancient ravine, which seems to have flowed in a general course from north to south.

Conclusion.

The facts furnished in this paper go to show—*1st*, That under the boulder-clay of part of Lanarkshire an ancient river channel has been preserved; *2d*, That the course of this stream is from

north to south, in which direction, as shown by mining operations, the water would still flow if the upper covering of clay were removed; 3d, that the present streams, flowing generally in an easterly and westerly direction, cross the buried watercourse at nearly right angles; and, 4th, that the early configuration of the district has been much changed by the deposit of the thick covering of "*surface*," and that the present streams have not, in the cases cited, resumed the former lines of drainage.

IV. *Notes on Chemical Geology.* By ANDREW TAYLOR.
(*Abstract.*)

No true geological theory can be established which ignores the action of those physical and chemical forces which act on our earth in common with the other heavenly bodies. The essential unity of the cosmos has received fresh confirmation from the recent labours of astronomic spectroscopists. It becomes, then, the knight of the hammer not to ignore the bearings of such inquiries on his own science, the more especially as the great terrane revolutions manifested by the volcanic and earthquake activities of the last two years have given such investigations an universal interest.

Recent researches have shown that most of our deductions on the internal condition of the earth have been founded on incomplete data. Arago's formula of the rate of increase of internal temperature, derived from observations made in the artesian well at Grenelle, does not hold universally. The increment of temperature appears to depend on a variety of conditions, such as the nature of the strata, their saturation or otherwise, the proximity of great bodies of water, and such like.

Many observations go to show remarkable coincidences betwixt the presence of magnetic currents, and such phenomena as volcanoes and earthquakes. M. Perrey has observed that seismic shocks occur with more or less violence according to the moon's distance from our planet. If these earth disturbances are the outcome of certain aberrations of those electric currents which we know daily pervade the whole surface of our globe, then accurate observations become necessary, that the character of these periodic perturbations of regular currents may be duly appreciated. Mr Mallet's observations go to prove that earthquake phenomena follow in pretty regular cycles of periodicity—periods of intense disturbance generally occurring at intervals of forty years, being most violent towards the close of the century; and when thus violent, the intensity appears to vary, in different hemispheres, with the month that the earth is nearest or furthest from the sun.

That magnetism varies in intensity throughout the earth, as