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ON

THE FOOT-PRINTS

OCCURRING IN THE

POTSDAM SANDSTONE OF CANADA.

BY W. E. LOGAN, Esq., F.G.S.

[*From the* Quarterly Journal of the Geological Society of London *for* August 1852, Vol. VIII.]

1. *On the* Foot-prints *occurring in the* Potsdam Sandstone *of* Canada. By W. E. Logan, Esq. F.G.S.

[Plates VI. to VIII.]

Since the reading of the paper communicated to the Society last year on the track and footsteps of an animal in the Potsdam Sandstone of Lower (East) Canada*, the lowest member of the Lower Silurian rocks, farther investigation by my assistants on the Provincial Survey and myself have brought to light a considerable number of similar tracks in the same rock; and, although quite convinced in my own mind of the age of the rock, the importance attached to these impressions has induced me to search for additional evidence on the point, in order that others as well as myself might be satisfied that no mistake had been made in regard to it.

In my previous paper it was stated that a sandstone formation, resting unconformably on a metamorphic series of gneiss and interstratified limestone, and occupying a narrow strip at a variable distance on the north side of the St. Lawrence, swept round from the valley of this river to that of the Ottawa, the turn forming an obtuse angle and occurring on the Rivière du Nord: that a similar rock, proceeding from Keesville in New York, turns from the Valley of Lake Champlain to that of the River St. Lawrence, and, forming at the bend a sharper angle, is projected out across Beauharnois towards the previously mentioned bend in a long tongue of sandstone, pierced near the extremity by Mont Calvaire, a protruding mass of

* Quart. Journ. Geol. Soc. vol. vii. p. 247 *et seq.*

the subjacent gneiss. From Beauharnois the rock has been traced in New York in a nearly straight south-west line, and at a distance of five to thirty miles from the south-east bank of the St. Lawrence, to Hammond and Alexandria on that river. Crossing the river then to Brockville, it was last summer followed in Canada through the Johnstown and Bathurst Districts in a tortuous course to the townships of M'Nab and Nepean on the Ottawa; and on this river it has been seen again once, below Bytown, trending to a junction with the exposure on the Rivière du Nord. Between Mont Calvaire and the Bathurst District it may thus be considered to form the perimeter of a peninsula-shaped area, the isthmus to which, between the exposures at Mont Calvaire and Rivière du Nord, is about ten miles wide. Around the whole of this peninsular space the sandstone rests upon the gneissoid metamorphic rocks, and it is succeeded by an interior zone of calcareo-arenaceous beds, bearing the fossils which characterize the Calciferous Sand-rock series of New York. Within this is another zone consisting of limestone corresponding in a considerable degree in its fossil contents with the Chazy Limestone; the organic remains of a large area in the centre can be identified with those of the Bird's-eye, Black River, and Trenton Limestones, and resting on the latter a trough of the Utica Slate with its characteristic *Trilobites* and *Graptolites* extends from Bytown some distance eastward. This concentric geographical arrangement of the rocks, even without the evidence of the dips, leaves little doubt that the more organic formations rest on the sandstone. Where the dips are appreciable, they give a general confirmation of this; but they are for the most part small, and strata over large areas have often to the eye the appearance of being quite flat. The east side of the Beauharnois tongue of sandstone is bounded by the same succession of formations.

The sandstone in Beauharnois County and the neighbouring part of the State of New York is from 300 to 700 feet thick. In the lower part it contains many beds of conglomerate with quartz-pebbles, and it has some red layers; but towards the top it becomes a fine-grained, hard, white sandstone, and at the summit it is interstratified with calcareous layers forming a passage to the rock which overlies it. In this part it is abundantly marked over considerable surfaces by what the geologists of New York have called *Scolithus linearis*, which consists, where the rock is weathered, of straight, vertical, cylindrical holes, of about an eighth of an inch in diameter, descending several inches, and, where the rock is unweathered, of corresponding solid cylinders, composed apparently of grains of sand, cemented by a slightly calcareous matrix, more or less tinged with peroxide of iron. Mr. Hall and other American geologists include them among the Fucoids of the rock, but they appear to me more like Worm-holes. In one or two instances I have perceived that the tubes are interrupted in their upward course by a thin layer of sand, of a portion which descends into them and stops them up; and from this it would appear that the cylinders were hollow when the superincumbent sand was spread over them. Whatever may be the origin of the tubes, they strongly mark many beds in the upper part of the sandstone throughout the Canadian portions of its distribution already mentioned; and it is stated by Mr. Hall that the same characteristic accompanies the Potsdam sandstone in New York and Pennsylvania, and as far as Tennessee.

With this part of the formation also are associated many indications of what have been considered as Fucoids. One form among others presents a reticulated arrangement of stem-like bodies spreading over some of the surfaces, the interspaces of the network being four-, five-, and six-sided, and sometimes, when largest, measuring 14 inches in diameter; while the ridges which divide them are an inch and a half wide, and stand out half an inch in relief on the sandstone. The compartments are sometimes filled with shale, and the low ridges, a good deal resembling crack-casts, might be taken for such, were not similar forms occasionally traceable on splitting open closely joined surfaces of sandstone where no shale intervenes, and were not smooth surfaces of arenaceo-bituminous limestone in the succeeding formation met with presenting black bituminous pellicles arranged in similar reticulated figures—both large and small.

At Beauharnois, in the locality in which the first Track was discovered, and on a bed in the same quarry, the trail of a Worm or of a Mollusk was very beautifully displayed; and in the Johnstown District not only do *Scolithus* and Fucoids exist in abundance, but my associate, Mr. Murray, has there met with *Lingula antiqua*, characterizing this part of the formation, as it does also at Hammond on the south side of the river.

The new localities in which foot-prints have been met with are five in number. In none of them is *Lingula* found immediately near, but *Scolithus* abounds in them all, as well as the Fucoids. Two of the new localities are in the vicinity of Beauharnois (see Map, Pl. VI.); one of these, in the field of Mr. Henault, is about half-a-mile westward of that in which the first impressions were discovered; the other about two-and-a-half miles still further westward, and about 500 yards from the mouth of the Beauharnois Canal. *Scolithus* and Fucoids are seen in beds a few feet above and a few feet below those having the foot-prints, and 7 feet below one of them the Worm-holes are accompanied by a thin band of interstratified limestone. Along the shore of Lake St. Louis, between the two localities, the sandstone, with the occasional appearance of a calcareous layer, can be seen nearly the whole distance, and a careful admeasurement of the distance and of the minute changes that occur in the very moderate dips prevailing enables me to bring the track-bearing beds to within 3 feet of one another in stratigraphical place, while geographically their positions are equivalent in relation to the Calciferous Sand-rock which on each side bounds the more siliceous formation.

Proceeding eastward from the exposures in Henault's field and the tracks on the St. Louis River (those first discovered), the sandstone, marked by *Scolithus*, can be followed along-shore for about a mile, and is very nearly flat. Then there is an interval of about a mile without any exposure, beyond which the Calciferous Sand-rock first makes its appearance. Thin interstratified bands, more arenaceous than others, are still characterized by *Scolithus*, and the more massive beds hold abundance of two species of *Maclurea*,—*M. matutina* of Hall, and a new species. The strata are nearly flat; and, seen at intervals, they continue so for about six miles to the bridge on the Chateauguay River, in the first two miles of which the same two species of *Maclurea* are met with in several exposures, while the lithological character of the rock varies little the whole way. An exposure near the bridge displays *Pleurotomaria rotuloides* of Hall (a Trenton species). In beds of good limestone*, three miles farther east, and in the Caughnawaga quarry two miles beyond these, occur *Atrypa plena* and *Orthis pectinella*. Four miles farther on, at St. Louis Rapids, the rock contains nine species belonging to the Trenton formation. They are *Leptæna sericea*, *L. deltoidea*, *Orthis striatula*, *Lingula quadrata*, *Murchisonia bicincta*, *Glyptocrinus decadactylus*, *Echino-encrinites anatiformis*, *Calymene senaria*, *Isotelus gigas*, besides the genera *Stromatopora*, *Orthoceras*, and an unfigured species of *Encrinurus*. Beyond this the Utica slate appears below the St. Louis Rapids, and, crossing the St. Lawrence, can be traced along the shore of the Island of Montreal to the city, displaying *Triarthrus Beckii* and *Graptolithus bicornis* in many places.

Passing westward from the track-bed near the mouth of the Beauharnois Canal, the sandstone can be followed with little intermission for a distance of three miles up the St. Lawrence, where it becomes interstratified with calcareo-arenaceous layers; but at St. Timothy, three miles farther, sandstone beds, holding *Scolithus*, are still met with, and *Raphistoma* occurs in Calciferous Sandrock. For between four and five miles farther up the river the strata are concealed by drift, until reaching Grande Isle, where quarries expose good limestone beds, resting horizontally on others of an arenaceous character, and containing *Raphistoma* (two species), *Murchisonia*, *Euomphalus*, and *Leperditia canadensis*† (Jones, MS.), all unfigured; and at the head (western end) of the Beauharnois Canal, three miles farther up, besides *Raphistoma* there is a *Phacops*, allied to *P. Downingiæ*, and *Isotelus gigas* (the latter belonging to the Chazy limestone). All

* In a communication from Mr. Logan, dated at Montreal, July 6, 1852, it is directed that the boundary-line of the Chazy and Trenton limestones between the bridge on the Chateauguay River and the St. Louis Rapids should be removed to about a mile east of the position of Caughnawaga. It being too late, however, to correct the map, this emendation is here referred to. Mr. Logan also observes, with regard to the Island of Montreal and the district eastward of the Rivière du Nord, where the colour is made to die out, that he is now examining the unrepresented part of the country which is in the vicinity of this shading off, and he finds that the Chazy limestone comes nearly up to the Montreal Mountain (green on the Map), thus displaying very distinctly the trough of which the deepest part is under the Utica Slates of the White Horse Rapids.

By too much colour on the Map, the Trenton limestone of the White Horse Rapids is shaded off into the Chazy limestone of Montreal.

We have also to remark that the district coloured yellow should be designated as "Hudson River Group, covered with Tertiaries and Drift."

† Occurring also at Hawkesbury, Grenville, and Loucks Mills (wrongly spelt on the Map), on the Castor River.

Fig. 1.—*Section from St. Louis Rapids to the Cedars Rapids.* Section No. 1 on the Map.

Horizontal Scale, 3 miles to 1 inch. Vertical Scale, 1 mile to 2 inches.

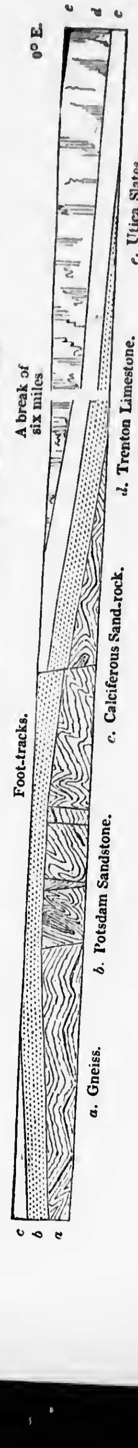
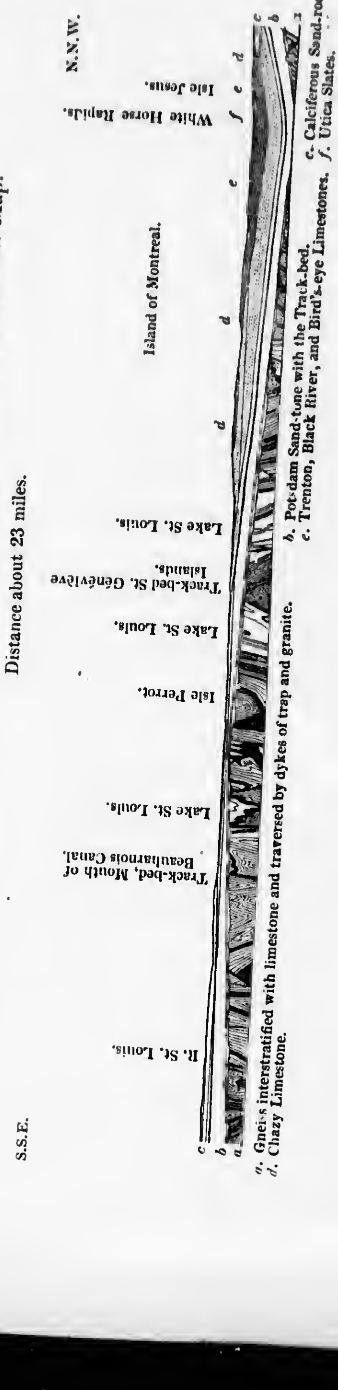


Fig. 2.—*Section from Isle Jesus to River St. Louis.* Section No. 2 on the Map.

Distance about 23 miles.



these localities, both to the east and west of the foot prints, are included in the line of section given with last year's communication*.

Another of the track-bed localities is in the vicinity of Point Cavagnol, on the south side of the Lake of the Two Mountains, about fifteen miles from the locality near the mouth of the Beauharnois Canal. Both of these localities are on the western side of the axis of the flat anticlinal arch, formed by the projecting tongue of sandstone between Beauharnois and Mont Calvaire, as described in my former paper. To the westward of the tracks of Point Cavagnol the country is so covered with drift and forest, that no traverse, starting immediately from the bed, has been attempted in that direction beyond a few miles, in which no exposure was met with; but on the lake side of the tracks, and a short distance beneath them, a bed of red sandstone occurs.

The fourth new locality is on one of the islands of St. Généviève, between two and three miles east of St. Ann, at the upper end of the Island of Montreal. This spot is about seven miles from the Beauharnois village exposures, and, with them, is on the east side of the anticlinal axis. If a line be followed obliquely across the anticlinal from the Canal track-bed to that of St. Généviève Island, and pursued to the White Horse Rapids between the Islands of Montreal and Jesus, a little below Isle Bizard, coarser sandstones would come from beneath the Canal track-bed about a mile out in Lake St. Louis (see fig. 2, & Section 2 of the Map). They are represented by the sandstones and conglomerates of Cascade Point and Cascade Island close by, of which they would be in the strike. A thickness of 65 feet of these coarser strata can be made out at the Point, and they are probably as much below the track-bed. The traverse-line would cross Isle Perrot, which is all underlaid by the sandstone, and on reaching the track-bed of St. Généviève Island, not a mile on the north side of Perrot, we again find the rock marked by *Scolithus*, with which it is in some spots completely honeycombed to the depth of 3 feet, while it is also interstratified with thin irregular calciferous bands. St. Ann's Point may be considered in the strike of the St. Généviève Island, and here we still find the sandstone marked by *Scolithus*; while on Isle Perrot, opposite, there occurs a bed of red sandstone identical in character with that of Point Cavagnol, and angular fragments of the same strew the shore above St. Ann. Proceeding northwards, we find immediately behind the village of St. Ann's the outcrop of the Calciferous Sand-rock holding geodes of calc-spar; and in a quarry to which resort has been had for building-stone we meet with a *Murchisonia*, like *M. gracilis*, but flat in the whorls, a *Pleurotomaria*, like *P. subconica*, but more depressed, *Leperditia Anna* (Jones, MS.), and *Orthoceras*. Further on the road, about half a mile, a *Raphistoma* occurs in calcareo-arenaceous beds, which with thin geodes of calc-spar are met with in several places further on. We then, in a low escarpment, come upon a rock composed almost entirely of *Atrypa plena*, a species characteristic of the Chazy Limestone. The rock usually affords good building-stone as well as

* *Loc. cit.* p. 249, and repeated here (fig. 1 & Section 1. of the Map).

stone for lime-burning, and it has been much quarried at the village of St. Génévièvе, just opposite the mid-length of Isle Bizard. The White Horse Rapids are situated about three miles to the east, and here, on both sides of the Rivière des Prairies (a branch of the Ottawa), black limestone-beds, lying in the form of a shallow trough, and displaying fifteen species of Trenton and one of Chazy fossils, are surmounted by black bituminous shales holding *Triarthrus Beckii* and *Graptolithus bicornis* of the Utica Slate, while loose fragments of black limestone (possibly Trenton limestone) at no great distance are characterized by *Leperditia gracilis* (Jones, MS.) and *Serpulites*. The Trenton Limestone of this part is probably continuous with that of the south side of Montreal Island, where, about three miles W. of Lachine, on the road to St. Ann, fifteen Trenton species have been met with; and in the quarries of Point St. Claire, six miles nearer St. Ann, we get five species characterizing the Bird's-eye Limestone, with one usually found in the Chazy, and four given by Hall to the Trenton.

Point St. Claire.*

Favistella (Columnaria) alveolata	Trenton
Stictopora acuta	"
Leptæna sericea	"
—— alternata	"
Pleurotomaria umbilicata	Bird's-eye.
Murchisonia perangulata	"
Modiolopsis obtusa	"
Favosites alveolaris?	"
Phytopsis cellulosa	"
Atrypa plena?	Chazy.

Three Miles above Lachine.

Favosites (Chætetes) lycoperdon	Trenton.
Orbicula lamellosa	"
—— terminalis?	"
Leptæna sericea	"
—— deltoidea; plentiful	"
Orthis (testudinaria) striatula (Emmons)	"
—— pectinella	"
Modiola (Tellinomya) anatiformis?	"
Bellerophon bilobatus	"
Oncoceras constrictum	"
Cyrtolites trentonensis	"
—— ornatus	"
Calymene senaria; plentiful	"
Isotelus gigas	"

Leperditia (L. Canadensis?), a species ¼ inch long.
Orthoceras.
Serpulites, allied to S. dispar (Salter).
Conularia.
Encrinurus, the same as at White Horse Rapids.

White Horse Rapids.

Favosites (Chætetes) lycoperdon	Trenton.
Stictopora acuta	"

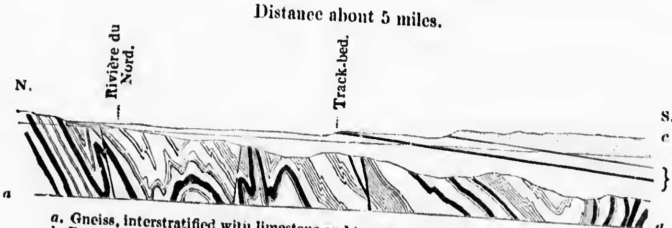
* These lists, and the names of the other fossils mentioned in the paper, are furnished by my friend Mr. Salter, of the Geological Survey of Great Britain.

Leptæna sericea; plentiful .... Trenton.
—— deltoidea; very abundant .... „
—— alternata .... „
Orthis (testudinaria) striatula .... „
—— lynx .... „
—— pectinella .... „
—— bella rugosa? .... „
—— disparilis .... „
Echino-encrinites anatiformis; plentiful .... „
Glyptocrinus decadactylus .... „
Calymene senaria .... „
Isotelus gigas .... „
Atrypa plena .... „
Encrinurus, with punctured cheeks. .... Chazy.
Raphistoma, two undescribed species, found also at Poquettes Rapid, Allumettes Island.
Atrypa, allied to A. extans.
—— or Rhynconella, allied to A. navicula, but with a sinus in the front of the larger valve.
Fenestella, Lingula, Bellerophon, Orthoceras.

The fifth new locality in which the foot-prints occur is on the Rivière du Nord, in the Seignory of Argenteuil, along which river the sandstone again crops out, and runs in a W.S.W. direction almost in a line with the Valley of the Ottawa (see Map, Sect 3; and fig. 3). The

Fig. 3.—*Section across the Rivière du Nord in the Seignory of Argenteuil.* Section No. 3 on the Map.

Distance about 5 miles.



a. Gneiss, interstratified with limestone and traversed by dykes of trap and granite.
b. Potsdam Sandstone with the Track-bed. *c*. Calciferous Sand-rock.

dip of the strata is here a little more decided than we have yet had it, the inclination being south at an angle of about 4°; and in the space of a mile and a quarter the stratigraphical relations of the rocks can be well made out. We have first the gneiss and its interstratified limestone; then the sandstone, not seen in actual contact with it, but forming an escarpment of between 30 and 40 feet in height, between which and the gneiss there is a flat sandy valley, varying in breadth from one quarter to half a mile, in which the stream winds its course. The sandstone has been traced thirteen miles consecutively to the eastward, and is known far beyond; and where a transverse section was measured the track-bed occurs at the top of the escarpment at a height of probably 100 or 200 feet over the gneiss. South of the outcrop of the track-bed, about 330 yards over a flat surface, another escarpment rises to the height of 70 feet. The white sandstone, perforated with *Scolithus*, is seen at the base, interstratified with calcareo-arenaceous beds for about 25 feet up, and these calcareo-arenaceous beds, holding geodes of calc-spar, compose the remainder of the rise. About 300 yards further, after a very gentle slope, there is a smaller step, composed of the same description of calcareous sandstones, and from this a level surface, of about a quarter of a mile broad, in which similar strata are seen once, reaches a small rise of 5 feet, composed of an arenaceous limestone, which is quarried for burning. In the quarry occurs *Ophileta levata* of Vanuxem (a Calciferous Sand-rock species) and *Raphistoma* (the same as that of St. Ann's section); and the general dip in the section is such as to leave no room to doubt the place of the track-bed, which would be about 160 feet beneath the limestone.

Farther south this line is covered up by sandy drift for several miles, but, if we go about five or six miles to the westward, and again starting from the gneiss, take a course at right angles to the strike (Section 4 of the Map), three and a half miles will bring us to a two-feet bed of good limestone. This rock, from its having been quarried for lime-burning in several places, has been followed from Carrillon to Grenville (thirteen miles). The dip of the limestone from its outcrop to the river (two miles) is about 75 feet in a mile. That it overlies the beds of the previous section is not considered uncertain; from the paucity of exposures, however, between it and the gneiss, and the increased dip near the gneiss, it is not easy to determine its relative position. It may be at least 150 feet higher; for there are seen in some of the naturally exposed sections of the Ottawa very nearly 100 feet of underlying calcareous claystone, weathering more or less yellow or brown, and in some parts bituminous and in others arenaceous, and often presenting in the latter case geodes of calc-spar and heavy-spar; and none of these beds appear in the Rivière du Nord section. Immediately beneath the 2-feet limestone there is a singular and extensively spread concretionary layer, in some large exposures of which, surfaces of half an acre show these concretions, consisting of concentric layers, cut in half and closely packed together, some of them being 2 to 3 feet in diameter. The limestone bed is fossiliferous, and displays *Maclurea sordida* (a Calciferous Sand-rock species), *Pleurotomaria nodulosa*? (a Bird's-eye species), *Murchisonia bicincta*, and another species, an *Atrypa* allied to *A. extans*, *Raphistoma*, *Turbo*, *Modiola*, *Orthoceras*, *Leperditia Canadensis* (Jones, MS.), and *Beyrichia Logani** (Jones, MS.), in abundance, and a new species of *Paradoxides*†; and at a short distance above the bed there are about 50 feet of sandstone, with bands of green shale, holding a vast collection of Fucoids, of which a bilobated species is most conspicuous. Some of the sandstone beds are

* Occurring also at Hawkesbury.

† The head is not perfect, but, from the general character of the glabella and eyes, Mr. Salter has little doubt that it belongs to *Paradoxides*. That genus, however, has not yet been noticed in America.

porous and moderately fine-grained and yield good fire-stones, whi[le] others are coarse, and, in addition to quartz-pebbles, hold a mult[i]tude of phosphatic nodules, mingled with small fragments of what appear to be *Lingulæ*. At Grenville, where these beds have been most exposed by the cutting of the canal, they are found to cross the Ottawa to Hamiltonville in Hawkesbury, and to extend half a mile back from the river; and half a mile beyond them a low escarpment presents the base of the Chazy Limestone, composed, as in the St. Ann's section, almost entirely of *Atrypa plena*. In this rock also small phosphatic nodules exist in some abundance, a few of which hold small fragments of shells.

Phosphatic nodules have also been met with higher up on the Ottawa, at the Allumettes Rapids, in a conglomerate bed occupying the same stratigraphical position as the Grenville beds, but there resting on the gneiss. Great numbers of one large species of *Lingula*, very like *L. parallela* of Phillips, and a few of *Pleurotomaria* or *Holopea*, occur with the nodules. Every one of the *Lingulæ* is imbedded in a coating of the phosphate, and in one instance a fragment of a *Lingula* was found lying across the length of the nodule. The specimen of *Pleurotomaria* is a phosphatic cast of the interior of the shell.

I may here mention also, that much higher in the Lower Silurian series of strata, in fact, just above the Hudson River Group, but considerably removed from this locality, phosphatic nodules occur in great abundance, and one of them, obtained at Rivière Ouelle, on the south side of the St. Lawrence, seventy-five miles below Quebec, whence the limestones and sandstones in which they occur are traceable to Point Levi, opposite the Capital, so much resembles a fragment of a cylindrical bone, and is so like bone in chemical composition, that I have had it sliced, fully expecting it would show bony structure. This, however, is wanting; but the specimen suggests the inquiry, whether, confined in its stony mould, any chemical action may have been exerted to obliterate its original structure without destroying its form.

I append to this paper the analyses, with which my friend Mr. Hunt, the chemist attached to the Canadian Survey, has furnished me, of four phosphatic specimens, two of them from the Rivière Ouelle, one of these being the bone-like fragment; the third is from the Chazy beds of Hawkesbury, and the fourth, from the Allumettes Rapids. By these analyses it will be perceived that the specimens yield from 36 to 67 per cent. of phosphate of lime, and that they all, on being heated, give out ammonia and an animal odour like that of burnt horn. One of the Grenville nodules was tested for phosphate of lime, and found to contain it largely, and it also gave out the animal odour, but it was not quantitatively analysed.

Examinations of Phosphatic matters, supposed Bones, and Coprolites, occurring in the Lower Silurian Rocks of Canada. By T. S. Hunt, Chemist to the Canadian Geological Survey.

Supposed coprolite from Lac des Allumettes, in sandstone, with *Lingulæ*.—Porous, having a specific gravity of 2·875. By ignition gave out water and an animal odour like burnt horn, and the vapours temporarily browned turmeric paper. It dissolved in acids with slight effervescence, leaving a residue of pure granular silica, which was in grains distinctly visible on fracturing the mass. 100 parts gave on analysis—

Phosphate of lime (PO_5, $3CaO$)	36·38
Carbonate of lime	5·00
Magnesia .. } Oxide of iron } by loss	7·02
Insoluble siliceous grains	49·90
Volatile	1·70
	100·00

Another fragment gave 42·54 of siliceous matter. The brown matter replacing or filling the *Lingulæ* in the bed was found to be phosphate, with a little carbonate of lime and animal matter, with siliceous particles.

No. 2. Coprolite from Chazy limestone, Hawkesbury.—Yellowish within, but penetrated for a little depth by a blackish matter (probably infiltrated oxide of iron). The powder when heated in a tube gives off so much ammonia as to produce white fumes with acetic acid. 100 parts gave—

Phosphate of lime	44·70
Carbonate of lime	6·60
Carbonate of magnesia	4·76
Oxide of iron	8·60
Insoluble siliceous matter	27·90
Volatile matter (water in part)	5·00
	97·66

No. 3. Fragment of supposed cylindrical bone from Rivière Ouelle.—It was blackish brown and compact. Within it was filled with earthy matter (the imbedding sandstone), which was not entirely detached before the analysis. Its analysis gave, for 100 parts, as follows:—

Phosphate of lime	67·53
Lime .. } as carbonates and fluorids	2·44
Magnesia } as carbonates and fluorids	1·65
Oxide of iron	2·95
Insoluble (in part, the adherent matrix)	21·10
Volatile	2·15
	97·82

The loss arises from the carbonic acid which is not here represented as combined with the excess of lime and magnesia.

The compact ivory-like fragment from Rivière Ouelle had a sp. gr. of 3·035 to 3·150. It gave out ammonia and water with an animal odour when heated, and with sulphuric acid the vapours corroded glass, indicating a fluorid. It contained a larger proportion of carbonate of lime and magnesia, and more oxide of iron, than the hollow bone from the same locality. 100 parts of it gave—

Phosphate of lime	40·34
Carbonate of lime and some fluorid	5·14
Carbonate of magnesia	9·70
Oxide of iron, with a little alumina and manganese	12·62
Insoluble siliceous matter	25·44
Volatile	2·13
	95·37

The analysis is defective from a loss of over 4 per cent., but the quantities actually found show sufficiently well the composition of the substance where scientific accuracy is not essential.

Before returning to the foot-prints, I would further state, on the subject of phosphatic nodules, that last season my associate, Mr. Murray, in examining the rocks on which the Lower Silurian unconformably rests in the Johnstown District, met with altered conglomerates interstratified with limestone not distinguishable from the highly crystalline rock which is interstratified with the gneiss; and associated with the quartz-pebbles of the conglomerate are soft white nodules containing phosphate of lime. In the beds of the crystalline limestone, separating the masses of gneiss, imperfect crystallizations of phosphate of lime are of very frequent occurrence. They are usually small, but in some parts they become large and so thickly disseminated as to give the rock an economic value. On Lake Huron the Lower Silurian group rests unconformably upon a siliceous series with only one known band of limestone, of about 150 feet thick, with leaves of chert in abundance, but as yet without discovered fossils. This series is supposed to be of the Cambrian epoch. It comprehends the copper-bearing rocks of that district, and with its igneous interstratified masses has a thickness of at least 10,000 feet. The gneissoid group, of which mention is made, is probably still older than this. Its conditions appear to me to make it reasonable to suppose that it consists of aqueous deposits in an altered state, and the origin of the phosphatic nodules and crystals in some of its members, with reference to a possible connexion with life in such ancient strata, becomes a question of great interest.

Having shown, I hope conclusively, the stratigraphical relations of the track-beds, I have only farther to state that, with the view of submitting to competent authority as large an amount of evidence as convenient to illustrate the nature of the animal or animals by which the foot-prints were impressed, I have brought over and temporarily placed in the Museum of the Society the original slab of sandstone, $12\frac{1}{2}$ feet in length, from which the casts of last year's communication were taken (No. 7 of Prof. Owen's description); a second slab of the original stone, from Mr. Henault's field, measuring 8 feet (No. 3 of Prof. Owen's description); and a third slab, with two tracks and ripple-mark upon it, from the Island of St. Geneviève. These are accompanied by about 100 slabs of plaster-casts, taken from various tracks as they are naturally exposed in the field. Adding one track to another they measure about 350 feet. Two of the casts are from tracks immediately near the one first discovered, and one of them shows the groove running out of the centre (No. 4 of Prof. Owen's description). The remainder are from Henault's field. In it four areas are comprehended within a distance of four chains, three of which are exhibited in their true relation to one another in Pl. VII. A, B, C; and each of these is displayed on a larger scale, 3 inches to 16 feet, in Pl. VIII. A, B, C.

In Pl. VIII. A. there are ten tracks, seven of them on a smooth-surfaced bed, which has been rubbed by ice moving in a direction S. 40° W. These tracks are indicated by lines of different colour, and are numbered 1 to 7. Their measurements are,—

	ft.	in.		in.		
1.	6	0	long by	5	wide.	
2.	10	3	„	$5\frac{1}{4}$	„	
3.	28	6	„	$5\frac{1}{2}$	„	(No. 5 of Prof. Owen's description.)
4.	24	6	„	$4\frac{1}{4}$	„	
5.	8	6	„	$5\frac{1}{2}$	„	
6.	6	3	„	5	„	(No. 1 of Prof. Owen's description.)
7.	12	0	„	5	„	(No. 6 of Prof. Owen's description.)
	96	0				

On a surface 2 inches lower, showing ripple-marks (the ridges of the ripple-mark running N. 75° E.), there are two tracks, numbered 9 and 10, measuring,

	ft.	in.	
9.	5	4	long,
10.	4	6	„
	9	10	

And there is another, on a surface still lower by about 1 inch, but showing no ripple-mark,

	ft.	in.		in.	
8.	4	6	long by	$5\frac{1}{2}$	wide.

Pl. VIII. B. shows seventeen tracks, twelve of which are on a smooth surface, which has been rubbed by ice moving in a S.W. direction. They are numbered 1 to 12, and measure

	ft.	in.		in.		
1.	3	0	long by	5	wide.	
2.	4	6	,,	$5\frac{1}{4}$	,,	
3.	4	0	,,	4	,,	
4.	5	3*	,,	5	,,	
5.	3	8	,,	$4\frac{1}{4}$	,,	
6.	5	5†	,,	$5\frac{1}{4}$	,,	(No. 2 of Prof. Owen's description.)
7.	11	8	,,	$5\frac{3}{4}$	,,	
8.	12	0	,,	$5\frac{3}{4}$	,,	
9.	12	0	,,	6	,,	
10.	18	0	,,	$5\frac{3}{4}$	,,	
11.	10	0	,,	6	,,	
12.	18	0‡	,,	$6\frac{1}{2}$	,,	(No. 3 of Prof. Owen's description.)
	107	6				

The remaining five, numbered 13 to 17, are upon a ripple-marked surface, the ridges of the ripples running in the direction N. 71° E., and this surface is 2 inches below the smooth one. The measurements are—

	ft.	in.		in.	
13.	14	6	long by	6	wide.
14.	3	3	,,		
15.	15	3	,,	$4\frac{1}{2}$	,,
16.	20	4	,,	4	,,
17.	8	3	,,	5	,,
	61	7			

Pl. VIII. C. shows six tracks, which are represented by coloured lines without numbers. One of them is very narrow, not exceeding three-quarters of an inch in breadth. Their measurements are—

ft.	in.		in.	
9	6	long by	$4\frac{1}{2}$	wide.
3	0	,,	$5\frac{1}{2}$	,,
3	6	,,	$5\frac{1}{4}$	,,
1	0	,,	$5\frac{1}{2}$	,,
1	0	,,	$0\frac{3}{4}$	,,
18	0			

The tracks are upon a smooth surface (marked *b*), which, like the other smooth surfaces, has been rubbed by the ice. On the same surface there is ripple-mark, the natural edge or termination of which is seen, and by it the tracks are obliterated. Three of them come up to the edge of the ripple, and are not traceable upon it. From the general line of the edge a part projects, like a spur or triangle, which is marked across by the ripple up to the apex, as if the cause producing the ripple had reached that far and no farther. The part lettered *d* also shows ripple-marks, and is 6 inches higher than the surface marked *c*, which runs on below it, and while the direction of the ripple-lines on *d* is S. 53° E, those on *c* run S. 80° E. On the

* Rather less of this track appears in the plan than on the plaster-casts.

† In the plan this track extends further than on the plaster-casts.

‡ A portion of this track, to the extent of 87 feet, on the sandstone slab, is temporarily placed in the Society's Museum by Mr. Logan.

part lettered *a* there is also ripple-mark. It is an inch or two below *b*, and the ripple-ridges on it run N. 15° E. The inference which I wish to draw from these facts is, that the ripple-ridges on succeeding surfaces, only a few inches above one another, being in different directions, and the limit of the producing cause of the ripple being indicated in one example, it appears probable that the ripple was produced by tide rather than by a current in deep water; that in the same area one part of the surface was dry when the wave was acting close by on another part; and that the direction of the wave was towards the apex of the triangular space.

The fourth area, of which no plan is given, is removed a few yards to the east of that lettered C in Pl. VII., and on the casts of this surface it will be seen that there are ten tracks, measuring—

ft.	in.		in.	
6	0	long by	5½	wide.
10	6	,,	5½	,,
8	0	,,	5	,,
2	5	,,	5½	,,
5	9	,,	6½	,,
2	7	,,	4½	,,
6	9	,,	5½	,,
5	7	,,	5½	,,
4	8	,,	4	,,
4	0	,,	5	,,
56	5			

The geological importance given to these tracks by the opinion expressed by Professor Owen in regard to the specimens produced last season, has induced me to spare no pains in bringing evidence to bear on the subject; and the materials having been submitted to the examination of the Professor, he has kindly undertaken to lay before the Meeting a description of them.

At the Evening Meeting, March 24, M. E. Desor exhibited an engraving of a slab with Foot-prints bearing a general resemblance to *Protichnites*. These Tracks are from the vicinity of the Niagara Falls, and belong to the "Clinton group." Prof. Owen has supplied the following note on these Foot-prints.

The plate exhibited by M. Desor gives a view of a series of prints on each side a median track, of about 18 inches in extent. The foot-prints on one side of the median track are in successive groups of three prints, the two next the track being most approximated. Only the pairs of prints corresponding to those median pairs are shown on the other side of the track. The plate gives no indication of successive groups of three sets of prints; but it would be unsafe to rely upon it for the precise character of the impressions.

[*Note.*—The casts of surface A, Pl. VIII. (including the tracks, *P. 7-notatus*, *P. lineatus*, and *P. alternans*), together with characteristic impressions of the remaining species, will be deposited in the British Museum.]

2. Description *of the* Impressions *and* Foot-prints *of the* Protichnites *from the* Potsdam Sandstone *of* Canada. By Prof. Owen, F.R.S., F.G.S. &c.

[Plates IX. to XIV. A.]

Of the extensive series of foot-prints found under the circumstances described in the preceding communication, the originals of some and good plaster-casts of more have been brought over with much labour and expense by their discoverer, Mr. Logan, and of these I have selected the best-marked and most intelligible portions for the following descriptions.

1. *Protichnites septem-notatus.* Pl. IX.

The subject, which for the convenience of reference I have so named, consists of a series of well-defined impressions, continued in regular succession along an extent of 4 feet; and traceable, with an inferior degree of definition, along a further extent of upwards of 2 feet. These impressions (see Plan, Pl. VIII. A. 6) are represented by plaster-casts.

In the first-selected extent of 4 feet there are thirty successive groups of foot-prints on each side of a median furrow, which is alternately deep and shallow along pretty regular spaces of about 2½ inches in extent. The number of prints is not the same in each group; where they are best marked, as in Pl. IX. 1 *L*, we see 3 prints in one group, *a*, *a′*, *a″*, 2 prints in the next, *b*, *b′*, and 2 in the third, *c*, *c′*, which is followed by a repetition of the group of 3 prints, *a*, *a′*, *a″*. But, in some instances, the outer print of the third set is divided, as at 1 *R*, *c′*, *c″*, making the numbers in the three successive groups 3, 2, 3, instead of 3, 2, 2: the three groups of impressions are, however, notwithstanding this occasional variety, recognizably repeated in succession along the whole series of tracks on both sides of the median groove*.

The principal foot-prints are disposed in pairs, placed with different degrees of obliquity, in each of the three groups, towards the median track; the innermost print in the second, *b*, and third, *c*, pairs, which are best marked, being usually rather more than half the size of the outer print, *b′* and *c′*.

The two foot-prints of the same pair are a little further apart from each other, in the three succeeding pairs, as at *a′*, *a″*, *b*, *b′*, *c*, *c′*, especially in the second and third groups of each set; the two forming the pair *a′*, *a″* again approximating in the next series, and the pairs *b*, *b′* and *c*, *c′* diverging in the same direction and degree; and this alternate approximation and divergence is repeated throughout the entire series of the present tracks.

* Should these descriptions express more or less than is shown in the Plates, the reader will be kind enough to bear in mind that they were penned after repeated examinations of the originals by varied applications of artificial and natural lights, and express the sum of the results of such comparisons extended over the entire series of tracks; whilst the able artist has given the effects of one light and shade only, as seen on one portion of the track.

But what strikes the ichnologist, heretofore conversant chiefly with the foot-prints of bipeds or quadrupeds, is the occurrence in the present series of the third impression, a, which complicates the most approximated pair, being placed in front and a little to the inner side of the innermost impression, a', of that pair. The superadded impression, a, is about the same size as the innermost in each pair, the average diameter of that impression being 5 lines.

Taking this view of the impressions, it appears that, whilst the innermost in each pair, a', b, c, are of equal size, the outermost, a'', b', c', 1 *L*, progressively increase in size, from the most approximated to the most divergent of the three pairs; that of the first, a'', being narrow in proportion to its length, that of the second, b', as broad as long, and the outermost, c', c'', of the third pair being oblong, but larger than that in the first pair. In some places where the most approximated pair of impressions, a', a'', are deeply marked, they are complicated by a fourth shallow and very small pit, a''', 2 *L*, midway between the third, a, and the outermost, a'', of the pair of impressions.

The deepest parts of the middle track usually occur between the second, b, b', of each of the three groups of foot-prints.

The first pair of impressions, a', a'', are included within a space of 1 inch 3 lines in diameter; the third pair within a space of 1 inch 9 lines in diameter. The longitudinal extent of the three groups of impressions, measured along the outermost, averages 3 inches 6 lines, and along the innermost 3 inches 3 lines: the extreme extent of the three sets of impressions averages 4 inches. The transverse interval between the innermost impressions, a, a, of the first pair is 3 inches, and between those of the third pair, c, c, 2 inches, measured from their innermost borders. The distance between the two outermost impressions of the first pair is 5 inches, and it is the same between the corresponding impressions of the third pair, measured from their outer borders; so that a line drawn along the outer margin of the impressions of one side would be parallel to the line drawn along the same parts on the opposite side, the difference in the distance from the midspace being presented by the innermost impressions.

The average breadth of the median groove is 5 lines, its depth at the deepest parts between 1 and 2 lines; the regular alternation of the deep and shallow parts of the median impression indicates the part that made it to have been alternately raised and depressed, an alternation which might affect a tail as well as the trunk, but is more likely to have affected the latter in an undulating mode of progression.

There are no clear or unequivocal marks of toes or nails on any of the impressions which form the lateral pairs or triplets. Their margins are not sharply defined, but are rounded off and sink gradually to the deepest part, which is a little behind the middle of the depression. There is a slight variation in the form and depth of the answerable impressions, but not such as to prevent their correspondence being readily appreciable through the whole of the extent here described; that is to say, the innermost of each of the three pairs here described as first, *A*, second, *B*, and third, *C*, may be identified with the corresponding innermost impression on the opposite side and with the same impression of the same pair in the three preceding and the three succeeding pairs.

This power of determining the homologies, so to speak, of the several impressions is a strong evidence of their having been made by the successive application of the same instruments; whilst the equal distances at which they recur proves them to have been made in regular succession, as in the ordinary progression of an animal walking by means of limbs.

The question next to be resolved is,—how those instruments were disposed in the body of the creature that made and left the impressions? It cannot be supposed that two limbs, answering to the fore and hind legs of a quadruped, could have made impressions so different in form and in their degrees of approximation as we see in each pair of the series of three sets on one side. In a quadruped we are accustomed to see the successive pairs of the same side resembling each other, the difference in the two impressions of such pairs indicating the difference between the fore and hind feet of the side to which they belonged; but in the present series of impressions each pair in the successive series of three so differs from the other two pairs in the form and size of the impressions, and their degree of divergence, as to render it scarcely possible to suppose that they could have been formed, either along the inner or the outer series of impressions, by successive steps of the same limb; and, were it contended that the animal by some peculiarity of gait more and more approximated its fore limbs in making three successive steps, and then divaricated them to commence another series of three steps, on the supposition that the inner impressions were formed by the same pair of fore limbs at each series of three steps, the difficulty would still remain of accounting for the third superadded impression, *a*, on the hypothesis of their being formed by a quadruped, with the additional difficulty of the difference in shape and size of the outer impressions of the same three pairs.

The first or most approximated pair, *a'*, *a''*, in each set of three pairs of impressions are the most equal in size. In the second pair, *b*, *b'*, which are nearly equally approximated, the outer impression is manifestly larger and broader than the inner one. In the third and most divergent pair, *c*, *c'*, the outer one is still larger, in length as well as in breadth, and is occasionally subdivided. Now, as the first pair in each series of three, *A*, 1 *L*, plainly answers to the same pair in the next series of three, *A*, 2 *L*, and the like in regard to the second pair and the third pair, it follows that the same instruments must have made the first pair in each of the three pairs, and so of the second and of the third pairs; or, in other words, each pair in a series of three must have been made by different members, or divisions of members; and the same must be inferred in respect to the small impression, *a*, which is superadded to the first pair in each triplet: whence it may be concluded either that the animal had seven pairs of ambulatory limbs, or that it had three pairs, of which two were bifid and the third trifid at the impressing extremity.

The impressions which are so clearly marked in the extent above described are continued less distinctly but uninterruptedly for more than 6 feet. The most constant of the small impressions are those which are nearest the median track, *c*, and which have been described as the innermost of the third pair, but which first arrest the eye as superadded foot-marks, occurring pretty regularly at intervals of from 4 inches to 4½ inches along the whole track.

There are three other series of tracks referable to the *Protichnites 7-notatus*.

2. *Protichnites octo-notatus*. Pl. X.

The series of foot-prints, here described as the *Protichnites 8-notatus*, extends for 5 feet 5 inches along a surface of hard sandstone, which has been rubbed by the ice. This track is represented by plaster-casts. It is seen on the Plan, Pl. VIII. B. 6. In this series the impressions of the feet are deeper and the median track is much fainter, yet it continues to show the alternately deep and shallow character, its traces being visible at regular intervals, which are, however, longer than those that divide the deeper parts of the same groove in the first-described series of impressions.

In the present series the small innermost impressions, *c*, are repeated at intervals of 5 inches; the distance between the right and the left of these impressions is 2 inches, being less than half their longitudinal interval; whereas in the former slab the transverse interval is exactly half the longitudinal one.

The larger and more exterior depressions present also a somewhat different arrangement from those first described. Where they are most clearly and regularly impressed it is as follows:—on the outside of the small innermost impression, *c*, there is a pair of larger impressions, c', c'', closely approximated one behind the other, in the direction of the track, the longitudinal extent of this pair of impressions being 1 inch. The next pair of impressions, b, b', answering to the middle pair before described, and here noticed in the contrary or retrograde course, are placed nearly transversely and are wider apart than the longitudinal pair, the innermost being the largest, and the diameter of the pair 1 inch 8 lines. Then follow three impressions, a, a', a'', forming an inequilateral triangle, with a broad base turned inwards and the apex outwards, the impression forming which (a'') is the largest of the three, although they are of nearly equal size, having a diameter each of about half an inch. These three impressions answer to the three, a, a', a'', Pl. IX., which have been described as forming the first pair of impressions with the accessory impression in the *Protichnites 7-notatus*; but the three are here so distinct and remote that the pair could only be chosen arbitrarily. The middle or second pair, b, b', answers to the same in the impressions first described, with the difference of direction above noted: the third pair differs in the more constant and complete division of the larger outermost impression into two pits, c, c'. In none of these impressions are there distinct and unequivocal traces of claws or digital divisions; they seem rather to have been impressed by one limb, or division of a limb, terminating in a hard, obtuse, subangular point.

The arrangement of the impressions just described is repeated with little modification throughout this series of tracks; that is to say, taking them in the order in which those of the first series were described, we have the group of three impressions, *a*, *a'*, *a''*, the transverse pair, *b*, *b'*, and the widest pair, *c*, *c'*, in which the outer and larger impression is divided into two, *c'*, *c''*.

Neither in this nor in the preceding series does any impression appear to be modified or in any degree obliterated by the print of another foot coming into the same place.

The median interval between the right and left of the first pit in the group of 3 impressions, *a'*, is 3 inches 9 lines; between the two pits in the same sets forming the apex of the triangle, *a''*, 4 inches 8 lines, and between the third, *a*, 3 inches 2 lines. These measurements are taken from the inner border of the right and left impressions respectively. The interval between the innermost, *b*, of the transverse pair of impressions is 3 inches 2 lines, and between the outermost, *b'*, from their outer borders 5 inches 8 lines: the interval between the longitudinal pairs, *c'*, *c''*, from their outer border is 5 inches 3 lines. The length of each series of three sets of impressions is from 5 inches to 5 inches 3 lines, and this distance is very regularly preserved throughout the series of tracks. Thus each series presents eight distinct impressions on each side, 1 *L*, 1 *R*, and tallying impressions of each of the eight can be determined in each successive series, 2 *L*, 2 *R*.

From this it is to be inferred that they were made by the same parts respectively; that is, that the impressions were repeated by the same limbs or impressing instruments at each successive series. Consequently if we regard each series as indicating the nature of the individual that impressed them, we must conclude it to have possessed either eight pairs of impressing instruments, or three pairs of limbs so divided as to leave 3 prints, 2 prints, and 3 prints in longitudinal succession on both the right and the left sides, and sufficiently long and flexible to make a step co-extensive with the space occupied by the entire series of such limbs; these impressions severally presenting characters so distinct in the same series of *A*, *B*, *C*, as to forbid the conclusion that they were made by the same instruments differently applied at regularly alternating intervals or distances in such series.

We have clearly, therefore, indications of the same kind or genus of animal in the present, as in the preceding series of tracks, but the difference in the proportions and arrangements of the individual impressions in the determinable groups indicates a difference of species. There are two other series of tracks of the *Protichnites 8-notatus* repeating very recognizably the characters above described.

3. *Protichnites latus.* Pl. XI.

A slab of the sandstone 8 feet long* by 2 feet wide shows three series of the impressions, two extending lengthwise and crossing each other very obliquely, and the third crossing both the others transversely. In the track which traverses the whole length of this slab the impressions of the feet are deeper and larger, whilst the median

* This track has a still greater extension on the plaster-casts taken from the sandstone-surface of which the slab here referred to is a portion. See the Plan, Pl. VIII. B. 12.

impression is much shallower and fainter than in the foregoing footprints, but it still shows the alternate deep and shallow parts. Although the impressions are less regular than in the before-described series, and the small innermost ones are less recognizable, yet they are discernible in certain parts, as at *c*, *c*, and they, in like manner, mark the boundaries of three sets of impressions on each side of the median one.

The first set consists of a pair, *a'*, *a''*, of nearly equal impressions, with occasional indications of a third print forming an inequilateral triangle. The second set of impressions is a transverse, more widely parted, pair, *b*, *b'*, the innermost being the smallest, the outermost the largest and sometimes, as in 1 *L*, divided into two, which are, however, included in a common circumference. Then that impression, *c'*, *c''*, which has been described as the outermost of the pair to which the small innermost impression, *c*, belongs, is very large and more distinctly bilobed than the outermost of the preceding pair, and its long axis is turned at right angles to that of the preceding outermost impression. The longitudinal extent of the three sets of impressions on one side is 5 inches. The transverse interspace between the two small innermost impressions, *c*, *c*, is 2 inches 2 lines, between the outermost, *a''*, *a''*, of the three sets of impressions from their outer borders 7 inches. The general resemblance of these successive series of three sets of impressions with those of the better-defined tracks before described leave no doubt of their having been made by the same genus of animal, but it would seem to be by a different species having a body broader in proportion to its length.

The sandstone allows a character of the lateral impressions to be seen which was not so distinctly recognizable in the casts, namely the great depth and angular figure of the bottom of the impressions, with some irregular angular notches towards its circumference, indicating them to have been made by a limb shod with a hard substance terminating in a somewhat obtuse point with angular processes from its base. This character of the impressions is irreconcileable with their having been formed by the convex sole of the foot of a Chelonian or by the more flattened foot of a Batrachian or Saurian reptile, or by the hoofed or padded foot of any mammal.

4. *Protichnites multinotatus.* Pl. XII. ($\frac{1}{2}$ nat. size.)

Casts of impressions along an extent of $4\frac{1}{2}$ feet, forming part of a series which was traced for an extent of 10 feet uninterruptedly, exhibit a strong deviation of the intermediate continuous groove from the mid-line between the two lateral series of impressions. The breadth of this track from the outer border of the outer impressions nowhere exceeds $3\frac{1}{2}$ inches. The impressions are subcircular with smooth, rounded, ill-defined borders, of varying depth, but most of them faint and shallow. Commencing at the end of the series, where they are least distinct, the intermediate groove inclines to the left and soon gets upon the innermost of the impressions along the left side. At about halfway from the other end it becomes deeper, obliterates many of the prints on that side, and has been impressed so strongly as to force up a ridge of the sand upon its left side. Some faint impressions of the outer prints may be seen on this ridge. The impressions of the right side opposite the deeper part of the ridge are unusually deep, and are more numerous and closer together than in the shallower parts of the tracks. In no part of the series are the impressions so distinct and well-defined as to allow a recognition of the groups of threes repeating each other; but in a few parts, as they approach the deep excentric groove, the small innermost pits may be observed. There are few places where two contiguous pits are divided by an interspace equal to their own breadth. Although many of the foot-prints on the same side are in pairs, more or less oblique, groups of three occur not unfrequently. Nothing like claws or digital divisions can be discerned where the impressions are deepest. The intermediate groove becomes shallow and gains the mid-space in the last two feet of the present series. Where the impression is deepest the tracks bend slightly in a different direction from the preceding part, making about an angle of 162°. This deviation of the middle impression would seem to indicate that it had been formed by some appendage which continued to incline to the left after the body had begun to bend to the right side, and the greater depth of the impression where the bend is greatest would show that there had been an increased exertion on the part of the animal at the time of making that bend.

5. *Protichnites lineatus.* Pl. XIII. ($\frac{1}{2}$ nat. size), and Pl. VIII. A. 3.

In a continuous track of the median impression, traceable along an extent of 13 feet, this impression preserves in some parts for an extent of between 2 and 3 feet a considerable and equable depth; it is also accompanied by a remarkable modification of the lateral impressions, which are rather represented by continuous grooves than by a succession of pits, although these are sufficiently evident in many parts of the lateral grooves, forming partial depressions in the grooves. Along an extent of 13 inches, where the deep median impression is equidistant from the two narrow and shallow impressions on each side, the outermost of these impressions is deepest on the left side, and the innermost is deepest on the right: a little further on the lateral grooves become broken up into a series of shallow foot-prints and then again become continuous in shallow grooves. After an uninterrupted course of 5 feet from one end of this series of impressions, the middle groove, after bending slightly to the right, terminates in a point, the impressing part appearing there to have been raised obliquely above the sand; but the impression recommences to the left and a little behind this point and somewhat more obtusely, and, again becoming shallower, it seems to have been partially reimpressed to the right of this, and then to have continued uninterruptedly, a little varied in its depth, for some feet further.

None of the impressions in this extent of tracks are sharply defined, the borders both of the grooves and pits being much rounded off, as if they had been partially effaced, either as having been made under water, or by water having passed over them soon after they were made. They give the idea of the animal having been partly supported by water whilst making them, so as to have occasionally dragged its lateral appendages along, and thereby to have made a continuous groove with faint impressions, interrupted where the feet have been applied to the sand in the usual successive way.

The breadth between the outer margins of the outermost tracks is 5 inches 6 lines; between the inner border of the innermost tracks 3 inches 10 lines; the breadth of the median track is 10 lines. For a short distance there is a shallow longitudinal depression on the left border of the median track, and here and there are faint indications of small impressions inside of the innermost of the lateral tracks. The name indicative of this series of tracks is one of convenience only, and is not to be regarded as the sign of a species recognized as actually distinct from the differently-marked and better-defined impressions of the same size and breadth.

6. *Protichnites alternans.* Pl. XIV. ($\frac{1}{2}$ nat. size), and Pl. VIII. A. 7.

In a series of impressions in which the middle groove is represented by a succession of interrupted shallow longitudinal channels, with unimpressed or slightly marked intervals of nearly their own extent, the lateral impressions are deep, small, and more or less of an angular character. In some parts there appears only a single impression, as at *a* on the left side, 1 *L*; an inch in advance of this there will be a pair, *b*, *b'*, placed rather obliquely, the innermost much larger than the outer one. One inch and a half in advance of this is a third more widely parted pair, *c*, *c'*, also placed obliquely, the inner impression being smaller than the outer one. Then at the same distance follows a triplet, *d*, *d'*, *d''*, or a pair, *d*, *d'*, of nearly equal size, and on the same transverse line, but wider apart than the rest. About 2 inches in advance of this is a pair, *e*, *e*, which are nearer together, and then comes either a very large single impression or one composed of a confluent pair, *f*. The outer impressions of the series describe a curve, with the convexity turned outwards, but the opposite impressions of the series are not symmetrical; for where the impressions are widest apart on the left side, those of the right, as in 1 *R*, are nearest together, or, being confluent, appear single; and where the right pair of impressions are widest apart, those of the left side are nearest together. The innermost impressions of both lateral series preserve best their regular distance from the middle tracks. The outer impressions differ most in this respect, and consequently describe an undulating line, but so that when the convexity is turned from the middle line on the left side it is turned to the middle line on the right, and *vice versâ*. Some of the innermost impressions are elongated transversely and become gradually shallow outwards, as if the foot impressing them had been moved from within outwards.

These impressions indicate a waddling gait, or an alternate oblique movement from side to side of the animal, with an alternate raising and depressing of the part of the animal which has left the middle impression. Here and there groups of three impressions are interposed between the impressions in pairs. The shape of the impressions indicates them to have been made by hard, pointed, subangular extremities.

The average breadth of the track from the outermost side of the outer impressions is 5 inches. From the median track to the outermost of the outer impressions is 3 inches, and to the innermost of the same pair of impressions 1 inch 3 lines. The longitudinal extent of one of the curves which includes five sets of prints is 7 inches. The interrupted impressions of the median track show a slight deviation from the straight line.

The modifications presented by this series of impressions equally militate against their having been left by a vertebrate animal, but differ so much from those already described as to clearly indicate a distinct genus of many-limbed animal.

There are four series of impressions on a great extent of ripple-marked sandstones, in one of which the median track has cut through the ripple-marks along an undulating curved line of nearly equal and considerable depth, not showing the alternate rise and fall which is seen in so many of the other sets of impressions. The margins of this median track are rounded off, and it is more rounded at the bottom. The lateral tracks are large, shallow, and faint, as if they had been partially obliterated by the action of water; yet the prints can be still distinctly traced, indicating a total and regular breadth of 6 inches across the whole of the impressions.

Along another extent of ripple-marked slab, a narrower median impression cuts through the ripple-risings for an extent of 7 feet in nearly a straight line. Here also the lateral impressions are faintly indicated, their borders being rounded off and as it were expanded, showing a total breadth of 5 inches, across the tracks. As the sand appears to have been of a dense siliceous character, the ripple-marks could have only been ploughed through to the depth shown by these impressions, by a pretty considerable momentum, either of velocity or of weight, occasioned by the moving animal.

Along a third extent of ripple-marked surface the median impressing part of the moving body has left only a narrow and shallow impression upon the summits of the successive sand-waves, the direction of the animal being shown by that in which the sand had been pushed into the intervening valleys of the ripples.

With these varied and well-marked evidences of the number, form, grouping, and arrangement of the foot-prints impressed upon the Potsdam sandstone, in the more clearly impressed specimens, now submitted, both in the original sandstones and in good plaster-casts, to our inspection, we may readily discern a general correspondence with them, of those comparatively more confused and obscurely marked impressions (Pl. XIV. A.), the casts of which were first brought over by Mr. Logan during the preceding year. The foot-print occasionally occurring on the inner side of the pairs of prints, may now be recognized as answering to that marked *c* in Pl. X., which forms the innermost impression of the regularly recurring group of 3, viz. *c*, *c′*, *c″*. It is not, as I at first supposed, the result of the fore-leg being applied to the ground a second time, on the inner side of the first step, during a temporary stop in the animal's progress.

The recognition of the real nature of this superadded print also leads to the recognition of the succession of the prints in progressive series of three groups, two of which seem to consist of a pair of prints, as in the *Protichnites 7-notatus**. That peculiarity could not, I believe, have been recognized, or satisfactorily confided in, without the aid and light of the analogies furnished by the more numerous and extensive, clearer and better-marked, impressions which have now been submitted to us by their zealous and indefatigable discoverer and collector. I need scarcely say, therefore, that although the foot-prints of a Tortoise are those to which the original series of the Potsdam sandstone impressions bore the closest resemblance, I have now the conviction that they were not made by a Chelonian reptile, nor by any vertebrated animal.

The impressions selected for Plates IX. and X. clearly demonstrate that the animal, progressing in an undulating course, made at each action of its locomotive members, answering to the single step of the biped, and the double step of the quadruped, not fewer than, in *Protichnites 7-notatus*, fourteen impressions, seven on the right and seven on the left; and in *Protichnites 8-notatus* sixteen impressions, eight on the right and eight on the left; these seven and eight impressions respectively being arranged in three groups; viz. in *Protichnites 7-notatus*, 3, 2, and 2; in *Protichnites 8-notatus*, 3, 2, and 3; the groups being reimpressed, in successive series, so similarly and so regularly as to admit of no doubt that they were made by repeated applications of the same impressing instruments, capable of being moved so far in advance, as to clear the previous impressions and make a series of new ones at the same distance from them, as the sets of impressions in the series are from each other. What then was the nature of these instruments? To this three replies may be given, or hypotheses suggested:—they were made, either, 1st, as in the case of quadrupedal impressions, each by its own limb, which would give seven and eight pairs of limbs to the two species respectively; or, 2ndly, certain pairs of the limbs were bifurcate, as in some insects and crustaceans, another pair or other pairs being trifurcate at their extremities; and each group of impressions was made by a single so-subdivided limb, in which case we have evidence of a remarkably broad and short hexapod creature; or, 3rdly, three pairs of limbs were bifurcate, and the supplementary pits were made by small superadded limbs, as in some crustaceans; or, 4thly, a single broad fin-like member, divided at its impressing border into seven or into eight obtuse points, so arranged as to leave the definite pattern described, must have made the series of three groups, by successive applications to the sand.

The latter hypothesis appears to me to be the least probable; first, as being most remote from any known analogy, and secondly, because there are occasional varieties in the groups of foot-prints which would hardly accord with impressions left by one definitely subdivided instrument or member. Thus in the group of impressions marked 1 *L*,

* This will be seen, on a comparison of the original and entire series of foot-prints, more satisfactorily than in the small portion figured in Plate XIV. A.

in Pl. IX., the outer impression, c', is single, but in the preceding set it is divided: whilst the impressions a, a', are confluent in that set, and are separate in 1 *L*. The same variety occurs in the outer pair, c', c'', in *Protichnites* 8-*notatus*.

Yet, with respect to the hypothesis that each impression was made by its own independent limb, I confess to much difficulty in conceiving how seven or eight pairs of jointed limbs could be aggregated in so short a space of the sides of one animal. So that I incline to adopt as the most probable hypothesis, that the creatures which have left these tracks and impressions on the most ancient of known sea-shores belonged to an articulate and probably crustaceous genus, either with three pairs of limbs employed in locomotion, and severally divided to accord with the number of prints in each of the three groups, or bifurcated merely, the supplementary and usually smaller impressions being made by a small and simple fourth, or fourth and fifth pair of extremities.

The *Limulus*, which has the small anterior pair of limbs near the middle line, and the next four lateral pairs of limbs, bifurcate at the free extremity, the last pair of lateral limbs with four lamelliform appendages, and a long and slender hard tail, comes the nearest to my idea of the kind of animal which has left the impressions on the Potsdam sandstone*.

The shape of the pits, so clearly shown in the ice-rubbed slabs, impressed by *Protichnites* 8-*notatus*, accords best with the hard, sub-obtuse, and subangular terminations of a crustaceous ambulatory limb, such as may be seen in the blunted legs of a large *Palinurus* or *Birgus*; and it is evident that the animal of the Potsdam sandstone moved directly forwards after the manner of the *Macrura* and *Xiphosura*, and not sideways, like the Brachyurous Crustaceans.

The appearances in the slab impressed by the *Protichnites multinotatus* favour the view of the median track having been formed by a caudal appendage, rather than by a prominent part of the under surface of the trunk.

What further conjectures the contemplation and comparison of the several series of foot-prints from the Potsdam sandstone have originated in my mind, I do not deem it very helpful to their full understanding at present to record.

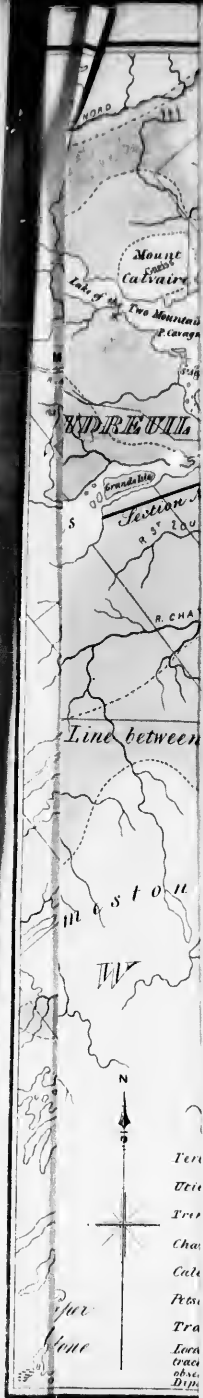
The imagination is baffled in the attempt to realize the extent of time past since the period when the creatures were in being that moved upon the sandy shores of that most ancient Silurian sea; and we know that, with the exception of the microscopic forms of life, all the actual species of animals came into being at a period geologically very recent in comparison with the Silurian epoch.

The deviations from the living exemplars of animal types usually become greater as we descend into the depths of time past; of this the Plesiosaur and Ichthyosaur are instances in the reptilian class, and the *Pterichthys*, *Coccosteus*, and *Cephalaspis* in that of fishes. If the Vertebrate type has undergone such inconceivable modifications

* [This paragraph was added whilst the paper was being prepared for the press. May 13, 1852.—R.O.]

during the Secondary and Devonian periods, what may not have been the modifications of the Articulate type during a period probably more remote from the Secondary period than this is from the present time! In all probability no living form of animal bears such a resemblance to that which the Potsdam foot-prints indicate, as to afford an exact illustration of the shape and number of the instruments and of the mode of locomotion of the Silurian *Protichnites*.

These most precious evidences of animal life, locomotive on land, of the oldest known sedimentary and unmetamorphosed deposits on this planet, have been, I am well aware, far too inadequately described in the paper which I have had the honour to submit to the Society. They offer characters which require more time for their due scrutiny and greater acumen and powers of interpretation than have hitherto been bestowed upon them. The symbols themselves are distinct enough. Old Nature speaks as plainly as she can do by them; and if we do not fully thereby read her meaning, the fault is in our powers of interpretation. In the present attempt I can, however, truly aver, that I have bestowed upon it all the leisure at my command, and have applied my best abilities in the endeavour to fulfil my obligations to their discoverer, and to satisfy the generally expressed wishes of the Society.


NORD
Mount
Calvaire
Lake of the Two Mountai
P. Cavagn
UDREUIL
Grande Isle
Section N
R. St. LOU
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Line between
meston
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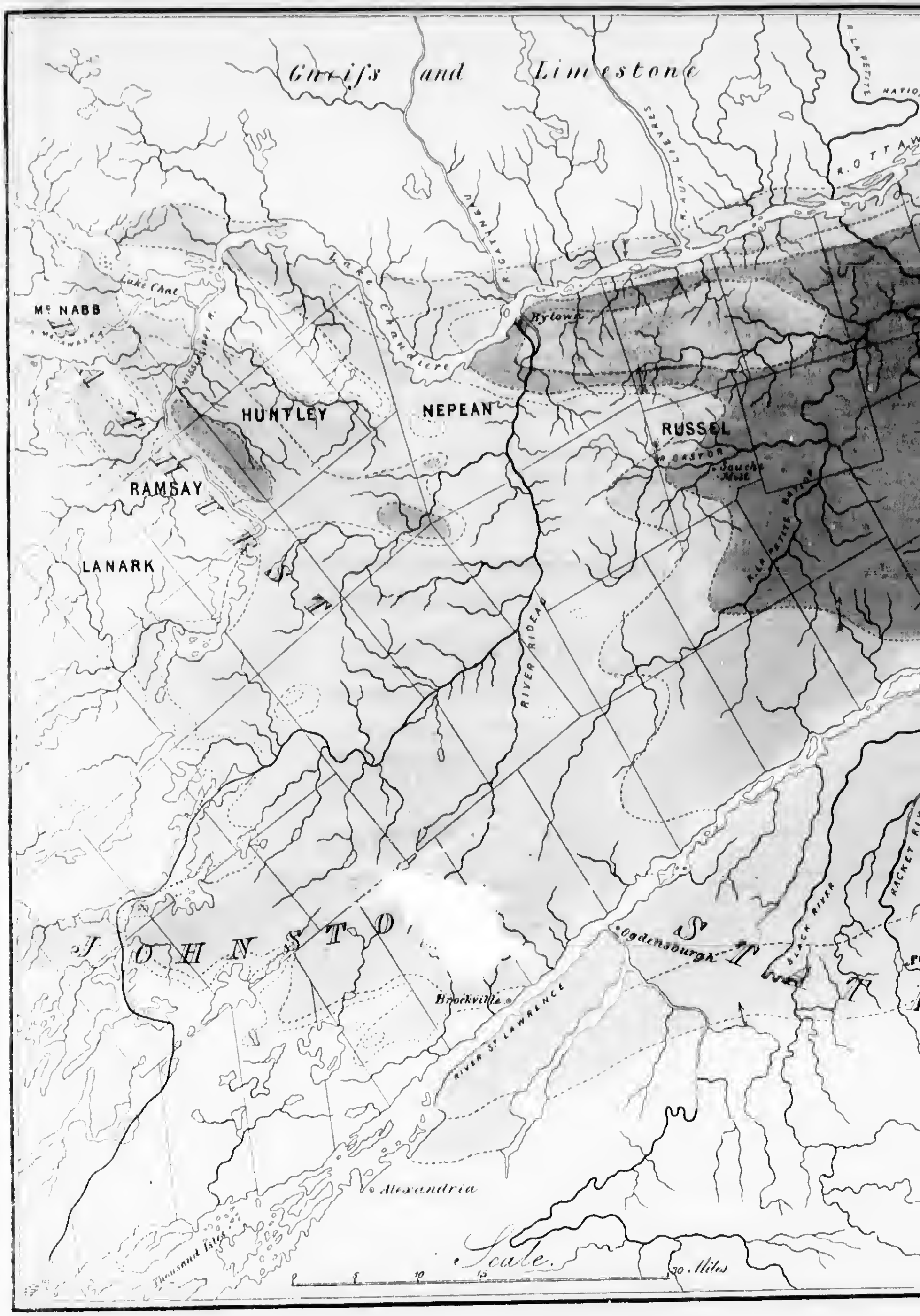
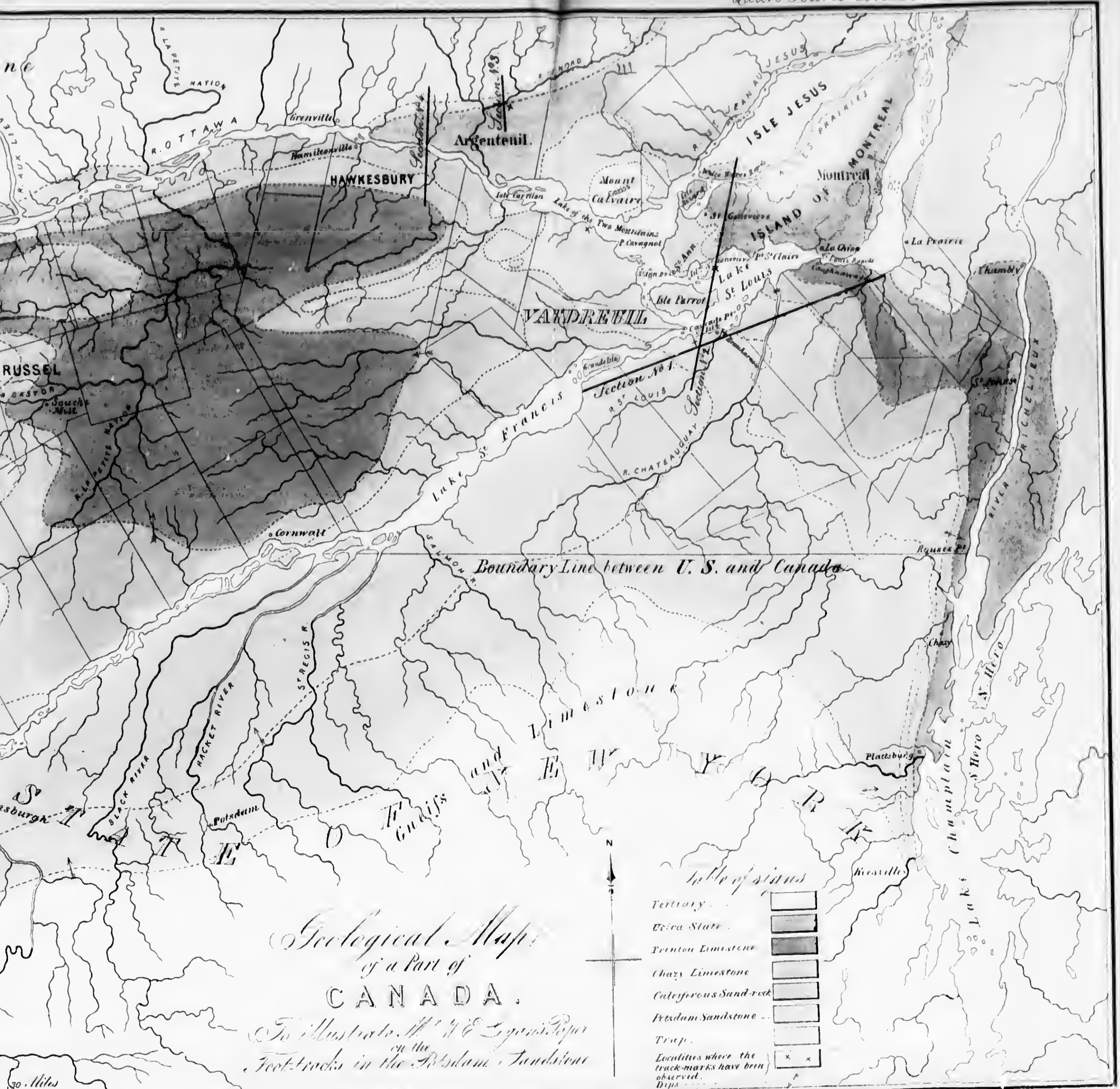
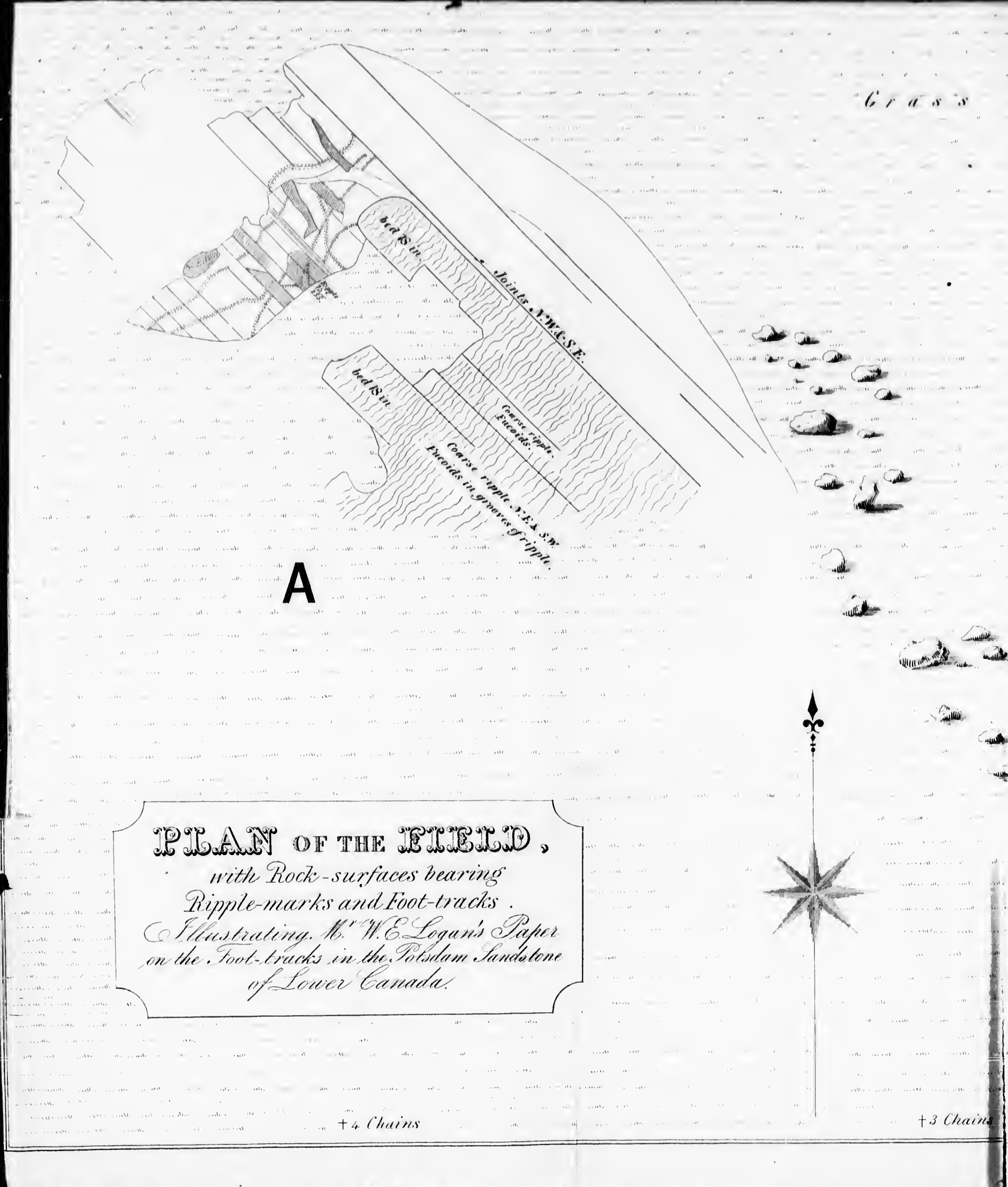
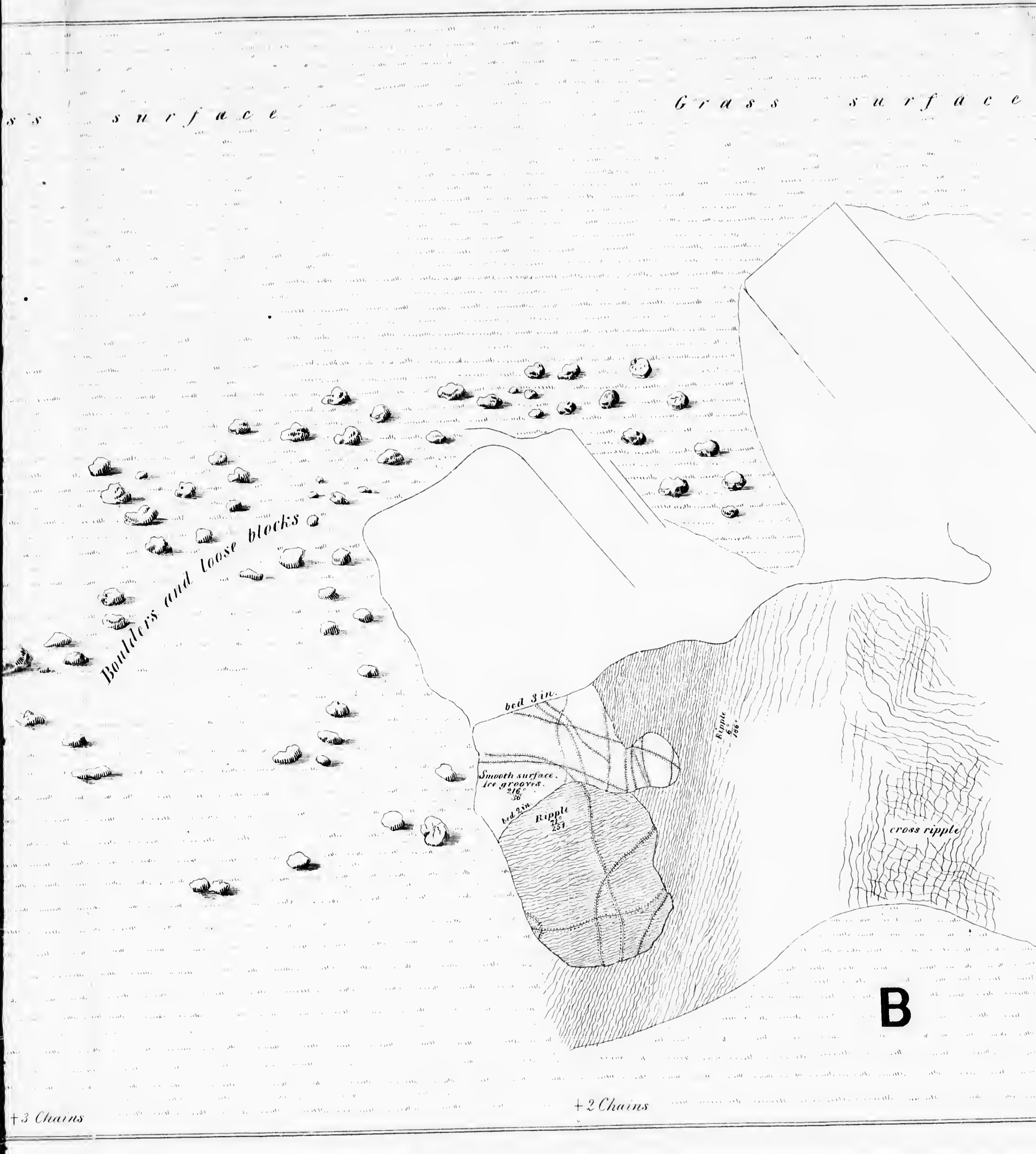

Gneiss and Limestone
Mc NABB
Lake Chat
HUNTLEY
NEPEAN
Bytown
RUSSEL
RAMSAY
LANARK
R. OTTAWA
RIVER RIDEAU
Lake Chaudiere
R. AUX LIEVRES
R. GATINEAU
JOHNSTO
Ogdensburgh
Brockville
RIVER St LAWRENCE
BLACK RIVER
RACKET RIVER
Alexandria
Thousand Isles
Scale.
30 Miles

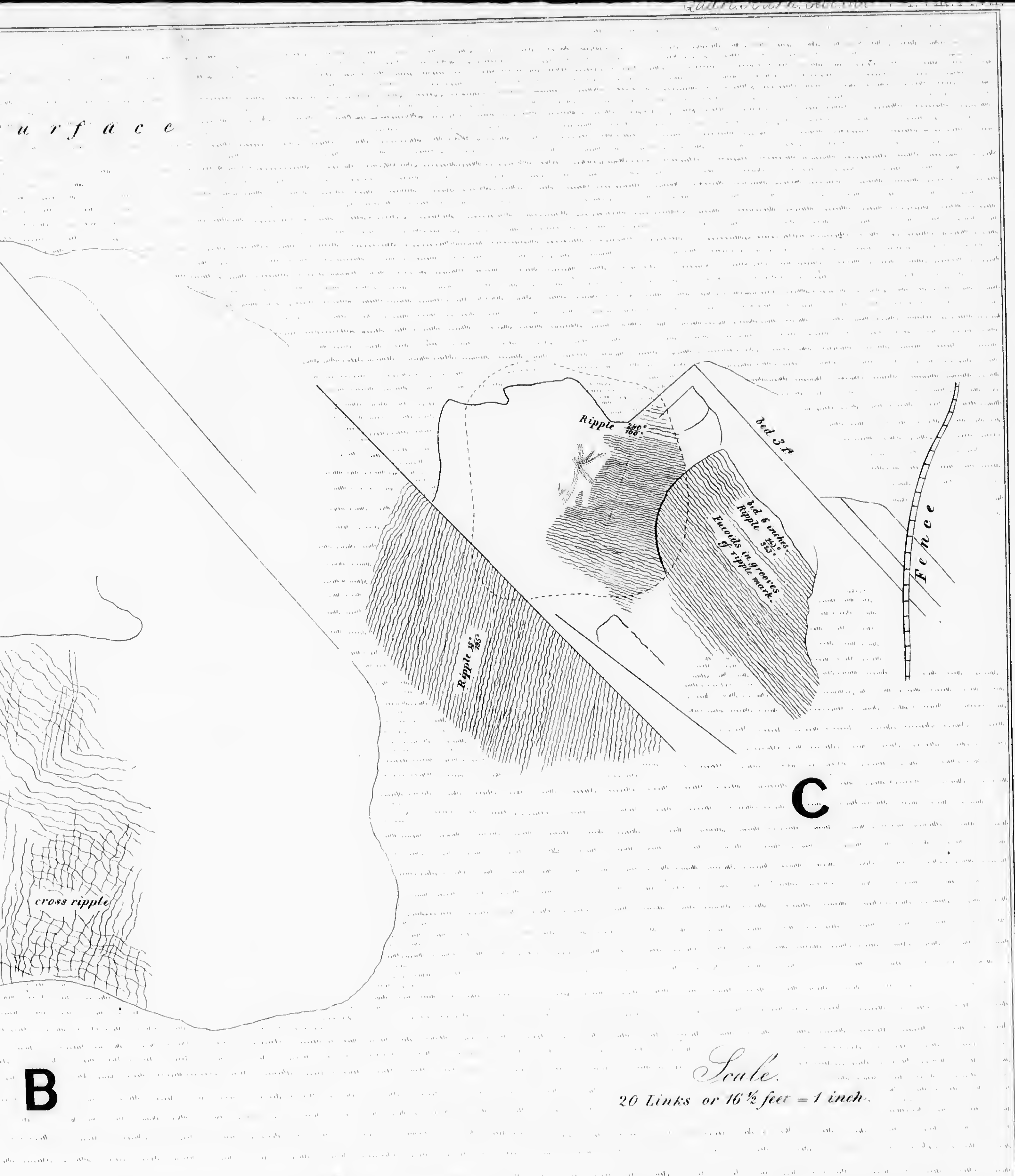

Geological Map of a Part of
CANADA.
To Illustrate Mr. W. E. Logan's Paper on the Foot-tracks in the Potsdam Sandstone
Table of signs
Tertiary
Utica Slate
Trenton Limestone
Chazy Limestone
Calciferous Sand-rock
Potsdam Sandstone
Trap
Localities where the track-marks have been observed
Dips
30 Miles
R. OTTAWA
Grenville
Argenteuil
Hamiltonville
HAWKESBURY
Section No 3
Section No 4
Mount Calvaire
Lake of the Two Mountains
ISLE JESUS
ISLAND OF MONTREAL
Montreal
La Chine
Caughnawaga
La Prairie
Chambly
Isle Perrot
Lake St Louis
VAUDREUIL
Section No 1
Section No 2
RUSSEL
Lake St Francis
Cornwall
R. CHATEAUGUAY
RIVER RICHELIEU
Rouses Pt.
Boundary Line between U. S. and Canada
SALMON R.
ST REGIS R.
RACKET RIVER
BLACK RIVER
Potsdam
Chazy
Plattsburg
Keeseville
Lake Champlain
Gneiss and Limestone
STATE OF NEW YORK


Grass
bed 18 in
Joints N.W.&S.E.
bed 18 in
Coarse ripple. Fucoids.
Coarse ripple N.E.& S.W.
Fucoids in grooves of ripple.
A
PLAN OF THE FIELD,
with Rock-surfaces bearing
Ripple-marks and Foot-tracks.
Illustrating Mr W. E. Logan's Paper
on the Foot-tracks in the Potsdam Sandstone
of Lower Canada.
+4 Chains
+3 Chains

Grass surface
Grass surf
Boulders and loose blocks
bed 3 in.
Smooth surface.
Ice grooves.
216°
36
bed 2 in
Ripple
71°
251
Ripple
6°
166°
cross ripp
B
+3 Chains
+2 Chains

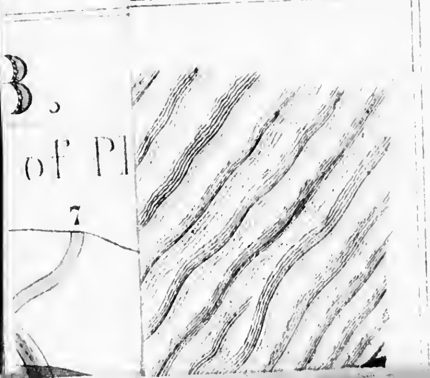


s s surface
Grass surface
Boulders and loose blocks
bed 3 in.
Smooth surface.
Ice grooves.
216°
36
bed 2 in.
Ripple
71°
251
Ripple
6°
186°
cross ripple
B
+3 Chains
+2 Chains



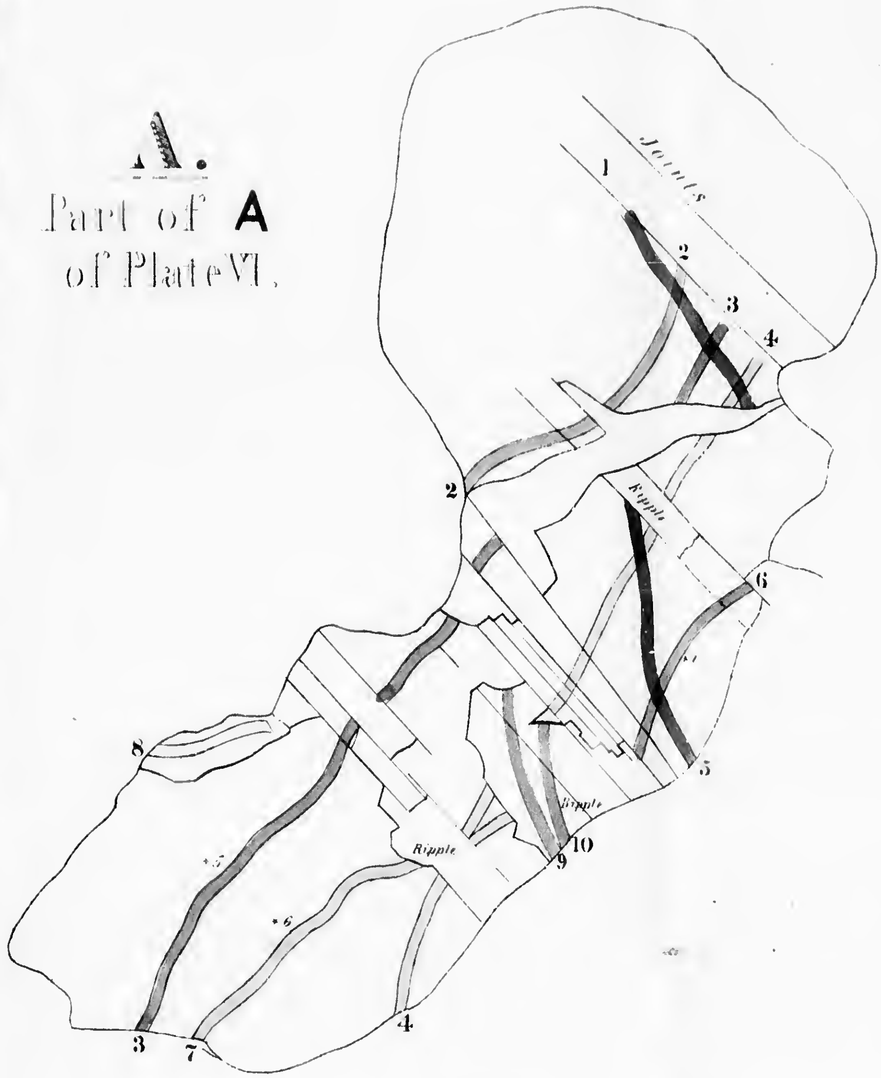
F. Reeve, lith. 414 Strand.

See Vol. VIII. Pl. VIII



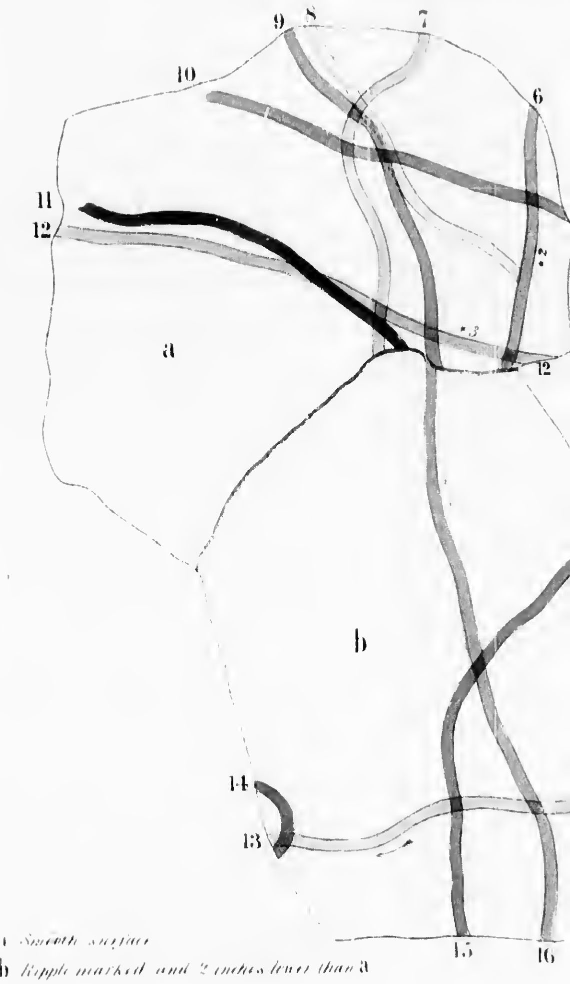
A.

Part of **A** of Plate VI.



B.

Part of **B** of Plate VI



a Smooth surface

b Ripple marked and 2 inches lower than a

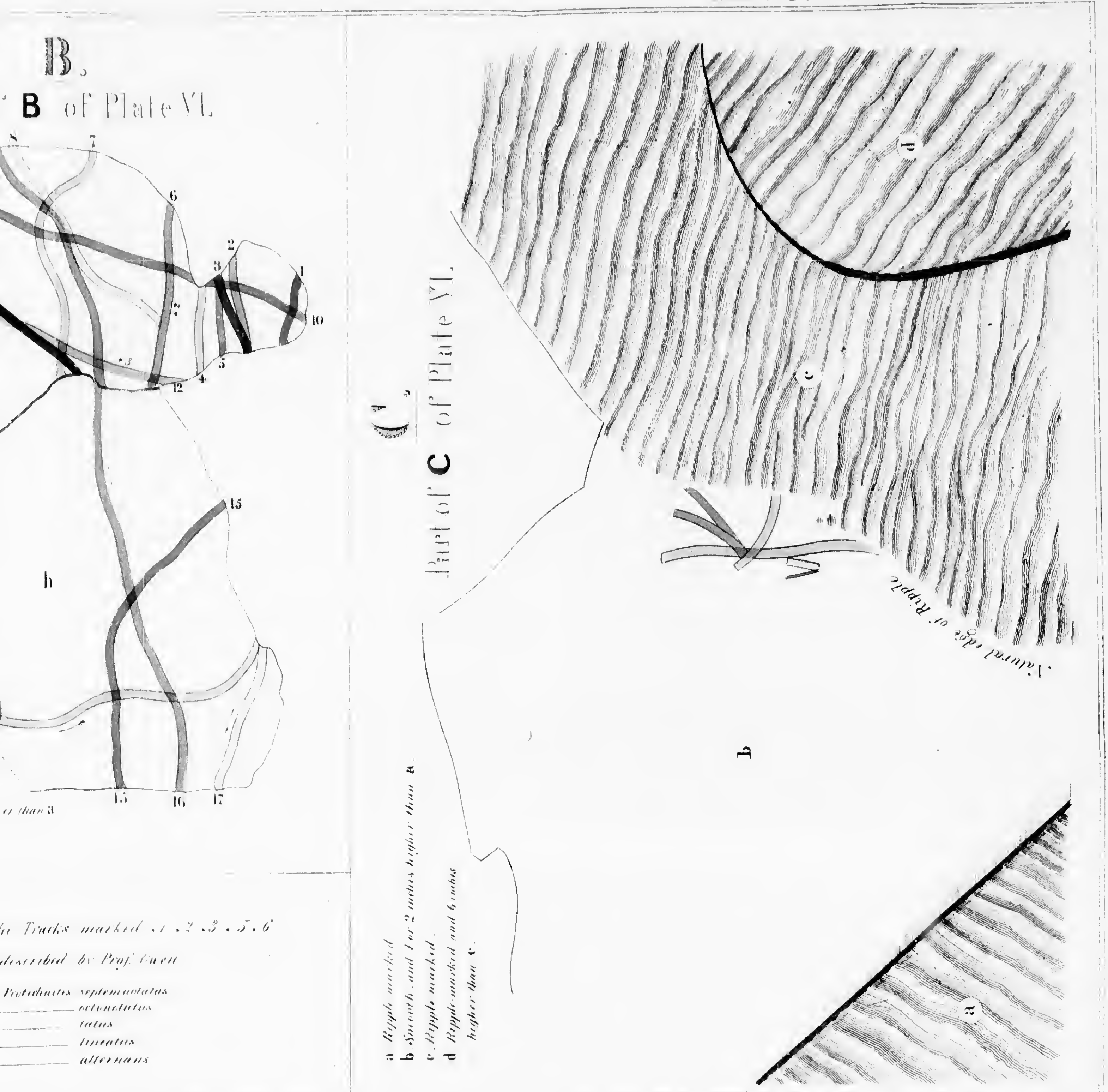
Enlarged Portions of Rock-surfaces of the Field-plan shown in Plate VI.

Illustrating M^r. W. E. Logan's Paper on the Foot tracks in the Potsdam Sandstone of Lower Canada.

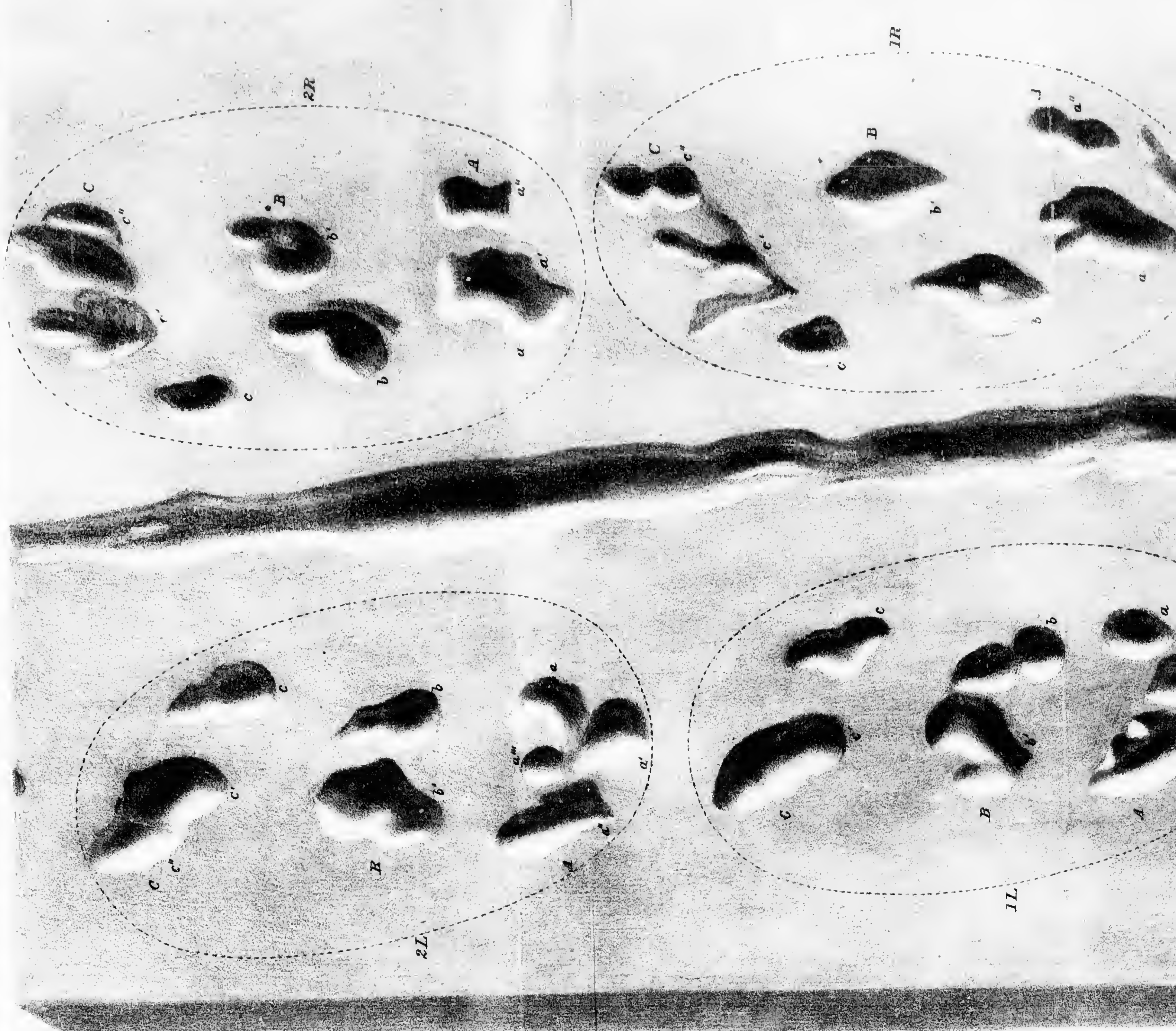
On the above Plans the Tracks marked ∗1 ∗2 are respectively those described by Prof. Owen

as

1 Protichnites septemnotatus
2 ——— octonotatus
3 ——— latus
5 ——— lineatus
6 ——— alternans


B2
B of Plate VI.
h
Tracks marked .1 .2 .3 .5 .6
described by Prof. Owen
Protichnites septemnotatus
octonotatus
latus
lineatus
alternans
C2
Part of C of Plate VI.
a Ripple marked
b Smooth, and 1 or 2 inches higher than a
c Ripple marked
d Ripple marked and 6 inches higher than c.
Natural edge of Ripple
a
b
c
d

b



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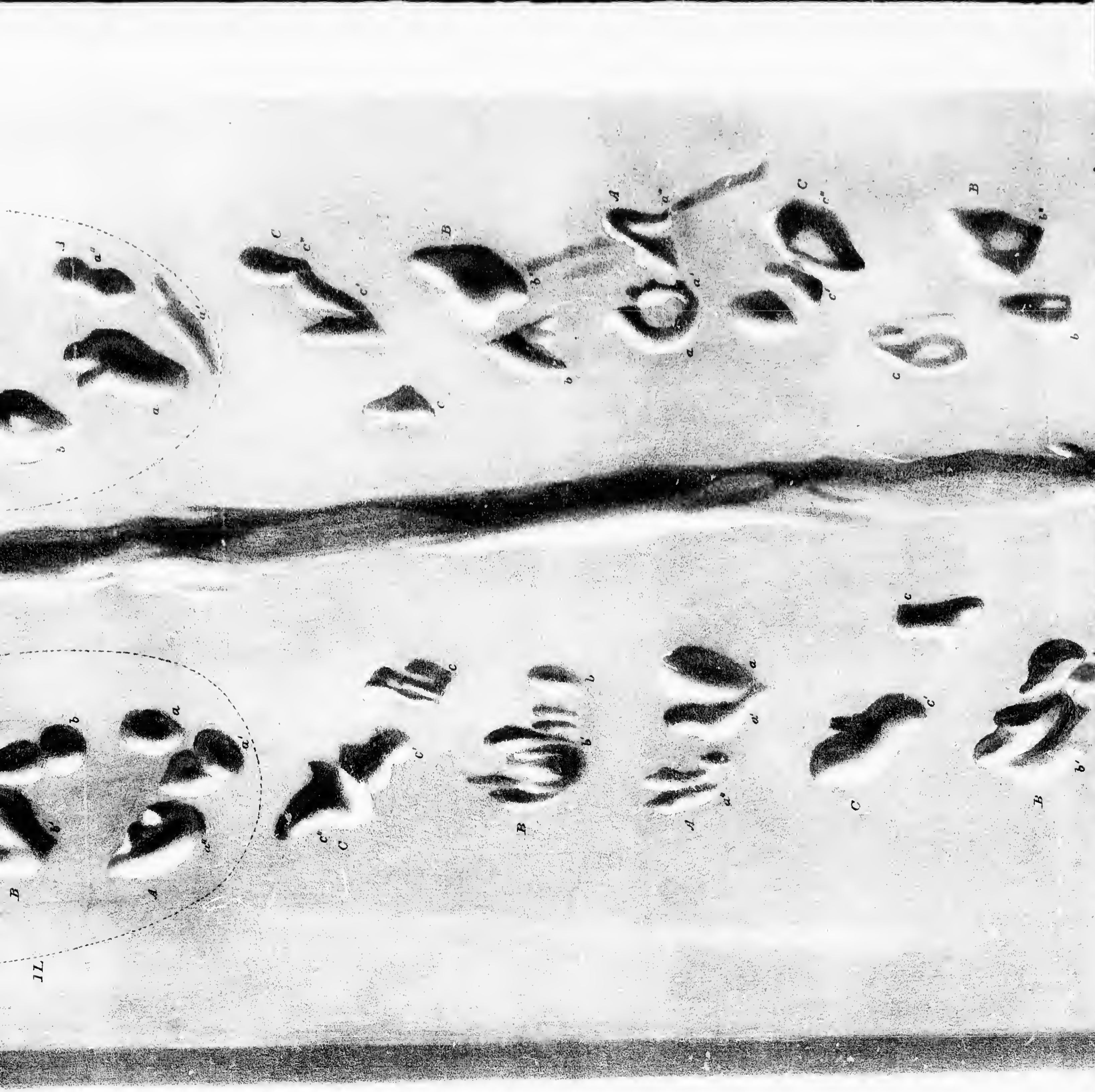
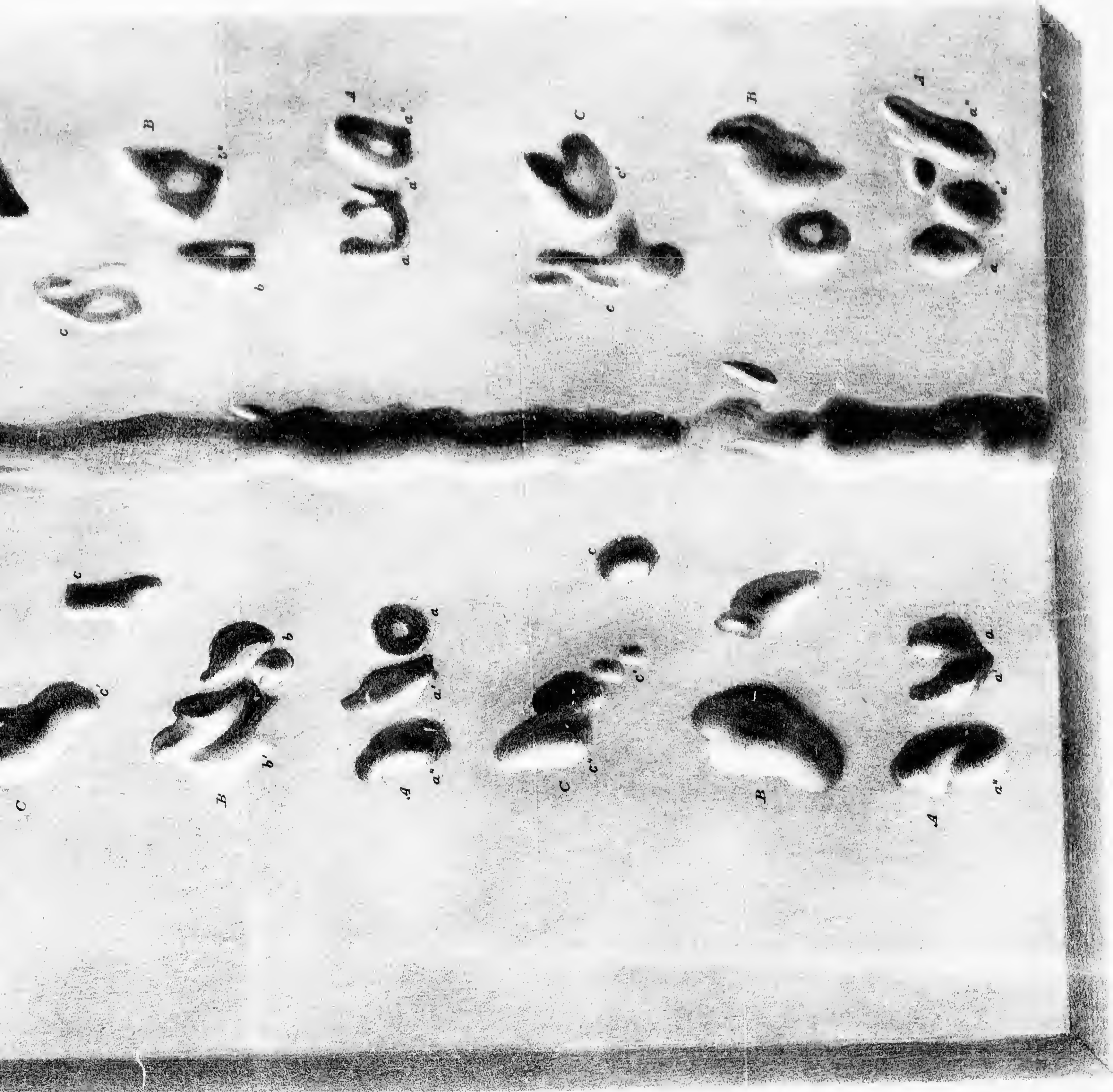


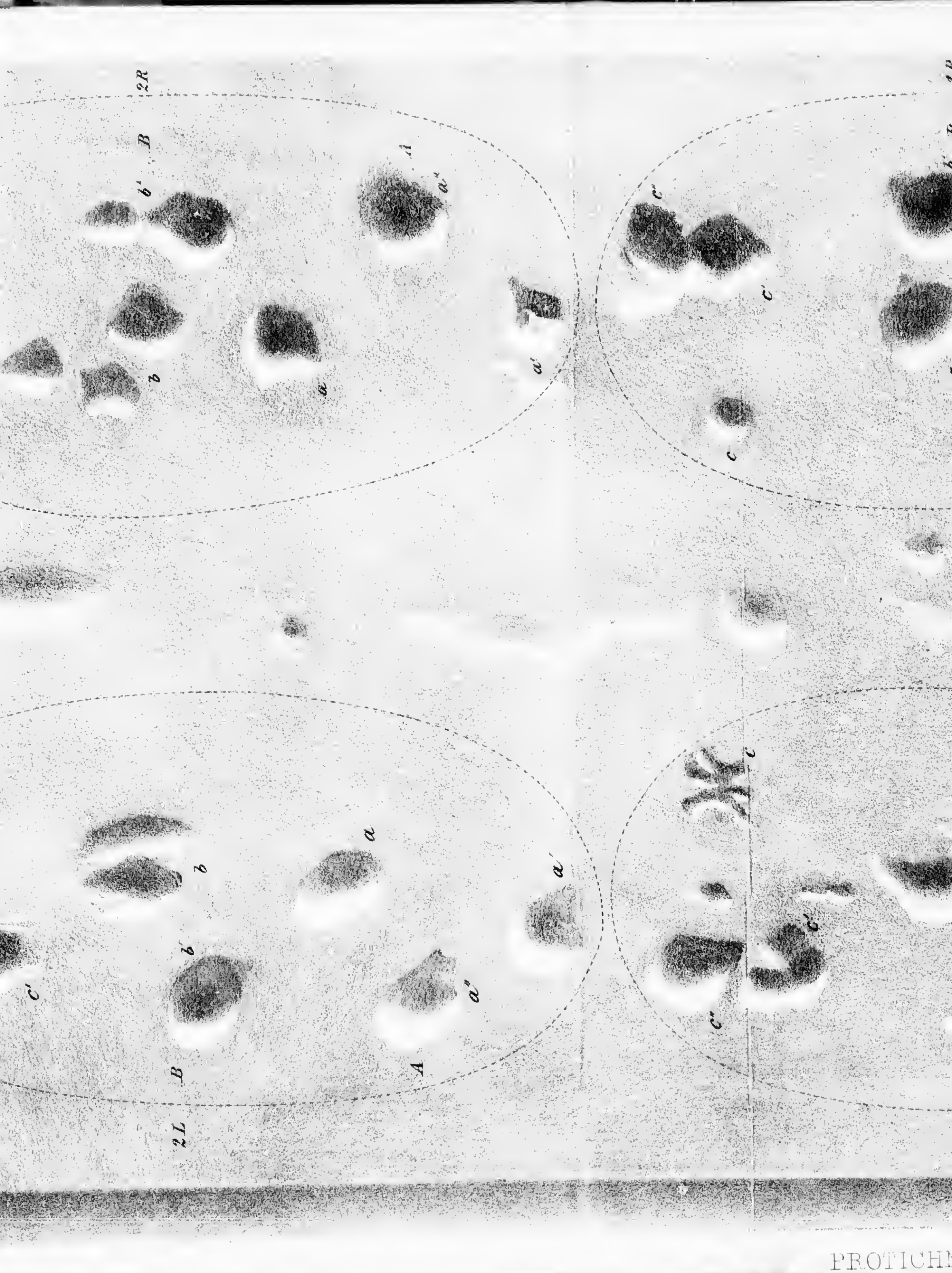
PROTICHNITES SEPTEMNOTATUS

PROTICHNITES SEPTEMNOTATUS

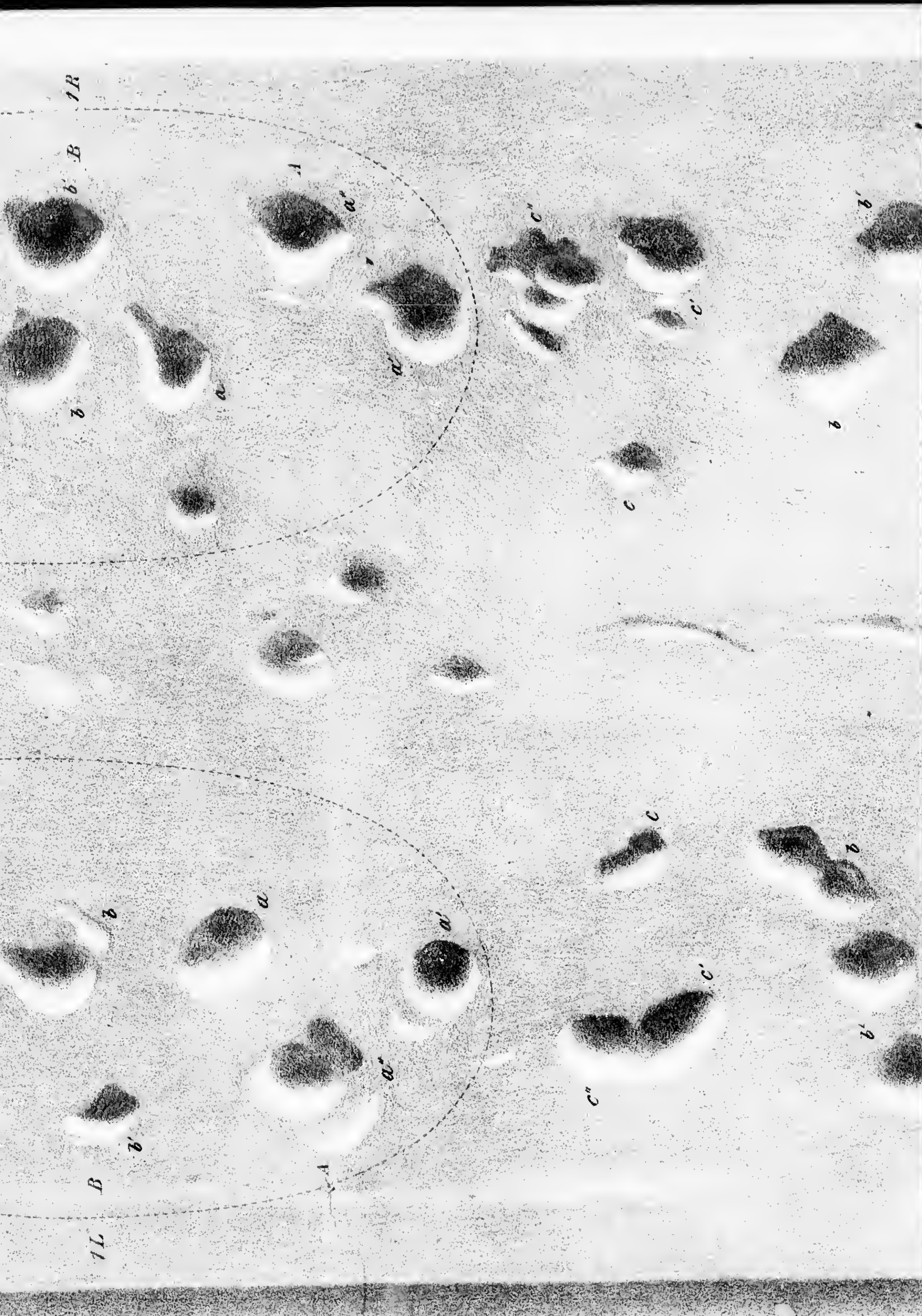


Ford & West, Imp., 54, Hatton Garden

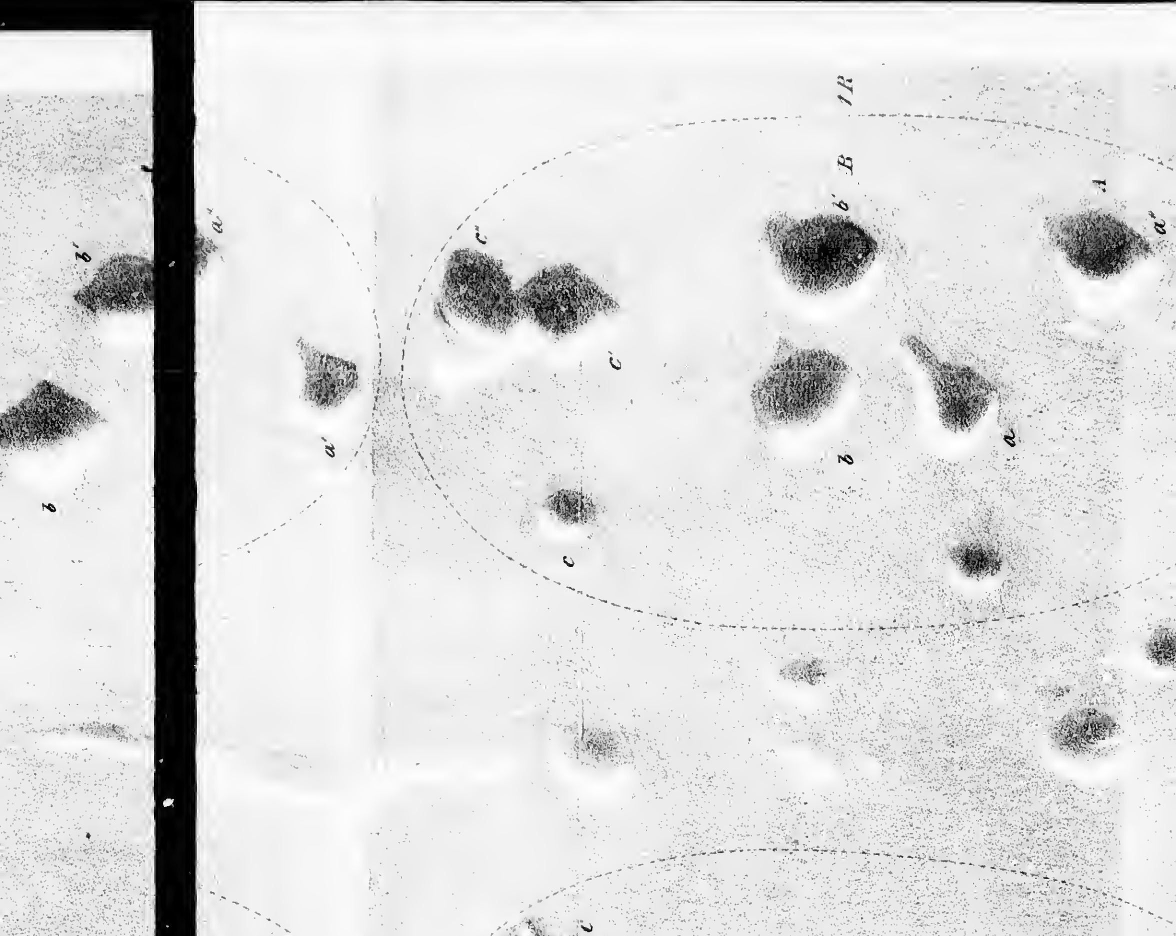
Dinkel del et lith



PROTICHN

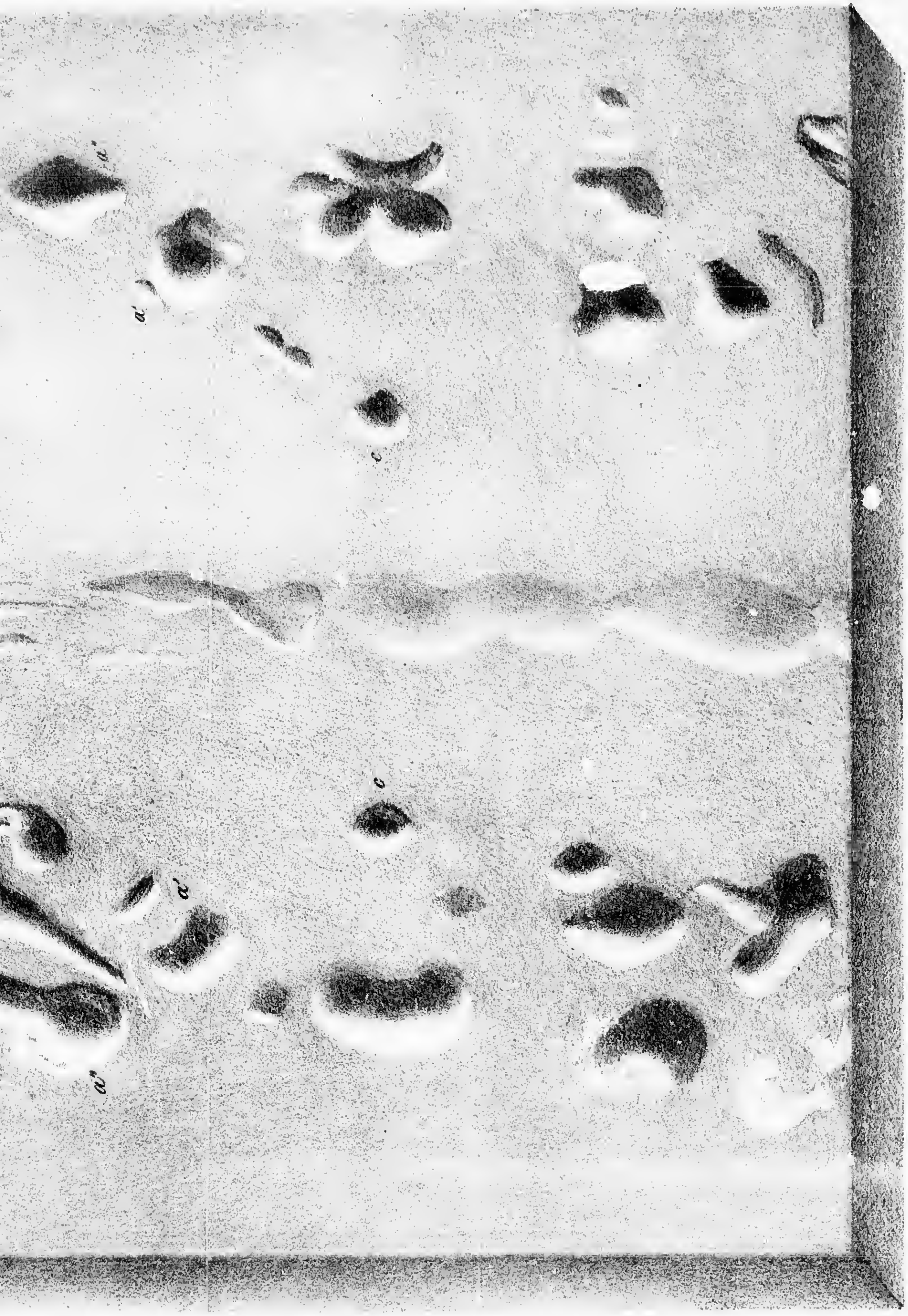


TICHNITES OCTONOTATUS.

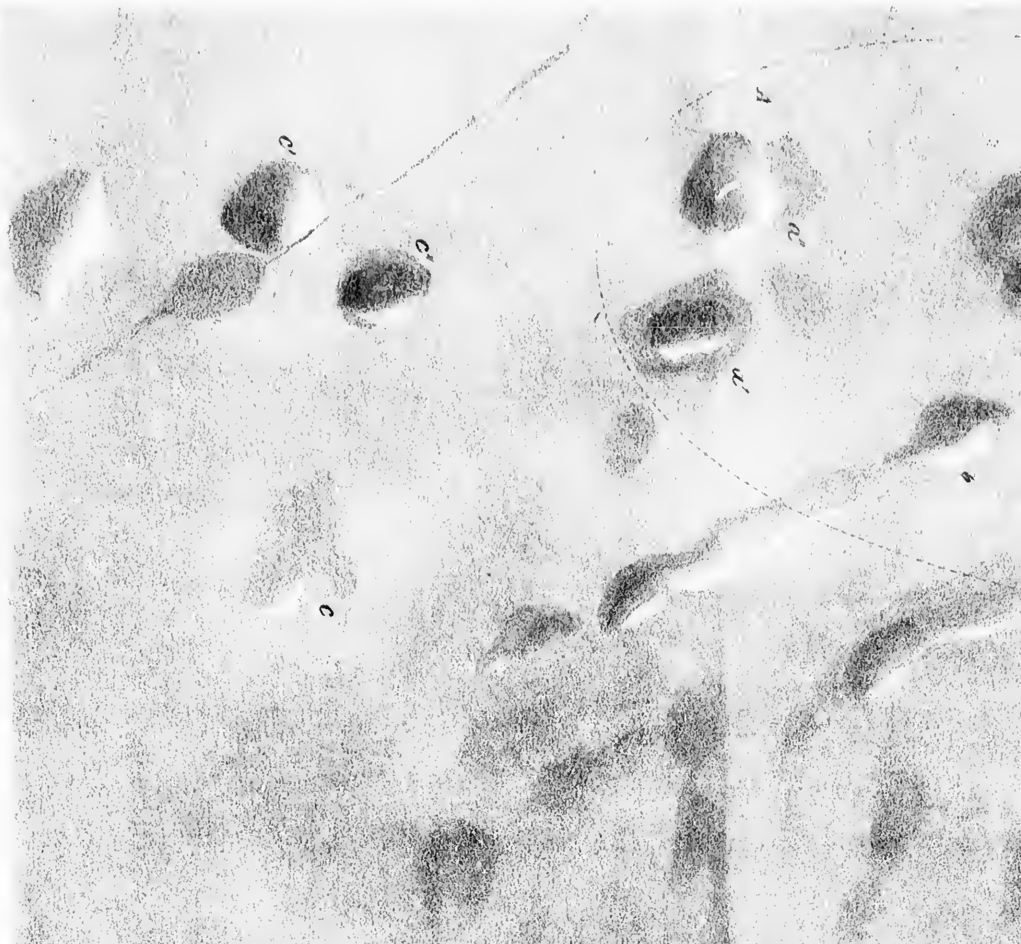


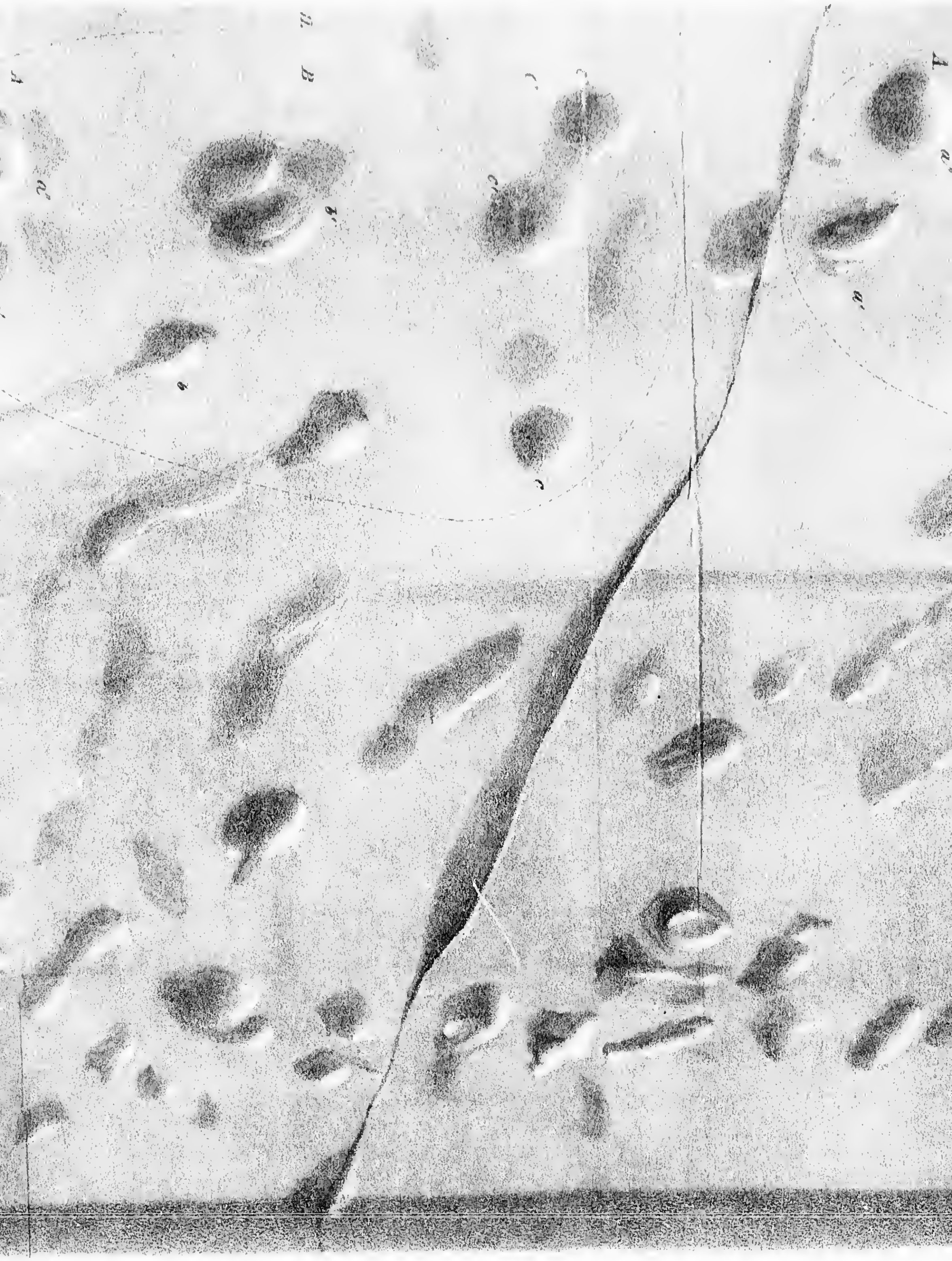
PROTICHNITES OCTONOTATUS.

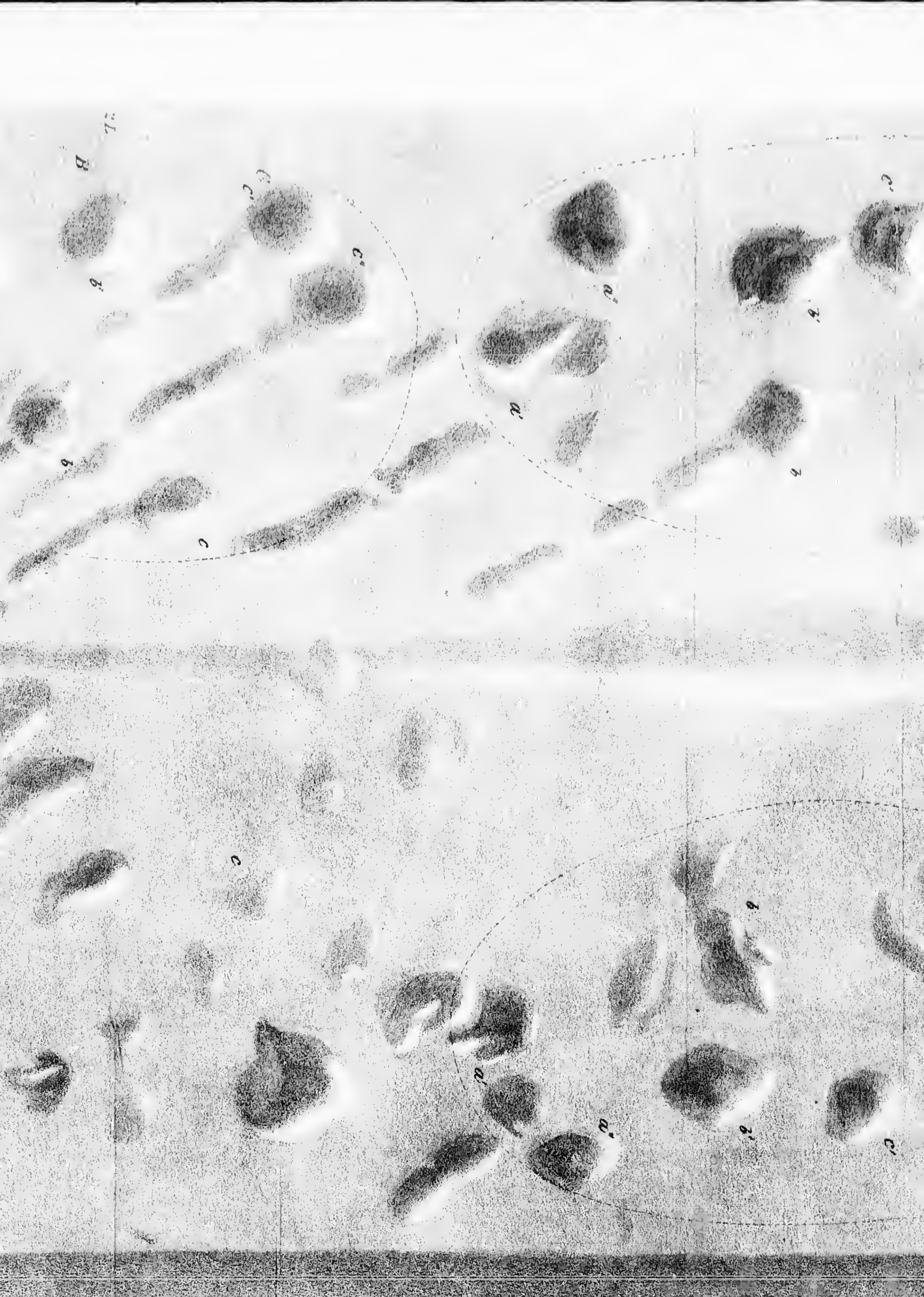
ATUS.



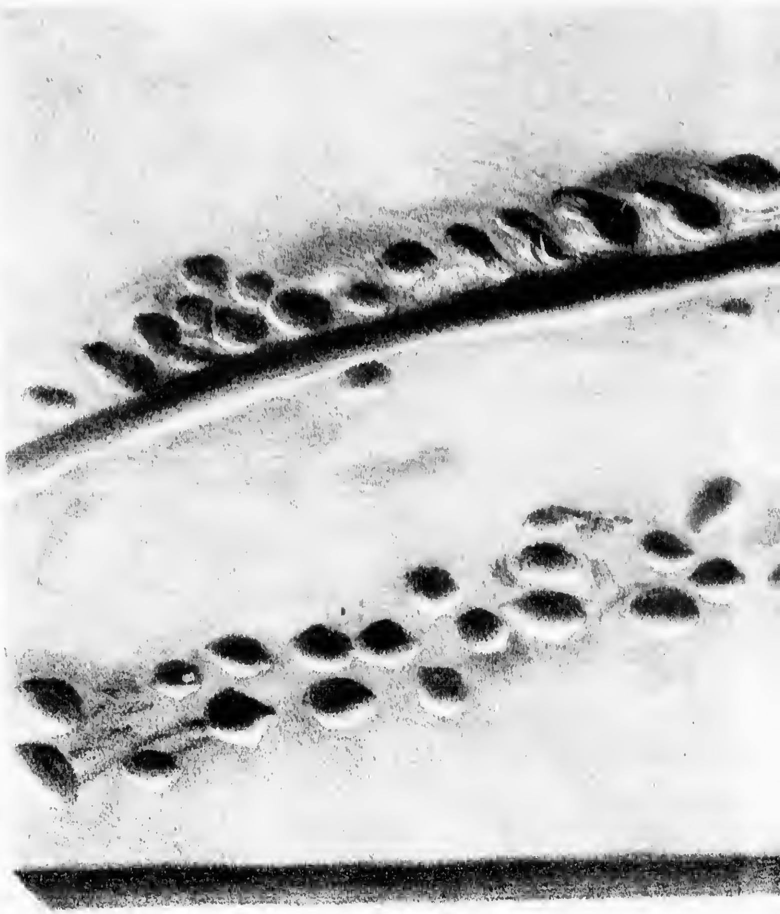
Printed by F. Reeve







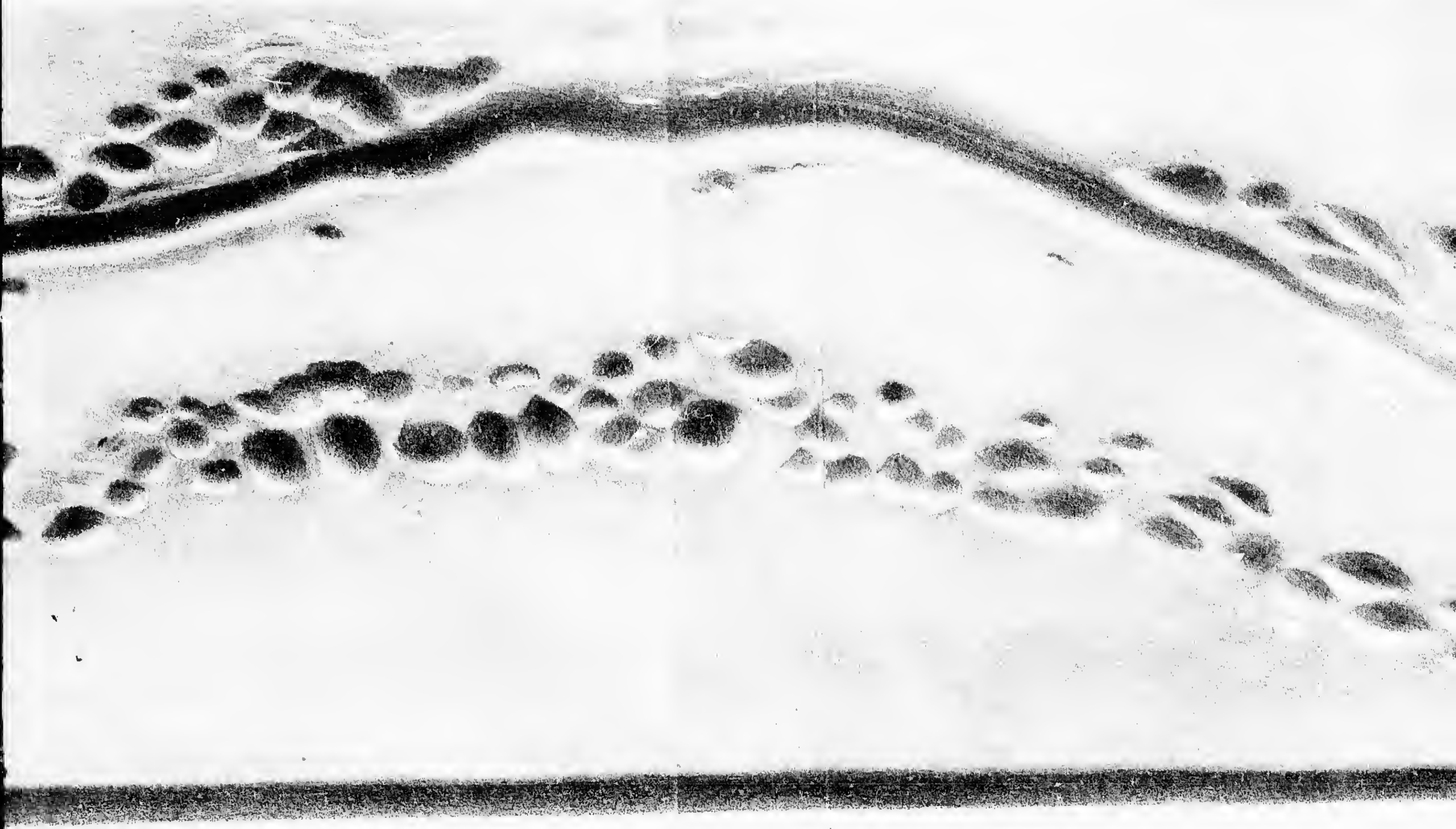
F. Bee



Jos Dinkel del et lith

PROTICHNITES MULTINOTATUS

TUS



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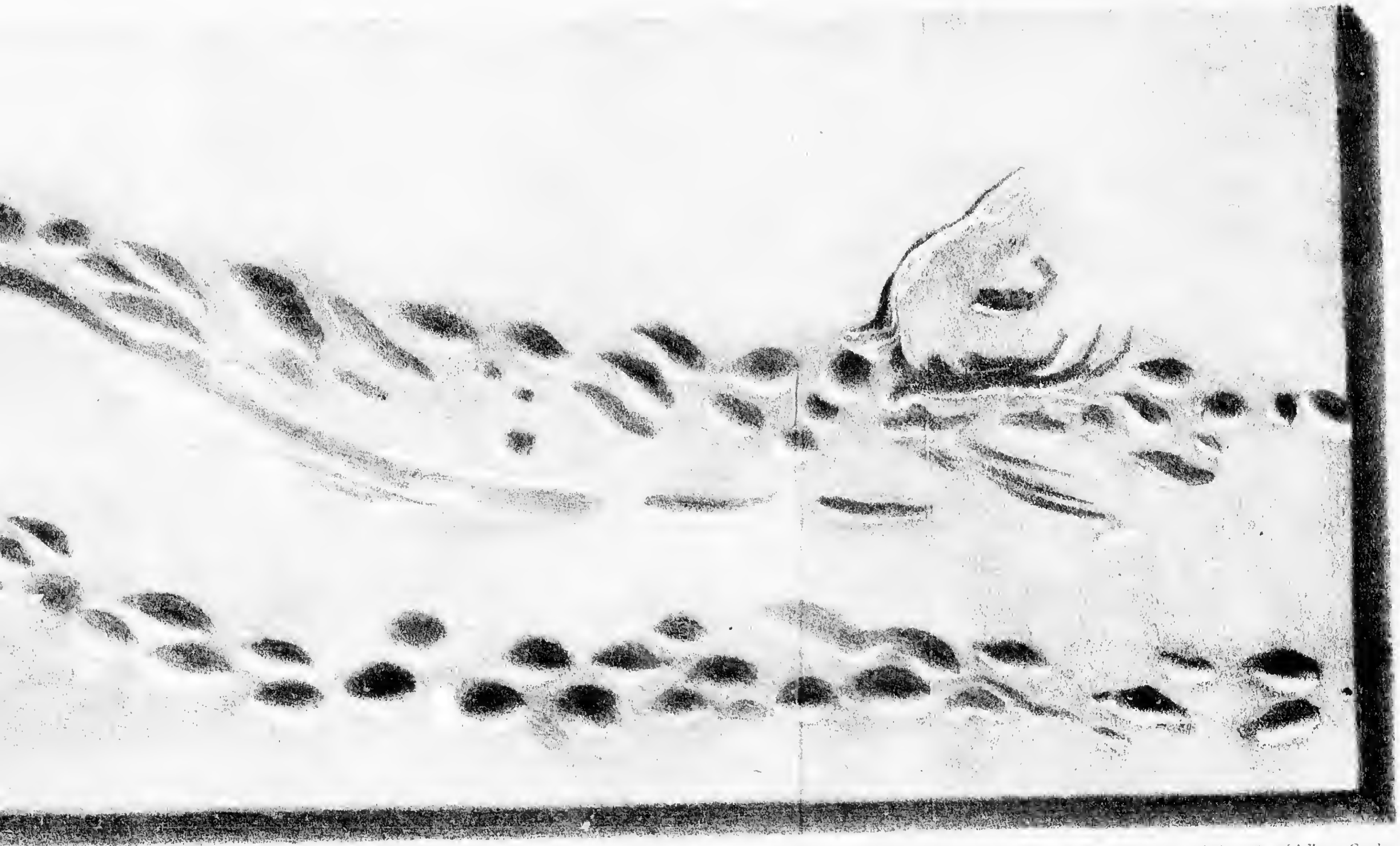

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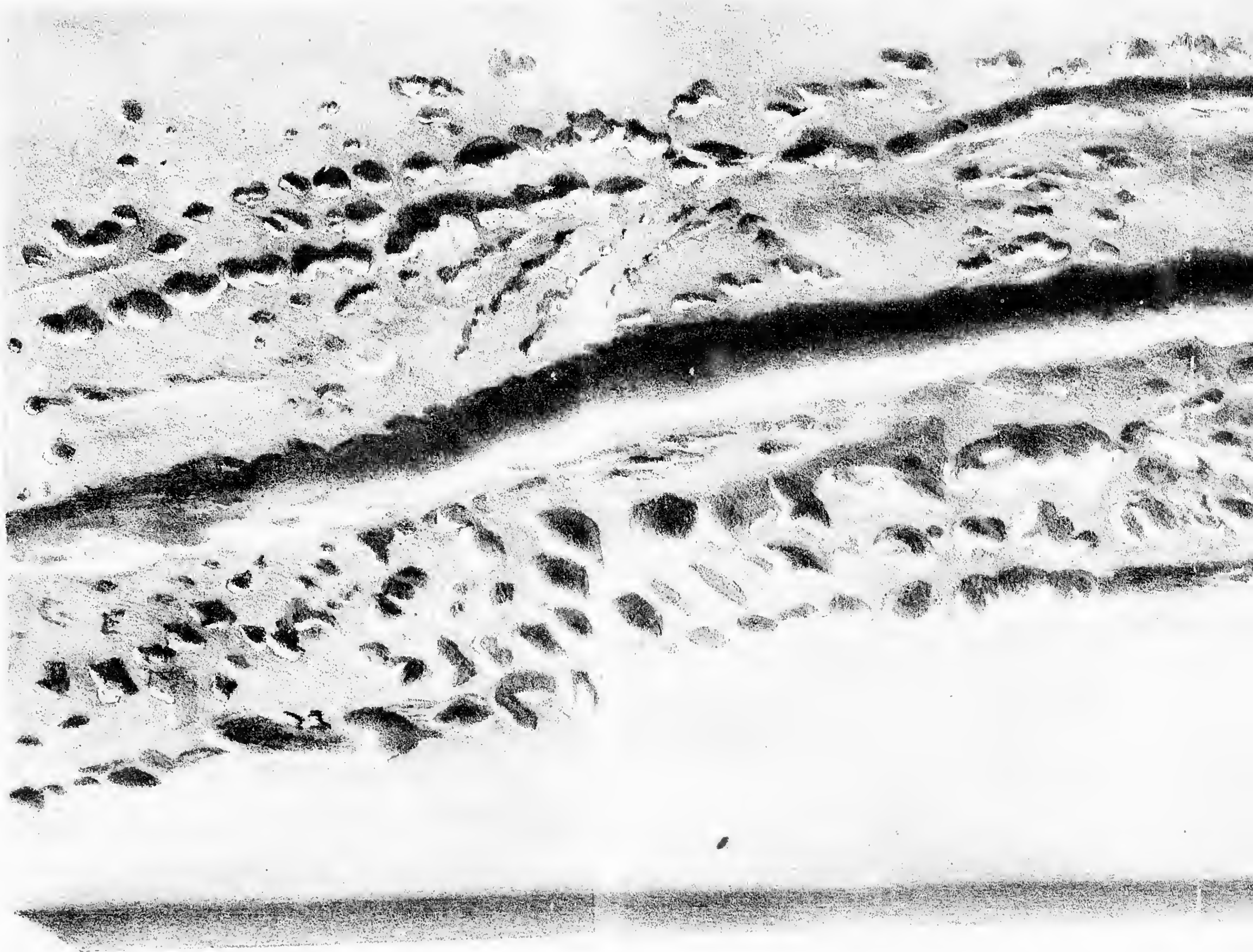

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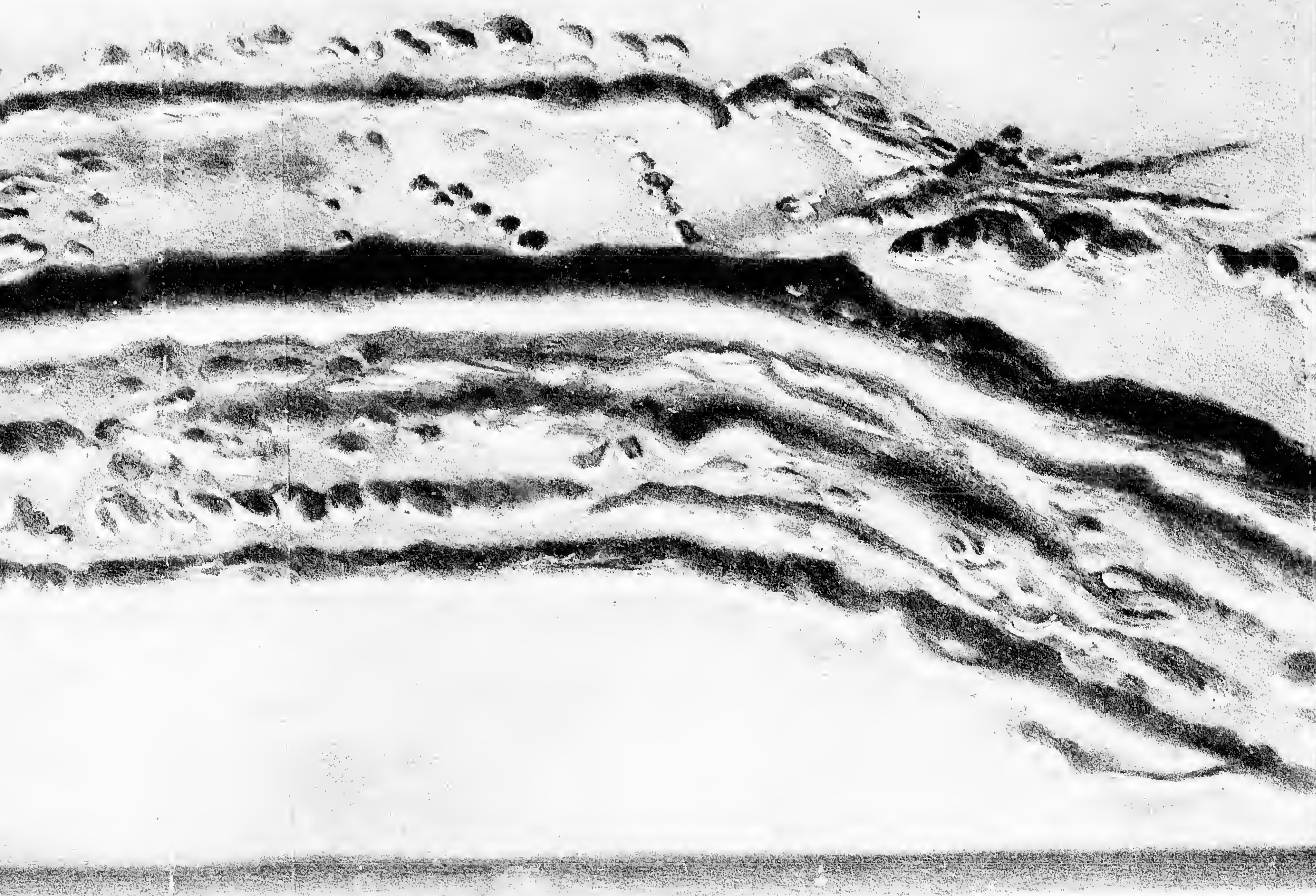

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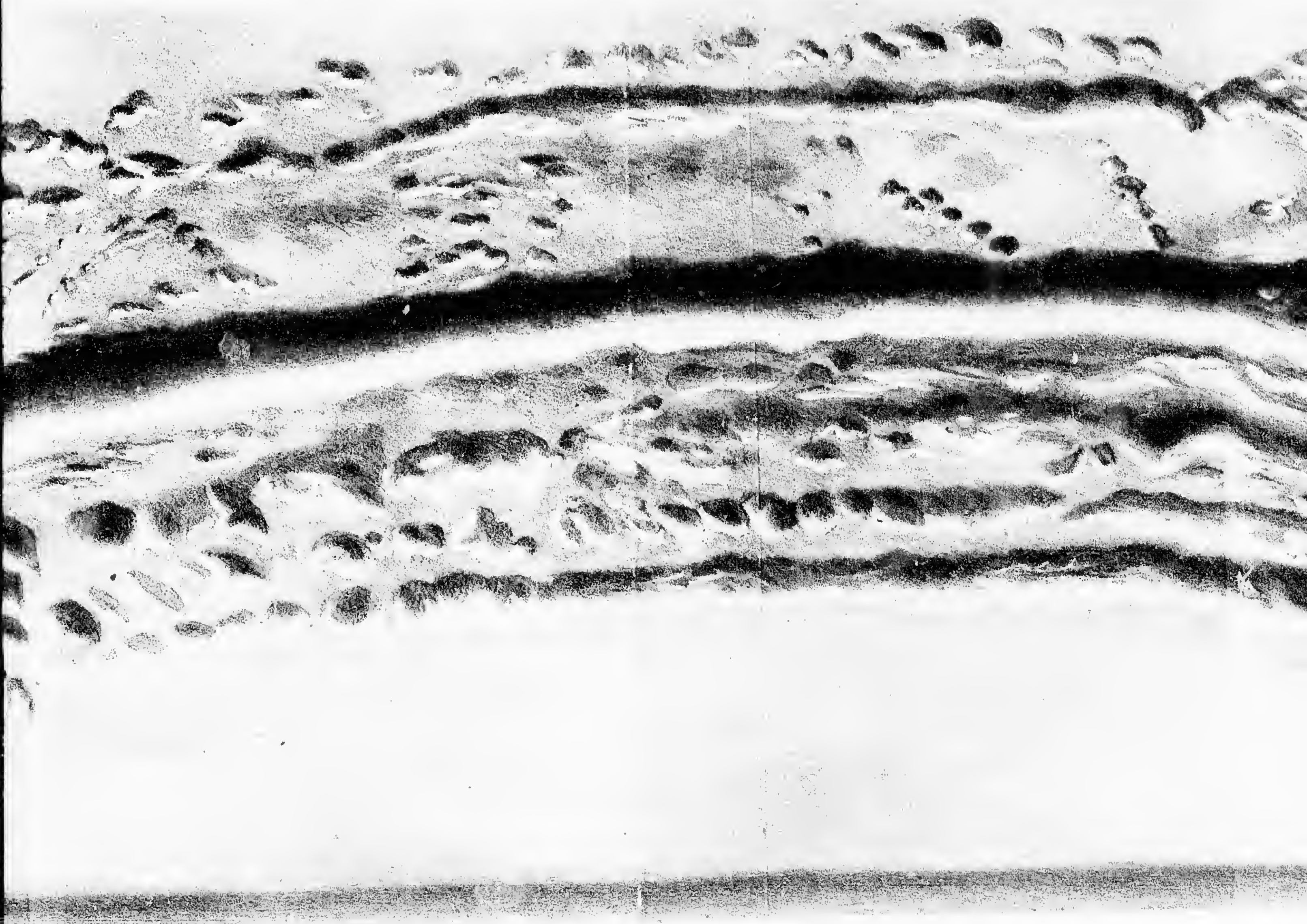

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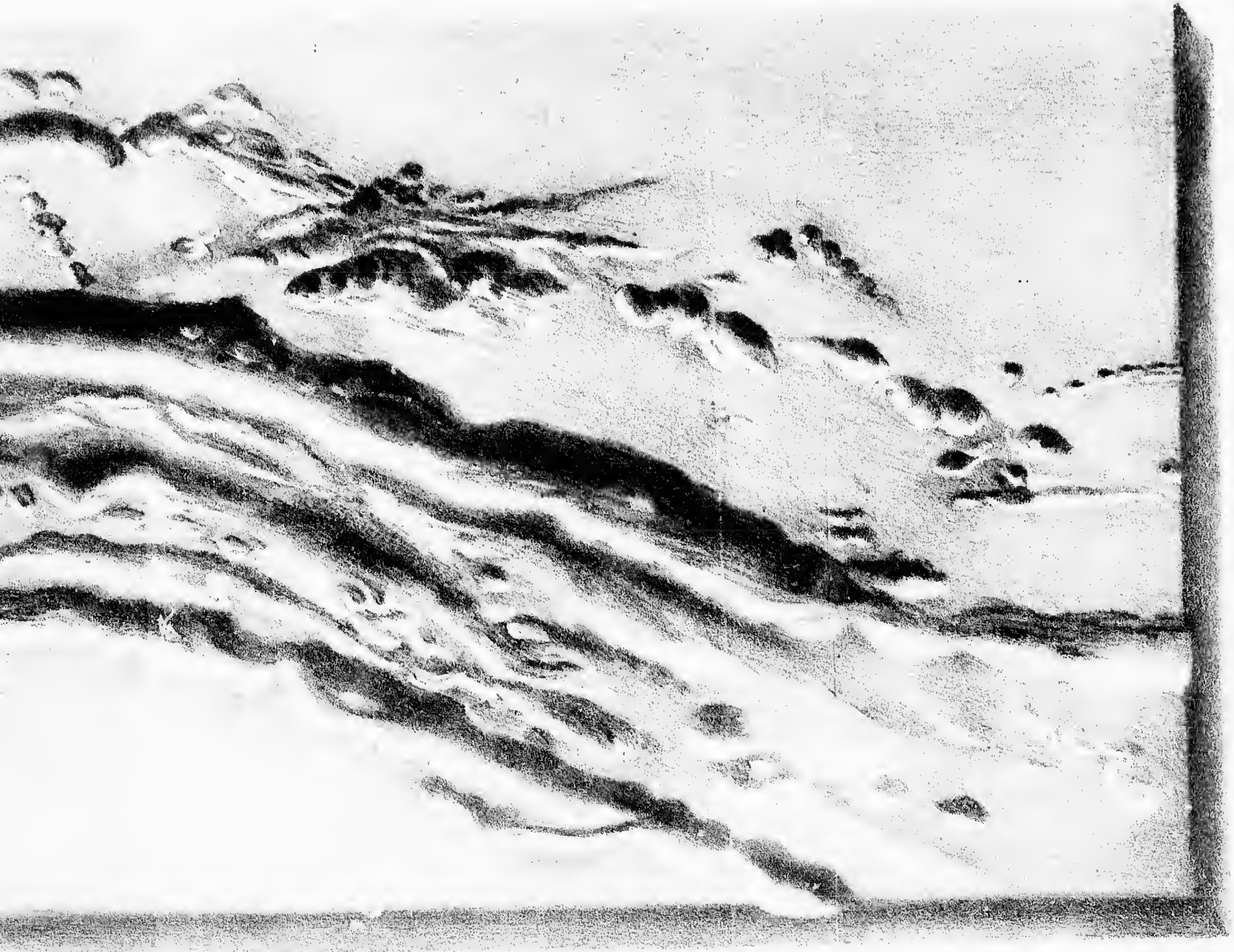

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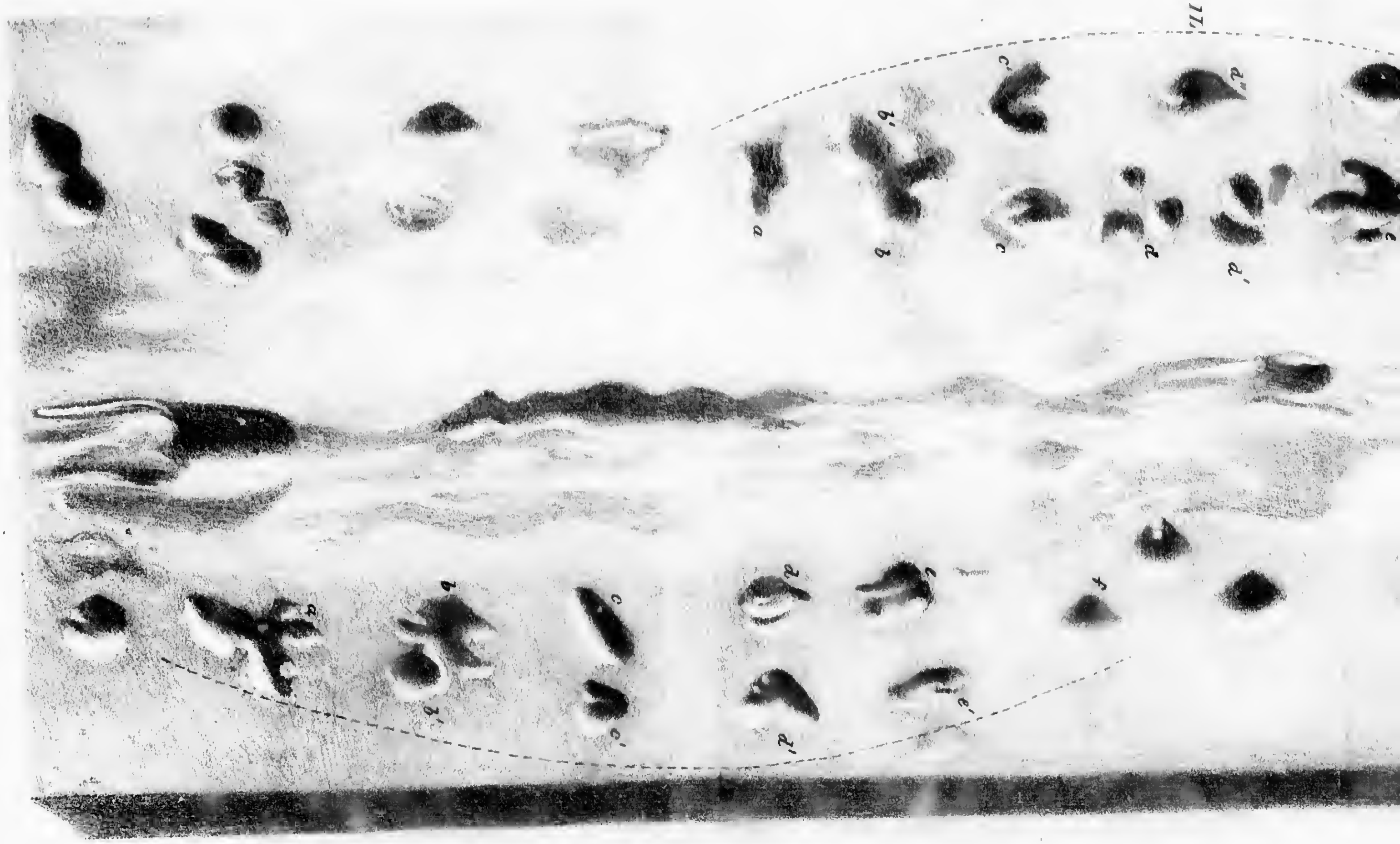

Ign. Dickel, del. et lith.

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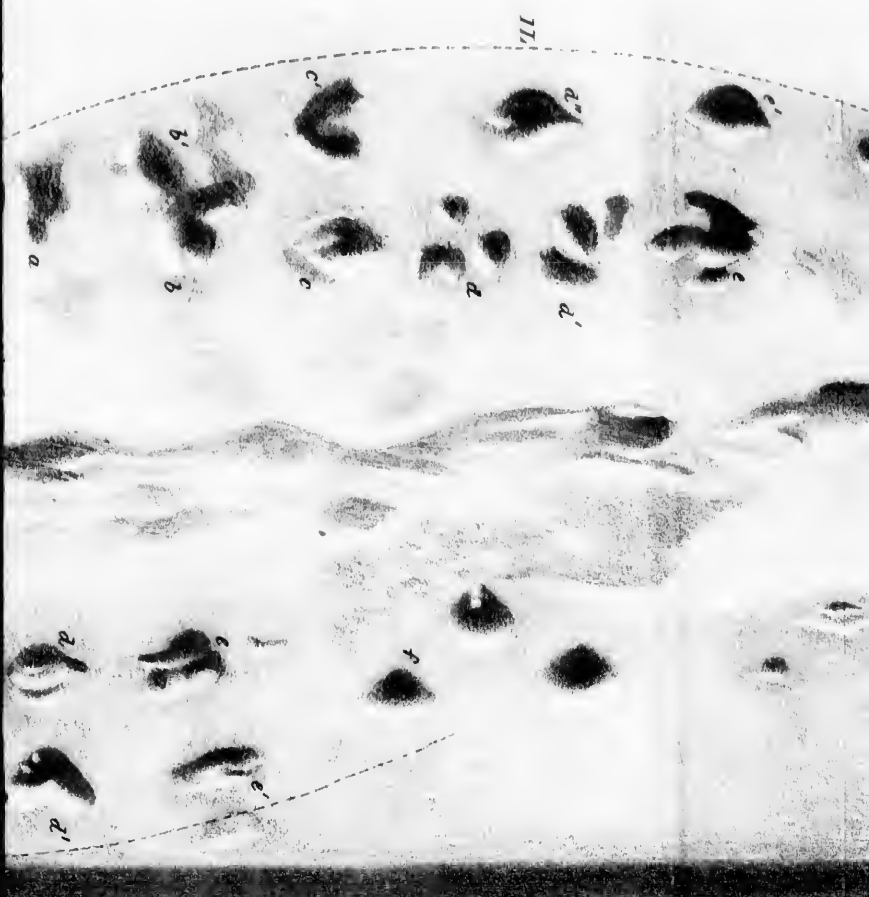

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