4.—The introduction of the abstract terms, length, lengthen, and their opposites.
5.—The application of a measure to one object.
6.—The application of it to two immoveable objects at a distance.
7.—The reasonings founded on this invention.
8.—The idea of breadth.
9.—That of depth or thickness.
10.—Extensive application and use of measures of length.
11.—Introduction of the abstract terms, space, solidity, &c.
12.—The mental faculties concerned in acquiring these ideas.
13.—The different kinds of lines, straight and curve.
14.—The principles assumed in geometry.

## *Additional* Notes *on the* Geognosy *of* Saint Paul's Bay, *by Lieut.* Baddeley, *R.E.*

There is no spot in Canada more likely to become the resort of the invalid and of the admirer of beautiful scenery than St. Paul's Bay and its captivating valley; nor is there any river in Canada more likely to have a flourishing manufacture established upon its shores than the Gouffre, which, intersecting the above mentioned valley on a course from the westward of north, enters the St. Lawrence at St. Paul's Bay.

The iron mines, mineral springs, and earthquakes which characterize this section of Lower Canada, are objects, the pursuit of which will not fail to gratify the scientific taste of the tourist, while his admiration of the picturesque will be unceasingly excited, as he wanders through the neighbourhood. It is scarcely possible to conceive a more beautiful drive than is afforded by both

banks of the Gouffre, over an excellent road for four or five leagues into the interior. In England this valley would be as celebrated as that of the Dove or Clywd: to the latter it bears a striking resemblance. Hitherto visitors have contented themselves in general with a view of the bay merely, and to this is partly owing the little information we possess respecting the interior; had it been otherwise, this place would not have experienced the neglect it has, but would, at least as a watering place, have rivalled Kamouraska, on the opposite shore, which can bear no comparison with it in point of scenery.

To those who may have a week's or a fortnight's leisure during the summer we strongly recommend the tour of this valley, the only drawback to which is the uncertainty of reaching or leaving St. Paul's Bay on account of contrary winds, and the probability which exists in consequence, of being confined to a boat or schooner for an unwelcome period; of the misery of which, as it has been twice our lot to incur it, we speak feelingly. If sufficient encouragement were given, a steam-boat would run between Quebec and St. Paul's Bay at stated periods, and then the difficulty would vanish; at all events, to those who possess a stout pair of legs and the desire to use them, the task of reaching the spot is an easy one.—For horses and carriages the road either is or was impassable. As to houses of entertainment at St. Paul's Bay, in the popular sense of the word, we know of none. There are, however, as elsewhere, many respectable Canadians who would not object to receive *en pension*. For ourselves, while there, we had the good luck, (which few must hope for, as it would be a breach of politeness to intrude,) to experience the hospitality of Mr. Chaperon and his family, and the

extreme attention and kindness of every member of it, made us all feel how much more there is in the manner of conferring a favor than even in the favor itself.

The mineral springs of St. Paul's Bay, &c. which will be among the first objects to attract the notice of the stranger, are of three kinds, saline, sulphuretted, and chalybeate. —The first the least abundant, the last the most so. The saline and sulphuretted springs are confined to the alluvial land of the valley of the Gouffre and principally, if not entirely, to the almost immediate neighbourhood of St. Paul's Bay.* This land consists of a very plastic marly clay, overlying carboniferous limestone, and underlying loamy, sandy, and vegetable deposits. Sandy ridges are also very characteristic of the valley. This valley, perhaps, half a league wide in its widest part, is enclosed on all sides, except towards the Bay, by a chain of mountains consisting of primary rocks. These rocks, towards the lower end of the valley, have large deposits of carboniferous limestone at their feet, while those at the upper end are characterised by being the matrices of large quantities of magnetic iron. Such is a short geological sketch of this valley, intended as explanatory of the geological position of these mineral springs to which we again return. The sulphuretted waters, which are found in many places in the lower part of the bay, are remarkable for a white slimy scum, or curd, which covers them. Pieces of wood, and the stones lying in the stream have often a coating of the same substance. When dried, these pieces, over the flame of a candle, burn with a weak, blue, and almost lambent flame, giving out the odour of sulphur. This coating has

* In the Eboulemens sulphuretted waters are said to be more abundant.

a tufaceous aspect, and is evidently not sulphur, neither is it a carbonate, as it does not effervesce in acid. It is more probable that it is a sulphate of lime containing a small portion of sulphur in a free state—the chemist, however, must decide this. The first intimation the stranger receives of being in the immediate vicinity of these springs is the strong disagreeable smell of sulphuretted hydrogen, which he liberally inhales, and if not satisfied with the proof which his nose affords, he requires the further evidence of his palate, the unwelcome flavour of spoilt eggs will convince him of the presence of sulphur under its most offensive form.

The iron, or chalybeate waters are very abundant, and are often found associated with the sulphuretted springs as if they had had one common origin, which indeed is very possible, as the decomposition of beds of iron pyrites would afford them both. Whatever may be the origin of the sulphuretted waters, however, we think that those containing iron are generally attributed to a partial solution of the magnetic oxide of iron of the neighbourhood; what the solvent may be, (if any other solvent than water be required,) we can only conjecture. Decaying vegetation affords the phosphoric acid, and it is well worthy of remark that bog ore, which is evidently a precipitation from waters holding iron in solution, *always* contains the phosphate of iron.

The astringent ink-like flavor of these waters is a sufficient distinction to the taste, and when stagnant, or nearly so, a scum or a deposit of a red colour, which is in fact the rust of iron, marks their course. An irised pellicle floating on the surface of such waters is also an indication of the presence of iron.

Salt springs, as has been said, are not abundant, nor have any been observed, as we think, at such heights as to preclude the *possibility* of their having their origin in the St. Lawrence. It must not be omitted to mention, however, that there is a close association in nature between sulphuretted and saline waters.

The salt and sulphurised waters appear to spring from the plastic clay before mentioned, while the chalybeates usually traverse the surface of the ground.

Of the mineral springs we shall soon have an analysis by an able hand, which, if it shall not give us the exact proportion, in which their several constituents enter, (a manipulation requiring considerable labour and skill) will at least make us acquainted with those constituents.

While at Mr. Chaperon's, we visited two sets of sulphuretted waters occurring on opposite sides of the bay, in low swampy ground, and near, or at the foot of the carboniferous limestone before mentioned.

On the western side of the bay, one of these springs was observed to enter into water of a remarkable blackness, and this water was observed in one or two other places.— Upon digging in several places a black gritty substance was thrown up, which bore a strong resemblance to a mixture of sand and lignite, and the occurrence of much rotten wood, appeared to account for the presence of the latter. However, upon exposing it to heat it neither formed a cinder nor gave out any inflammable gas, but appears to be composed almost entirely of common sand. In a wet state the sand possessed almost the inky blackness of the water. We feel much inclined to think that the spring here, containing sulphuretted hydrogen, meets with other waters containing lead antimony, or some other metallic

oxide in solution, and produces the phenomenon described. But this is a chemical question which we approach with extreme diffidence. Mr. Gagnon, the priest, informed us that he had detected antimony in the waters hereabouts, and to that circumstance he attributed the poor condition of the sheep in this neighbourhood.

The limestone on the eastern side of the bay, dips to the westward, while that to the westward dips eastward. This limestone is of a dark shade of colour, fetid odor, compact structure, and is destitute of organic remains, at least we saw none. The last character, together with its high dip (about 45°) and contact with rocks esteemed to be of the primary order, induces us to consider it as belonging to that portion of the carboniferous order of Phillips, called transition limestone by some authors. The position of this limestone dipping away, at a high angle, from the base of the primary rocks on both sides of the valley, induces the belief that the latter have been elevated since the deposition of the former.*

Kalm has mentioned the occurrence of an argentiferous galena in some of the rocks of St. Paul's Bay. We have seen several specimens, and have tested successfully the presence of silver, which indeed is common enough in lead ores, every where.

We searched in vain for the actual position of the rock

* Analogous appearances indicating the same event are not wanting in other places in Canada. Capt. Bayfield, R. N. has given instances at page 18, pl. 4 and 5, vol. I. of these Transactions; and the left bank of the St. Maurice near the falls of the Greys, offers another, where the old red sandstone below the falls, dips down the river, while above the falls it dips in a contrary direction. A thick stratum of grey wacke lies above the sandstone, and granite or gneiss below, the whole surmounted by a fetid and fossilized limestone, of the carboniferous order, covered by a deep alluvium, first of clay and then of sand, the latter uppermost.

in which it is found. But in a field at the foot of some felspathose rocks on the eastern side of the bay, a large block or two were found of a white laminar carbonate of lime much mixed up with a beautiful light green fluate of lime, (colorophane?) having disseminated through the mass threads and seams of galena, the laminæ of which are small and brilliant. These blocks were angular, and could not have travelled far. We ascended the hill in search of the vein or bed, but found nothing but bare and whitened surfaces of primary rocks projecting from the ground. A more particular examination, however, would probably be attended with success, for the matrix of the ore is of too remarkable and beautiful an appearance to be easily concealed. It should be sought for in the transition or corboniferous limestone of the place, which is in other countries its usual position. In the specimens we saw, the quantity of ore is small, but its matrix is a promising one: much of the lead ore of England is found in a vein of carbonate and fluate of lime, &c. traversing the same formation of limestone. It is worthy of remark that a vein precisely agreeing with the one now the subject of discussion, (with the exception of its not showing any traces of lead,) was observed at Cape Maillard by Mr. Nixon, 66th Regt. for a description of which see page 166 of the first volume of these Transactions. Veins of this description are considered to be very metalliferous, and are often explored with great advantage.

The predominating rock on the western side of the bay appears to be a felspathic granite, or one in which the felspar is in excess, the quartz less abundant and the mica very subordinate. It is often characterized by containing garnets, and this, in the estimation of Maculloch, is a proof,

if any were wanting, of its being primary.

In our Geognostical Essay on a portion of the Saguenay country, &c. just referred to, allusion has been frequently made to the deeply decomposed surface of these rocks, by which they have acquired their remarkably whitened aspect. In this therefore we will pass it over, as well as other facts therein stated, our object being to confine ourselves almost entirely to any *new* matter collected during our second visit to St. Paul's Bay, in the Spring of 1829, leaving the first report to speak for itself.

On our former visit to this place, we obtained from Mr. Gagnon, priest, some interesting information respecting a volcanic eruption which he appears to have witnessed at the latter end of the year 1791. In the account of this event given in the Geognostical Report, an error or two appears, which we here correct; it was in the month of December and not October that this phenomenon was observed. Also for 11° au dessous du thermometre de Reaumur, (plus 7¼ of Fahr.) read 11° au dessus, &c. (plus 56. 7. of Fahr.) Neither did the 6th of December, of that year, fall on Saturday, but on Tuesday, as appears from the following extract from the journals of the period.*

*Extract of a Letter from St. Paul's Bay, dated 15th December,* 1791.

"On Tuesday, the 6th instant, about half after seven o'clock in the evening, we had one of the most violent

* The printed letter was rightly copied from the original manuscript, but having been written by an old gentleman, it contains a few discrepancies, originating in the failure of his memory, but which deduct nothing from the accuracy of the essential facts. He corrected the temperature himself upon our second visit. In entering these corrections in the errata to the first volume of these Transactions, a most absurd blunder has been made, which our absence from Quebec prevented the suppression of.

shocks of an earthquake ever remembered to have been felt here; it came on like the explosion of a cannon against the back of our house, which made us imagine that the roof was falling in, it was followed by the shaking of the whole frame which fairly rocked about the furniture, &c. on which we took the children in our arms and ran out of doors, expecting, as is usual, three successive shocks, but this was not the case, there came two more moderate shocks at about a minute distance from each other, after which we returned into the house expecting all was over; but we had not been long in when another most violent shock came on, and though not accompanied with the same explosion as the first, continued much longer, for we had time to leave the house again before it was ended; when without, we perceived the earth rocking under our feet—thinking it not safe to remain in the house during the night, in the intervals of the shocks we went into it, and after extinguishing all the fires and lights, retired, eighteen in number, on board the sloop, where we remained till eight o'clock next morning, in which space we felt upwards of thirty shocks,—only nine of them were severe—the heavens and the earth seemed to be convulsed; it continued alternately snowing, raining, hailing, and blowing gusts of wind from the south-west and north-east.

"The weather still continued in that state, and the earth trembling at intervals both by day and night, ever since, though none have been so severe as those of the first night. One chimney and part of another have been shook down in the parish.

AT THE EBOULEMENS,

"It was most severely felt—the church is very much damaged, only one end of it remaining sound—the crucifix

on the altar was broken by the fall, as was also the lamp, which was thrown down by the rocking of the building—three chimneys have been thrown down, but happily no lives lost, a poor woman has lost her senses by the fright, being obliged to run out naked.

AT MALBAY,

"It was not so violently felt, and we hear of no damage being sustained. No advices have been received since from the Little River.

ON THE ISLE AUX COUDRES,

"The different shocks were severely felt, but we do not learn that any accident happened.

"Every where the shocks were felt more violently in stone than in wooden houses.

"A frightful rumbling noise was heard in the mountains both in the intervals and during the shocks, which still continued when the last accounts came away, (the 16th)."

*29th December.*

EARTHQUKE AT ST. PAUL'S BAY, EBOULEMENS, &c.

(Accounts received since our last.)

When the latest advices came off from these places on Monday the 19th inst. the earthquake still continued to the great alarm of the inhabitants. An ingenious correspondent on the spot has favoured us with a circumstantial account, from its commencement up to that date. The following is an extract:

"All the different shocks were felt from west to east, and did most damage within the breadth of two leagues, comprehending in their course (the length of which is yet unknown) the lower part of St. Paul's Bay, striking north and south, the lower end of the Island of Coudres, and the lower part of the Eboulemens.

"Within the above space, twenty-one chimnies have been thrown down or damaged. One stone house almost entirely demolished, several others split, and many stoves and ovens broke down, besides the damage done to the church of the Eboulemens, (mentioned in our last).

"It is remarkable that during the first days the shock came on regularly at the same hour, morning and evening, —and since the 6th till now, (the 19th,) we have had at least four or five shocks every day.

"The 17th, about half after five o'clock in the evening, *a globe of fire*, appearing to the eye of the size of a forty-eight pound cannon ball, was observed coming from the south-west, striking towards the north-east, and at the height of about one hundred and forty toises, disappeared in its perpendicular descent, above St. Paul's Bay, after bursting with an explosion.

"Many old people remark that for several quarter-centuries back, earthquakes similar to the present have happened; which lasted forty days, and find their return tolerably exact every twenty-five years, to a year or two of variation, and that the present is the third which to their recollection has taken place in the same season, within the difference of a month or two.

"In the history of Canada mention is made of a more violent earthquake, in the month of July, 1663, than any felt since, having then lasted six months, and began in the preceding January.

"Dating from that period there appears to have happened one regularly every twenty-five years—for since 1663 to the present year, five quarter-centuries and three years have elapsed.

"Previous to and ever since the 6th inst. the weather

has been clouded and gloomy, particularly west and east, and whenever it cleared up (which was very seldom) it always began to darken from thence."

The existence of iron mines in the rear of St. Paul's Bay, was known in the time of Charlevoix; but the public is in possession of few facts respecting them, up to the present day. In the summer of 1827, the Surveyor General reported favourably of them, after a personal inspection. And upon our return from the Saguenay country last year, we visited these mines at the request of Mr. Andrew Stuart, (one of the Commissioners for exploring unsettled lands,) the report respecting which may be seen in the Essay before alluded to. On our departure, instructions were left for further exploring these mines, and in consequence, very favourable reports were received during the following winter. It was to test the truth of these reports, and to make additional researches, that having finished our observations at St. Paul's Bay, we commenced a tour of the valley. Ascending, as before, on the western shore of the Gouffre, we shortly reached a saw mill, situated at the foot of a fall occasioned by a branch of the river tumbling over the carboniferous limestone, dipping to the eastward. Plastic clay was observed to be in contact with the limestone, and the latter is known to succeed to primary formations here.*

In a deep section of the plastic clay near at hand, sulphuretted water was seen oozing from it. It is worthy of

* We are not in this country, at least in the Lower Province, perplexed by the presence of the secondary formation lying above the carboniferous limestone of England, salt springs and gypsum occur in the Upper Province, but it seems to be doubtful whether they are not there associated with rocks whose analogies in Europe are considered to be of earlier formation.

remark that these springs almost always appear to be issuing from the body of the clay, a fact not consonant with the character of the clays in general, which usually throw off waters. This phenomenon may, perhaps, be accounted for thus: The fetid carbonate of lime is probably the source from whence the sulphuretted hydrogen is derived, which, rising in the state of gas is absorbed by the clay, and finding an outlet, is partially converted into water, by its hydrogen attracting oxygen from the atmosphere. It may however, be explained more simply, by supposing that the sulphuretted hydrogen combines with the water in the clay.—Both cases, indeed, may occur. There appears also to be something contradictory in saying that clays (notoriously so absorbent when *dry*) throw off water; but it is well know that they do, and the reason appears to be, that in consequence of their absorbent qualities, they soon become saturated with water, in which case they will receive no more, but oblige it to traverse their surfaces.—Near this place, there is also a salt spring, situated in the lower part of the valley.

Wishing to ascertain a little more respecting the geology of the valley, we left the road to the right, and ascending an alluvial ridge, came once more upon the carboniferous lime stone. Our view from hence was magnificent. Before us lay the whitened and rounded summits of the primary chain which, bending eastward, encloses the valley to the northwards, and makes of it a species of Cul-de-Sac.—Behind us the graceful sweep of the bay, the Isle aux Coudres, and the far away blue of the south shore. Below, a singularly undulated and well cultivated alluvial country, intersected by the Gouffre.

Crossing a field or two we came upon the junction of the

primary and secondary (including the transition limestone under the latter term) rocks. This had been before observed near the second mill, on the western side of the bay. The specimens of primary rocks we collected, were, first—an aggregate composed of blackish brown mica, red felspar, and grey quartz; secondly, of felspar and quartz alone, both of a pale colour; thirdly, a trapp containing much hornblend; fourthly, micaceous schist. The limestone was the same as has been described.

Descending again into the road, we pursued our journey over alluvium, until reaching a bluff, or precipice by the road side, we stopped to dine. This bluff, which is caused by a spur from the primary chain here meeting the road, is of granite.

Some distance beyond this bluff, we crossed a plentiful stream of water, strongly impregnated with iron, and which had its source in some hills on our left hand.

The next thing that particularly attracted our notice was a species of eboulement, by which a part of the road had been broken away and thrown into the river, an event evidently of common occurrence, as many portions of the western bank attest.

It appears that the river is rapidly gaining on this bank, and receding from the eastern, a fact which is owing to the deep alluvial section that the former presents in many places, while the latter forms in general a gradual slope to the foot of the mountains, which on the eastern side is much nearer the river than on the western.

Against this section, already weakened by the general thaw, the spring torrents rush with such impetuosity as to tear away a portion of the feeble barrier opposed to them, particularly at the sudden bends of the river, where their

effect is greatest. These torrents, by undermining the bank, soon make it top heavy, and the superincumbent mass falling, is gradually removed to the bay, where a species of delta is forming. The operation of this cause is constant throughout the year, but with diminished effect, nor does there appear any prospect of its being arrested, until a decided change is effected in the course of the river, by which a large portion of the property belonging to proprietors on the western shore will be cut off and bestowed, (if the river be considered a legal boundary here,) upon their neighbours on the eastern shore. May we not expect to hear of an action being instituted one of these days, by the Seminary *versus* the heirs of Madame Drapeau?—What would be the judicial decision in such a case? In equity the Seminary has a right to its land; but so has the other party to its water lot. To sink piles or construct other expensive works in order to resist these encroaching waters, appears to be out of the question in the present state of the country, but something of the kind must eventually be done.* On the bank of this river are often seen prostrate trees deeply embedded in its sandy alluvium, and this is characteristic of much of the alluvial land of the Lower Province. In a deep section formed by a river which crosses the Charlesbourg road, near Quebec, they may be seen in some abundance. It is remarkable that these trees are generally cedars, which are now rare in these parts.

* Captain B. Hall describes similar encroachments of the Mississippi near New Orleans, but of course on a much more extensive scale. There the river, whatever alteration in its course may take place, appears to be the boundary on one side, and the inhabitants are said, in consequence, to use artificial means to increase the encroachment, although at the risk of losing more than they had previously gained.

We arrived about six o'clock at St. Urbin's, which is between four and five leagues northward of St. Paul's Bay, where passing the night, we made preparations in the morning to visit some deposites of iron ore said to occur in the mountain chain to the northward, and to test the truth of a report which had been brought to Quebec respecting the occurrence of coal hereabouts.

We had many reasons, geological as well as other, to question the accuracy of this latter report; but none of them were of so positive a nature as to render our visit to the spot unnecessary, particularly as if we had not done so, some doubt would always have existed on the subject, as it was only from seeing the total discredit with which their story was received by us, after having visited the place, and the utter hopelessness which existed of imposing upon us that we obtained from one of the conspirators the following account.

They purchased a bushel of good Newcastle coal about three weeks before our arrival, and deposited the same in a small stream in rear of St. Paul's Bay.

Fortunately there was not a geologist among them and their *bituminous* coal was deposited in defiance of the beautiful laws of nature, upon the sides, and in close contact with primary rocks, with not a vestige of a secondary or transition formation within several miles. To see was therefore to be satisfied, or rather dissatisfied, and we turned our backs upon the beautiful but meretricious charms of the wanton sparkling with all her jetty blackness at the bottom, of a pellucid stream gurgling over a fine felspathose sand, up which we were invited to walk, under the plea of collecting more of this artificial deposit, but probably with the real intention of extinguishing the flame

raised in our breasts by the view of this intrusive combustible. We returned to St. Urbin's after two days absence, having seen only one new bed of ore about twenty feet long by ten feet wide.

The little expectation which was entertained of finding coal in these parts had previously been expressed in the printed report of our former visit, and that little entirely vanished when we examined the nature of the country through which our guides conducted us in order to find it. Having bestowed some attention on the rocks in this neighbourhood, it appears to us barely possible that coal in abundance should be found towards the mouth of the river; but to seek for it towards the upper end of the valley would be waste of time. The very circumstance of the abundance of the magnetic oxide of iron in those parts is against the probability of finding it. That we failed in finding much of this ore in our trip northwards is to be attributed to the lying duplicity of our guides, who persuaded us that they knew of several localities. We are satisfied, however, that a strict search in the neighbourhood of the chain at the upper end of the valley where we were would be attended with success. Some detached fragments and small insignificant veins and embedded pieces were frequently seen.

If the motive which these men had for deceiving us were a pecuniary one, (and it is scarcely possible to conceive any other,) they must have been greatly disappointed, as they were not even paid for the days they were with us.

On the first of April, (ominous day,) 1829, two of these men communicated to several gentlemen in Quebec, the story of the abundance of coal in rear of St. Paul's Bay, and endeavoured to extort money in consequence; but we are

pleased in being able to add that their attempts were vain. It was fortunate that one of our party, (Mr. Bowen,) staid behind to explore in the neighbourhood of St. Urbin's, otherwise the two days of our absence would have proved a loss of time of some importance, as the period of our stay was limited. This gentleman exerted himself so successfully during these two days, as to confirm all former reports respecting the abundance of ore, and to discover new localities: to his journal, we refer our readers for the details.

The position of these mines situated near both banks of the Gouffre, a river which at its shallowest periods might easily be rendered navigable for bateaux;—the abundance of limestone as a flux for the ore;—the ample supply of wood for making charcoal, render this spot well deserving the notice of government, or of some private capitalists.—The ore is of that excellent description called magnetic oxide of iron by mineralogists, or rock ore by miners. It sometimes occurs solid and free from admixture, at others it is mixed up with fusible minerals, so that if the latter is not so rich in metal, neither is it so difficult to fuse; there is also, as might be expected, bog ore in the low grounds, but how much has not been ascertained. On both sides of the river there is an excellent road, and the occasional occurrence of small streams descending from the hills affords the opportunity of working machinery, by water. In short the only thing which occurs to us as wanting to render the position complete, is the discovery of a good fire stone, such as is found near Mr. Bell's establishment on the St. Maurice river. Even this might be found, to the probability of which there is no geological objection; that at the forges belonging to the old red sandstone