formed of red and variegated marles, associated with, resting on, and beyond all doubt belonging to the red sandstone, which forms the substructure of the whole. The Guadiela, which is the western branch of the Tagus, has its course deeply cut in this sandstone, and nothing is seen underneath it. The mass of marle is of considerable thickness, and forms hills of moderate elevations, deep and open vallies having been worn by the waters, leaving gentle undulations, and forming one of the most beautiful territories in the world. The summits of these heights across a considerable tract are invariably covered by a horizontal deposit of white limestone, similar to that of Arganda and Tarancon. These formations of marles, covered by thin courses of limestone, varying only in the indenture of the vallies, which in the tongue between the Tagus and Guadiela and near the course of the former river are more precipitous than in the other parts; extend from Priego across the Alcarria into the province of Guadalaxara, and east as far as the neighbourhood of Stera which is to the eastward of Alcolea on the road to Zaragoza, where they appear to rest on the sandstone formation which divides the waters of the Ebro from those of the Tagus. About this point I lost trace of the formation, but I do not give it as the real termination.

This long line is only broken by a mass of secondary limestone, evidently similar to that of the Sierra de Cuenca, which appears near Sacedon, and forms a range of considerable height, the Tagus passing through it. The extent of the sandstone formation to the north of Guadalaxara was not seen, but it probably rests on the great primary formation which is seen beyond the plain, and may no doubt be made out in the district of Cogol-

ludo, from which neighbourhood *terebratulæ* are brought and sold in the fair at Madrid as curiosities, and I have understood there are traces of coal near it.

On the side of Madrid from Guadalaxara near Alcala de Henares, the red marle which forms the soil of the rich plain of Guadalaxara is succeeded by white and gypseous clay which forms the dismal country immediately around the metropolis. At Colmenar, near Aranjuez, is a formation of white limestone exactly similar in appearance to that mentioned in this section, which is wrought for sculpture and other purposes at Madrid. This is no doubt the same formation, but I had not the opportunity of visiting it.

The limestone which is traced in this section in a triangular direction of which the apex is near Priego, a distance altogether of two hundred and twenty miles, appears to have been deposited horizontally on the marle belonging to the red sandstone which underlies the Sierra de Cuenca on its northern side. It is quite different in every respect from the secondary limestone which forms that Sierra, and which occurs again as mentioned in the middle of the section, near the confluence of the two branches of the Tagus in the neighbourhood of Sacedon. This deposit is not only different from that secondary rock, but from every other seen by me in Spain. It has apparently been very little disturbed since its deposition, the vallies having been swept out without deranging the remaining parts. It is spread horizontally over a large tract of country. I never discovered any organic remains in any part of it, but it has entirely the characteristics of a fresh water or lacustrine deposition, which would seem to have covered that extensive surface at a period subsequent to the raising of the Sierra de Cuenca,

and occupies a large territory between that Sierra and the primary range of the Guadarrama, both branches of the Tagus above and below their junction flowing through it. The thickness varies considerably, but in general it is only a few feet, and it is completely different from any of the numerous varieties of secondary limestone of the southern range.

It must be observed that this lacustrine deposit occupies a similar situation, geographically, with extensive horizontal deposits which I have reason to believe are both marine and freshwater, in old Castile, and which lie respectively between the secondary range or barrier of the north division of the great plateau, and the great dorsal or primary central range which separates the two Castiles. These interesting deposits would cause it to be inferred that both parts or divisions of the great table of Castile have been covered by water at a period subsequent to the occupation of their present position by the two flanking chains of the north and south, the great central range separating them respectively.

The Sierra de Cuenca on the northern side is little more than an elevated plateau with peaks moderately elevated above the great table of Castile. From information I have received, the sandstone on which it rests appears at its southern foot above the plain of Valencia to which the descent is more rapid. An opinion is held in the country that this limestone alternates with the sandstone, but I have doubts on this subject and believe that the whole mass of it rests on the sandstone.

I was informed by professor Garcia of Madrid that orthoceratites were found near Cuenca, but I know not the locality.

The sections of new Castile are now resumed from the neighbourhood of Madrid. and carried to the west through Estremadura. Beyond Aranjuez the gypseous marles appear to the right of the Tagus and form the dismal country of Ocaña. The country intervening between the two roads of La Mancha in a direction from Albacete to Valdepeñas is limestone of the marly kind which occurs so much in the south, but it was not particularly examined. Beyond Valdepeñas the primary range of the Sierra Morena appears which divides this district from the regions of Andalusia. The immediate country of Valdepeñas is marly limestone resting on primary slate which I saw on descending into the deep cellars of that place in order to dip into the tinaxas. A detached mass, probably of secondary or tertiary formation is seen to the right of the road from Madrid, in which I have been informed fossils have been found. The whole of this must apparently be considered as detached or subordinate parts of the great southern secondary range, which covers the Sierra Morena in the neighbourhood of Alcaraz. In descending the Tagus from Aranjuez, the primary formation of the central range closes in, and soon forms a continuous mass, parts of it being thiuly covered by alluvions and transported materials. At Toledo the country is chiefly granite At the Puente de Almaraz are slates vertically thrown up, running north and south, and at the Puerto de Miravete quartzose and other rocks. At Truxillo is granite. The greater part of the wide range of Estremadura, from the Tagus to the Sierra Morena appears to be primary, covered by alluvions and transported materials, which no doubt form the country at the mouth of the Guadiana. At Merida, greenstone,

and at Badajoz, limestone, probably of the primary series, on which is built the fort of St.-Cristobal, are the prevailing rocks. The portion of the Sierra Morena between Badajoz and Seville is composed of rocks of many sorts, slates, granular limestone, hornblend, etc.

OLD CASTILE.

The upper parts of old Castile from the right of the Ebro I have been informed are of sandstone, which in all probability covers the primary central range and is connected with the formation which is on the right of the Ebro in Aragon *.

In the neighbourhood of Burgos are sandstone and limestone, which appear to be connected with the bold limestone formation of Pancorbo and to stretch away to the lofty uplands of Soria, probably forming an uninterrupted series with that between new Castile and Aragon. The citadel of Burgos is on limestone covered by a more recent deposit, containing some marine remains.

Between Burgos and Valladolid are a series of horizontal beds which require, and would well repay examination. Some beds contain marine shells but in small quantities. They valley of the Pisuerga is bounded by and has apparently been excavated out of these beds. At Valladolid are beds of clay and sand, covered near Fuen Saldaña by a conglomerate. These beds of clay and transported materials extend to the flank of the great central chain which separates it from new Castile and rest upon it, near the range of the Guadarrama.

* I was indebted for this information to the Conde de Villafuerte, of Tolosa.

In the neighbourhood of Lerma is a white limestone bearing some resemblance in appearance to the interesting formation of new Castile, but it must be borne in mind, that the elevated central primary chain separates these deposits. The whole of the lower part of old Castile between Valladolid, Benevente, and Leon, is a continuous mass of clay and transported materials passing into sand or gravel, resting on the great range which separates it from Asturias. I was incapacitated by an accident which had happened to me from attending to the formations on the flank of this chain in descending from the Puerto de Pajares, but I observed fragments of limestone containing orthoceratites and nummulites on the way to Leon. The gypsiferous marles of new Castile are wanting in the parts of the other province I traversed, and the soil is generally more sandy than in the sister plain. I believe the sandy structure increases towards Salamanca, which district I had not the apportunity of examining.

NORTH COAST.

From the Pyrennees there is an uninterrupted succession of sandstone and limestone, metalliferous and carboniferous, extending to Asturias. The coast line is nearly parallel to these formations, and is formed, sometimes of one, sometimes of the other. The general form, direction and composition of these formations might cause it to be inferred that the chain is the prolongation of the western flank of the Pyrennees. A nummulite lime stone is seen near Riba de Cella between Santander and Gijon. West of Riba de Cella, the limestone forms bold

mountains, which close in upon the coast, after which is a vast field of sandstone, almost continuous, traversed by thin beds of limestone, and extending over the whole country of Oviedo from the central chain of the interior, which separates it from Castile, until it is lost in the ocean at Cape Peñas.

These formations continue uninterruptedly, and contain the remarkable deposite of coal of which mention is made in the visit to the province, and in the account of the mines. The beds are all vertical or nearly so, and in the route to the Puerto de Pajares near Campo manes, is a section with impressions of very large plants also upright. There are grits and conglomerates of various kinds in the usual style of coal formations, and the miners informed me they occasionally found impression of plants in the seams. With the exception of a coralline found near Cape Peñas in one of the bands of limestone, I did not meet with any organic remains in this most interesting formation. The coal strata are cut through by the deep course of the Nalon, which has precipitous banks on either side, in which the strata are seen, extending to an estimated distance of four leagues, seventeen miles. The quantity of coal is enormous, and scarcely any has yet been extracted. It is however a most blind country to the geologist, the rocks being covered up with luxuriant vegetation in almost every part, rendering continuous observation extremely difficult and almost impossible. In approaching the central chain, beds of slate appear, and are thrown up regularly to the centre, which is black and white limestone. On the southern side are a variety of beds quite different from those on the northern side, but I regret that an accident which wholly incapaci-

tated me from working, prevented my taking more than a hasty and imperfect view of this range. Notwithstanding the uninterrupted continuation of these sandstones and limestones along the north coast, there is great reason to believe, that the axis changes either near Santander or at the elevated range of Riba de Cella, leaving the younger beds nearer to the Pyrennees, and the older which include the great coal basin of Asturias, to another axis, possibly the primary formation of the west of Asturias. There is no reason whatever to suppose that the real coal formations of Asturias are otherwise than much older, and probably quite independent of the carboniferous limestones of the vicinity of Vittoria and Oyarzun, although the sandstone and limestone occur uninterruptedly between these distant points. See the desiderata at the end of the chapter.

SECTION ACROSS THE CASTILES.

S. B. Sea of Biscay.
a. Coal Basin of Asturias.
P. P. Puerto de Pajares.
b. Beds of limestone.
c. More recent formations not examined.
V. Valladolid.
e. Recent formations salt and probably fresh water of the Pisuerga.

G. Guadarrama.
b. Primary range.
g. Detritus etc.
M. Madrid.
i. Gypsiferous marle.
A. Alcarria.

h. Thin limestone, supposed to be fresh water covering
i. Red Marle.
k. Redsandstone, passing under
l. Secondary limestone of
S. C. Sierra de Cuenca.
V. Valencia.
M. Mediterranean.

In this sketch the distance between the ranges on the flanks from the centre is shortened, in order to shew detail more clearly without extending the length.

ARAGON.

On the route from Madrid to Zaragoza, the horizontal deposit of limestone, resting on red marle, as before mentioned, is succeeded by sandstone, and other beds which extend to the neighbourhood of Ariza. Below that place, in following the Xalon, there are appearances of a regular axis near Alhama de Aragon. This axis is of slates nearly vertical, and running in a line of bearing towards the great isolated mountain of the Sierra de Moncayo, near the Ebro, on the frontier of Aragon and old Castile, which I have been informed is also of slate. This formation is of great importance in the geology of the centre of Spain, and requires examination. On this account only is it noticed, as I passed it rapidly, and had no time for detailed observations, but it is too essential to be omitted in a region where there are so few landmarks to direct the course of the geologist.

It is extremely probable that this is part of a formation at Molina de Aragon, in which are the copper mines. It extends beyond Calatayud, where the red sandstone appears to rest on it, which seems in its turn to be covered by white gypseous marles, and that by a mass of transported materials, which form the country near Zaragoza, and the immediate vale of the Ebro.

In upper Aragon and Catalonia are, as far as my observations and information go, a series of secondary formations, principally limestone and sandstone, which may very probably be traced to a connection with the great limestone range through which the Ebro breaks

at Tortosa, and which from that point forms a nearly uninterrupted line to Gibraltar.

ON THE SOUTH OF SPAIN.

SIERRA DE SEGURA.

The great plateau, or table land of new Castile, is supported, on its southern side, by the vast limestone range, part of which has been mentioned as the Sierra de Cuenca. It forms the greater part of the kingdoms of Murcia and Valencia, ending abruptly in the magnificent cliffs of Cape St.-Martin, to the west of Valencia, and at Carthagena, where the harbour is an indenture into the secondary limestone. The greater part however, excepting in these places, is covered at its southern foot by recent formations, as will be mentioned hereafter.

In following the central part of this range from the Sierra de Cuenca to the west, we meet with the Sierra de Segura, which I followed from its commencement near Baza to the village of Segura de la Sierra, and Orcera. The whole formed nearly one unbroken mass of limestone, white and grey, but weathering blue in places. The part of it which terminates at Pozo de Alcon near Baza, is covered by various masses of recent gypsiferous sandstone and transported materials, which are to the north of the basin of Baza. There are however detached peaks rising like islands in the midst of these recent formations, and the Sierra de Baza, which is the largest of them, extends towards the Sierra Nevada. The main secondary range then turns or trends, in nautical language, away to the north from Pozo de Alcon,

forming the lofty range of Jaen, where it is nearly white, and passes by the Sierra de Loxa to Antequera, and by the Serrania de Ronda to Gibraltar, where it forms, without doubt, the Peñon or rock, and the opposite range of Ape's Hill, on the other side the straits. To return to the Sierra de Segura. At its southern commencement, near Baza, there is no appearance of the understructure, the whole mass visible being homogeneous. In the Sierra de Cazorla, a division of it, where the Guadalquivir has its source, it seen associated a brown steatitic slate in thin laminae, which is probably of the older series, or immediately connected with it. At the source of the Segura the limestone is milk white.

In this chain, the most rapid fall is to the western side, or to Andalusia, where are bold and precipitous cliffs. On the side of Murcia it is more regular and gradual, being inversely the order of the Sierra de Cuenca, where the rapid descent is on the southern face, and that on the north is little more than an elevated plateau, as before mentioned.

Below Orcera, in the bed of the Guadalquivir, granite appears, being the last visible line of the southern and lower part of the Sierra Morena, in the parallel of Alcaraz, where it is understood the higher part of it passes under the limestone of the same range. Lower down red and variegated marles and sandstones are seen, near Veas, and again at Linares, where the granite is immediately covered by thin beds of marle, over which is the sandstone.

These observations are of some importance in the determining the relative positions of strata, ou a large scale. They were made in 1830, and confirmed subsequently by visiting the Sierra de Cuenca, where the

respective situation of the limestone is better seen, only that that of the marles is inverted, as in the last district they rest on the sandstone, of which the substructure is not visible. I never saw the junction of the limestone formation at Orcera, as it is covered up by landslips and luxuriant vegetation, but I have no doubt it may be found by following the line of the Sierra to the south and no reasonable doubt can exist, of the relative position being as here stated, and that this vast range rests on red sandstone with its marle, over granite.

It may be mentioned that I ascertained at Granada, where it is brought for domestic purposes, that an entire *cerro*, or mountain, of red sandstone exists near Cabrillas, between Ubeda and Granada, which will probably repay a visit to compare its position with that of the limestone of the more recent formation, now to be mentioned.

From Veas, near which the red sandstone and marles are seen, and which is in a small valley near the confluence of a stream, on the left of the Guadalimar, commences a series of beds of clay, forming hills of moderate elevation, and rising gradually to the Lomo or ridge of Ubeda, on which that city and Baeza are built. The summit of it is covered, at Torre de Ubeda, by a greenish friable sandy grit, precisely of the same character as the lacustrine formation of Alhama de Granada, and bearing strong evidence of a similar deposit having existed resting on these marles, which are geographically separated from that of Alhama by the secondary range of Jaen.

Below this ridge of Ubeda, in descending to Linares, is indurated white marle, which, with conglomerates, also extends in the direction of Jaen. These beds of clay, or marle, agree in character with the gypsiferous marles

of different parts of the north side of Andalusia, and, beyond doubt, rest on the sandstone and marles which cover the granite at Linares, in their turn supporting the lacustrine formation, if it prove to be so, of Torre de Ubeda.

At Jaen, the above mentioned formations are associated with, and appear to rest on the secondary range which is the prolongation of the Sierra de Segura, as before mentioned, united by the Sierra de Cabra. At Jaen it is of great height and the mass which is crossed in proceeding to Granada is of considerable breadth, reaching nearly seventy miles. I saw green stone appearing underneath in places, and probably near Campillo, from information I received, there is serpentine, with some graphite.

This secondary range passes quite clear to the north of the Sierra Nevada, from which it is separated by the recent formation of the plain in front of the city, although a connection might probably be found, to the east of the Sierra de Elvira, with the marles and secondary limestone, which rest on the north eastern shoulder of the mountain, in the line of Guadix.

From Jaen the secondary formation continues to Loxa, and thence to Antequera. On its northern side are marles, stones, and gypsiferous marles and clays, which form the country of Cordova, Ecija, and Antequera, in the plain of which are salt springs.

These beds of clay are broken off at Estepa, to the west of Ecija, by a formation of limestone, noticed in the marbles, and which has the appearance of a primary formation, but which I had no opportunity of examining.

GRANADA.

The Sierra Nevada, the greater part of which on the northern side, is a mass of mica slate and serpentine, rises to a height estimated by Roxas de San Clemente to be greater than that of the highest points of the Pyrennees. It is however of comparatively small extent, soon disappearing under the secondary and recent formations which surround it on all sides. The southern flanks form the deep vallies of the Alpujarras, the summits of which I believe to be chiefly secondary limestone, resting on slates, greenstone, primary limestone and others of the older rocks. The slates, most of which are in a state of disintegration, hourly perishing by the weather, and are highly metalliferous, form the principal feature in the vallies of that district which I have traversed. Of unknown age, but probably of the older series, is the limestone of the Sierra de Gador, where are the lead mines. I missed the junction in the line I followed in search of it but it agrees very much in character with the mass which lies immediately on the mica slate, upon the opposite side of the range, and in its mineralogical character is quite different from any of the known secondary limestones of the country. The coast line will be mentioned with the general outline of that of the Mediterranean *.

* My stay in the interesting neighbourhood of Gador was extremely short, as I thought it better in that and other instances, to sacrifice localities, of which there is an absolute certainty that the superintendant of mines must arrive at the knowledge of, and give my time to the countries which were less likely to be examined. The same observations apply to the part along the French frontiers, on both sides of Catalonia, Navarre, and the Provincias.

NORTHERN SIDE OF THE SIERRA NEVADA.

The north side of the Sierra Nevada, as is well known, supports the great table land of Granada, which may be taken at two thousand feet elevation above the level of the sea. The centre nucleus of the mountain is mica slate, which I believe forms the summit of it. Associated with it is the serpentine formation of the barranco de San Juan, near the sources of the Xenil. On this is placed a mass of limestone, which no doubt must, from its situatuation, be referred to the same ancient formation. The junction is seen in ascending from the city by the road of the barranco de San Juan, to the left of that of the Nieve, used for the supply of the city with that article, opposite to the village of Huejar.

This limestone ends abruptly at a comparatively small distance from the city, above the village of Monachil. Against it lies an enormous deposit of rolled and transported materials, the ruin of former formations, which descend with a rapid talus to the city. The Alhambra and upper parts of the city stand on the last elevation of it, above the Vega, which appears to be formed of the silt and finer materials of it. The highest point of this mass I estimated at three thousand feet above the Vega, and in an apex I noticed a small horizontal deposit of sand, proving, from its position, that there had been a tranquil deposition and a subsequent destruction of the surrounding parts. This mass is cut through by the Xenil; and the Monachil and Darro, its principal tributaries. There is a great difference in the deposit in the immediate vicinity of the city. That under the Alhambra is composed of primary rocks, almost if not quite exclu-

sively. The cement of this part weathers a blood red, and from it proceed the gold washings which the people imagine to be connected with that, instead of the true cause. To the east of the city the deposit is of much more recent rocks, consisting almost wholly of limestone, apparently secondary, and loosely held together, whilst the other part is extremely compact, and affords the numerous habitations of the troglodyte-Hispano-Moro-Egypto population of the place.

The lower part of this conglomerate ends abruptly at the point where the city is placed, in the immediate vicinity of which, near Azubia, is indurated red marle, and calcareous conglomerate. Below this is the Vega, the soil of which is sand and pebbles, passing into clay, beyond doubt composed of the finer parts of the deposit and ruin above mentioned. The sand is regularly stratified in places, and forms beds near the city, sufficiently compact to be wrought for inferior purposes, and it has been used in constructing the curious wall in the Alhambra, attributed to the Phœnicians. In other parts of this formation, the beds have been slightly raised since their deposition, possibly by the same operations that drained the waters of the lake of Alhama, which were not improbably the last great changes to which this curious region has been subjected. A league distant from the termination of this recent deposit, is the Sierra de Elvira, a secondary limestone, of dark grey with red veins, which is extensively worked, having been from all time the principal building stone for better purposes at Granada. The beds of this Sierra are in part regularly inclined to the north, as if they depended on the Sierra Nevada, from which it is detached by the short distance of about two leagues in a straight line. There

is strong presumptive evidence of the whole intervening mass, between the older limestone on the flank of the mountain and this secondary range, having been destroyed, and that its ruins, in part, form that division of the conglomerate, which is to the east of the city. In the illustrative sketch this is referred to by D. In beds of this limestone of the Sierra de Elvira, was found a new and beautiful ammonite, named *Gori*, after the Duke of Gor, to whom I was indebted for the information that fossils existed in that Sierra, and a great deal of other valuable intelligence respecting the province of Granada. It appears to be connected with the great secondary chain of Loxa which passes to the north of it. If it be a part of it, it is one of the older members, but it is by no means clear, that that chain belongs to the Sierra Nevada, which the Elvira very evidently does*.

To return to the recent formations of Granada. Beyond the Vega are vast beds of clay and sand, associated with which is gypsum and salt. Future observation must determine, whether these clays belong to the formation of the Vega, or are of older date. Associated with this gypsiferous clay is a recent marine formation, composed almost entirely of exuviæ, and containing pectens and no doubt other shells. It is seen near Escuzar, three leagues from Granada, where it forms an elevated ridge, descending in a line to Padul. I estimated the highest point of this marine formation at one thousand feet above the Vega, giving three thousand for its elevation above the sea. It is wrought for domestic use at Gra-

* By a communication made to me by my friend Colonel Silvertop, he has since found ammonites similar to those of the Sierra de Elvira, near Antequera, which might favour the supposition of this mass being of similar formation, although it does not prove it.

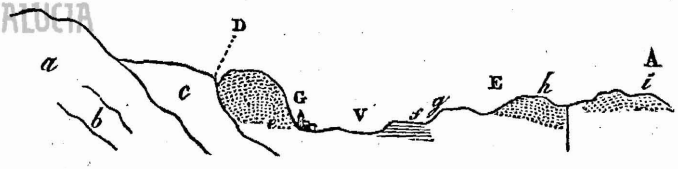
nada, where it is next in quality to the limestone of Elvira, being better than the sandstone of the Vega. This deposit is of great interest in this upland region. It is associated with, and lies geographically between, the gypsiferous and saliferous marles at La Mala, and the lacustrine formation of Alhama, which is probably the most recent of all the formations of the table land of Granada. The situation of this marine deposit makes it extremely difficult to ascertain its relations with the marle, as it is almost entirely covered up, but it is by no means unlikely, that both it and the basin of Alhama rest upon the gypsiferous formation. All this mass appears to rest on the secondary red sandstone, marly and other limestones, which form the Sierra de Tejeda, and that to repose on mica slate, the prolongation of the Sierra Nevada to the west.

On the route to Motril and the Alpujarras, after leaving the sand, clay, and marles which form the Suspiro del Moro, you descend to Padul, a village situated at the head of a small marshy plain, drained in modern times, and exhibiting the last remains of the fresh water formations of this upland region. The approach to the sea is by an open defile, having the western shoulder of the Sierra Nevada on one side, and the lofty range of Tejeda on the other. The primary slate which forms the base is seen in a few spots near Tablarte. There are indurated marly limestones, and other features of the country, in this part, and the lower parts have been filled with vast deposits of transported ruin, which have been in their turn excavated by the torrents that descend from the Alpine region above, and form magnificent barrancos in the neighbourhood of Durcal. The deposits in these ravines bear evidence of having been transported simul-

taneously with the mass which has been in motion at the time of the formation of the Vega, and other operations of the uplands above it. It extends nearly to the precipitous ridge, or puerto, which conducts to the secondary vallies on the south side of the Sierra as before mentioned.

The recapitulation of this series ascending, gives the mica slate and serpentine of the central range; the limestone resting on the mica slate and in immediate contact with it; the secondary limestone of the Sierra de Elvira; the gypsiferous marles of La Mala, probably the older of the recent series; the conglomerate of Granada, and the formation of the Vega; the tertiary marine deposite of Escuzar, and the lacustrine formation of Alhama, presumed to be the youngest of this series, if the recent peaty formation of Padul be not considered to deserve a place amomgst them. This will be made more clear by the accompanying sketch.

ENVIRONS OF GRANADA.



a. Primary range of Sierra Nevada of Mica Slate etc.
b. Serpentine of barranco de San Juan.
c. Limestone of older series.
e. Conglomerate of Granada.
D. Geological position of the Ammonitic limestone of Sierra de Elvira.
G. City of Granada.
V. Vega, clay, sand, Marle.
f. Horizontal beds of recent sandstone.
g. Gypsiferous and Saliferous Marles.
E. Escuzar village.
h. Recent marine formation with pectens etc
A, Alhama.
i. Lacustrine formation of Alhama.

There are besides these, a mass of marly limestone above Viznar to the south east of the city, whence issue the beautiful springs which supply the city, and a copious deposition of carbonate of lime proceeding from them. A similar deposit, but of much greater beauty, is formed at Lanjaron, on the opposite side of the mountain. See the account of marble. There is a formation at Monte Frio, which I have been informed contains shells. It is very probably similar to that of Escuzar, but I had not time to visit it. It is on the opposite side of the Vega, three leagues from Loxa. The limestone seen on the right of the road to Guadix, which appears to be a part of the same formation as that of Viznar, require examination, and amongst other desiderata of the geology of Granada, it would be adviseable to carry a section from the point mentioned of the junction of the primary to the Sierra de Elvira, and through the secondary strata to the marles which cover it, on the side of the Guadalquivir.

It will be remembered that the Vega of Granada is a mass of transported materials and ruin of former rocks. It extends some distance on the road to Guadix, and at its termination the mica slate may be seen in a spot, the only one I saw on that side of the mountain, where the primary is shown under the recent strata.

After this is a gorge or barranco in the limestone, no doubt of the secondary formation, which terminates in a long promontory, running out into a vast sea of sand and transported materials, extending, with a flat surface worn into innumerable hillocks and ravines, to the foot of the Sierra de Filabres, which is the eastern continuation of the Sierra Nevada. The city of Guadix stands on this formation, which is hollowed into numerous habi-

tations in the vicinity. The Sierra de Baza. which seems to be a continuation of the Sierra de Segura, rises through this recent formation, and separates it from the basin of Baza, which contains a lacustrine formation, observed and described by Colonel Silvertop. The formation at the eastward of the basin of Baza, after crossing the Guadiana, which is the eastern feeder of the Guadalquivir, is of gypsiferous loose sand stone and appears to rest on the Sierra de Segura. The formation of sand and detritus which has been followed from beyond Granada, to Guadix and Baza, probably supports the lacustrine formation of the latter place, and it is continued towards Murcia and the vale of Lorca, on the south east. To the south, from corresponding observations made in different places, though I cannot aver it to be the case, not having actually traversed it, I have no doubt whatever that it extends uninterruptedly to the delta of the Almanzora, where there is a wide tract, exactly of the same description, resting on one side, upon the range which divides the vale of that river from that of the Lorca in Murcia. On the other side of this vale of the Almanzora it reposes on the primary range of the Sierra de Macael, where are the marble quarries, which is part of the Sierra de Filabres. On its northern side, to the right of the Almanzora, it is tolerably level, but towards Murcia, it is heaped up, and has been worn into innumerable hillocks, or hummocks, as termed at sea. In this part it contains lignite* and gypsum, but is essentially composed of reddish sand, giving the peculiar African character to this interesting region. Near

* I am indebted for the information of this liguite, which is near Cuevas de Baza, and which I did not see, to Mr. Lambert, F. G. S., who visited it officially, but it was found unfit for any economical purpose.

a village called Cantoria, close to Purchena, the primary rocks are nearly uncovered on both sides of the stream, but only for a short distance, leaving the water course open between them, and with the very small intervals mentioned in this sketch, I have traced this formation, which may be termed the Granada detritus, and which is mainly composed of sand, from the sea at the mouth of the Almanzora, by Purchena, Baza, Guadix, Granada, Padul, and Tablarte, almost to the sea again at Motril, thus forming a nearly uninterrupted stream around the Sierra Nevada. An extensive deposition, of exactly the same nature, is also seen in ascending the great river of Almeria, to Tabernas. In this last line, it forms perpendicular walls, of several hundred feet in height, worn by the torrents. There is some reason to believe that the Sierra de Filabres is entirely detached from the principal chain, and that it is covered by more recent formations, in the line between Guadix and Almeria, but I cannot assert that it is so, not having crossed it in that direction. Amongst the rocks which compose it, are mica slate, and granular limestone, the latter rock resting on the mica slate. It may be observéd, that the name of nummulite limestone, given in the accounts of the neighbourhood of Granada at the geological society, is not used here. The term, I have understood, was given provisorily, and certainly there is no formation in that neighbourhood to which it applies. It is, in fact, the secondary limestone of the general chain that has received this appellation. The nummulite rock which gave the name, is, I understood from Colonel Silvertop, at Velez Rubio in Murcia, which place I did not visit. It may be a member of the secondary series, but is much more probably of the tertiary, or more re-

cent epoch. I never met with it in any part near Granada. The relations of this nummulite rock are not yet established, and it would only lead to error, to consider it identified with the vast mass of secondary limestone which plays so important a part in Spanish geology, and to which it is almost certainly superposed.

ENVIRONS OF MALAGA.

The territory of Malaga is principally of red sandstone, crossed by bands of grey limestone. The sandstone, appears, on the whole, to occupy the lower place, although, after much examination, I cannot affirm that it does so. Traces of coal have been discovered at a place about three leagues to the west, where a small seam is associated with grits of various kinds, similar to the beds usually found with regular coal.

The understructure of the district is compact blue slate, which may be seen in the sea close to the town, and in a barranco to the east. This slate is extremely like that which underlies Monserrat in Catalonia. In pursuing the royal road to Antequera, a variety of primary rocks shew themselves, which are covered by the sandstone, its grits, and limestone. At the base of the lofty Puerto, which is passed to arrive at Antequera, is red sandstone. The Puerto itself is a magnificent ridge, which is formed by mural precipices, exactly similar to those of the Breche de Roland, in the Pyrennees, and of a limestone very like it, appears to rest on this sandstone, but it was too much covered to enable me to see the junction. On the Antequera side is a wide plain of saliferous marle or clay, which rests on this secondary chain, and extends, with little interruption, to the Gua-

dalquivir. The chain of Estepa, which is mentioned before, and which I believe to be formed of primary limestone, is an abutment or continuation of a chain commencing at Antequera which runs in a rectangular direction to the secondary limestone, but the state of the country, latterly, made it impossible to carry on observations in that vicinity. A tertiary, or recent deposit, is observed near Malaga, but it will be subsequently mentioned, in the general coast outline, in which it will be more clearly brought under view.

To the west of Malaga, after crossing the Vega and the great river, a bold Sierra presents itself, which is of blue limestone, and running in a semicircular direction, forms part of the Serrania de Ronda, closing in the Vega at its western end, where serpentine or greenstone comes through it. On the coast side it leaves a narrow pass where the substructure is seen, composed of primary granular limestone and mica slate. In the sea, near Frangirola, are appearances of members of the sandstone formation similar to those of the interior. They are now isolated and crumbling with the ceaseless efforts of the ocean, which will no doubt cause them, at no distant period, to disappear. At Marbella, the primary formation rises to a considerable height, when it breaks off, and is succeeded at once by red sandstone which, with bands of grey limestone crossing it, is continued, without interruption, round the western end of Andalusia, and to the great plain, which we shall designate as lower Andalusia.

The tract enclosed between this plain and the Mediterranean, is that termed the Serrania de Ronda. From observation, and some scanty information I have obtained, I believe this mass to be composed almost en-

tirely of sandstone and secondary limestone, with indurated marles, resting on serpentine and other rocks, which are seen on the southern side of it. A line followed from Marbella to Ronda, which I had not time to make, would probably throw light on this district. About the centre is a magnificent range, the highest peak of which is named St.-Cristobal in the country, but by seamen is known as the Moor's head, which is a landmark in the Atlantic, and might be one in the Mediterranean. I am ignorant what the upper part of this range is composed of, but it appears to be limestone, and it has been said to be primary.

The rock or Peñon of Gibraltar is a mass of grey limestone, exactly similar to that forming the secondary chain, and which we have traced, almost uninterruptedly, from the frontiers of Aragon, and which varies only in colour in different situations. A few fossils have lately been found in the mass of the limestone, and as the attention of the officers of engineers has now been called to the preservation of them, it is to be hoped there may be collected data, to throw some light on the age of this limestone. Those hitherto found are terebratulæ; a magnificent univalve, probably a terebra; patella; fissarella? At the south end of the rock are indications which I have generally seen to accompany the vicinity of the primary of this formation. They may be seen on the road to Europa point, in ascending from Rosea. There are stalactites, stalagmites, and conglomerates, with osseous breccia, in abundance, the former being common in this formation every where. A cu-

* I was indebted for assistance in obtaining these fossils to Dr. Farrell and Colonel Harding R. E.

rious specimen is in possession of an officer of the naval arsenal, a mass of bones and skeletons of birds, chiefly of the gull species, which are covered with a thin stalagmite, leaving the forms quite perfect. At the east side of the rock is a quantity of drift sand, thrown up from a great distance by the furious swirls of the Levant winds, from the sandy isthmus, and lodged against the limestone, which only requires a cementing liquid to form a compact sandstone. The neighbourhood of St.-Roque is covered by a recent marine deposit, which is mentioned in the coast line. The sandstone and limestone appear to extend beyond the straits, and to be carried, according to information I have received, far into Africa.

LOWER ANDALUSIA.

Vast beds of clay and marle appear to cover the sandstone and limestone of the Serrania de Ronda; and form the territory of Xeres, and the greater part of what may be termed, lower or western Andalusia. At Xeres and the vicinity, it is covered by a marine formation, exactly identical with that of the coast. At Vejer, between Gibraltar and Cadiz, is a similar formation to that traced along the coast, and no doubt contemporaneous with it. Here it is in thin beds, with a dip from the sea. I have some reason to believe that the same formation is found at Medina Sidonia, and Arcos. Near the former are beds which supply the best mill stones in the south of Spain. I have never seen them, but from the description they ought to belong to the sandstone.

At Alcala de Guadaira and Carmona, the marine for-

mation is of great extent, and considerable elevation, especially at Carmona, where it rises above the plain to some hundred feet. At the Molino de los Cartuxos, a mill upon the Guadaira, at a short distance above Alcala, I found the marine deposit resting on a stratum of blue clay, in which were pectens, shewing what I have no doubt is the regular position. I had sought in vain, previously, for a direct junction, or any organic remains, in this vast deposit of clay, in which at Xeres they have pierced to a very great depth, in search for water, without getting through it. The marine deposit extends far inland. At Villa Nueva del Rio, on the opposite side of the Guadalquivir, it covers the sandstone and coal formation, and I have seen something which resembles it in the bed of the Guadalquivir, between Cordova and Andujar, which requires examination. Near Andujar pectens were found in a stratum of clay and were sent to Madrid by a nobleman residing at Andujar, who communicated to me his observations *. I have no doubt whatever, that it is the same formation extending by the course of the Guadalquivir and covered by its alluvions in great part. I saw nothing of this formation further up than Andujar, where I crossed the line of it, but it is of great interest in the geology of Spain. This marine formation of Carmona and Alcala de Guadaira or of los Panaderos, is a rough crag, formed chiefly of marine exuviæ, and is loose and friable. The curious aqueduct of the Moors, which supplies Seville with beautiful water from this same formation, is driven through it, and passes underneath the town of Alcala, where there is a subterraneous mill worked by the stream

* I was indebted for the first information respecting this interesting deposit of Andujar to Professor Gutierrez of Madrid, and General Zareo Valle.

in its passage. On approaching the Guadalquivir it is covered by the diluvions of the river. At Cadiz and in the neighbourhood, there is a crag, apparently much more recent, with oysters, of which the walls of the city are built. On the north side of the Guadalquivir opposite to Seville, are beds of clay, apparently the same as those of the Xeresano, etc., and which most probably rest on the primary rock of the Sierra-Morena, at a short distance from the city. Higher up the river, at about thirty miles from Seville, is the sandstone and coal formation of Villanueva del Rio, which contains grits and the usual accompaniments of coal strata. It is associated with a formation of red sandstone, to which it no doubt belongs, which rests on the primary formation of the Sierra Morena. I saw the junction on the road to Cazalla, after crossing the river at Cantillana. Above the coal formation is a patch of the tertiary marine formation which is burnt for lime. There is every probability that this mass of carboniferous sandstone on the right of the Guadalquivir, which rests on the primary formations of the Sierra Morena, and is covered by a capping of recent marine formation, is a part of the sandstone of the Serrania de Ronda, opposite to it, and from which it is separated by the overlying beds of clay and marine formation of Carmona and Alcala, and the yet more recent diluvions of the Guadalquivir. The section of lower Andalusia will be more intelligible by the help of the accompanying sketch.

The secondary limestone of the Serrania de Ronda is seen at Moron, nine leagues from Seville, where it is of a blood red, and is quarried as an ornamental marble. I have seen a slab which contained nautili of a large size.

SECTION ACROSS LOWER ANDALUSIA.

S. M. Sierra Morena.
a. Primary range.
b. Redsandstone.
c. Coal basin of Villanueva del Rio.
d. Capping of recent marine formation, believed to be identical with *g*.
R. G. River Guadalquivir.
e. Diluvions.
C. A. Carmona and Alcala.
g. Recent marine formation with oysters etc., resting on
h. Blue clay, supposed to be identical with clay of Xeres etc.
S. R. Serrania de Ronda.
I. Secondary limestone etc.

The distance across the plain is diminished for the same reasons as given before.

ON THE COAST OF THE MEDITERRANEAN.

The observations hitherto made, give a general outline of the formations which compose considerable portions of the internal structure of Spain. To make the remaining part more clear it will be better to take the coast line, from Valencia to the western extremity of the Peninsula, which I have followed in nearly all its length. The reason of this arrangement is, that it will condense, and bring under one view many details which seem to bear on the same point, and will obviate much repetition, and that these sections offer some of the more remarkable features of the geology of an almost unknown country.

I had no opportunity of observing in detail, the eastern part of the kingdom of Valencia. From the Ebro to the west is a long and almost uninterrupted flat, between the great secondary chain and the sea, which is highly cultivated. There is reason to suppose it is of the same character as the coast line further west, but I have no correct information on this subject.

The Huerta, or plain, of Valencia, which is composed of alluvions and transported materials, is bounded to the west by the great secondary chain of the Sierra de Cuenca, and Segura, which ends abruptly in the sea at Cape St.-Martin, forming bold and magnificent cliffs. In approaching Alicante are masses of white indureted marle, at the base of which near Xixona is gypsiferous marle, and on the coast a variety of recent marine formations, containing pectens, oysters, Venus, pectuncula and many other recent fossils. These beds are in various forms and positions. The castle hill is formed of

them, and associated with them is marle, and a thin bed of nummulites, to the north of the town. In proceeding to the west along the shore, white marle is seen near the mouth of the Segura, in which are various recent shells. Torre Vieja, the scene of the earth quake, stands on a solid rock of indurated marle, which dips into the sea, and appears of recent formation. The country inland, to the foot of the secondary range at Orihuela, is of marle, but I saw no organic remains. Through this formation was the line of the earth quake, on which almost every building was levelled, but the surface was scarcely disturbed, and has reverted to its original state. The vale, or *huerta*, of Murcia in the course of the Segura, is between a range of the secondary limestone, and another more recent formation. Greenstone is seen on both sides the valley, especially near the curious isolated Monte Agudo, of which the base is that rock, and the apex limestone. This valley has been the scene of earthquakes in modern times, especially in its western side, where there are signs of much disturbance. The chain between the Segura and the sea, to the south, is a masss of sandstone and conglomerates with marle on the outer flank. Between this and Cartagena is a flat plain, covered by alluvions. An excellent section of the range to the right of the Segura, is seen by following a barranco a few miles south of the city of Murcia. It exhibited marles and recent sandstones, the boldest feature being a mass of conglomerate, of blood red, which forms a noble cliff of considerable height. I followed it quite through the range, until I came to beds of marle etc. I think there can be little doubt that this is part of the series of the recent formations, which ought to rest on the secondary limestone of the

opposite side of the valley of the Segura. I saw no traces of fossils in any of the various beds, but they would certainly pay the examination of any one who might have leisure for the purpose.

The town of Cartagena is situated at the termination of a bay or indenture of the limestone, which forms bold cliffs to the east and west. To the east ward they soon end in the low land of Cape Palos, which appears to be the continuation of that of Torre Vieja and the Alicante coast. Outside the town of Cartagena, associated with thin beds of sandstone, are beds of trachyte, which run in a direction to the Volcanic district of Almazarron, on the flanks of the mass of limestone which lies to the west of Cartagena. Along the inland flanks of this range, associated with the trachyte, further to the west, is a recent marine formation, which extends to near Almazarron, which is seven leagues distant from Cartagena. Almazarron bears the strongest marks of having been the scene of volcanic action. There are masses of trachyte, and volcanic conglomerate, of which there is a bold *cerro* of considerable height, and the curious alumiferous rock of St.-Cristobal, which has been wrought for many ages. These are associated with a porphyritic rock of blood red, with primary slates, and a recent marine formation inland of it. To the west is a vast mass of trachyte, followed by more recent beds, and the line is suddenly interrupted by a bold and lofty and most remarkable primary chain, called the Lomo de Vaca, cow's back, from its precipitous ridge. It is in this ridge or its branches that it appears probable were the celebrated mines of the Carthaginians, of which all trace has been lost. This range has on either flank, beds of marles and other recent formations,

of small extent, and ends precipitously in the sea between Almazarron and Aguilas, a small town on the coast. The castle of the latter place occupies a promontory of secondary limestone, to the east of which are two others quite detached from each other, and on the coast line, upon the flank of the Lomo de Vaca, forming an interesting feature in this part of the country. The slate is close to the town of Aguilas, on which this limestone no doubt rests. Aguilas stands on a small semicircular plain round which the primary continuation of the Lomo de Vaca would appear to sweep, closing in the western end, where it forms a vast mass of black slates, much contorted, running to the east and west, over which, as I ascertained from the fallen masses, there is a capping of recent marine exuviæ, forming a compact mass, and rising to a considerable height. This range is termed Sierra de Almagro. The plain of Aguilas is primary, as shown in places, and is covered by transported materials and other recent formations, and in one place is a curious conglomerate of unrolled primary fragments. There is also marle with oysters, and pectens; the whole at a moderate elevation above the sea. After passing the Sierra de Almagro, which closes in the westenr end of the plain, the vast delta of the Almanzora is met with, which exactly corresponds with the Vega of Granada, and the plain of Guadix. As it has already been described, it requires no further mention. My route now left the coast, which I revisited at Almeria, after crossing the primary Sierra de Filabres, and descending from Tabernas, by a tract exactly similar to that of the mouth of the Almanzora, also mentioned above.

Almeria is situated in a nook, at the foot of the secon-

dary chain which covers the south east flank of the Sierra Nevada. The immediate rocks are however more recent. There is a ferruginous sand, containing pectens and balani, associated with white marle; a compact mass of marine exuviæ, which is quarried, and exhibits a solid mass of sixty or seventy feet thick. From it has been built the citadel of the Christians, which crowns the summit of the Moorish fortress directly opposite, and was built soon after the conquest. This rock also forms a revêtement, or facing, to the older limestone, in the precipitous cliff along which the road is carried, proceeding to the westward. In a ravine behind the citadel are indications of red and purple sandstone, uuderneath the limestone. On the summit of the ridge, above this sandstone, is a bed of pectens in white marle. To the east of Almeria is a flat beach, with a formation of white indurated marle and conglomerate. This terminates abruptly in the volcanic rocks of Cape de Gatt, which rise like a wall at the extremity of it, and forms a sort of circular mass, surrounded in great part by the sea. The state of the country prevented my examining this district in detail, but I have heard that at Nijar are traces of a crater *. To the west of Almeria, after passing the defile above mentioned, the plain called the campo de Dalias opens. This is of bare white indurated marle, forming a table, a little elevated above the sea, and gradually closing in at the western end, where is a sandy beach and lagoon. Near this lagoon is a bed of oysters a little above the sea. At Adra is found slate, which seems to be of the primary series. A part of these

* These volcanic formations of Cape de Gatt and Almazarron, with that of Olot, which I was prevented visiting in 1830, are the only volcanic traces I am acquainted with, in the wide range covered by these observations.

slates is covered by a mass of sand and fragments of rolled quartz, to which balani are adhering. This formation is somewhat different from any I saw elsewhere, although probably of the same age with some of them. It is about half a league from the town on the road to Berja, and rises to an elevation of probably four hundred feet above the sea. From Adra I again formed the coast line at Motril, about ten leagues to the west. In this part, the coast line is formed alternately of primary slates, covered by secondary limestone, of which the rock of Salobreña forms the largest mass. Near Nerja, where there is a small elevated plain, I found recent shells in marle. A sandy beach extends from Velez Malaga, and to the west of the river is a bold mass of recent marine formation, in which clypeaster has been found. It rises to the height of an hundred and fifty feet above the sea. To Malaga is seen sandstone, and limestone, and in places patches of the same recent marine formation above mentioned, the last of which is near the town, to the east. To the west, on the skirts of the Vega of Malaga, this recent marine formation is again seen, where it attains a height of some hundred feet but, after a diligent search, I coud find no fossils. It is entirely of marine exuviœ. I have been informed that oysters have been found near Alhaurin, at a corresponding height on the western side of the Vega, which almost certainly belongs to it.

The coast line between Malaga and Gibraltar is of primary slates, and limestone, and sandstone with its limestone, covered in places, by recent white marle rock. The country at the gates of Gibraltar is covered by a recent marine deposit, previously mentioned in the geology of Andalusia, and which appears to be identical

with that stated to have been traced by me at Vejer, Xeres, Alcala de Guadaira, Carmona, Villanueva del Rio, near Seville, and up the Guadalquivir to Andujar. This detail of the coast line is given, in order to make it more clear at one view, that, in the long line from Valencia, round the coast of Gibraltar, and across western Andalusia, along the course of the Guadalquivir, for a distance of nearly two hundred miles inland from the present coast line, there has been a regular lift of the coast, at a period comparatively recent. The formations which suggest this observation rest sometimes on primary, but more frequently on secondary strata, and rise to the height of some hundred feet, the highest point being that where it covers the slates of the Sierra de Almagro; between Aguilas and the delta of the Almanzora. If however the marine formation of Granada be hereafter assigned to this epoch, as I have little doubt it will, it gives a much more wide extent to it. In general this formation is a crag, or, as at Almeria, a compact mass of marine particles, strongly cemented together. To the eye this description of rock appears to be friable, but it is excessively tough to the hammer. I saw the facility of its cohesion at Alicante, where the convicts employed in quarrying it for the mole, were making a small road for the convenience of working, by breaking the fragments extremely small, and throwing salt water upon them, when with the assistance of a burning sun, they quickly formed a hard cement. The fossils in this formation are not numerous, having no doubt been destroyed in the compression, and they are found both above and below the beds. At Almeria beautiful pectens in great numbers are in a bed, at a considerable, height, and in a corresponding situation, further to the

west, there were appearances of them. The clypeaster is sometimes found in the mass of rock. The oysters in some instances are low down in the beds, but at Alcala de Guadaira, there are pectens still lower, passing into the blue clay as before noticed.

I am not acquainted geologically with Lisbon or the coast of Portugal, but I have strong reason for believing that the heights of Almada, on the left of the Tagus, are of a similar nature with the recent marine formation of the coasts of Andalusia. The patches examined in the neighbourhood of Nantes and mentioned by M. Lyell in his second volume, are exactly of a similar description to a great part of this widely spread mass, and the marine beds I have subsequently examined at Rome, which underlie the volcanic formations and appear to rest on blue clay, bear the strongest external analogy to some parts of them.

DESIDERATA.

The outline of the formations which cover a great part of this region being given, we will conclude by stating what appear to be some of the principal desiderata, in order to have a fuller knowledge of the geology of Spain.

In old Castile the beds of the formation between Valladolid and Burgos require examination, in order to ascertain whether they be entirely marine, and what fossils are to be obtained from them. One only, of which I have lost the name, was found by me in some rock used in the public works at Valladolid. A section across the country from Burgos, in a direction by Soria, until the primary or older formation of Alhama de Aragon or of

the Sierra de Moncayo be met with, and from Soria or that neighbourhood to the presumed lacustrine formation of the district of Guadalaxara in New Castile. To ascertain whether any recent formations, besides the diluvions of the lower part of old Castile, are dependant on the Sierra de Gata, which is the prolongation of the chain of the Somosierra and Guadarrama.

NORTHERN PROVINCES.

To ascertain whether the section of Vittoria really commences near the Ebro, or whether the sandstone in the neighbourhood of Miranda del Ebro belong to it, or be part of another series, and the relations of the limestone of Pancorbo with the latter rocks. A section to be carried across the chain from Burgos to Santander, and the ammonitic remains mentioned by Bowles as existing near Reynosa, to be examined. The important and difficult question to be solved, whether the axis be changed along the north coast, and whether, as I believe, the formation in which the great coal basin of Asturias is situated, be older than the carboniferous series of Vittoria. The solution of this must be sought either near the parallel of the bay of Santander, where the strata are broken off, or between that place and Riva de Cella. In must be sought in the interior, by following the rivers, as I fear the coast will be of no assistance, being a longitudinal line.

A section across the Puerto de Pajares, between Oviedo and Leon, and an examination and drawings of the gigantic vegetables, which cannot be removed, near Campomanes, and appear to belong to the coal field of Asturias. A careful examination of the beds on the southern flank

of the Puerto de Pajares, in descending to Leon. The chain which separates old Castile from Galicia, and the chain to the western end of Asturias, between that province and the primary formations of Coruña to be examined.

NEW CASTILE.

The relations of the gypsiferous marles of Madrid with those of the red sandstone, which form the soil of the Alcarria, and of the district of Sacedon and Guadalaxara, and the important fact of the extent of the presumed fresh water formation, by carrying a section from Colmenar, by Arganda, or Villarejo, across the Alcarria to Priego, on some point of the Sierra de Cuenca, and to observe the situation of the rock gypsum above Tarancon, relatively to the supposed fresh water limestone, and the marles on which it rests. A line carried across the Sierra de Cuenca to Valencia, by Mignanilla, in order to ascertain if the limestone of the upper formation above the city of Cuenca lie entirely above the sandstone, as I suspect it to do, or whether it alternates, as an opinion is held in the country, also to determine where the central axis of that chain is, and of what it is composed.

A line by the plateau where the Tagus, Guadalaviar and Xucar rise, into Aragon, by Teruel, and from the Alcarria, across by Molina de Aragon until the slates of Alhama de Aragon are met with, and to ascertain what the quartzose formation is, in which are the copper mines, and the shells in close contact with it, at Molina, mentioned by Bowles, and to what formation these last are to be referred, and whether the quartzose rock be, as I suspect, a continuation of the axis of Alhama de Aragon.

This line to be prolonged from Alhama to the Sierra de Moncayo. A line to be carried from the widest range of secondary and tertiary formations in lower La Mancha, from the neighbourhood of Cuidad Real, until the primary of Estremadura shows the beginning of the section, quite through the Valdepeñas chain to Almanza, where the beds of secondary limestone are thrown up perpendicular, and have the appearance of an axis, to be continued through Alcoy, where the nummulite formation must be examined, and from thence to Cape St.-Martin.

IN VALENCIA.

The relations of the chain through which the Ebro breaks to be traced from that of the Sierra de Cuenca and thence to be followed through Catalonia, and its connection, if any, with the limestone and sandstone of Mont Perdu made out. A section from Cape Palos through Murcia by the defile of the village of Cañarejo across the secondary chain to the Sierra de Segura or until the central axis of it be found in the line of bearing from Almanza, or where ever it be discovered. From thence by the Sierra de Segura to Alcaraz. The important point of the nummulite limestone at Velez Rubio to be made clear, and sections to be taken, especially from that place to the Sierra de Filabres and Lomo de Vaca, or Sierra de Almagro and Sierra de Huescar. The volcanic formations of Almazarron and Cape de Gatt to be examined in detail.

ANDALUSIA.

The limestone of the Sierra de Gador to be examined

and its junction with the formations of granular limestone and other undoubted primary rocks at the head of the valley of Derines on the route to Cadiar. Near Granada the real position of the great classes of recent formations, the conglomerate of the city and the diluvions of the Vega, the clay and gypsum, the marine formation of Escuzar and the lacustrine basin of Alhama to be positively fixed, whether they stand in the relations supposed in these sketches. A section carefully carried across the Sierra de Elvira, and the secondary chain to the Guadalquivir and the bed of the river examined in all its length, from Andujar to Carmona, to trace the connection supposed to exist through that line, especially between Cordova and Andujar.

The Sierra Morena behind Cordova to be examined. A line to be carried from the recent marine formations of Xeres across the Serrania de Ronda to Marbella and a section from St.-Cristobal to the marles of the plain of Antequera on the flanks of that elevated range.

These are the outlines of what it appears adviseable should be done in order to have a general knowledge of this almost terra incognita of geology and the designation of it will facilitate the operations of those who may have leisure for a part only. The whole of course will require time and much labour. Of details it is needless to say they must suggest themselves every where, in collecting local notices and especially fossile remains wherever they are to be obtained.

It remains to notice the soils of Spain, which are, as may be supposed extremely varied under their geological bearings. The alluvial soil of old Castile is fertile, apparently in the middle degree, but much of it is sandy and not sufficiently retentive of water. Near Villal

pando it is excellent, being a tenacious loam, whilst near Valladollid it is a white and unproductive clay, the formation in that vicinity giving only in different soil. Towards the primary chain it improves. In new Castile there is every variety. The dismal country of Madrid and Ocaña is of the gypseous marle, which gives the dreary look to the country scarcely differing in May or in December, whilst the limestone of Arganda, etc. is a light and productive soil and the red marle of Guadalaxara and the Alcarria, is about the best in Spain for every purpose. The Sierra Morena which is formed of primary detritus cannot be excelled in beauty and natural fertility, being capable of every kind of culture. The country of Valdepeñas is decomposed limestone and of excellent quality for all purposes.

The soil of Estremadura especially near Merida is primary detritus, and in the world there is not a more beautiful country, which is now almost a desert. The rich plain of Talavera and the country near Toledo appear to be of the same quality, but near Toledo in some parts there is an excellent red marle. In upper Andalusia the country of Ubeda formerly so celebrated and of Jaen is of clay, whilst Linares and the country below Orcera and Segura de la Sierra, are red marle. The rich vale of Andujar appears to be of transported materials and the dreary country from thence to Granada, excepting some hoyas or basins, as that of Archidona which is decomposed limestone forming a mass of great thickness is chiefly of the unfertile gypseous marles.

The celebrated Vega of Granada is a sandy and gravelly marle passing into clay and is an unfertile, ungrateful soil, as is the vast district of Guadix and of Baza, to

the sea. All this soil can only be made productive by irrigation.

Lower Andalusia is chiefly clay and bad marle only to be forced by irrigation, none of it being really good soil, until the red sandstone marles of the Serrania of Ronda appear, which give the fertility to that beautiful region. The Tierra Caliente or strip along the mediterranean varies exceedingly. In the Vega of Malaga now a desert it is naturally of surprising fertility, and west of Marbella is an excellent small tract upon the sandstone, now quite uncultivated. Along the coast near Velez Malaga there is red marle like that of Malaga and it is equally fertile. The beautiful sugar and cotton grounds are chiefly the deltas of the torrents and all around them is bare rock. Almeria and the campo de Dalias are bare rocks only to be managed by irrigation and the establishment of pantanos or reservoirs, as is all the country to Murcia. This vale owes its fertility to the Moors by the establishment of irrigation. It is probably better soil than Valencia and like that, alluvial or transported materials. Alicante resembles the country further west and requires only additional pantanos to make it a garden.

Valencia is a poor and ungrateful soil which is constantly exhausted and yields its crops only by forced cultivation and especially the use of water. Most of the country to the Ebro is the detritus of limestone which it thinly covers. Catalonia contains beautiful red marles and tracts of white gypseous marle as dreary as any in Castile. Aragon has both unproductive gypseous marles and rich red marles as in the valley of the Xalon. The bed of the Ebro is of sand and gravel, which with the irrigation from the canal

prove what may be done, the produce in a very imperfect state of agriculture being seven times the consumption in good years. The northern provinces have the soil principally from the red sandstone as is that of the upper part of old Castile. If steps were to be taken seriously to revive the agriculture and people the *despoblados*, care should be taken in seleeting as commencements those parts where the return will be most rapid and certain. The Sierra Morena, the Alcarria, the province of Toledo, and of Guadalaxara, the Vega of Malaga, and the country between Gibraltar and Cadiz would probably repay exertion more than any others in Spain. In a vast proportion of soils, it is a mere calculation of the quantity of water which can be bestowed on them. The gypseous marles give the white and dreary appearance so striking in many parts of the country and so distressing to the traveller when the glare of their brilliant sun induces the wearied eye to court repose on verdure, which is sought in vain in these districts. These clays give the peculiar state called *barro* which is frequently mentioned in travelling. In the important branch of springs, this arid country prossesses certainly the most beautiful waters in the world, and in the greatest abundance. Attempts have been made to increase the supply in some peaces by the introduction of the Artesian system, unfortunately without success, as it may deter others from making the attempt.

Tbe foot of the limestone ranges are the most promising localities, but in general in these it is not wanted, as nature affords it in abundance, without the troubling of boring. The mining districts are mentioned under that head, and do not require repetition under the geological notice. The Sierra Morena and range

of the Sierra Nevada are beyond question the best, and most likely to repay the examination now going on in almost all parts. The veins in the Sierra Morena are generally in a direction from north to south and are perpendicular in most parts. Those which are sterile are filled, at least at Guadalcanal, with quartz.

ERRATUM.

Page 105, line 26, *for* San Pauls, *read* St.-Pauls.

Note to page 244. In the ascending series of the Pines, the p. pinea is placed above the Hispanica, on account of the *latitude* and elevation of the plateau of old Castile, but it is not meant to be asserted as positively higher. Experiments will soon prove, in England, their relative hardiness. It is probable that in actual level above the sea, the Hispanica in the forests yet remaining, will, when the levels are taken, be found the highest of these two species.