in another? The difference of their action in the several circumstances, must depend upon some difference in the soils themselves.

Then Chemistry was asked to analyse these soils—a work at first but unskilfully performed, and still very rarely completed with accuracy and care. This has arisen in part from the inherent difficulties of the process, and partly from the little remuneration *of any kind, either for time or skill, which those most deeply interested* in such inquiries have offered to the chemical investigator. So little, indeed, is still understood by practical men of the analytical—the highest branch of the chemical art—that the rigorous analyses of a soil is looked upon as the work of a few hours, or, at the utmost, of two or three days only; and the money or other value attached to the discovery of this or that ingredient, is judged of accordingly. In this line, the largest amount of work hitherto done has been performed by the German agricultural chemist, Sprengel, and is recorded in his work upon soils, of which we have, among other publications, prefixed the title to the present article. The accuracy of Sprengel has recently been impugned by Liebig, in that *fortiter in re* style he usually employs in reference to those with whom he happens to differ. But we are not inclined to go along with him in his sweeping condemnation of *all* Spregnel's analyses; and we cannot agree ungraciously to reject the entire labours of a long life—expended upon a branch to which no other equally skilful Chemist had, for nearly twenty years, thought proper to turn his attention.

Now, through the labours of Sprengel chiefly—not solely, for he had predecessors and contemporaries also, though less laborious, and less clear and decided in their opinions than himself—it has been established regarding soils—

1. That they all contain a certain proportion of organic, chiefly vegetable matter, which readily burns away when they are heated to redness in the air. This combustible matter in peaty soils sometimes amounts to 50 or 60 per cent. of the whole weight; while in clay soils, such as the white undrained clays of Lanarkshire, less than one per cent. is present.

2. That in all naturally fertile soils, the incombustible part contains a notable quantity of each of ten or eleven different mineral substances.

3. That soils in which one or more of these substances is either wholly wanting, or is not present in sufficient quantity, will not produce good crops.

4. That to these latter soils what is wanting may be artificially added, and that thus their fertility may be increased, restored, or maintained.

5. That some of these substances, when present in excess in the soil, become noxious to the plant; and that, to render such a soil productive, this excess must be, in some way or other, removed.

These five propositions comprehend nearly all that is of importance, in regard to the incombustible part of the soil. They are all fully and frequently stated in the works of Sprengel. They are illustrated and enforced in those of Liebig and Johnston. It would interfere with our present purpose to dwell upon the combustible or organic part of the soil.

But, with the aid of these propositions, the general doctrine of soils, and the action of saline or mineral manures, becomes so far clear and simple. A soil, to be fertile, must contain ten or eleven known [illegible]ances. If any of these be altogether absent, you will improve your soil by adding them to it; if they are present, the addition of them *will do no good. If salt or gypsum*, for example, or the ingredients of wood ashes, be wholly absent, you will obtain large crops by adding these substances largely to the soil; if they are merely deficient, a smaller application will be of service; if they are already present in sufficient quantity, any application of them to the soil will be so much money thrown away. The substances hitherto called *stimulants*, now appear to be only necessary ingredients of a fertile soil. Their true relation to vegetable life, was only ascertained by a further advance on the road of discovery, to which we shall by and by advert.

But here other branches of science stepped in to aid—in some degree, to generalize—this *important* deduction of analytical chemistry, and to make it more widely useful. Geology has ascertained, that the several varieties of loose or drifted materials which cover the earth's surface, and form our soils, are only the *debris*, or weather-worn relics of the solid rocks; and that *they* are more or less related in composition to the rocks themselves, from which they are respectively derived. Further, with the aid of Chemistry and Mineralogy, it was known to geologists that the several beds or masses of rock which form the crust of the globe, consist either of different materials, or of the same materials in different proportions. The same must be the case, therefore, to a certain extent, with the soils formed from them. Thus a limestone soil would originally abound in lime—a dolomitic soil in both lime and magnesia—a red marl, or red sand-stone soil, in gypsum perhaps, or in common salt—a trap soil in lime and oxide of iron; and a mica-slate, or granite soil, in potash and other alcaline matter.

Now a geological map exhibits, by its several colours, the several *areas over which this or that rock extends*. The general character and composition, therefore, of the soils over those areas is known by a simple inspection of the map. And if one kind of treatment has been found profitable, or one kind of application favourable to the crops in one part of each of those areas, the probability becomes very strong that they will prove equally beneficial on other parts of the same areas, or in other countries where the same rocks and soils occur. The amount of really useful practical knowledge which this relation between the geological structure of a district, and the chemical constitution of its soils, puts within the reach of the intelligent agriculturist, is very great. The broad generalizations of which it is susceptible, or to which it points, must enter as an element into the most important political considerations.

Again, the Physical Geography of a district we know has much influence *upon its climate*, and *therefore upon the fertility of its* soils, and their capability of growing or ripening this or that crop. The broad plain, the deep valley, and the high mountain, all affect the agricultural capabilities of a tract of country, whatever the composition of its soils may be. But we do not at first sight see how, independently of their geological structure, such differences in Physical Geography should affect the actual chemical composition, and consequently modify the chemical and agricultural treatment of the soil. And yet they do so in many ways, some of which are striking enough. Thus a plain country receives over all its surface the equal influences of the rains and winds of heaven, and consequently is alike rendered fertile or alike injured over its whole extent by atmospheric agencies; but where high lands exist, the mountain tops attract the rains, and streams of water flow down the sides, washing the soils of the upper country, and carrying down their spoils to the more level spots, or to the bottoms of the valleys. An important chemical difference is thus produced among the soils of the district. The elements of fertility may abound in the land below, while comparative unproductiveness distinguishes the soil above. So one side of a hill exposed to the beating rain and long prevailing winds, will yield a different produce and in different quantities from that which is sheltered from the cold, and is watered by less frequent and warmer rains. Again, where the sea girdles an island-coast like ours, its hills and valleys affect the constitution of its soils more strikingly still. The wind sweeps across the North Sea, or it comes over the broad *Atlantic. It frets and ruffles the waters as it passes along*; it lifts the crests of the waves, and plays among their streaming hair; it bears along a briny spray, which it sprinkles widely over the land, moistening with a salt dew the fields and forests which lie in its way. Let a ridge of hills interrupt its course, it deposits on the seaward slope a large proportion of its watery burden, and is turned upwards from the land in its further career. Thus the salt is spread in abundance over the face of the hills which look towards the sea, and along the plain which separates them from its shores—while the flats or valleys on the other side of the ridge are seldom reached by these bounteous visitings of nature.

And in what does this alleged bounty of nature consist, or in what way is it felt? A fertile soil contains, as we have seen, in its incombustible part a sensible proportion of ten or eleven different substances, which are necessary to its fertility. Of these substances sea water contains six or seven. Where it is constantly sprinkled over the land, therefore, it is constantly adding these to the soil. Thus it happens that those saline substances which the sea water contains—namely, common salt, and gypsum, and sulphate of magnesia—may prove of no use when sprinkled by the farmer upon lands which are more or less exposed to the sea breeze; while on the landward side of mountain ridges, and in sheltered flats and valleys, they may return many times the cost of their application, to the farmer who skilfully and with knowledge applies them.

The rains of heaven, as we have seen, wash the tops of the high hills, and carry the soluble parts of their soils to the bottoms. So the same rains more or less quickly wash all soils, and carry into the sea the riches of the land. But kind nature, on the wings of the wind wafts back again a part at least of those substances which the rain had carried away; and thus, in spite even of the neglect or careless waste of unskilful husbandry, maintains the fertility of whole districts, of which the productiveness would